From: Jerry Brown [jbrown@sitesproject.org]
Sent: 6/1/2021 7:34:19 AM
To: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Subject: Re: Climate Change - WSIP

Thanks. Do you have amounts for the other alternatives? Please provide.

From: "Heydinger, Erin" <Erin.Heydinger@hdrinc.com>
Date: Monday, May 31, 2021 at 9:45 PM
To: Jerry Brown <jbrown@sitesproject.org>
Subject: Climate Change - WSIP

Hi Jerry,

A couple of weeks ago you asked me to let you know what the climate change results were showing for WSIP. The long-term average release numbers for 2030 are 253 TAF and for 2070 are 259 TAF. This is above the current baseline of 234 TAF. Please let me know if you want a further breakdown or any more information.

Thanks!
Erin

Erin Heydinger, PE, PMP
Project Manager
Water/Wastewater

HDR
2379 Gateway Oaks Dr, #200
Sacramento, CA 95833
D 916.679.8863 M 651.307.9758

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Topic: **Summary of NODOS Biological Resources Surveys** **2021 May 26**

Subject: **Overview and summary of the NODOS biological and botanical surveys as they relate to the Sites Reservoir project area.**

The following information has been excised and summarized from the following documents:

- North of the Delta Offstream Storage (NODOS) Investigation Progress Report to CALFED, July 2000
- North-Of-The-Delta Offstream Storage Investigation Final Initial Alternatives Information Report, May 2006
- Preliminary Administrative Draft North-Of-The-Delta Offstream Storage Project EIR/EIS. California Department of Water Resources (DWR) and U.S Department of the Interior (DOI), Bureau of Reclamation, Mid-Pacific Region (Reclamation). December 2013

Initial surveys were performed in the NODOS "Sites and Colusa Project Area" from approximately 1997 to 2000, additional surveys by DWR and California Department of Fish and Wildlife (CDFW) were performed from 2001 – 2004, then again in 2010 to 2011 at newer proposed Project facility locations (Delevan Pipeline and associated facilities).

Reptiles and Amphibian

Surveys for reptiles and amphibians were conducted by CDFW from August 1997 through spring 1999 in the Sites and Colusa Project areas. Amphibian and reptile surveys included night driving, dip-netting, seining, ground searches, habitat assessment, consultation with United States Fish and Wildlife (USFWS), and the use of the USFWS and CDFW's protocol guidelines for red-legged frog and California tiger salamander surveys.

The major objectives of these surveys were to search for California red-legged frogs, federally threatened; California tiger salamanders, candidate for federal listing and California Stat State Species of Concern; and to conduct general herpetology surveys. Four species listed as federal and California State Species of Concern that could potentially occur in the Sites and Colusa Project areas—foothill yellow-legged frogs, western pond turtles, western spadefoot toads, and California horned lizard—were also looked for during the course of this survey.

Results

A total of 2,400 hours in the spring and summer of 1998 and 1999 were spent in the Sites and Colusa Project areas looking for reptiles and amphibians. A total of 19 species, 5 amphibians and 14 reptiles, were found during this survey. Only one special species targeted by these surveys was found in the Sites Project study area, the western pond turtle. California red-legged frogs and California tiger salamanders were not found.

Mammal Surveys

A variety of field survey methods were used by CDFW biologists in 1998 and 1999 to sample the mammal populations at the Sites Project study area. These methods included small mammal trapping, mist netting, acoustical surveys, roost searches, track plates, camera stations, spotlighting, general habitat measurements and assessment, and incidental observation.

Results for Sites Project Area

No federally or state listed species were found during field surveys in the Sites Project study area. Six mammal California State Species of Special Concern were documented at the four project areas. Table 1 identifies those found within the Sites Reservoir study area.

Table 1. Special Status Mammals Observed in Sites Study Area

Species	Status
American badger	SSC
Pallid bat	SSC
San Joaquin pocket mouse	SSC
Western red bat	SSC
Source: North-Of-The-Delta Offstream Storage Investigation Final Initial Alternatives Information Report, May 2006	

Avian Surveys

Avian surveys in the Sites Reservoir study area included general line transects and focused bank swallow, yellow-billed cuckoo, and owl surveys. The most relevant studies were confined primarily to the area of the reservoir footprint. However, line transects extended up to 2.5 miles from the reservoir footprint along key drainages. In addition to the surveys in the reservoir footprint, surveys were also initiated at Funks Reservoir to document which state or federally listed avian species would use a reservoir within low elevation grassland habitats. Sites Reservoir data are most comprehensive, being surveyed monthly from March 1997 to at least March 2000.

Results for Sites Project Area

No federally or state listed species identified as potentially occurring were found during field surveys in the Sites Project study area. Eleven avian species classified as either California Species of Special Concern or federal Migratory Nongame Birds of Management Concern were observed during the surveys at Funks Reservoir and are listed in Table 2.

Table 2. Special Status Species Observed at Funks Reservoir

Species	Status
American white pelican	SSC (breeding only)
Common loon	SSC (breeding only)
Golden eagle	FP
Grasshopper sparrow	SSC (breeding only)
Lawrence's goldfinch	MNBMC
Loggerhead shrike	SSC (breeding only)
Long-billed curlew	MNBMC
Northern harrier	SSC (breeding only)
Short-eared owl	SSC (breeding only), MNBMC
Bald eagle	SE
White-tailed kite	FP

Source: North-Of-The-Delta Offstream Storage Investigation Final Initial Alternatives Information Report, May 2006.
Key
CSSC = California Species of Special Concern
MNBMC = Migratory Nongame Birds of Management Concern (USFWS)
SE = State Endangered
FP = State Fully Protected

Valley Elderberry Longhorn Beetle (VELB)

A survey of all potential reservoir sites for the VELB and its habitat was conducted during the periods January through July 1998 and April through June 1999. Surveys focused on identifying potential habitat for VELB, the number of elderberry stems found measuring more than one inch, and the presence of exit holes. A total of 45 days was spent field surveying the drainages.

Results for Sites Project Area

Six hundred seventy-two stems were counted within the proposed Sites Project area. Emergence holes were found on 18 individual stems. The plants within this area tend to be individuals with multiple trunks and range from unhealthy stressed plants to occasional large healthy individuals. The majority of plants at this site and the riparian vegetation in general tend to be in poor condition.

Table 3. Elderberry Stems and Emergence Holes Found at Sites Reservoir

Sites Reservoir NODOS VELB 1998/99 Survey Results	
Number of elderberry stem	672
Number of stems with emergence hole	18
Percentage of stems with emergence holes:	2.7

Vernal Pool Brachiopods

Surveys of potential special status shrimp habitat at the potential reservoir sites were performed in 1998 and 1999. The 1999 surveys were conducted to verify potential special status shrimp habitat mapped in 1998 and to survey in areas where access was unavailable in the previous surveys because of flooded creeks, washed-out roads, and issues with property owners.

Special status shrimp include species in the following categories:

- Shrimp listed or proposed for listing as Threatened or Endangered Species under the federal Endangered Species Act (50 Code of Federal Regulations [CFR] 17.11 for listed animals and various Federal Register notices for proposed species).
- Other shrimp species meeting the definition of Rare, Threatened, or Endangered Species under the California Environmental Quality Act (CEQA) Guidelines (Section 15380).

Potential special status shrimp habitat is defined as seasonal wetlands and other temporarily ponded areas of sufficient size (depth and area) and seasonality to support specific vegetation. Grasslands and vernal pools characterize the majority of the potential landcover where special status shrimp could be found within the Sites Reservoir study area.

Results for Sites Project Area

A summary of potential special status shrimp habitat mapped in the 1998 and 1999 surveys is presented in Table 4. The majority of the areas identified as potential habitat is degraded by cattle activity, erosion, and debris from cattle feeding areas.

Table 4: Total Acreage of Potential Special Status Shrimp Habitat

Survey Year	Total Extent of Potential Special Status Species
1998	73
1999	71

Plant Surveys

Focused habitat-specific surveys were conducted, using wandering transect methodology, between February and October 1998 and 1999 and within potential routes for conveyances, recreation areas, and road relocations for the Sites Project area in 2000 through 2003. These months coincided with the appropriate flowering and fruiting stages necessary for the identification of most plant species occurring in the area, including all special-status species.

Results for Sites Project Area

No federally or state listed species identified as potentially occurring were found in the Sites Project study area. Five species with California Rare Plant Rank (CNPR) status were found during field surveys that were conducted within the Primary Study Area. This status is considered for purposes of CEQA analysis.

Table 5. Rare Plant Species Found in the Sites Project Study Area

Species	Status
Adobe lily	California Rare Plant Rank (CRPR) of 1B.2
Bent-flowered fiddleneck	CRPR of 1B.2
Red-flowered bird's-foot trefoil	CRPR of 1B.1
Brittlescale	CRPR of 1B.2
San Joaquin spearscale	CRPR of 1B.2

California Rare Plant Rank:
1A = presumed extinct in California
1B = rare, threatened, or endangered in California and elsewhere
2B = rare, threatened, or endangered in California, but more common elsewhere
3 = more information is needed to determine whether assigning a rank is appropriate
4 = plants of limited distribution that are on a watch list
0.1 = seriously endangered in California
0.2 = fairly endangered in California

From: Oakes, Harry [Harry.Oakes@icf.com]
Sent: 6/1/2021 4:45:28 PM
To: Spranza, John [john.spranza@hdrinc.com]
CC: Alicia Forsythe [aforsythe@sitesproject.org]; Briard, Monique [Monique.Briard@icf.com]; Arsenijevic, Jelica [Jelica.Arsenijevic@hdrinc.com]; MacKay, Kevin [Kevin.MacKay@icf.com]
Subject: Re: Mitigation Cost Review

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Sent from my iPhone

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I think we are now ready to start focusing on the mitigation plans we will need this year. Do you think continuing the weekly Tuesday meetings is warranted or should we go every other week?

John Spranza

D 916.679.8858 M 818.640.2487

From: Oakes, Harry <Harry.Oakes@icf.com>
Sent: Friday, May 28, 2021 10:49 AM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Spranza, John <John.Spranza@hdrinc.com>; Briard, Monique <Monique.Briard@icf.com>; Arsenijevic, Jelica <Jelica.Arsenijevic@hdrinc.com>
Subject: RE: Mitigation Cost Review

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Thanks!

Have a great weekend everyone!

Harry

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, May 25, 2021 6:31 AM
To: John Spranza <John.Spranza@hdrinc.com>; Briard, Monique <Monique.Briard@icf.com>; Oakes, Harry <Harry.Oakes@icf.com>; Arsenijevic, Jelica <Jelica.Arsenijevic@hdrinc.com>
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6. Cultural sheet – I think we should just walk though this one more time to make sure we are not missing anything that should be costed out here. OK

Thanks!

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

---

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Monday, May 24, 2021 1:57 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; Oakes, Harry <Harry.Oakes@icf.com>; Arsenijevic, Jelica <Jelica.Arsenijevic@hdrinc.com>
Subject: FW: Mitigation Cost Review

I asked Jeff H to take a look at the mitigation sheet and he has provided a few comments. I think we have good rational behind all of the assumptions that he has hit on, but its nice to get a different perspective. Please let me know if you see any comments that we should address further.

Thanks.

John Spranza

D 916.679.8858 M 818.640.2487

From: Herrin, Jeff <jeff.herrin@aecom.com>
Sent: Monday, May 24, 2021 10:59 AM
To: Spranza, John <John.Spranza@hdrinc.com>
Cc: Luu, Henry <Henry.Luu@hdrinc.com>
Subject: FW: Mitigation Cost Review

John,

My comments are as follows:

- The cost per acre for annual grassland mitigation banking is about exactly double the cost that we used. Maybe the cost for the mitigation bank is double. Your cost may be for irrigated grassland. If we can use unirrigated rangeland, that should suffice to mitigate for the valley inundated by Sites and I believe it may be less expensive. Irrigation is a pretty big cost driver. I don't think we want to use a mitigation bank with irrigation if it can be avoided. We used 2 costs for annual grassland mitigation. $2,000/ac for rangeland (11,690 acres). The remainder was assumed to be on a mitigation bank to account for stacking of habitat credits for species. We selected 14,500 acres required which roughly equates to what would be required for Swainson's hawk upland.
- I'm not sure if the stream mitigation includes Funks and Stone Corral Creeks. We are spending a lot of money to put in pipelines and to maintain flows in the creeks prior to construction that would interrupt flow to Funks and Stone Corral Creeks. Maybe you are mitigating a different creek, but the cost seems high for these two creeks. Our stream mitigation costs assumes is assumed to be the same as the per acre cost for other wetland types. Since we aren't sure we can create stream streams or get enough LF at a bank it may need to be out-of-kind.
- The mitigation cost for blue oak woodlands/oak savannah is also a much higher per acre than we were using (about 6 times our cost). Suggest you check the cost per acre ($35,000/acre may generate some questions). Our cost assumes oak mitigation at a bank.

• Here is what we had on elderberry previously: We assumed up to 500 shrubs impacted, which admittedly is probably high. We can reduce the number of assumed shrubs affected. Total cost for the 500 shrubs is $2.75M, we could reduce that by half?

There are two elderberry shrubs located within the potential construction disturbance area for Sites Reservoir and Dams that could be completely avoided by establishing and maintaining a 100-foot-wide or wider buffer around them. Construction crews shall be briefed regarding the need to avoid these plants, and signs shall be posted during construction to avoid the buffer area. After Project construction is complete, this area would not be affected by Project operation or maintenance.

The elderberry shrub immediately adjacent to the footprint of the Delevan Pipeline Intake/Discharge Facility is located on the edge of an irrigation canal that is situated along an existing access road. Because of its proximity to the road, it would not be possible to establish a 100-foot-wide buffer. It would also not be possible to establish a 100-foot-wide buffer for the shrubs located immediately adjacent to the existing Maxwell Sites Road. Consultation with USFWS would be initiated for possible approval to encroach on the buffer. Otherwise, appropriate mitigation measures shall be implemented.

The elderberry shrubs within the footprint of Sites Reservoir, Sites Dam, and Golden Gate Dam, as well as the one shrub within the footprint of the Delevan Pipeline Intake/Discharge Facility, would not be avoided by Project construction, and therefore, shall be transplanted or replaced, depending on the likelihood of survival post-transplantation. Transplantation procedures shall comply with USFWS's 1999 Conservation Guidelines for the Elderberry Longhorn Beetle (USFWS, 1999). If transplantation is not feasible, USFWS general guidelines require replacement of elderberry plants in designated mitigation areas. Elderberry plants are typically replaced at a ratio of 2:1 for stems greater than one inch in diameter at ground level with no adult emergence holes, 3:1 for stems where emergence holes are documented in less than 50 percent of the shrubs, and 5:1 for stems greater than one inch in diameter with emergence holes.

Mitigation measures already required for the loss of riparian habitat pursuant to the mitigation for loss of wildlife habitat types described above could potentially compensate for the native planting requirement for elderberry plant mitigation.

• Red-legged Frog is a much bigger issue now than it was when the prior estimate was put together due to USFW focus. It is a pretty significant contributor to cost growth. Comment noted

• We have a pretty significant difference on Williamson Act associated costs. We had assumed that contracts could be rescinded for many acres. The current estimate did not take this approach. The delta is about $26M. Comment noted. We removed the tax costs for rescinded acres which saved approx. $7M. Per my response to Ali, could all ag land costs be removed and covered under real estate costs?

• Henry mentioned this was a 2019 cost estimate. Given the cost per acre, you may want to consider making it 2020 or 2021. Comment noted.

Jeff Herrin
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aecom.com

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Friday, May 21, 2021 10:27 AM
To: Herrin, Jeff <jeff.herrin@aecom.com>
Subject: [EXTERNAL] Mitigation Cost Review

Hi Jeff,

Could you take a look at the attached mitigation cost estimate and get back to me with comments on items you see as potential issues? We're looking to finalize it the first week in June so if you could get those over to me by the end of next week I would appreciate it.

Let me know if you can't squeeze this in or if you have any questions.

Thanks
John

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

HDR
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Sacramento, CA 95833
D 916.679.8858 M 818.640.2487
john.spranza@hdrinc.com

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<Summay of NODOS Surveys In Sites Reservoir_ 20210526.docx>

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/2/2021 1:48:10 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Oakes, Harry [Harry.Oakes@icf.com]
CC: Briard, Monique [Monique.Briard@icf.com]; Arsenijevic, Jelica [Jelica.Arsenijevic@hdrinc.com]; MacKay, Kevin [Kevin.MacKay@icf.com]
Subject: RE: Mitigation Cost Review
Attachments: SitesReservoir_MitigationCostEstimate__Final Draft_06022021.xlsx

Okay, all the changes are made and the winner is $562,477,300.0

Harry, if you have not done so already can you please upload all of your reference material and admin record related documents and QA/QC form to the Sharepoint site when you have time? Here is the link:

https://sitesreservoirproject.sharepoint.com/:f:/r/envpermitting/Working%20Documents/7.%20Mitigation%20and%20AMP?csf=1&web=1&e=mtCMOg

Thanks.

John Spranza

D 916.679.8858 M 818.640.2487

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, June 1, 2021 5:09 PM
To: Oakes, Harry <Harry.Oakes@icf.com>; Spranza, John <John.Spranza@hdrinc.com>
Cc: Briard, Monique <Monique.Briard@icf.com>; Arsenijevic, Jelica <Jelica.Arsenijevic@hdrinc.com>; MacKay, Kevin <Kevin.MacKay@icf.com>
Subject: RE: Mitigation Cost Review

Hi all – I just had a chance to look at all of this. I don't think we can remove all ag costs. We will have to mitigate for the loss of ag lands. That might stack with our grassland mitigation, but I am just not sure that I am comfortable with that right now as this ag land mitigation might need to be in the county that the impact occurred in and we only have 11,690 acres of easement (14,500 acres of grasslands is assumed mitigation bank), which is less than the ag land impact. Anyway, I am not confident that we will be able to stack these together and thus not comfortable that we take out all ag land mitigation costs. While these are land costs, the land acquisition costs only cover those costs to buy land to build the project (and any costs associate with that transaction to the landowner). So these mitigation costs are not covered in the land acquisition costs. Plus, small amount of this ag land might end up being permanent crops, which the cost is wayyyyy higher.

I do think we can take out the $2.4 for remnant parcels in Glenn County and the $3.87 for remnant parcels in Colusa County. These are costs that I think we would take on in land acquisition – meaning we wouldn't leave the landowner with remnant parcels that got bumped out of WAC and cost them money without compensating them for this cost as part of the land acquisition purchase. So I think this would be an effect/change that we would compensate the landowner for in the normal course of purchasing property for the project and will be addressed in our land acquisition costs.

I am good with dropping the elderberry to 250 bushes if you think that is warranted. With these two changes, I think this bring us to $563,852,300.

Ali

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John,

My comments are as follows:

- The cost per acre for annual grassland mitigation banking is about exactly double the cost that we used. Maybe the cost for the mitigation bank is double. Your cost may be for irrigated grassland. If we can use unirrigated rangeland, that should suffice to mitigate for the valley inundated by Sites and I believe it may be less expensive. Irrigation is a pretty big cost driver. I don't think we want to use a mitigation bank with irrigation if it can be avoided. We used 2 costs for annual grassland mitigation. $2,000/ac for rangeland (11,690 acres). The remainder was assumed to be on a mitigation bank to account for stacking of habitat credits for species. We selected 14,500 acres required which roughly equates to what would be required for Swainson's hawk upland.

- I'm not sure if the stream mitigation includes Funks and Stone Corral Creeks. We are spending a lot of money to put in pipelines and to maintain flows in the creeks prior to construction that would interrupt flow to Funks and Stone Corral Creeks. Maybe you are mitigating a different creek, but the cost seems high for these two creeks. Our stream mitigation costs assumes is assumed to be the same as the per acre cost for other wetland types. Since we aren't sure we can create stream streams or get enough LF at a bank it may need to be out-of-kind.
- The mitigation cost for blue oak woodlands/oak savannah is also a much higher per acre than we were using (about 6 times our cost). Suggest you check the cost per acre ($35,000/acre may generate some questions). Our cost assumes oak mitigation at a bank.
- Here is what we had on elderberry previously: We assumed up to 500 shrubs impacted, which admittedly is probably high. We can reduce the number of assumed shrubs affected. Total cost for the 500 shrubs is $2.75M, we could reduce that by half?

There are two elderberry shrubs located within the potential construction disturbance area for Sites Reservoir and Dams that could be completely avoided by establishing and maintaining a 100-foot-wide or wider buffer around them. Construction crews shall be briefed regarding the need to avoid these plants, and signs shall be posted during construction to avoid the buffer area. After Project construction is complete, this area would not be affected by Project operation or maintenance.

The elderberry shrub immediately adjacent to the footprint of the Delevan Pipeline Intake/Discharge Facility is located on the edge of an irrigation canal that is situated along an existing access road. Because of its proximity to the road, it would not be possible to establish a 100-foot-wide buffer. It would also not be possible to establish a 100-foot-wide buffer for the shrubs located immediately adjacent to the existing Maxwell Sites Road. Consultation with USFWS would be initiated for possible approval to encroach on the buffer. Otherwise, appropriate mitigation measures shall be implemented.

The elderberry shrubs within the footprint of Sites Reservoir, Sites Dam, and Golden Gate Dam, as well as the one shrub within the footprint of the Delevan Pipeline Intake/Discharge Facility, would not be avoided by Project construction, and therefore, shall be transplanted or replaced, depending on the likelihood of survival post-transplantation. Transplantation procedures shall comply with USFWS's 1999 Conservation Guidelines for the Elderberry Longhorn Beetle (USFWS, 1999). If transplantation is not feasible, USFWS general guidelines require replacement of elderberry plants in designated mitigation areas. Elderberry plants are typically replaced at a ratio of 2:1 for stems greater than one inch in diameter at ground level with no adult emergence holes, 3:1 for stems where emergence holes are documented in less than 50 percent of the shrubs, and 5:1 for stems greater than one inch in diameter with emergence holes.

Mitigation measures already required for the loss of riparian habitat pursuant to the mitigation for loss of wildlife habitat types described above could potentially compensate for the native planting requirement for elderberry plant mitigation.

- Red-legged Frog is a much bigger issue now than it was when the prior estimate was put together due to USFW focus. It is a pretty significant contributor to cost growth. Comment noted
- We have a pretty significant difference on Williamson Act associated costs. We had assumed that contracts could be rescinded for many acres. The current estimate did not take this approach. The delta is about $26M. Comment noted. We removed the tax costs for rescinded acres which saved approx. $7M. Per my response to Ali, could all ag land costs be removed and covered under real estate costs?
- Henry mentioned this was a 2019 cost estimate. Given the cost per acre, you may want to consider making it 2020 or 2021. Comment noted.

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From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Friday, May 21, 2021 10:27 AM
To: Herrin, Jeff <jeff.herrin@aecom.com>
Subject: [EXTERNAL] Mitigation Cost Review

Hi Jeff,
Could you take a look at the attached mitigation cost estimate and get back to me with comments on items you see as potential issues? We're looking to finalize it the first week in June so if you could get those over to me by the end of next week I would appreciate it.

Let me know if you can't squeeze this in or if you have any questions.

Thanks
John

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

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<Summay of NODOS Surveys In Sites Reservoir_ 20210526.docx>

From: Leaf, Rob/SAC [Rob.Leaf@jacobs.com]
Sent: 6/2/2021 1:59:11 PM
To: Heydinger, Erin [erin.heydinger@hdrinc.com]
CC: steve.micko@jacobs.com; Thayer, Reed/SAC [Reed.Thayer@jacobs.com]; Alicia Forsythe [aforsythe@sitesproject.org]
Subject: RE: CBD Operations
Attachments: SitesMetrics_rev20_ScenCharts_5scn__ALT1B_011221_SA_limitDunn_CBD_30p_50p_80p_and_woDunn TABLES.pdf; SitesMetrics_rev20_ScenCharts_5scn__ALT1B_011221_SA_limitDunn_CBD_30p_50p_80p_and_woDunn - CHARTS.pdf

Erin,

Please see the attached for preliminary Sites Metrics results of the following sensitivity analyses of Alternative 1B:

- Dunnigan pipeline limited to 30% Dry values
- Dunnigan pipeline limited to 50% Dry values
- Dunnigan pipeline limited to 80% Dry values
- Without Dunnigan pipeline

We will be developing trend reporting and release analysis spreadsheets to look more specifically at results.

Rob

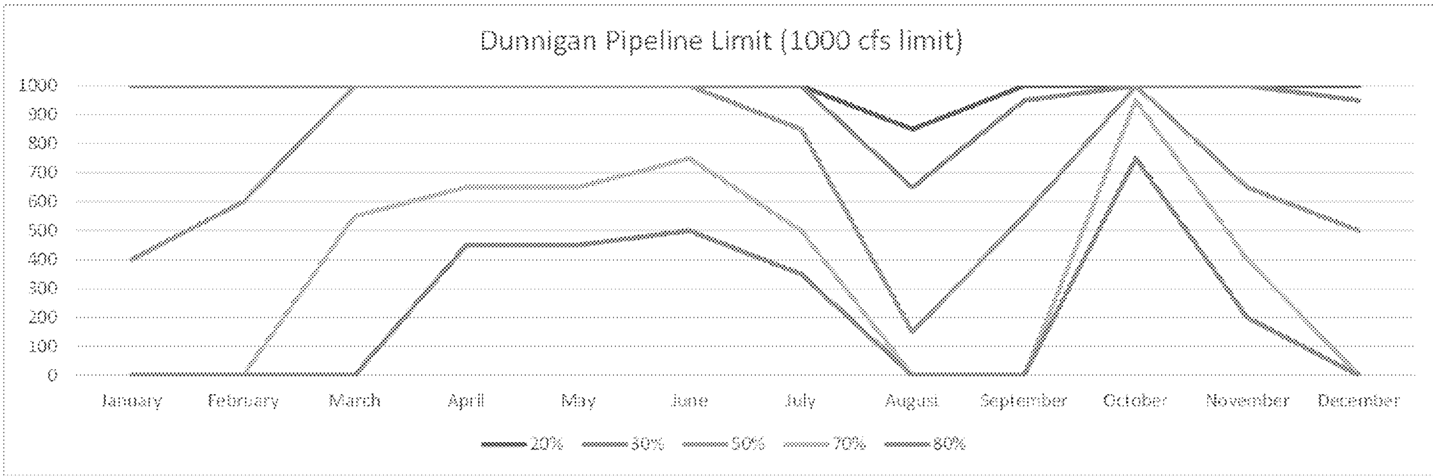
From: Leaf, Rob/SAC
Sent: Wednesday, May 12, 2021 12:19 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Cc: Micko, Steve/SAC <Steve.Micko@jacobs.com>; Thayer, Reed/SAC <Reed.Thayer@jacobs.com>
Subject: RE: CBD Operations

Erin,

The two charts below are taken from the latest analysis by Kyle Winslow re CBD capacity constraints (4/15/21).
Source document: CBD_HydModel_Prelim_Results_0408021 v3_phr_nb.pdf pages 22 & 24

Due to the lack of data at the CalSim II scenario period of record (1922 – 2003) and similarity of variability across BN, D & C conditions,
I am recommending that we first do a probabilistic approach to testing sensitivity of Dunnigan pipeline constraints.

For example, using the Dry years probability table shown below, do sensitivity analysis CalSim II runs limiting Dunnigan pipeline to the following chart.
Run 50%, 80% and 30% at least (see attached spreadsheet for data)



By testing these scenarios, we can see at what probability level the Sites Project performance begins to deteriorate and we can see how the conveyance operations adapt through the range.

Other considerations:
- Use a probability table that includes all BD, D and C years evaluated by Winslow
- Can TCC be reoperated to exchange water back to the river to avoid deterioration of project performance (this is not currently used for other than CVP Op Flex)?
- What if Dunnigan was extended to KLRC so as to convey Yolo Bypass water without affecting drain flows (August-October)?
- What if Dunnigan was only designed to provide flow to Yolo Bypass and not flow to the river?

Rob

CBD_HydModel_Prelim_Results_0408021 v3_phr_nb.pdf page 22:

Dry Years (26.5 foot critical WL impacts, 1700 cfs capacity)

	Davis Weir from Regression											
	Daily Average Flow Percentiles by Month (cfs)											
	Regression developed with Davis Weir Flow Data January 2013 to June 2020											
Percentile	January	February	March	April	May	June	July	August	September	October	November	December
10	156	78	52	101	108	94	211	595	170	39	229	229
20	374	245	269	261	231	237	342	819	396	119	372	429
30	563	432	375	347	369	346	494	1026	722	208	628	725
40	893	687	503	430	539	452	649	1320	901	277	814	970
50	1291	1051	694	558	693	599	827	1521	1101	426	1090	1200
60	1802	1468	856	751	859	746	986	1670	1369	602	1136	1459
70	2490	2230	1104	1022	1017	938	1173	1825	1696	732	1295	1790
80	5205	4360	1961	1201	1224	1193	1329	2075	2127	934	1474	2800
90	9433	7596	5304	1689	1667	1581	1571	2285	2506	1156	1766	5976
95	16608	16316	8562	6247	2670	2057	1738	2480	2961	1986	2287	8357
	monthly average Project flow by year type											
	January	February	March	April	May	June	July	August	September	October	November	December
Dry	0	15	15	184	178	765	956	840	725	347	119	45
1700	cfs capacity											
	Available Capacity at Monthly Average Project Delivery											
Dry	1700	1685	1685	1516	1522	935	744	860	975	1353	1581	1655

CBD_HydModel_Prelim_Results_0408021 v3_phr_nb.pdf page 24:

CDR Gauge 23-year dataset

Water Year Average					
Average Daily Q CDR Gauge					
1805	W	WY 1998	711	D	WY 2001
221	W	WY 1999	931	D	WY 2002
1069	W	WY 2006	519	D	WY 2007
814	W	WY 2011	565	D	WY 2009
907	W	WY 2017	553	D	WY 2013
862	W	WY 2019	252	D	WY 2020
924	W	Average	590	D	Average
685	AN	WY 2000	849	C	WY 2008
789	AN	WY 2003	179	C	WY 2014
1058	AN	WY 2005	372	C	WY 2015
844	AN	Average	466	C	Average
1036	BN	WY 2004			
966	BN	WY 2010			
553	BN	WY 2012			
232	BN	WY 2016			
258	BN	WY 2018			
620	BN	Average			

From: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Sent: Monday, May 3, 2021 2:22 PM
To: Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Cc: Micko, Steve/SAC <Steve.Micko@jacobs.com>
Subject: [EXTERNAL] CBD Operations

Hi Rob,

Following up on our call earlier on CBD – it sounded like you had some ideas for running a sensitivity level analysis of options to see what we might be able to shift around to accommodate drain restrictions. I think the team is hoping to have a high-level evaluation done near the end of the week to be able to report on it at the next Ops & Engineering WG meeting (Wednesday 5/12). What are your thoughts on how we address this and is it something that would be quick to run over the next 4-5 days?

Erin

Erin Heydinger, PE, PMP
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CVP/SWP Deliveries Table

Deliveries (TAF/year) (change from No Project Alternative conditions)[a]	ALT 1B 011221		ALT 1B 011221 SA CBD Cap 30% Dry		ALT 1B 011221 SA CBD Cap 50% Dry		ALT 1B 011221 SA CBD Cap 80% Dry		ALT 1B 011221 SA w/o Dunnigan Pipeline	
	Average	**Dry and Critical**	**Average**	**Dry and Critical**	**Average**	**Dry and Critical**	**Average**	**Dry and Critical**	**Average**	**Dry and Critical**
	1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD)		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD)		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD)		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD)		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD)	
	Historic Climate		Historic Climate		Historic Climate		Historic Climate		Historic Climate	
CVP Deliveries	11	29	7	20	8	23	7	21	11	30
NOD Ag	0	5	0	3	-1	3	0	4	3	9
NOD M&I	0	0	0	0	0	0	0	0	1	2
SOD Ag	10	24	7	17	9	19	6	17	7	20
SOD M&I	1	0	0	0	0	0	1	0	0	0
Subtotal - CVP Operational Flexibility *(Diff from Alt A1 CVP values)*	**8**	**19**	**4**	**10**	**6**	**13**	**4**	**11**	**8**	**20**
CVP Refuge Water Supply	**1**	**2**	**1**	**2**	**1**	**2**	**2**	**2**	**2**	**3**
NOD (Level 2)	1	2	1	2	1	2	2	2	2	3
SOD (Level 2)	0	0	0	0	0	0	0	0	0	0
SWP Deliveries	-2	0	-2	-1	4	1	5	6	-2	-12
SWP SOD Ag (Table A)	0	1	0	0	0	1	0	1	-1	-5
SWP SOD M&I (Table A)	-1	1	-1	0	-2	-1	-2	0	-4	-9
SWP SOD Interruptible (Article 21)	-1	-1	-1	-1	6	1	7	5	4	1
Total change in CVP/SWP Deliveries with CVP Operational Flexibility	10	31	6	21	14	25	13	30	11	21
Total change in CVP/SWP Deliveries without CVP Operational Flexibility	2	12	2	11	8	13	9	18	3	1

Notes:

[a] Values shown are the net change between the Project Alternative and No Project Alternative

Results are dependent on storage allocations (see storage allocation table)

Authority Deliveries Table

Deliveries (TAF/year) (change from No Project Alternative conditions)[a]	ALT 1B 011221		ALT 1B 011221 SA CBD Cap 30% Dry		ALT 1B 011221 SA CBD Cap 50% Dry		ALT 1B 011221 SA CBD Cap 80% Dry		ALT 1B 011221 SA w/o Dunnigan Pipeline	
	Average	**Dry and Critical**	**Average**	**Dry and Critical**	**Average**	**Dry and Critical**	**Average**	**Dry and Critical**	**Average**	**Dry and Critical**
	1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate	
Authority PWA Deliveries	**119**	**286**	**121**	**286**	**121**	**285**	**109**	**252**	**93**	**216**
NOD	29	60	29	60	29	61	29	61	30	62
SOD	91	226	91	226	92	224	79	192	64	154
CVP Operational Flexibility	**8**	**19**	**4**	**10**	**6**	**13**	**4**	**11**	**8**	**20**
Sub-Total Supplemental Deliveries for Water Supply	**127**	**305**	**125**	**295**	**127**	**298**	**112**	**264**	**101**	**236**
Refuge Water Supply	**20**	**34**	**20**	**33**	**20**	**33**	**21**	**36**	**22**	**36**
NOD (Level 4)	5	6	5	6	5	6	5	7	5	7
SOD (Level 4)	15	27	15	27	15	27	16	29	17	29
Yolo Bypass Habitat Water Supply	**36**	**21**	**36**	**20**	**32**	**15**	**16**	**11**	**0**	**0**
Total Authority Deliveries	**184**	**359**	**182**	**349**	**179**	**345**	**150**	**310**	**123**	**272**
Percentage of Total Authority Deliveries										
Authority PWA Deliveries - North of Delta	16%	17%	16%	17%	16%	18%	19%	20%	24%	23%
Authority PWA Deliveries - South of Delta	49%	63%	50%	65%	51%	65%	53%	62%	52%	57%
CVP Deliveries - Operational Flexibility	4%	5%	2%	3%	3%	4%	3%	4%	6%	7%
Refuge Water Supply	11%	9%	11%	10%	11%	10%	14%	11%	18%	13%
Yolo Bypass Habitat Water Supply	20%	6%	20%	6%	18%	4%	11%	4%	0%	0%

Consideration of Incidental Change to CVP and SWP Deliveries										
Incidental Change to CVP and SWP Deliveries without CVP Operational Flexibility	2	12	2	11	8	13	9	18	3	1
Total Authority, CVP and SWP Deliveries	186	371	183	360	187	358	159	329	126	273
Incremental Change as a Percentage of Total Authority Deliveres	1%	3%	1%	3%	5%	4%	6%	6%	2%	0%
Incremental Change as a Percentage of Total Authority, CVP and SWP Deliveres	1%	3%	1%	3%	4%	4%	6%	6%	2%	0%

Notes:

[a] Values shown are the net change between the Project Alternative and No Project Alternative

Results are dependent on storage allocations (see storage allocation table)

Storage Table

Storage Increases (TAF) (above No Project Alternative conditions) [a]	ALT 1B 011221		ALT 1B 011221 SA CBD Cap 30% Dry		ALT 1B 011221 SA CBD Cap 50% Dry		ALT 1B 011221 SA CBD Cap 80% Dry		ALT 1B 011221 SA w/o Dunnigan Pipeline	
	Average	**Dry and Critical**	**Average**	**Dry and Critical**	**Average**	**Dry and Critical**	**Average**	**Dry and Critical**	**Average**	**Dry and Critical**
	1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate	
Additional end-of-September storage	**50**	**72**	**52**	**79**	**52**	**79**	**55**	**75**	**47**	**51**
Trinity	0	0	0	0	0	0	0	0	0	0
Shasta	28	39	31	47	32	49	36	52	36	49
CVP Storage	*25*	*31*	*28*	*39*	*29*	*41*	*33*	*45*	*35*	*45*
Subtotal - CVP OpFlex Storage (Diff from Alt A1 CVP values)	*18*	*21*	*21*	*28*	*22*	*31*	*26*	*35*	*28*	*35*
Storage exchanged from Sites	*3*	*9*	*3*	*8*	*3*	*9*	*2*	*7*	*1*	*4*
Oroville	12	21	12	19	10	16	8	10	1	-8
SWP Storage	*-6*	*-16*	*-5*	*-14*	*-5*	*-13*	*-5*	*-12*	*-6*	*-16*
Sites Delta Participants Storage	*17*	*36*	*17*	*33*	*15*	*29*	*13*	*22*	*7*	*7*
Folsom	9	12	9	13	10	13	11	14	11	11
Subtotal - CVP OpFlex Storage (Diff from Alt A1 CVP values)	*6*	*7*	*6*	*8*	*6*	*8*	*7*	*8*	*7*	*6*
Percentage of Total Additional End-of-September Storage										
Portion of total additional end-of-September storage										
Trinity	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Shasta	57%	55%	59%	59%	62%	62%	65%	69%	77%	95%
Oroville	24%	29%	22%	24%	20%	21%	15%	13%	1%	-17%
Folsom	19%	16%	18%	17%	19%	17%	19%	18%	22%	22%

Notes:

[a] Values shown are the net change between the Project Alternative and No Project Alternative

Results are dependent on storage allocations (see storage allocation table)

Sites Releases Table

Releases (TAF/year)	ALT 1B 011221		ALT 1B 011221 SA CBD Cap 30% Dry		ALT 1B 011221 SA CBD Cap 50% Dry		ALT 1B 011221 SA CBD Cap 80% Dry		ALT 1B 011221 SA w/o Dunnigan Pipeline	
	Average	Dry and Critical	Average	Dry and Critical	Average	Dry and Critical	Average	Dry and Critical	Average	Dry and Critical
	1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate	
Releases for Authority PWA Deliveries - North of Delta	29	60	29	60	29	61	29	61	30	62
Assumed transfer from North of Delta to South of Delta	6	6	6	6	6	6	6	6	6	6
Releases for Authority PWA Deliveries - South of Delta	105	250	103	245	97	235	80	194	60	150
Releases for CVP Deliveries - Operational Flexibility	28	26	28	27	27	26	27	31	29	31
Releases for Refuge Water Supply	24	38	24	37	24	38	25	40	28	44
Releases for Yolo Bypass Habitat Water Supply	41	24	42	24	37	17	19	13	0	0
Total Releases	**234**	**404**	**232**	**400**	**220**	**383**	**186**	**345**	**152**	**292**
Percentage of Total Releases from Sites										
Releases for Authority PWA Deliveries - North of Delta	12%	15%	13%	15%	13%	16%	16%	18%	19%	21%
Assumed transfer from North of Delta to South of Delta	3%	2%	3%	2%	3%	2%	3%	2%	4%	2%
Releases for Authority PWA Deliveries - South of Delta	45%	62%	44%	61%	44%	61%	43%	56%	39%	51%
Releases for CVP Deliveries - Operational Flexibility	12%	7%	12%	7%	12%	7%	15%	9%	19%	10%
Releases for Refuge Water Supply	10%	9%	10%	9%	11%	10%	14%	12%	18%	15%
Releases for Yolo Bypass Habitat Water Supply	18%	6%	18%	6%	17%	4%	10%	4%	0%	0%

Notes:
Results are dependent on storage allocations (see storage allocation table)

Sites Fills Table

Fills (TAF/year)	ALT 1B 011221		ALT 1B 011221 SA CBD Cap 30% Dry		ALT 1B 011221 SA CBD Cap 50% Dry		ALT 1B 011221 SA CBD Cap 80% Dry		ALT 1B 011221 SA w/o Dunnigan Pipeline	
	Average	Dry and Critical	Average	Dry and Critical	Average	Dry and Critical	Average	Dry and Critical	Average	Dry and Critical
	1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate		1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate	
Fills for Authority PWA Deliveries - North of Delta	43	16	43	17	43	18	42	19	42	19
Fills for Authority PWA Deliveries - South of Delta	115	43	113	42	108	43	95	42	80	42
Fills for CVP Deliveries - Operational Flexibility	29	16	29	16	27	16	28	16	29	15
Fills for Refuge Water Supply	26	11	25	11	26	10	27	11	29	12
Fills for Yolo Bypass Habitat Water Supply	43	18	43	19	39	17	22	10	4	4
Total Fill	**255**	**104**	**254**	**104**	**244**	**104**	**215**	**98**	**185**	**92**
Percentage of Total Fills										
Fills for Authority PWA Deliveries - North of Delta	17%	15%	17%	16%	18%	17%	20%	20%	23%	21%
Fills for Authority PWA Deliveries - South of Delta	45%	41%	45%	41%	44%	41%	44%	43%	43%	46%
Fills for CVP Deliveries - Operational Flexibility	11%	16%	11%	15%	11%	16%	13%	16%	16%	16%
Fills for Refuge Water Supply	10%	11%	10%	10%	11%	10%	13%	11%	16%	13%
Fills for Yolo Bypass Habitat Water Supply	17%	17%	17%	18%	16%	16%	10%	10%	2%	4%

Notes:

Results are dependent on storage allocations (see storage allocation table)

Sites Storage Allocation Table

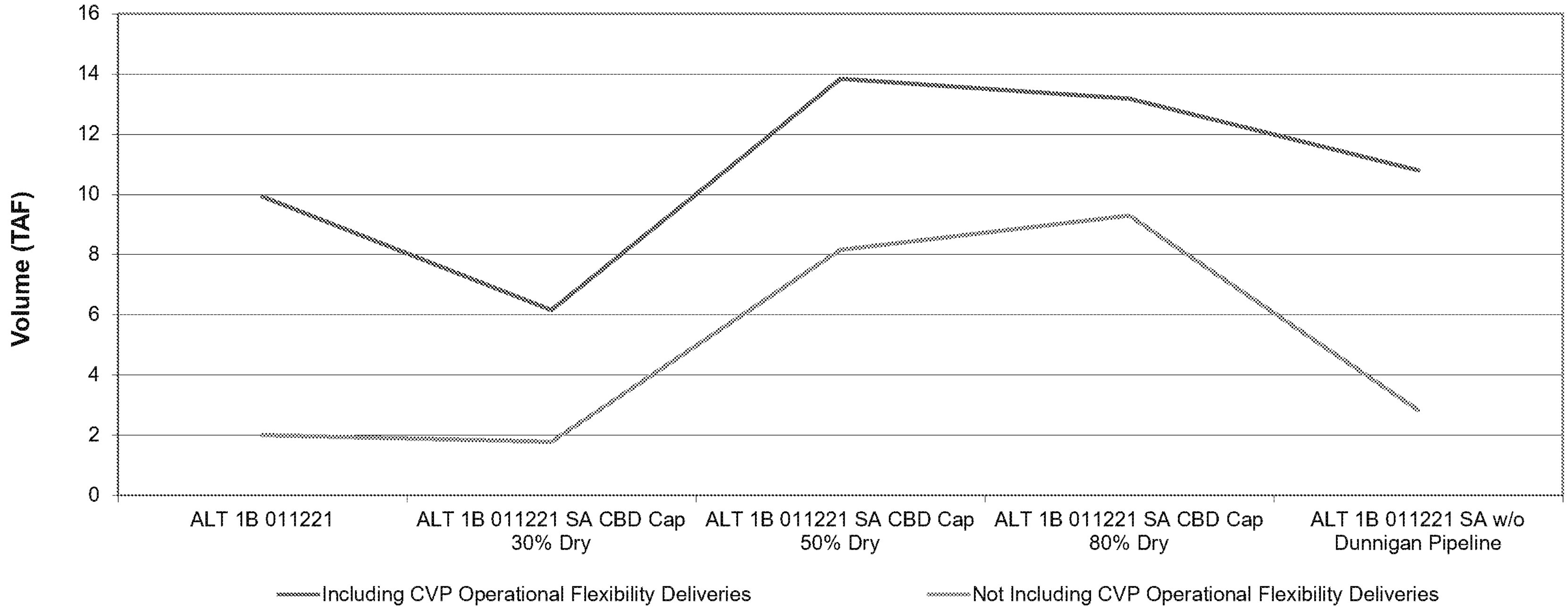
Storage Volumes (TAF)	ALT 1B 011221	ALT 1B 011221 SA CBD Cap 30% Dry	ALT 1B 011221 SA CBD Cap 50% Dry	ALT 1B 011221 SA CBD Cap 80% Dry	ALT 1B 011221 SA w/o Dunnigan Pipeline
	1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate	1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate	1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate	1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate	1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD) Historic Climate
Authority PWA Deliveries - North of Delta	256	256	256	256	256
TCCA	*138*	*138*	*138*	*138*	*138*
GCID	*31*	*31*	*31*	*31*	*31*
RD108	*25*	*25*	*25*	*25*	*25*
Other Sacramento Valley	*62*	*62*	*62*	*62*	*62*
Authority PWA Deliveries - South of Delta	788	788	788	788	788
CVP Deliveries - Operational Flexibility	91	91	91	91	91
Refuge Water Supply	124	124	124	124	124
Yolo Bypass Habitat Water Supply	120	120	120	120	120
Dead Pool Storage	120	120	120	120	120
Total Storage	**1499**	**1499**	**1499**	**1499**	**1499**
Percentage of Total Storage Capacity					
Authority PWA Deliveries - North of Delta	17%	17%	17%	17%	17%
Authority PWA Deliveries - South of Delta	53%	53%	53%	53%	53%
CVP Deliveries - Operational Flexibility	6%	6%	6%	6%	6%
Refuge Water Supply	8%	8%	8%	8%	8%
Yolo Bypass Habitat Water Supply	8%	8%	8%	8%	8%
Dead Pool Storage	8%	8%	8%	8%	8%

Notes:

Results are dependent on storage allocations

	Table 1. - Total Change in CVP/SWP Deliveries with and without CVP Operational Flexibility Deliveries (TAF)				
	ALT 1B 011221	ALT 1B 011221 SA CBD Cap 30% Dry	ALT 1B 011221 SA CBD Cap 50% Dry	ALT 1B 011221 SA CBD Cap 80% Dry	ALT 1B 011221 SA w/o Dunnigan Pipeline
	Average	Average	Average	Average	Average
Including CVP Operational Flexibility Deliveries	10	6	14	13	11
Not Including CVP Operational Flexibility Deliv	2	2	8	9	3

Figure 1. - Total Change in CVP/SWP Deliveries with and without CVP Operational Flexibiliy Deliveries
Long Term Average



	ALT 1B 011221	ALT 1B 011221 SA CBD Cap 30% Dry	ALT 1B 011221 SA CBD Cap 50% Dry	ALT 1B 011221 SA CBD Cap 80% Dry	ALT 1B 011221 SA w/o Dunnigan Pipeline
	Dry and Critical	Dry and Critical	Dry and Critical	Dry and Critical	Dry and Critical
Including CVP Operational Flexibility Deliveries	31	21	25	30	21
Not Including CVP Operational Flexibility Delive	12	11	13	18	1

Table 2. - Total Change in CVP/SWP Deliveries with and without CVP Operational Flexibility Deliveries (TAF)

Figure 2. - Total Change in CVP/SWP Deliveries with and without CVP Operational Flexibiliy Deliveries
Dry & Critical Average

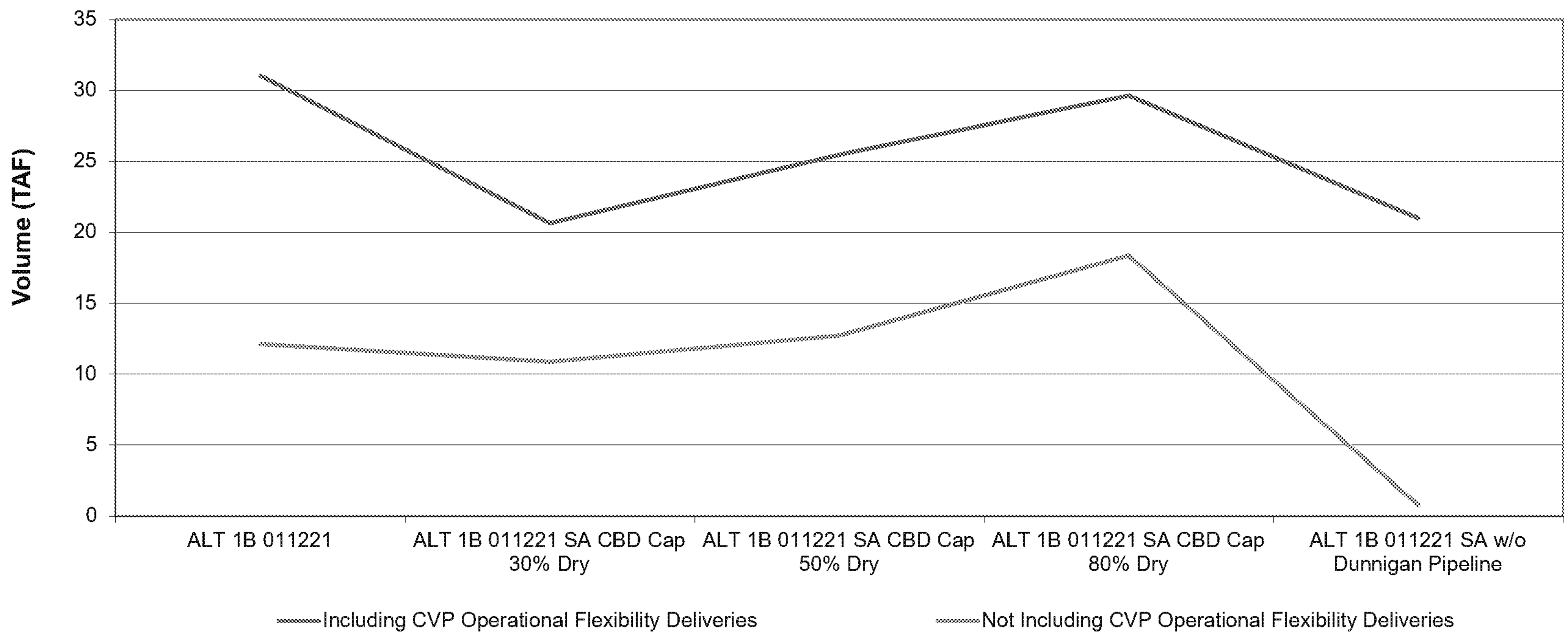


	Table 3. - Change in Authority Deliveries (TAF)				
	ALT 1B 011221	ALT 1B 011221 SA CBD Cap 30% Dry	ALT 1B 011221 SA CBD Cap 50% Dry	ALT 1B 011221 SA CBD Cap 80% Dry	ALT 1B 011221 SA w/o Dunnigan Pipeline
Authority Participant	Average	Average	Average	Average	Average
PWA NOD	29	29	29	29	30
PWA SOD	91	91	92	79	64
NOD Refuge (Level 4) + Yolo Bypass	41	41	37	21	5
SOD Refuge (Level 4)	15	15	15	16	17

Figure 3. - Change in Authority Deliveries
Long Term Average

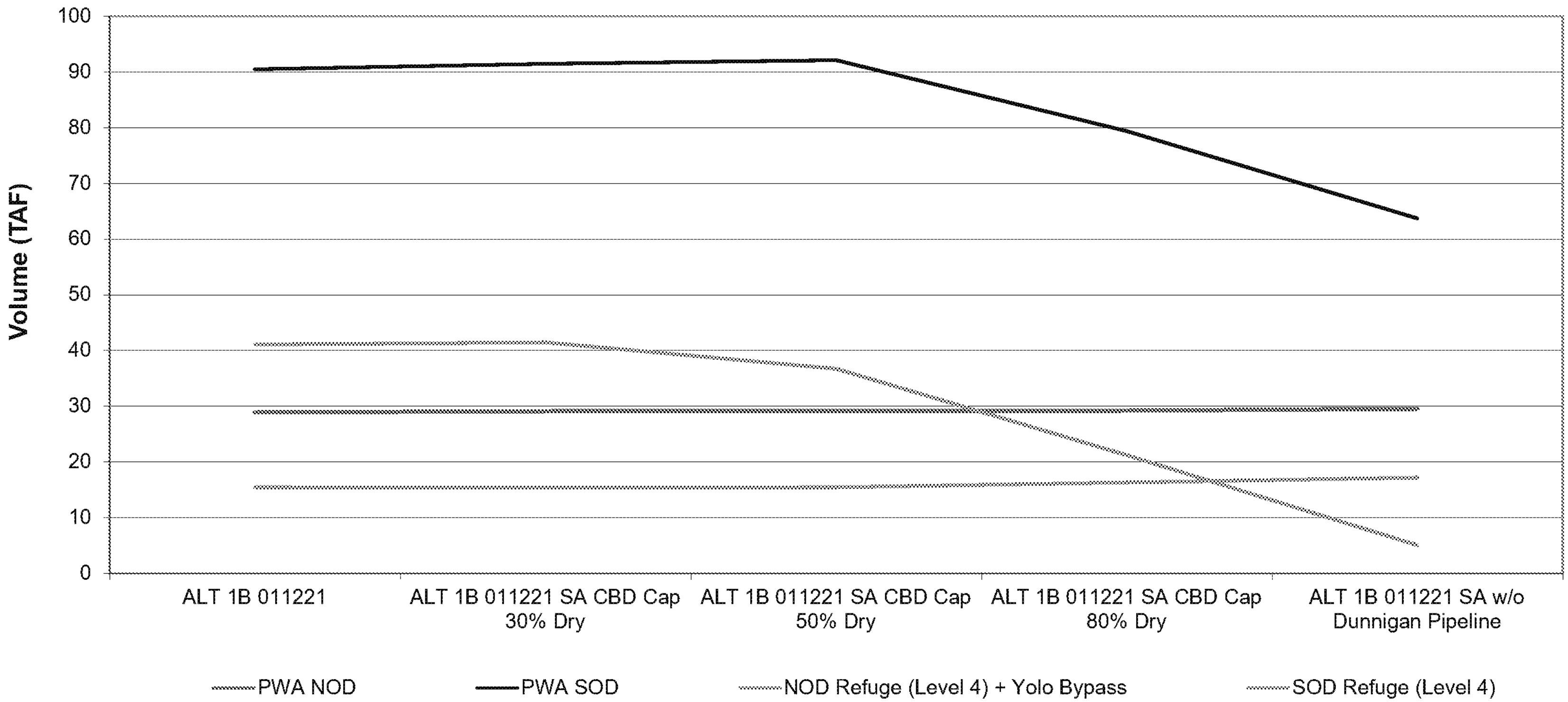


	Table 4. - Change in Authority Deliveries (TAF)				
	ALT 1B 011221	ALT 1B 011221 SA CBD Cap 30% Dry	ALT 1B 011221 SA CBD Cap 50% Dry	ALT 1B 011221 SA CBD Cap 80% Dry	ALT 1B 011221 SA w/o Dunnigan Pipeline
Authority Participant	**Dry and Critical**	**Dry and Critical**	**Dry and Critical**	**Dry and Critical**	**Dry and Critical**
PWA NOD	60	60	61	61	62
PWA SOD	226	226	224	192	154
NOD Refuge (Level 4) + Yolo Bypass	27	27	21	18	7
SOD Refuge (Level 4)	27	27	27	29	29

Figure 4. - Change in Authority Deliveries
Dry & Critical Average

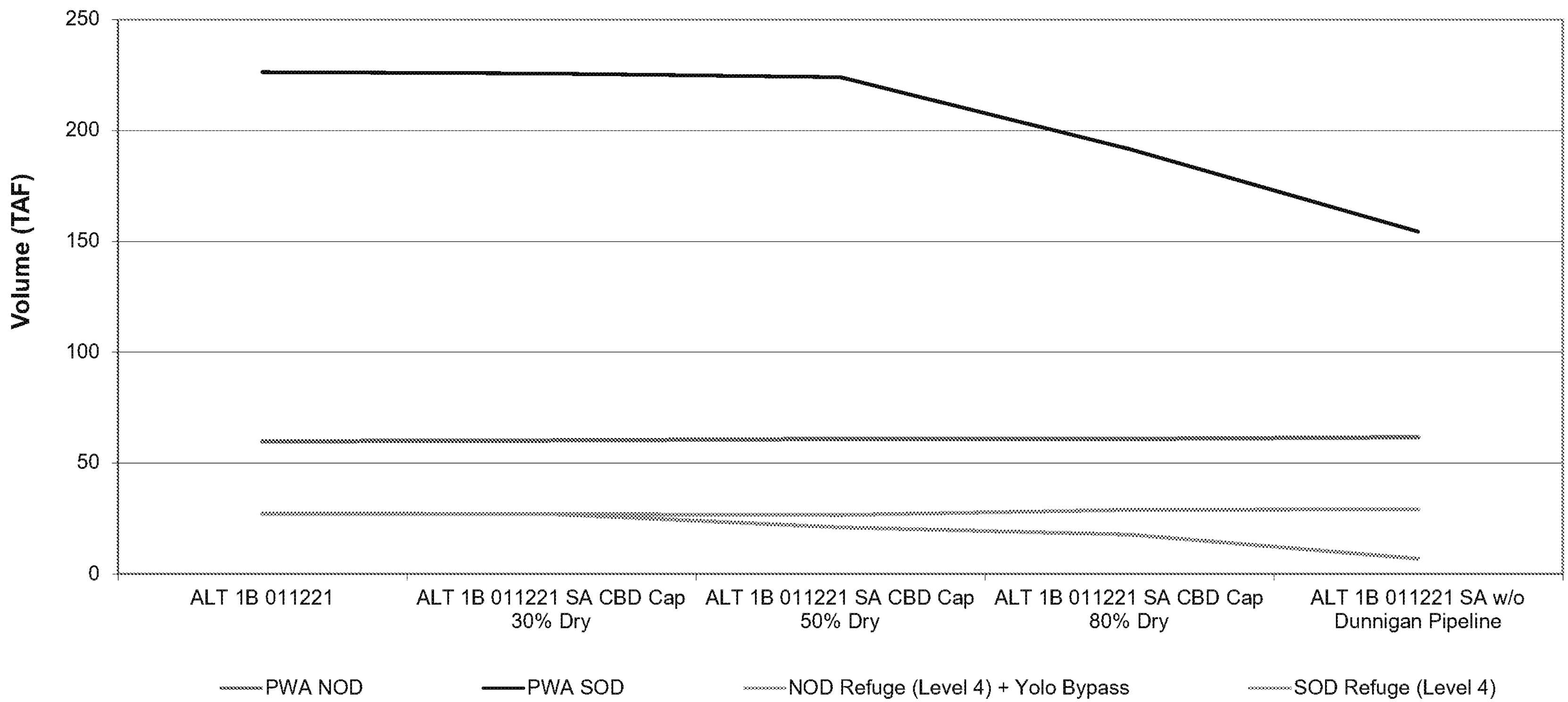


	Table 5. - Change in Deliveries (TAF)				
	ALT 1B 011221	ALT 1B 011221 SA CBD Cap 30% Dry	ALT 1B 011221 SA CBD Cap 50% Dry	ALT 1B 011221 SA CBD Cap 80% Dry	ALT 1B 011221 SA w/o Dunnigan Pipeline
Participant	Average	Average	Average	Average	Average
CVP/SWP Not Including CVP Op Flex	2	2	8	9	3
CVP Op Flex	8	4	6	4	8
PWA NOD	29	29	29	29	30
PWA SOD	91	91	92	79	64
NOD Refuge (Level 4) + Yolo Bypass	41	41	37	21	5
SOD Refuge (Level 4)	15	15	15	16	17

Figure 5. - Change in Deliveries
Long Term Average

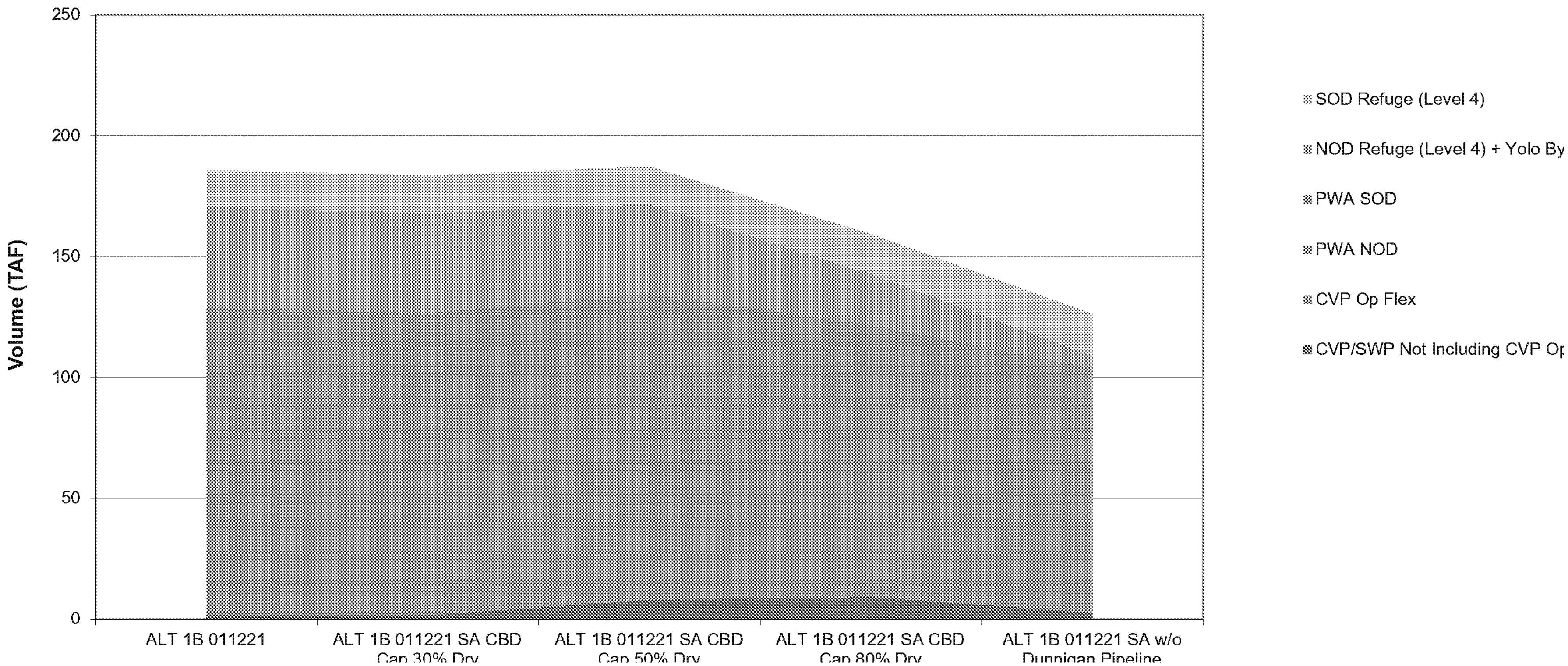


	Table 6. - Change in Deliveries (TAF)				
	ALT 1B 011221	ALT 1B 011221 SA CBD Cap 30% Dry	ALT 1B 011221 SA CBD Cap 50% Dry	ALT 1B 011221 SA CBD Cap 80% Dry	ALT 1B 011221 SA w/o Dunnigan Pipeline
Participant	**Dry and Critical**	**Dry and Critical**	**Dry and Critical**	**Dry and Critical**	**Dry and Critical**
CVP/SWP Not Including CVP Op Flex	12	11	13	18	1
CVP Op Flex	19	10	13	11	20
PWA NOD	60	60	61	61	62
PWA SOD	226	226	224	192	154
NOD Refuge (Level 4) + Yolo Bypass	27	27	21	18	7
SOD Refuge (Level 4)	27	27	27	29	29

Figure 6. - Change in Deliveries
Dry & Critical Average

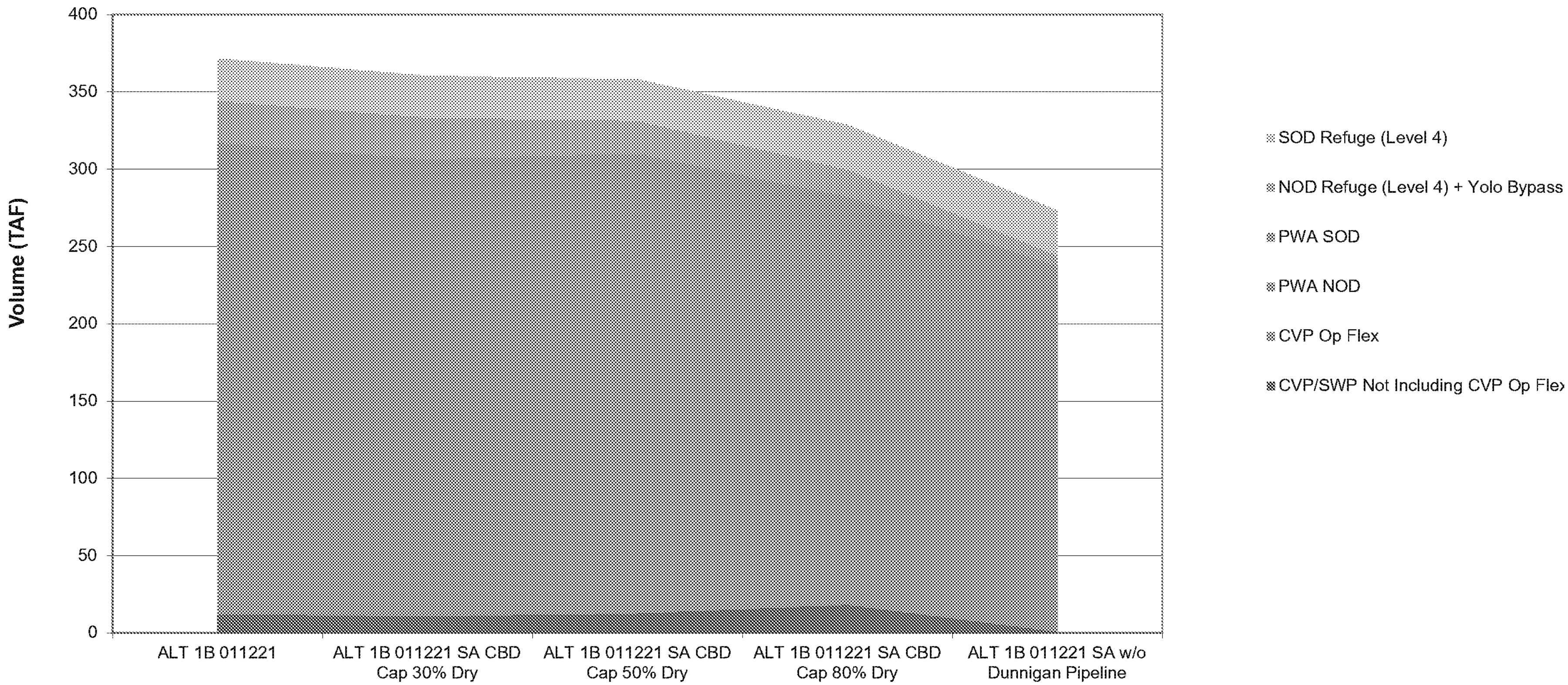


	Table 7. - Change in Releases (TAF)				
	ALT 1B 011221	ALT 1B 011221 SA CBD Cap 30% Dry	ALT 1B 011221 SA CBD Cap 50% Dry	ALT 1B 011221 SA CBD Cap 80% Dry	ALT 1B 011221 SA w/o Dunnigan Pipeline
Participant	**Average**	**Average**	**Average**	**Average**	**Average**
CVP Op Flex	28	28	27	27	29
PWA NOD	29	29	29	29	30
PWA SOD	105	103	97	80	60
NOD Refuge (Level 4) + Yolo Bypass	46	47	41	24	5
SOD Refuge (Level 4)	19	19	19	20	23

Figure 7. - Change in Releases
Long Term Average

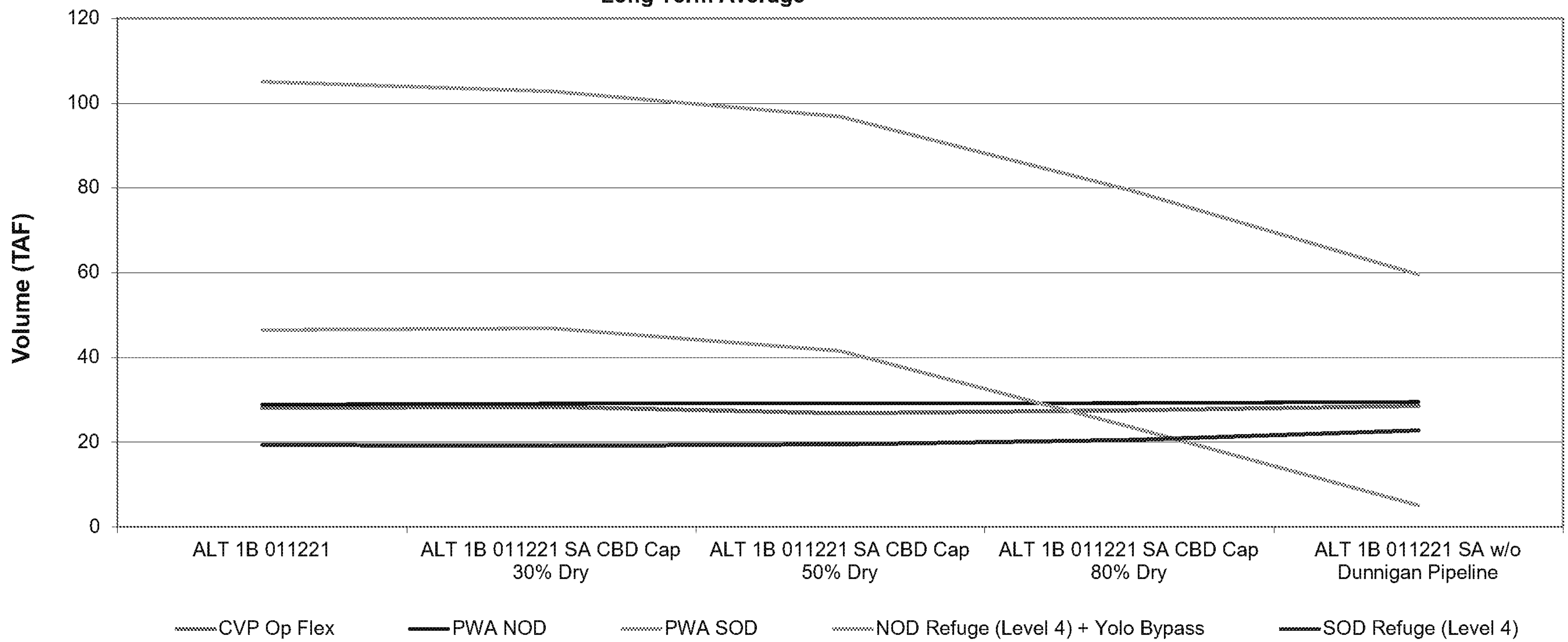


	Table 8. - Change in Releases (TAF)				
	ALT 1B 011221	ALT 1B 011221 SA CBD Cap 30% Dry	ALT 1B 011221 SA CBD Cap 50% Dry	ALT 1B 011221 SA CBD Cap 80% Dry	ALT 1B 011221 SA w/o Dunnigan Pipeline
Participant	Dry and Critical	Dry and Critical	Dry and Critical	Dry and Critical	Dry and Critical
CVP Op Flex	26	27	26	31	31
PWA NOD	60	60	61	61	62
PWA SOD	250	245	235	194	150
NOD Refuge (Level 4) + Yolo Bypass	30	30	23	19	7
SOD Refuge (Level 4)	32	31	31	33	37

Figure 8. - Change in Releases
Dry & Critical Average

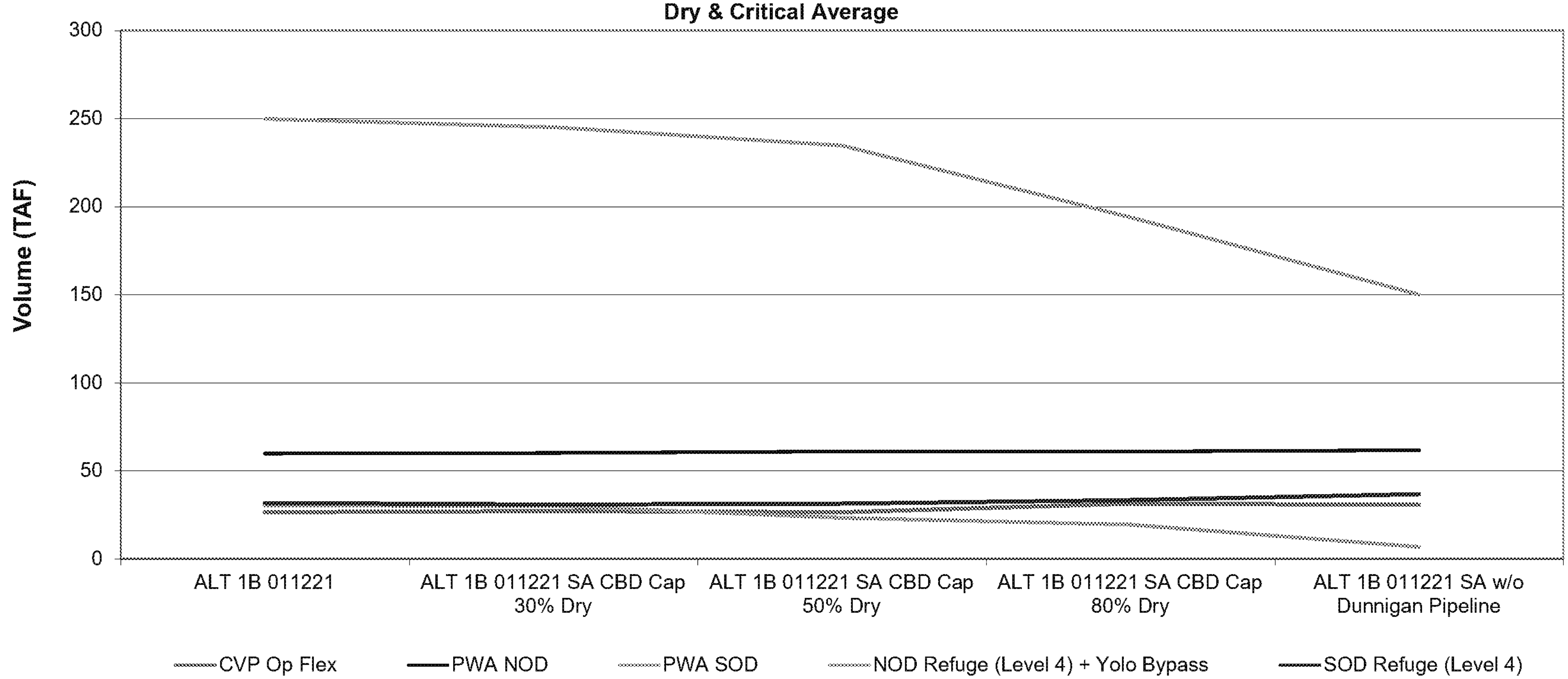


	Table 9. - Change in Releases (TAF)				
	ALT 1B 011221	ALT 1B 011221 SA CBD Cap 30% Dry	ALT 1B 011221 SA CBD Cap 50% Dry	ALT 1B 011221 SA CBD Cap 80% Dry	ALT 1B 011221 SA w/o Dunnigan Pipeline
Participant	Average	Average	Average	Average	Average
CVP Op Flex	28	28	27	27	29
PWA NOD	29	29	29	29	30
PWA SOD	105	103	97	80	60
NOD Refuge (Level 4) + Yolo Bypass	46	47	41	24	5
SOD Refuge (Level 4)	19	19	19	20	23

Figure 9. - Change in Releases
Long Term Average

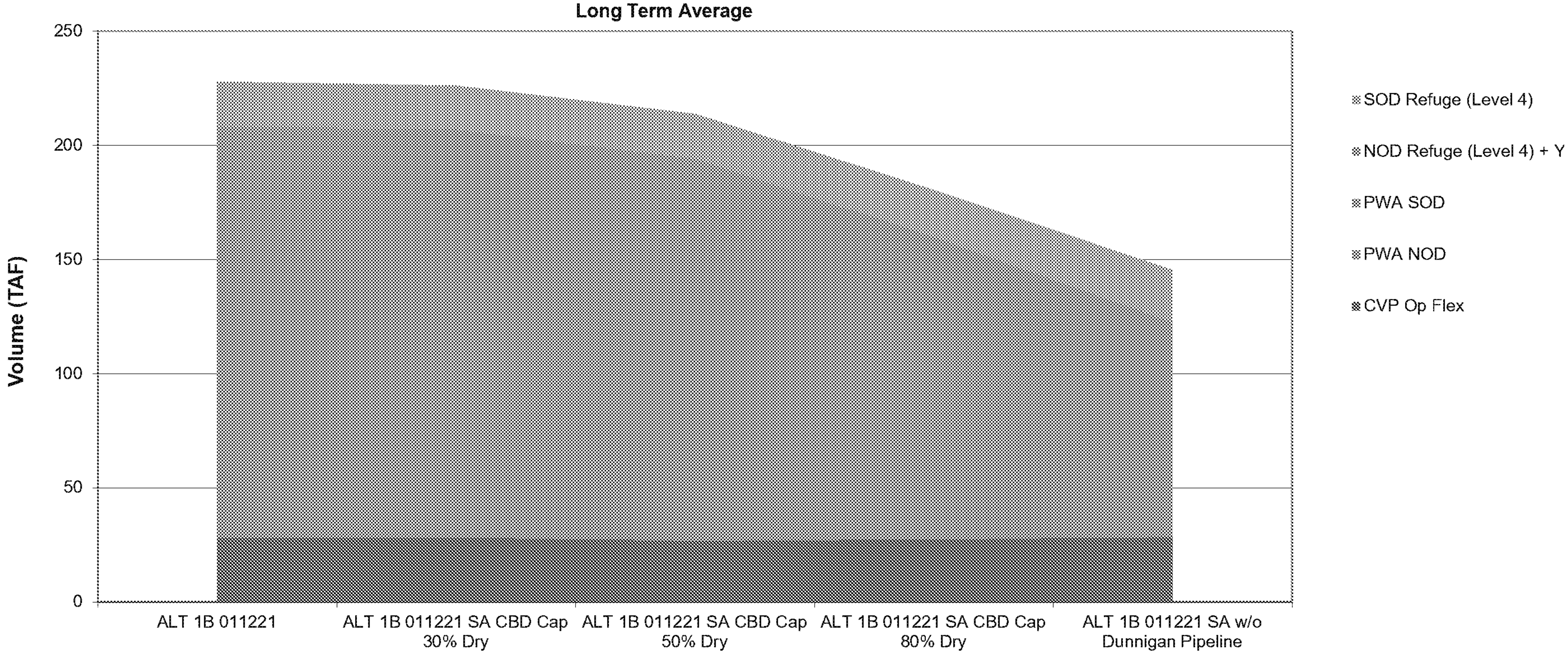


	Table 10. - Change in Releases (TAF)				
	ALT 1B 011221	ALT 1B 011221 SA CBD Cap 30% Dry	ALT 1B 011221 SA CBD Cap 50% Dry	ALT 1B 011221 SA CBD Cap 80% Dry	ALT 1B 011221 SA w/o Dunnigan Pipeline
Participant	**Dry and Critical**	**Dry and Critical**	**Dry and Critical**	**Dry and Critical**	**Dry and Critical**
CVP Op Flex	26	27	26	31	31
PWA NOD	60	60	61	61	62
PWA SOD	250	245	235	194	150
NOD Refuge (Level 4) + Yolo Bypass	30	30	23	19	7
SOD Refuge (Level 4)	32	31	31	33	37

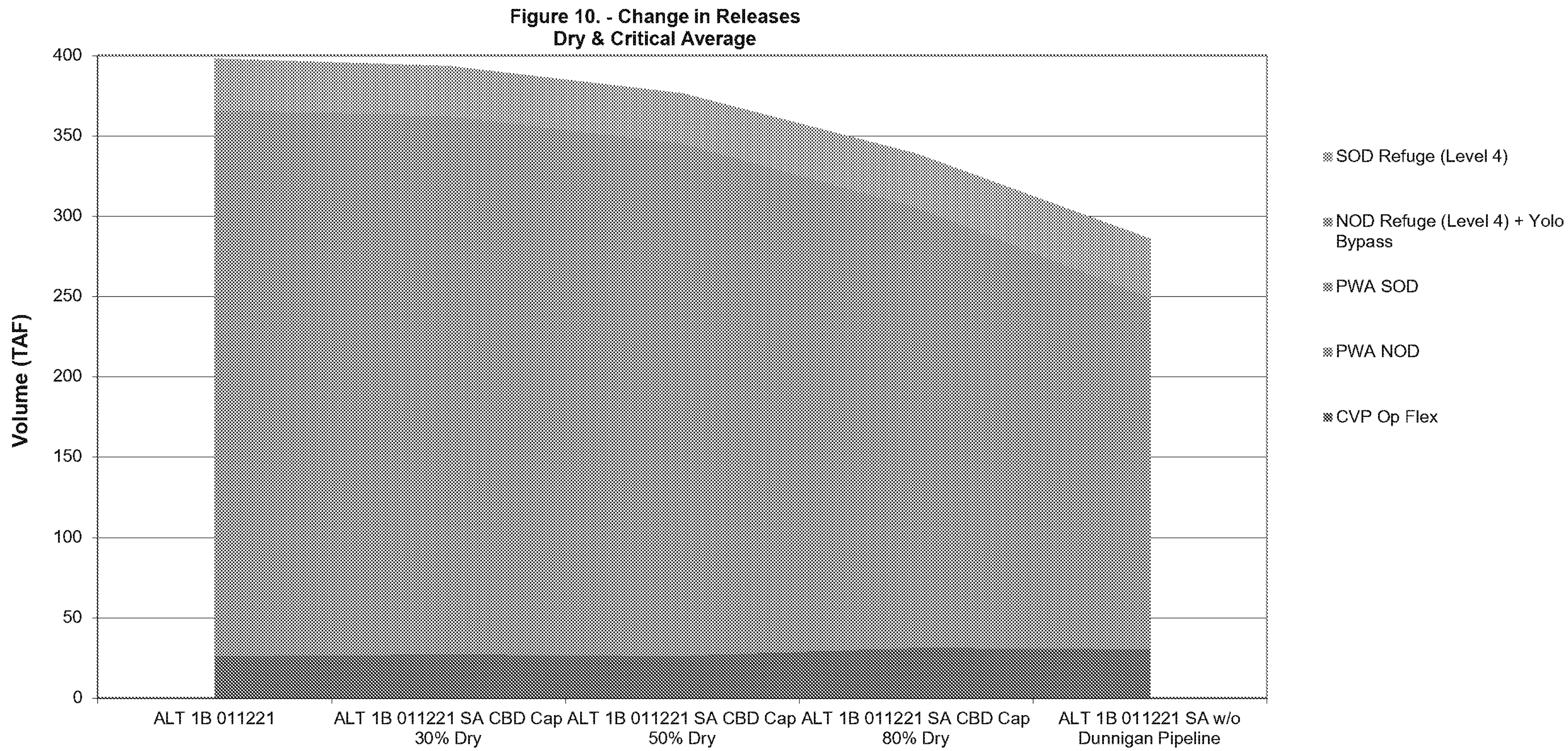
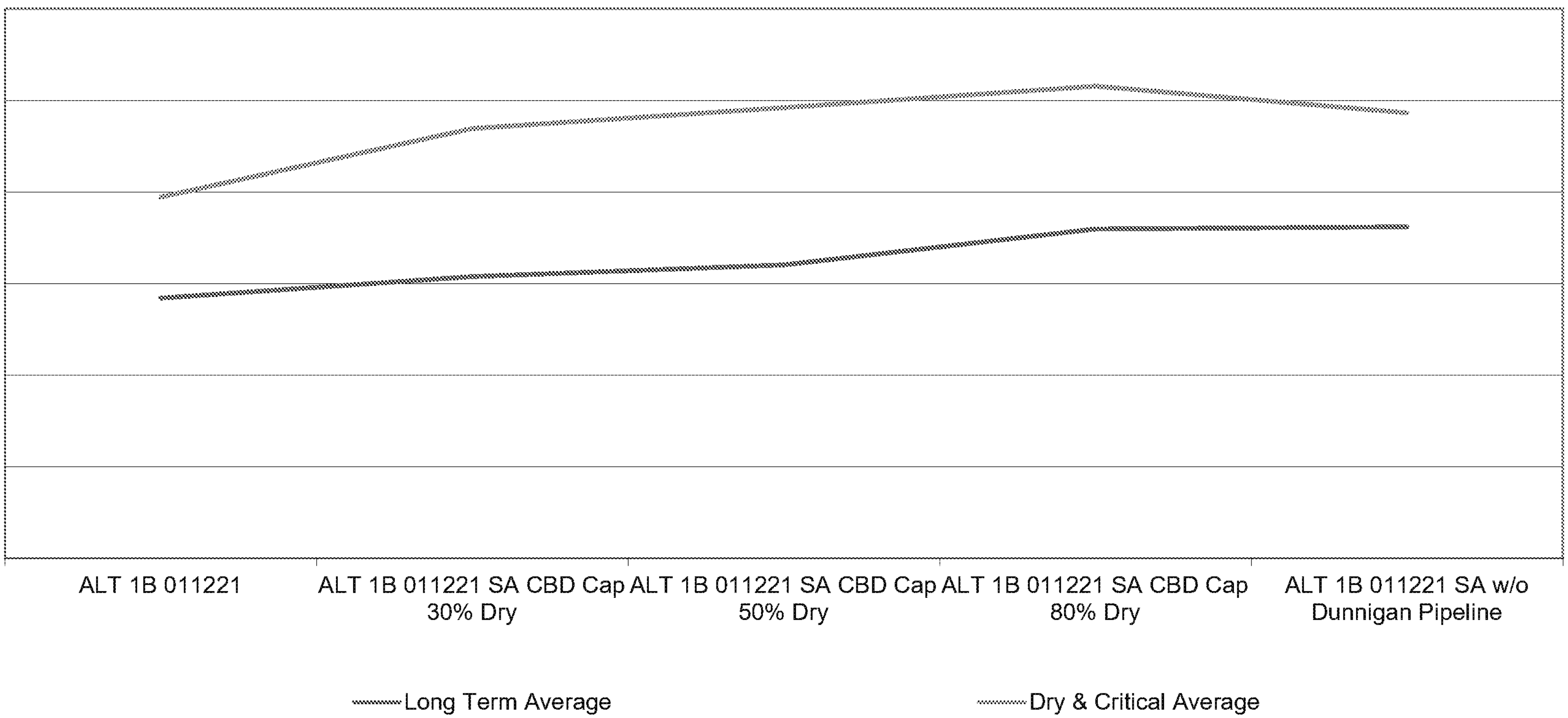


Table 11. - Change in Shasta Storage (TAF)									
ALT 1B 011221		ALT 1B 011221 SA CBD Cap 30% Dry		ALT 1B 011221 SA CBD Cap 50% Dry		ALT 1B 011221 SA CBD Cap 80% Dry		ALT 1B 011221 SA w/o Dunnigan Pipeline	
Average	Dry and Critical	Average	Dry and Critical	Average	Dry and Critical	Average	Dry and Critical	Average	Dry and Critical
28	39	31	47	32	49	36	52	36	49

Figure 11. - Change in Shasta Storage



From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/3/2021 8:41:01 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Oakes, Harry [Harry.Oakes@icf.com]
CC: Briard, Monique [Monique.Briard@icf.com]; Arsenijevic, Jelica [Jelica.Arsenijevic@hdrinc.com]; MacKay, Kevin [Kevin.MacKay@icf.com]
Subject: RE: Mitigation Cost Review

You got it, emails already drafted. Harry's team is working up the breakout and I have let Cheyanne know that it is a week or so out.

John Spranza

D 916.679.8858 M 818.640.2487

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Thursday, June 3, 2021 5:56 AM
To: Spranza, John <John.Spranza@hdrinc.com>; Oakes, Harry <Harry.Oakes@icf.com>
Cc: Briard, Monique <Monique.Briard@icf.com>; Arsenijevic, Jelica <Jelica.Arsenijevic@hdrinc.com>; MacKay, Kevin <Kevin.MacKay@icf.com>
Subject: RE: Mitigation Cost Review

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

This looks good John. Can you coordinate with Henry to get this info to him?

Also, JP and Cheyanne will need the Dunnigan break out when available.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Wednesday, June 2, 2021 1:48 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Oakes, Harry <Harry.Oakes@icf.com>
Cc: Briard, Monique <Monique.Briard@icf.com>; Arsenijevic, Jelica <Jelica.Arsenijevic@hdrinc.com>; MacKay, Kevin <Kevin.MacKay@icf.com>
Subject: RE: Mitigation Cost Review

Okay, all the changes are made and the winner is $562,477,300.0

Harry, if you have not done so already can you please upload all of your reference material and admin record related documents and QA/QC form to the Sharepoint site when you have time? Here is the link:

https://sitesreservoirproject.sharepoint.com/:f:/r/envpermitting/Working%20Documents/7.%20Mitigation%20and%20AMP?csf=1&web=1&e=mtCMOg

Thanks.

John Spranza

D 916.679.8858 M 818.640.2487

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, June 1, 2021 5:09 PM
To: Oakes, Harry <Harry.Oakes@icf.com>; Spranza, John <John.Spranza@hdrinc.com>
Cc: Briard, Monique <Monique.Briard@icf.com>; Arsenijevic, Jelica <Jelica.Arsenijevic@hdrinc.com>; MacKay, Kevin <Kevin.MacKay@icf.com>
Subject: RE: Mitigation Cost Review

Hi all – I just had a chance to look at all of this. I don't think we can remove all ag costs. We will have to mitigate for the loss of ag lands. That might stack with our grassland mitigation, but I am just not sure that I am comfortable with that right now as this ag land mitigation might need to be in the county that the impact occurred in and we only have 11,690 acres of easement (14,500 acres of grasslands is assumed mitigation bank), which is less than the ag land impact. Anyway, I am not confident that we will be able to stack these together and thus not comfortable that we take out all ag land mitigation costs. While these are land costs, the land acquisition costs only cover those costs to buy land to build the project (and any costs associate with that transaction to the landowner). So these mitigation costs are not covered in the land acquisition costs. Plus, small amount of this ag land might end up being permanent crops, which the cost is wayyyyy higher.

I do think we can take out the $2.4 for remnant parcels in Glenn County and the $3.87 for remnant parcels in Colusa County. These are costs that I think we would take on in land acquisition – meaning we wouldn't leave the landowner with remnant parcels that got bumped out of WAC and cost them money without compensating them for this cost as part of the land acquisition purchase. So I think this would be an effect/change that we would compensate the landowner for in the normal course of purchasing property for the project and will be addressed in our land acquisition costs.

I am good with dropping the elderberry to 250 bushes if you think that is warranted. With these two changes, I think this bring us to $563,852,300.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Oakes, Harry <Harry.Oakes@icf.com>
Sent: Tuesday, June 1, 2021 4:45 PM
To: Spranza, John <john.spranza@hdrinc.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Briard, Monique <Monique.Briard@icf.com>; Arsenijevic, Jelica <Jelica.Arsenijevic@hdrinc.com>; MacKay, Kevin <Kevin.MacKay@icf.com>
Subject: Re: Mitigation Cost Review

Thanks John. I think we can have every other week calls for mit plan for now. We have an internal one scheduled for next week to coordinate with our permit lead and get our team rolling - maybe we can set up first mit call for week of June 14th?

Sent from my iPhone

On Jun 1, 2021, at 8:14 AM, Spranza, John <John.Spranza@hdrinc.com> wrote:

Harry this is great, and much appreciated. I agree with halving the shrubs as I think that 500 is quite high based on some additional information from DWR surveys I found that back that up (see attached). It will also be in direct alignment with where some of the local participants think some adjustments could be warranted. I also agree that we can remove the WAC costs and assume that they are included in the land acquisition, which is a pretty solid assumption. Provided Ali is good with everything I am hoping that this pretty much wraps up the task with maybe a few minor tweaks that might need to be made in the future.

I think we are now ready to start focusing on the mitigation plans we will need this year. Do you think continuing the weekly Tuesday meetings is warranted or should we go every other week?

John Spranza

D 916.679.8858 M 818.640.2487

From: Oakes, Harry <Harry.Oakes@icf.com>
Sent: Friday, May 28, 2021 10:49 AM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Spranza, John <John.Spranza@hdrinc.com>; Briard, Monique <Monique.Briard@icf.com>; Arsenijevic, Jelica <Jelica.Arsenijevic@hdrinc.com>
Subject: RE: Mitigation Cost Review

Thanks for the feedback/info, Ali & John.

Ali, I incorporated the revisions into the cost tables and provided responses to your email (in red) below. I also provided responses to Jeff's comments, further below (in red)

You may recall that the 2021 aquatic cost ($46.5M) was below the 2020 VP estimate ($56M). I revised the current aquatic mitigation cost to match the 2020 VP cost.

The changes to aquatic costs, in addition to edits/reductions to RLF and WCA, pretty much balance out (-$6M). So the total mitigation cost is still in the area of $570M

John, I'll be out of town for field work next week but can work on editing the PPT as needed. I do plan to be on next TH's ad hoc prep call

Also, just an update that we are coordinating internally to develop the mitigation costs associated with Dunnigan and Colusa Drain. Can I assume that we "will not" include those numbers in the ad hoc presentation?

Thanks!

Have a great weekend everyone!

Harry

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, May 25, 2021 6:31 AM
To: John Spranza <John.Spranza@hdrinc.com>; Briard, Monique <Monique.Briard@icf.com>; Oakes, Harry <Harry.Oakes@icf.com>; Arsenijevic, Jelica <Jelica.Arsenijevic@hdrinc.com>
Subject: RE: Mitigation Cost Review

Thanks John. I think we can explain the differences that Jeff notes below.

A few more comments:

1. On the Wildlife tab – we mention that total costs for CRLF aquatic mitigation current includes funks reservoir. We should take this text out as I thought we took this out of the cost estimate. Complete. Aquatic acreage reduced to 287 acres, cost reduced by approx. 12M

2. On the wildlife tab – I think we should double check the notes for swainsons hawk. There is costs for nesting habitat, but the note doesn't seem to correspond. Note removed

3. Under Wild-1.16 – lets delete the 1 in the acre box as I think we removed this, but this 1 just hanging out there might be a little confusing. Number removed

4. Wild-1.21 – Let change box to say – No additional costs associated with this mitigation measure. Vegetation removal costs covered under Construction phase. Note revised

5. Ag – WAC contracts rescinded – I think these costs would be covered under our land acquisition costs. We would not leave landowners with a tax bill due to the change in ownership. I feel like these can be removed, but maybe we should talk to make sure I understand what these costs are for. I concur that they could be removed. Could all of the costs on these tabs be considered land acquisition costs? If so, it would zero-out all the Ag Land costs

6. Cultural sheet – I think we should just walk though this one more time to make sure we are not missing anything that should be costed out here. OK

Thanks!

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Monday, May 24, 2021 1:57 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; Oakes, Harry <Harry.Oakes@icf.com>; Arsenijevic, Jelica <Jelica.Arsenijevic@hdrinc.com>
Subject: FW: Mitigation Cost Review

I asked Jeff H to take a look at the mitigation sheet and he has provided a few comments. I think we have good rational behind all of the assumptions that he has hit on, but its nice to get a different perspective. Please let me know if you see any comments that we should address further.

Thanks.

John Spranza

D 916.679.8858 M 818.640.2487

From: Herrin, Jeff <jeff.herrin@aecom.com>
Sent: Monday, May 24, 2021 10:59 AM
To: Spranza, John <John.Spranza@hdrinc.com>
Cc: Luu, Henry <Henry.Luu@hdrinc.com>
Subject: FW: Mitigation Cost Review

John,

My comments are as follows:

- The cost per acre for annual grassland mitigation banking is about exactly double the cost that we used. Maybe the cost for the mitigation bank is double. Your cost may be for irrigated grassland. If we can use unirrigated rangeland, that should suffice to mitigate for the valley inundated by Sites and I believe it may be less expensive. Irrigation is a pretty big cost driver. I don't think we want to use a mitigation bank with irrigation if it can be avoided. We used 2 costs for annual grassland mitigation. $2,000/ac for rangeland (11,690 acres). The remainder was assumed to be on a mitigation bank to account for stacking of habitat credits for species. We selected 14,500 acres required which roughly equates to what would be required for Swainson's hawk upland.
- I'm not sure if the stream mitigation includes Funks and Stone Corral Creeks. We are spending a lot of money to put in pipelines and to maintain flows in the creeks prior to construction that would interrupt flow to Funks and Stone Corral Creeks. Maybe you are mitigating a different creek, but the cost seems high for these two creeks. Our stream mitigation costs assumes is assumed to be the same as the per acre cost for other wetland types. Since we aren't sure we can create stream streams or get enough LF at a bank it may need to be out-of-kind.
- The mitigation cost for blue oak woodlands/oak savannah is also a much higher per acre than we were using (about 6 times our cost). Suggest you check the cost per acre ($35,000/acre may generate some questions). Our cost assumes oak mitigation at a bank.
- Here is what we had on elderberry previously: We assumed up to 500 shrubs impacted, which admittedly is probably high. We can reduce the number of assumed shrubs affected. Total cost for the 500 shrubs is $2.75M, we could reduce that by half?

There are two elderberry shrubs located within the potential construction disturbance area for Sites Reservoir and Dams that could be completely avoided by establishing and maintaining a 100-foot-wide or wider buffer around them. Construction crews shall be briefed regarding the need to avoid these plants, and signs shall be posted during construction to avoid the buffer area. After Project construction is complete, this area would not be affected by Project operation or maintenance.

The elderberry shrub immediately adjacent to the footprint of the Delevan Pipeline Intake/Discharge Facility is located on the edge of an irrigation canal that is situated along an existing access road. Because of its proximity to the road, it would not be possible to establish a 100-foot-wide buffer. It would also not be possible to establish a 100-foot-wide buffer for the shrubs located immediately adjacent to the existing Maxwell Sites Road. Consultation with USFWS would be initiated for possible approval to encroach on the buffer. Otherwise, appropriate mitigation measures shall be implemented.

The elderberry shrubs within the footprint of Sites Reservoir, Sites Dam, and Golden Gate Dam, as well as the one shrub within the footprint of the Delevan Pipeline Intake/Discharge Facility, would not be avoided by Project construction, and therefore, shall be transplanted or replaced, depending on the likelihood of survival post-transplantation. Transplantation procedures shall comply with USFWS's 1999 Conservation Guidelines for the Elderberry Longhorn Beetle (USFWS, 1999). If transplantation is not feasible, USFWS general guidelines require replacement of elderberry plants in designated mitigation areas. Elderberry plants are typically replaced at a ratio of 2:1 for stems greater than one inch in diameter at ground level with no adult emergence holes, 3:1 for stems where emergence holes are documented in less than 50 percent of the shrubs, and 5:1 for stems greater than one inch in diameter with emergence holes.

Mitigation measures already required for the loss of riparian habitat pursuant to the mitigation for loss of wildlife habitat types described above could potentially compensate for the native planting requirement for elderberry plant mitigation.

- Red-legged Frog is a much bigger issue now than it was when the prior estimate was put together due to USFW focus. It is a pretty significant contributor to cost growth. Comment noted
- We have a pretty significant difference on Williamson Act associated costs. We had assumed that contracts could be rescinded for many acres. The current estimate did not take this approach. The delta is about $26M. Comment noted. We removed the tax costs for rescinded acres which saved approx. $7M. Per my response to Ali, could all ag land costs be removed and covered under real estate costs?
- Henry mentioned this was a 2019 cost estimate. Given the cost per acre, you may want to consider making it 2020 or 2021. Comment noted.

Jeff Herrin
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From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Friday, May 21, 2021 10:27 AM
To: Herrin, Jeff <jeff.herrin@aecom.com>
Subject: [EXTERNAL] Mitigation Cost Review

Hi Jeff,
Could you take a look at the attached mitigation cost estimate and get back to me with comments on items you see as potential issues? We're looking to finalize it the first week in June so if you could get those over to me by the end of next week I would appreciate it.

Let me know if you can’t squeeze this in or if you have any questions.

Thanks
John

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

HDR
2379 Gateway Oaks Drive, Suite 200
Sacramento, CA 95833
D 916.679.8858 M 818.640.2487
john.spranza@hdrinc.com

hdrinc.com/follow-us
hdrinc.com/follow-us

<Summay of NODOS Surveys In Sites Reservoir_ 20210526.docx>

From: Fisher, Linda [Linda.Fisher@hdrinc.com]
Sent: 6/3/2021 9:54:55 PM
To: Williams, Jonathan@Wildlife [jonathan.williams@wildlife.ca.gov]
CC: Uttley, Paige@Wildlife [Paige.Uttley@wildlife.ca.gov]; Kearns, Zachary@Wildlife [Zachary.Kearns@Wildlife.ca.gov]; Alicia Forsythe [aforsythe@sitesproject.org]
Subject: RE: Sites Reservoir Project - Responsible Agency Review - Group 3 Chapters - Due June 21

Chapter 33 has been posted.

-Linda

Linda Fisher, M.S.
D 916.817.4962 M 530.400.3212

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From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Thursday, June 3, 2021 4:34 PM
To: Williams, Jonathan@Wildlife <jonathan.williams@wildlife.ca.gov>; Fisher, Linda <Linda.Fisher@hdrinc.com>
Cc: Uttley, Paige@Wildlife <Paige.Uttley@wildlife.ca.gov>; Kearns, Zachary@Wildlife <Zachary.Kearns@Wildlife.ca.gov>
Subject: RE: Sites Reservoir Project - Responsible Agency Review - Group 3 Chapters - Due June 21

Whoops. Yes, sorry. Chapter 33.

Ali

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---

From: Williams, Jonathan@Wildlife <Jonathan.Williams@wildlife.ca.gov>
Sent: Thursday, June 3, 2021 4:32 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Linda Fisher (linda.fisher@hdrinc.com) <linda.fisher@hdrinc.com>
Cc: Uttley, Paige@Wildlife <Paige.Uttley@wildlife.ca.gov>; Kearns, Zachary@Wildlife <Zachary.Kearns@Wildlife.ca.gov>
Subject: RE: Sites Reservoir Project - Responsible Agency Review - Group 3 Chapters - Due June 21

Hi Ali and Linda,

Quick correction, its Chapter 33 that we want, not Chapter 22.

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Thursday, June 3, 2021 4:30 PM
To: Williams, Jonathan@Wildlife <Jonathan.Williams@wildlife.ca.gov>; Linda Fisher (linda.fisher@hdrinc.com) <linda.fisher@hdrinc.com>

Cc: Uttley, Paige@Wildlife <Paige.Uttley@wildlife.ca.gov>; Kearns, Zachary@Wildlife <Zachary.Kearns@Wildlife.ca.gov>
Subject: RE: Sites Reservoir Project - Responsible Agency Review - Group 3 Chapters - Due June 21

Yep. We will get that posted for you.

Linda, Please see below. Can you post Chapter 22 for CDFW?

Ali

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aforsythe@sitesproject.org | www.SitesProject.org

From: Williams, Jonathan@Wildlife <Jonathan.Williams@wildlife.ca.gov>
Sent: Thursday, June 3, 2021 1:27 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Cc: Uttley, Paige@Wildlife <Paige.Uttley@wildlife.ca.gov>; Kearns, Zachary@Wildlife <Zachary.Kearns@Wildlife.ca.gov>
Subject: RE: Sites Reservoir Project - Responsible Agency Review - Group 3 Chapters - Due June 21

Hi Ali,

Would it be possible for CDFW to review draft chapter 33?

Thanks,
Jon

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Thursday, June 3, 2021 5:35 AM
To: Davis-Fadtke, Kristal@Wildlife <Kristal.Davis-Fadtke@wildlife.ca.gov>; Fisher, Linda <Linda.Fisher@hdrinc.com>; Young, Amy@DWR <Amy.Young@water.ca.gov>; Montgomery, Amanda@Waterboards <Amanda.Montgomery@waterboards.ca.gov>; Okita, David@DWR <David.Okita@water.ca.gov>; Kearns, Zachary@Wildlife <Zachary.Kearns@Wildlife.ca.gov>; Torres, Juan@Wildlife <Juan.Torres@wildlife.ca.gov>; Uttley, Paige@Wildlife <Paige.Uttley@wildlife.ca.gov>; Barker, Kelley@Wildlife <Kelley.Barker@wildlife.ca.gov>; Purdy, Colin@Wildlife <Colin.Purdy@wildlife.ca.gov>; Huneycutt, Andrew@Wildlife <Andrew.Huneycutt@Wildlife.ca.gov>; Williams, Jonathan@Wildlife <Jonathan.Williams@wildlife.ca.gov>; Cooke, Robert@DWR <Robert.Cooke@water.ca.gov>; Biondi, Oscar@Waterboards <Oscar.Biondi@waterboards.ca.gov>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Heydinger, Erin <erin.heydinger@hdrinc.com>; Linda Fisher (linda.fisher@hdrinc.com) <linda.fisher@hdrinc.com>
Subject: RE: Sites Reservoir Project - Responsible Agency Review - Group 3 Chapters - Due June 21

CEQA Responsible Agencies – We now have Group 3 Chapters ready on OneDrive for your review. Below are the Group 3 Chapters along with the Responsible Agencies identified for review. Please let me know if you would like to review additional chapters not currently identified for your organization. Comments are due June 21.

- Executive Summary – CDFW, CWC, SWRCB, DWR
- App 2D (BMPs and AMMs) – CDFW, SWRCB
- Ch 5, Surface Water Resources - CDFW, CWC, SWRCB, DWR
- Ch 11, Aquatic Resources - CDFW, SWRCB, DWR
- Ch 15, Agriculture and Forestry Resources
- Ch 20, Air Quality
- Ch 28, Climate Change – CDFW, SWRCB
- Ch 30, Environmental Justice and Socioeconomics
- Ch 31, Cumulative Impacts - CDFW, SWRCB
- Ch 33, Consultation and Coordination

A note on Chapter 11. The ICF technical fisheries team has been working literally day and night on this chapter. To allow the technical team as much time as possible, we elected to NOT have this chapter edited prior to your review. Therefore, there is still a good amount of work to do on this chapter and ICF will be doing that in parallel with our collective review (this is the first time we have also seen this chapter). Please focus your comments on issues of substance and not editorial, repetition, or length issues. We will clean these up in parallel, but wanted to allow you all as much time as possible to review and as much time as possible for ICF to be able to make substance changes in response to your comments.

Thanks all for your continued review and efforts on the Sites Project. We very much appreciate it!

Ali

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---

From: Alicia Forsythe
Sent: Thursday, May 27, 2021 3:56 PM
To: Davis-Fadtke, Kristal@Wildlife <Kristal.Davis-Fadtke@wildlife.ca.gov>; Fisher, Linda <Linda.Fisher@hdrinc.com>; Young, Amy@DWR <Amy.Young@water.ca.gov>; Montgomery, Amanda@Waterboards <Amanda.Montgomery@waterboards.ca.gov>; Okita, David@DWR <David.Okita@water.ca.gov>; Kearns, Zachary@Wildlife <Zachary.Kearns@Wildlife.ca.gov>; Torres, Juan@Wildlife <Juan.Torres@wildlife.ca.gov>; Uttley, Paige@Wildlife <Paige.Uttley@wildlife.ca.gov>; Barker, Kelley@Wildlife <Kelley.Barker@wildlife.ca.gov>; Purdy, Colin@Wildlife <Colin.Purdy@wildlife.ca.gov>; Huneycutt, Andrew@Wildlife <Andrew.Huneycutt@Wildlife.ca.gov>; Williams, Jonathan@Wildlife <Jonathan.Williams@wildlife.ca.gov>; Cooke, Robert@DWR <Robert.Cooke@water.ca.gov>; Biondi, Oscar@Waterboards <Oscar.Biondi@waterboards.ca.gov>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>; Linda Fisher (linda.fisher@hdrinc.com) <linda.fisher@hdrinc.com>
Subject: RE: Sites Reservoir Project - Responsible Agency Review - Group 2 Chapters - Due June 14

Hi all – I was just reviewing the attached file that thought it would be useful for those that are reviewing appendices. (Especially for the Chapter 11 Appendices as there are a number of them.)

Also, it occurred to me earlier today and we should have DWR look at recreation resources as we look at Oroville.

Linda, can you get recreation loaded for DWR?

Thanks all!

Ali

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From: Alicia Forsythe
Sent: Wednesday, May 26, 2021 11:05 AM
To: 'Davis-Fadtke, Kristal@Wildlife' <Kristal.Davis-Fadtke@wildlife.ca.gov>; 'Fisher, Linda' <Linda.Fisher@hdrinc.com>; 'Young, Amy@DWR' <Amy.Young@water.ca.gov>; 'Montgomery, Amanda@Waterboards' <Amanda.Montgomery@waterboards.ca.gov>; 'Okita, David@DWR' <David.Okita@water.ca.gov>; 'Kearns, Zachary@Wildlife' <Zachary.Kearns@Wildlife.ca.gov>; 'Torres, Juan@Wildlife' <Juan.Torres@wildlife.ca.gov>; 'Uttley, Paige@Wildlife' <Paige.Uttley@wildlife.ca.gov>; 'Barker, Kelley@Wildlife' <Kelley.Barker@wildlife.ca.gov>; 'Purdy, Colin@Wildlife' <Colin.Purdy@wildlife.ca.gov>; 'Huneycutt, Andrew@Wildlife' <Andrew.Huneycutt@Wildlife.ca.gov>; 'Williams, Jonathan@Wildlife' <Jonathan.Williams@wildlife.ca.gov>; 'Cooke, Robert@DWR' <Robert.Cooke@water.ca.gov>; 'Biondi, Oscar@Waterboards' <Oscar.Biondi@waterboards.ca.gov>
Cc: 'Laurie Warner Herson' <laurie.warner.herson@phenixenv.com>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>; Linda Fisher (linda.fisher@hdrinc.com) <linda.fisher@hdrinc.com>
Subject: Sites Reservoir Project - Responsible Agency Review - Group 2 Chapters - Due June 14

CEQA Responsible Agencies – Thank you for your comments on the "Group 1" Chapters. We now have Group 2 Chapters ready for your review. Below are the Group 2 Chapters along with the Responsible Agencies identified for review. Please let me know if you would like to review additional chapters not currently identified for your organization. Comments are due June 14.

6 – Surface Water Quality – CDFW, SWRCB, DWR
11 – Aquatic Resources, Some Appendices ONLY – CDFW and SWRCB
12 – Geology and Soils – DWR, would you want this one for DSOD?
13 – Minerals
14 – Land Use
16 – Recreation Resources
19 – Noise
21 – Greenhouse Gas Emissions
23 – Tribal Cultural Resources
24 – Visual Resources
25 – Population and Housing
26 – Public Services and Utilities
27 – Public Health and Environmental Hazards
29 – Indian Trust Assets
32 – Other Required Analyses
33 – Consultation and Coordination
34 – Document Distribution

We had originally envisioned getting Chapter 5, Surface Water Resources, in this group also. However, this chapter needs a little more work and is being pushed back to Group 3 (coming next week). For CDFW, SWRCB, and DWR, there are some appendices for Chapter 5 that are posted and ready for review.

Let me know if you would like any additional chapters not currently identified for your agency review. Linda can help if you have any challenges connecting to OneDrive.

We look forward to your comments.

Ali

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From: Alicia Forsythe
Sent: Wednesday, May 12, 2021 10:35 AM
To: Davis-Fadtke, Kristal@Wildlife <Kristal.Davis-Fadtke@wildlife.ca.gov>; Fisher, Linda <Linda.Fisher@hdrinc.com>; Young, Amy@DWR <Amy.Young@water.ca.gov>; Montgomery, Amanda@Waterboards <Amanda.Montgomery@waterboards.ca.gov>; Okita, David@DWR <David.Okita@water.ca.gov>; Kearns, Zachary@Wildlife <Zachary.Kearns@Wildlife.ca.gov>; Torres, Juan@Wildlife <Juan.Torres@wildlife.ca.gov>; Barker, Kelley@Wildlife <Kelley.Barker@wildlife.ca.gov>; Purdy, Colin@Wildlife <Colin.Purdy@wildlife.ca.gov>; Huneycutt, Andrew@Wildlife <Andrew.Huneycutt@Wildlife.ca.gov>; Williams, Jonathan@Wildlife <Jonathan.Williams@wildlife.ca.gov>; Cooke, Robert@DWR <Robert.Cooke@water.ca.gov>; Biondi, Oscar@Waterboards <Oscar.Biondi@waterboards.ca.gov>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Uttley, Paige@Wildlife <Paige.Uttley@wildlife.ca.gov>; Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Subject: RE: Sites Reservoir Project - Responsible Agency Review - Next Batch of Chapters

Hi Kristal – We are also struggling with the amount of work/review in the time we have. We can extend to June 18, but really no later. With trying to get the document out for public review in late August, we have just got to make sure we leave enough time for ICF and the Authority team to address comments/make changes and then final format and get into our and Reclamation's final review process. I realize this is tight and we are struggling with this with our own internal review.

I'd encourage the group to review the Group 2 chapters ASAP once you receive them to leave schedules open for that last Group 3 chapters.

I will also talk with the team to see if we can get any of the Fisheries appendices out early.

Ali

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From: Davis-Fadtke, Kristal@Wildlife <Kristal.Davis-Fadtke@wildlife.ca.gov>
Sent: Wednesday, May 12, 2021 9:58 AM
To: Fisher, Linda <Linda.Fisher@hdrinc.com>; Young, Amy@DWR <Amy.Young@water.ca.gov>; Montgomery, Amanda@Waterboards <Amanda.Montgomery@waterboards.ca.gov>; Okita, David@DWR <David.Okita@water.ca.gov>; Cooke, Robert@DWR <Robert.Cooke@water.ca.gov>; Biondi, Oscar@Waterboards <Oscar.Biondi@waterboards.ca.gov>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Alicia Forsythe <aforsythe@sitesproject.org>; Uttley, Paige@Wildlife <Paige.Uttley@wildlife.ca.gov>; Kearns, Zachary@Wildlife <Zachary.Kearns@Wildlife.ca.gov>; Torres, Juan@Wildlife <Juan.Torres@wildlife.ca.gov>; Barker, Kelley@Wildlife <Kelley.Barker@wildlife.ca.gov>; Purdy, Colin@Wildlife <Colin.Purdy@wildlife.ca.gov>; Huneycutt, Andrew@Wildlife <Andrew.Huneycutt@Wildlife.ca.gov>; Williams, Jonathan@Wildlife <Jonathan.Williams@wildlife.ca.gov>
Subject: RE: Sites Reservoir Project - Responsible Agency Review - Next Batch of Chapters

Good morning,

Thank you for the list of chapters and projected timeline – it is very helpful. I see you are requesting comments on all the remaining chapters by June 14. I anticipate the review of the aquatic and water quality resources and associated modeling will be a significant effort on our part and we are in a time of year when a lot of staff are in the field. We would like to provide meaningful input and request more time for review. Understanding that you have a schedule to meet, I propose we provide comments on the last batch of chapters by June 30.

Kristal

From: Fisher, Linda <Linda.Fisher@hdrinc.com>
Sent: Tuesday, May 11, 2021 9:26 PM
To: Young, Amy@DWR <Amy.Young@water.ca.gov>; Montgomery, Amanda@Waterboards <Amanda.Montgomery@waterboards.ca.gov>; Davis-Fadtke, Kristal@Wildlife <Kristal.Davis-Fadtke@wildlife.ca.gov>; Okita, David@DWR <David.Okita@water.ca.gov>; Cooke, Robert@DWR <Robert.Cooke@water.ca.gov>; Biondi, Oscar@Waterboards <Oscar.Biondi@waterboards.ca.gov>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Sites Reservoir Project - Responsible Agency Review - Next Batch of Chapters

Please find below the list of Chapters and Appendices being delivered this month. If you have any additional questions please let us know.

Deliverable	**Review Period**
May 3, 2021	
Chapter 7, Fluvial Geomorphology	5/11/2021-5/24/2021
Chapter 8, Groundwater Resources	5/11/2021-5/24/2021
Chapter 9, Vegetation Resources	5/11/2021-5/24/2021
Chapter 10, Wildlife Resources	5/11/2021-5/24/2021
Chapter 17, Energy	5/11/2021-5/24/2021

Chapter 18, Navigation, Transportation, and Traffic	5/11/2021-5/24/2021
Chapter 22, Cultural Resources	5/11/2021-5/24/2021
Appendix 8A, Groundwater Resources Basin Setting	5/11/2021-5/24/2021
Appendix 8B, Groundwater Modeling	5/11/2021-5/24/2021
Appendix 9A, Special-Status Plant Species	5/11/2021-5/24/2021
Appendix 9B, Vegetation and Wetland Methods and Information	5/11/2021-5/24/2021
Appendix 10A, Special-status Wildlife Table and Non-listed Wildlife Species Accounts	5/11/2021-5/24/2021
Appendix 10B, Wildlife Habitat Models and Methods	5/11/2021-5/24/2021
Appendix 10C, Special-status Wildlife Impact Tables	5/11/2021-5/24/2021
Appendix 17A (formerly 31B), CVP/SWP Power Modeling	5/11/2021-5/24/2021
May 24, 2021	
Chapter 5, Surface Water Resources	5/25/2021-6/14/2021
Chapter 6, Surface Water Quality	5/25/2021-6/14/2021
Chapter 12, Geology and Soils (includes Faults and Seismicity and Paleo)	5/25/2021-6/14/2021
Chapter 13, Minerals	5/25/2021-6/14/2021
Chapter 14, Land Use	5/25/2021-6/14/2021
Chapter 15, Agriculture and Forestry Resources	5/25/2021-6/14/2021
Chapter 16, Recreation Resources	5/25/2021-6/14/2021
Chapter 19, Noise	5/25/2021-6/14/2021
Chapter 23, Tribal Cultural Resources	5/25/2021-6/14/2021
Chapter 24, Visual Resources	5/25/2021-6/14/2021
Chapter 25, Population and Housing	5/25/2021-6/14/2021
Chapter 26, Public Services and Utilities	5/25/2021-6/14/2021]
Chapter 27, Public Health and Environmental Hazards (includes hazards and hazardous materials and wildfires)	5/25/2021-6/14/2021
Chapter 29, Indian Trust Assets	5/25/2021-6/14/2021
Chapter 30, Environmental Justice and Socioeconomics	5/25/2021-6/14/2021
Chapter 32, Other Required Analyses (includes Growth Inducing, Relationship Between Short-term Uses and Long-term Productivity and Irreversible or Irretrievable Resource Commitments)	5/25/2021-6/14/2021

Chapter 33, Consultation and Coordination and List of Preparers	5/25/2021-6/14/2021
Chapter 34, EIR/EIS Document Distribution	5/25/2021-6/14/2021
Appendix 5A (formerly 6A), Surface Water Resources Modeling of Alternatives	5/25/2021-6/14/2021
Appendix 5B (formerly 6B), Water Resources System Modeling	5/25/2021-6/14/2021
Appendix 5B1 (formerly 6B1), Project Operations	5/25/2021-6/14/2021
Appendix 5B2 (formerly 6B2), River Operations	5/25/2021-6/14/2021
Appendix 5B3 (formerly 6B3), Delta Operations	5/25/2021-6/14/2021
Appendix 5B4 (formerly 6B4), Regional Deliveries	5/25/2021-6/14/2021
Appendix 5C (formerly 6C), Upper Sacramento River Daily River Flow and Operations Models	5/25/2021-6/14/2021
Appendix 6A (formerly 7A), California State Water Resources Control Board Constituents of Concern	5/25/2021-6/14/2021
Appendix 6B (formerly 7B), Sacramento-San Joaquin Delta Modeling	5/25/2021-6/14/2021
Appendix 6C (formerly 7C), River Temperature Modeling	5/25/2021-6/14/2021
Appendix 6D (formerly 7C), Sites Reservoir Discharge Temperature Modeling	5/25/2021-6/14/2021
Appendix 6E, Water Quality Data	5/25/2021-6/14/2021
Appendix 6F (new), Mercury	5/25/2021-6/14/2021
Appendix 12A, Soils Survey Map	5/25/2021-6/14/2021
Appendix 12B, Soils Plan	5/25/2021-6/14/2021
Appendix 19A, Noise Calculations	5/25/2021-6/14/2021
Appendix 24A, Aesthetics	5/25/2021-6/14/2021
Appendix 24B, Aesthetics Existing Conditions/Setting	5/25/2021-6/14/2021
Appendix 27A, Environmental Records Search	5/25/2021-6/14/2021
Appendix 30A, Regional Economics Modeling (No change from 2017 Appendix 22C)	5/25/2021-6/14/2021
Appendix 32A (formerly 34A), Growth Inducing Considerations for Municipal and Industrial Water Users	5/25/2021-6/14/2021
Appendix 33A, 2017 Draft EIR/EIS Chapter 36 Consultation and Coordination	5/25/2021-6/14/2021
May 31, 2021	
Executive Summary – text only	6/1/2021-6/14/2021
Chapter 11, Aquatic Biological Resources	6/1/2021-6/14/2021
Chapter 20, Air Quality	6/1/2021-6/14/2021
Chapter 21, Greenhouse Gases	6/1/2021-6/14/2021

Chapter 28, Climate Change	6/1/2021-6/14/2021
Chapter 31, Cumulative Impacts	6/1/2021-6/14/2021
Appendix 2C, Construction Means, Methods, and Assumptions	6/1/2021-6/14/2021
Appendix 2D, Environmental Commitments and BMPs	6/1/2021-6/14/2021
Appendix 4A, Regulatory Requirements	6/1/2021-6/14/2021
Appendix 11A (formerly 12A), Aquatic Species Life Histories	6/1/2021-6/14/2021
Appendix 11B (formerly 12B), Fisheries Impact Assessment Methodology	6/1/2021-6/14/2021
Appendix 11C (formerly 12C), Fisheries Impact Summary	6/1/2021-6/14/2021
Appendix 11D (formerly 12E), Fisheries Water Temperature Assessment Summary Table	6/1/2021-6/14/2021
Appendix 11E (formerly 12F), Reservoir Water Surface Elevation Summary Table	6/1/2021-6/14/2021
Appendix 11F, (formerly 12G), Smelt Analysis	6/1/2021-6/14/2021
Appendix 11H Salmonid Population Modeling	6/1/2021-6/14/2021
Appendix 11I (formerly 12J), Winter Run Chinook Salmon Life Cycle Modeling	6/1/2021-6/14/2021
Appendix 11J (formerly 12K), Through Delta Survival of Juvenile Salmonids	6/1/2021-6/14/2021
Appendix 11K (formerly 12L), Weighted Usable Area Analysis	6/1/2021-6/14/2021
Appendix 11L (formerly 12M), Sturgeon Analysis	6/1/2021-6/14/2021
Appendix 11M (formerly 12N), Yolo and Sutter Bypass Flow and Weir Spill Analysis	6/1/2021-6/14/2021
Appendix 11N (new), Other Flow-Related Upstream Analyses	6/1/2021-6/14/2021
Appendix 11O (new), *Anderson-Martin Models*	6/1/2021-6/14/2021
Appendix 11P (new), Riverine Flow-Survival	6/1/2021-6/14/2021
Appendix 11Q (new), Other Bay-Delta Species Analyses	6/1/2021-6/14/2021
Appendix 20A (formerly 24A), Methodology for Air Quality and GHG Emissions Calculations	6/1/2021-6/14/2021
Appendix 28A (new), Climate Change	6/1/2021-6/14/2021

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From: Alicia Forsythe <aforsythe@sitesproject.org>
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To: Amy.Young@water.ca.gov; Montgomery, Amanda@Waterboards <amanda.montgomery@waterboards.ca.gov>; Davis-Fadtke, Kristal@Wildlife <kristal.davis-fadtke@wildlife.ca.gov>; Okita, David@DWR <David.Okita@water.ca.gov>; Cooke, Robert@DWR <Robert.Cooke@water.ca.gov>; Biondi, Oscar@Waterboards <Oscar.Biondi@waterboards.ca.gov>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Fisher, Linda <Linda.Fisher@hdrinc.com>
Subject: RE: Sites Reservoir Project - Responsible Agency Review - Next Batch of Chapters

Responsible Agency Reps – The Group 1 Chapters are posted to a SharePoint site for your review and input. You will be receiving an email from Linda Fisher shortly with access information. It would likely be best if you download the files and share in your organization and then re-post them with comments. We can give others access to SharePoint also if you would like. If you have any issues accessing the files or need access for anyone else, please contact Linda.

Just a reminder that these chapters are due by COB, Monday, May 24. We appreciate your review and input on these chapters.

Also a few folks have asked for a listing of all chapters to understand the bigger picture. We will get that out tomorrow.

Ali

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Sent: Tuesday, May 4, 2021 4:15 PM
To: 'Amy.Young@water.ca.gov' <Amy.Young@water.ca.gov>; 'Montgomery, Amanda@Waterboards' <Amanda.Montgomery@waterboards.ca.gov>; Kristal Davis Fadtke (Kristal.Davis-Fadtke@wildlife.ca.gov) <Kristal.Davis-Fadtke@wildlife.ca.gov>; 'Okita, David@DWR' <David.Okita@water.ca.gov>; Cooke, Robert@DWR <Robert.Cooke@water.ca.gov>; 'Biondi, Oscar@Waterboards' <Oscar.Biondi@waterboards.ca.gov>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: Sites Reservoir Project - Responsible Agency Review - Next Batch of Chapters

Responsible Agency Reps – Thank you for taking the time to review Chapters 1 to 4 of the Revised Draft EIR/Supplemental Draft EIS. We are working to incorporate the comments we received.

We are diligently working on the remainder of the Admin Draft document. Chapters are coming to the Authority in "Groups" from ICF as they are completed. We expect to be able to transmit the following chapters as associated appendices on Monday, May 10 for your review. Note that I have identified the Responsible Agency review by chapter. If you would like chapters that I currently do not have identified for your review, please let me know.

Chapter 7, Fluvial Geomorphology – CDFW, SWRCB
Chapter 8, Groundwater Resources – DWR
Chapter 9, Vegetation Resources – CDFW, SWRCB
Chapter 10, Wildlife Resources – CDFW, SWRCB

Chapter 17, Energy
Chapter 18, Navigation, Transportation and Traffic
Chapter 22, Cultural Resources

Comments on these "Group 1" chapters will be due Monday, May 24.

The next batch of Chapters will be available around May 31.

Ali

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From: Alicia Forsythe
Sent: Wednesday, March 24, 2021 10:13 AM
To: Amy.Young@water.ca.gov; Montgomery, Amanda@Waterboards <Amanda.Montgomery@waterboards.ca.gov>; Kristal Davis Fadtke (Kristal.Davis-Fadtke@wildlife.ca.gov) <Kristal.Davis-Fadtke@wildlife.ca.gov>; Okita, David@DWR <David.Okita@water.ca.gov>; Cooke, Robert@DWR <Robert.Cooke@water.ca.gov>; Biondi, Oscar@Waterboards <Oscar.Biondi@waterboards.ca.gov>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: RE: Sites Reservoir Project - Responsible Agency Review of Chapters 1 to 4; Due 4/21 (2 of 2 Emails)

Attached is Chapter 2. This is the same version of Chapter 2 that the Authority released to the public on February 19.

Ali

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From: Alicia Forsythe
Sent: Wednesday, March 24, 2021 10:07 AM
To: Amy.Young@water.ca.gov; Montgomery, Amanda@Waterboards <Amanda.Montgomery@waterboards.ca.gov>; Kristal Davis Fadtke (Kristal.Davis-Fadtke@wildlife.ca.gov) <Kristal.Davis-Fadtke@wildlife.ca.gov>; Okita, David@DWR <David.Okita@water.ca.gov>; Cooke, Robert@DWR <Robert.Cooke@water.ca.gov>; Biondi, Oscar@Waterboards <Oscar.Biondi@waterboards.ca.gov>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: Sites Reservoir Project - Responsible Agency Review of Chapters 1 to 4; Due 4/21 (1 of 2 Emails)

Responsible Agency Reps – The Sites Authority has prepared preliminary drafts of Chapters 1, 2, 3, and 4 of the our upcoming Revised Draft EIR, which is scheduled for release in August. These chapters cover the following topics:

1 – Introduction
2 – Project Description (same as previously sent to some of you)

3 – Environmental Analysis Approach
4 – Regulatory and Environmental Compliance: Project Permits, Approvals, and Consultation Requirements

These preliminary draft chapters are attached. As an agency that may be taking a CEQA action on the Project, we welcome your review and input on these preliminary chapters. We would like to received input by April 21. Please feel free to make changes, using track changes and/or comment bubbles in the files.

These preliminary draft chapters have also been distributed by Reclamation to a number of federal agencies that are Cooperating Agencies under NEPA. And as a reminder, these preliminary chapters are not for public review and should not be distributed to the public unless required to do so by law.

We continue to work on the remainder of the document and will get you additional preliminary draft chapters as they become available.

We appreciate and look forward to your feedback. If you have any questions or concerns, please feel free to contact me. We are also happy to host a call and walk the group through these chapters if folks would find that helpful – just let me know.

(Note, this email includes Chapters 1, 3, and 4. Chapter 2 will be sent in a separate email due to file size.)

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Janis Offermann [janis@horizonh2o.com]
Sent: 6/4/2021 12:56:00 PM
To: Laurie Warner Herson [laurie.warner.herson@phenixenv.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Kevin Spesert [kspesert@sitesproject.org]
Subject: RE: Yocha Dehe Meeting today

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That's it for today. I will keep you posted on the meeting with DWR next week. Should I ask Anecita to include you in the invitation?

Thanks
Janis

Janis Offermann
Cultural Resources Practice Leader
Horizon Water and Environment
400 Capitol Mall, Suite 2500
Sacramento, CA 95814
916.465.8076 – office
530.220.4918 – mobile

From: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Sent: Friday, June 04, 2021 7:35 AM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Janis Offermann <janis@horizonh2o.com>
Subject: RE: Yocha Dehe Meeting today

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Sent: Friday, June 4, 2021 7:22 AM
To: Janis Offermann <janis@horizonh2o.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: Re: Yocha Dehe Meeting today

Thanks all. I won't attend. I should be around if something comes up.

————————
Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

---

From: Janis Offermann <janis@horizonh2o.com>
Sent: Friday, June 4, 2021 6:51:24 AM
To: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Yocha Dehe Meeting today

Hi, Laurie
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Sent: Friday, June 04, 2021 6:46 AM
To: Janis Offermann (Janis@Horizonh2o.com) <Janis@Horizonh2o.com>
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Subject: Yocha Dehe Meeting today

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Laurie Warner Herson
Principal/Owner

Phenix
Environmental Planning

916.201.3935
laurie.warner.herson@phenixenv.com
State of California Small Business (#1796182)
Supplier Clearinghouse Women Business Enterprise (#16000323)

http://phenixenv.com/

From: Laurie Warner Herson [laurie.warner.herson@phenixenv.com]
Sent: 6/4/2021 1:32:22 PM
To: Janis Offermann [janis@horizonh2o.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Kevin Spesert [kspesert@sitesproject.org]
Subject: RE: Yocha Dehe Meeting today

Great – thanks for keeping this moving. I am assuming that you will also inform the cultural team so everyone is on the same page. The cultural team needs to fully revise Chapter 22, Cultural Resources and this is information (highlighted in yellow) will help them in their revisions - as well as in updating Chapters 23, Tribal Cultural Resources.

From: Janis Offermann <janis@horizonh2o.com>
Sent: Friday, June 4, 2021 12:56 PM
To: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Alicia Forsythe <aforsythe@sitesproject.org>; Kevin Spesert <kspesert@sitesproject.org>
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Subject: Re: Yocha Dehe Meeting today

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Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

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From: Janis Offermann [janis@horizonh2o.com]
Sent: 6/4/2021 1:34:24 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Laurie Warner Herson [laurie.warner.herson@phenixenv.com]; Kevin Spesert [kspesert@sitesproject.org]
Subject: RE: Yocha Dehe Meeting today

Thanks for the quick reply, Ali. Yocha Dehe has their own GPR equipment, so they want use that. As for the cadaver dogs, they are quite efficient at finding human remains that are thousands of years old in archaeological sites. They are amazing pups!

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Friday, June 04, 2021 1:27 PM
To: Janis Offermann <janis@horizonh2o.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Kevin Spesert <kspesert@sitesproject.org>
Subject: RE: Yocha Dehe Meeting today

This is fantastic. Thanks Janis. I will be out next week, so wont be able to participate in the DWR discussion. I do think it would be good to include Laurie and Kevin if they can participate. It would be fabulous if DWR gave this data directly.

I don't know the cost of ground penetrating radar. Cadaver dogs seem like it wouldn't be too costly. But since there is likely no tissue left (or at least not much), can they find buried individuals from so long ago? No need to answer that. Anyway, I think it's in the Authority's interest to do something like ground penetrating radar in the most likely areas. We want to respect these individuals and their families and if we can find them and relocate intentionally rather than once they are impacted by wave erosion – that would be the absolute best scenario. I would support doing ground penetrating radar to the Board.

Ali

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From: Janis Offermann <janis@horizonh2o.com>
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State of California Small Business (#1796182)
Supplier Clearinghouse Women Business Enterprise (#16000323)

http://phenixenv.com/

From: Luu, Henry [Henry.Luu@hdrinc.com]
Sent: 6/8/2021 9:13:31 AM
To: Marcia Kivett [MKivett@sitesproject.org]
Subject: RE: Favor
Attachments: Feasibility Design Considerations TM.pdf; HR_Feasibility Cost Estimate TM.pdf; HC_Feasibility Design Basis of Estimate.pdf

Hi Marcia,

Sorry for the delay…I am in meetings all morning. Attached are the documents highlighted in yellow. I've also made minor edits to the email language, which is highlighted in green. Let me know if I can help with additional clarifications.

Thank you,
Henry H. Luu, PE
D 916.679.8857 M 916.754.7566

hdrinc.com/follow-us

From: Marcia Kivett <MKivett@sitesproject.org>
Sent: Tuesday, June 8, 2021 8:17 AM
To: Luu, Henry <Henry.Luu@hdrinc.com>
Subject: Favor
Importance: High

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Before I send this out, can you send me the documents or links to the below 3 documents so I can have them posted first?

Reservoir Committee Participants,

As you know, the project team has been working with Reservoir Committee workgroups over the past 3 months to develop a feasibility design cost estimate that incorporates the latest design information and value engineering options for the project alternatives. The final feasibility cost estimate is scheduled to be considered for acceptance at this month's Joint Reservoir Committee/Authority Board meeting on June 23, 2021.

This work has resulted in a feasibility design cost estimate increase of ~30% (in 2021 dollars) over the appraisal level cost estimate that came out of value planning. To assist ~~in your~~ you in communicating the cost changes to your agency's management, boards and councils the project team has put together the attached communications messages. We're getting these to you in advance of the June 23 meeting so that your internal communications can occur prior to the public release of the estimate. Also, for those of you seeking additional details about the cost estimate, we have placed the following reference documents on the participant web portal (https://sitesproject.org/participant-portal-documents/):

1. Feasibility Design Considerations TM – a brief summary of the Sites Project Authority feasibility design and considerations.
2. HR Feasibility Cost Estimate TM – basis of feasibility cost estimate for the reservoir and roadway project features.
3. HC Feasibility Design Basis of Estimate – basis of feasibility cost estimate for the conveyance project features.

As a reminder, the project cost estimate is one of several factors that affect the project's affordability. The project team will present~~ing~~ all of the updated information around affordability at our July 23 affordability workshop.

Please don't hesitate to reach out to me ~~of~~ or Henry Luu if there is anything else you need in this regard.

Jerry

Jerry Brown | Executive Director | Sites Reservoir Project | 925.260.7417
| jbrown@sitesproject.org | www.SitesProject.org

Marcia Kivett
Sites Project Admin
Phone: 561.843.9740
Email: mkivett@sitesproject.org
Web: www.SitesProject.org
P.O. Box 517
122 Old Hwy 99W
Maxwell, CA 95955

Feasibility Design Considerations Technical Memorandum

Sites

To:	Jerry Brown
Date:	June 4, 2021
From:	Henry Luu
Subject:	Summary of Feasibility Design Progression and Considerations

1.0 Introduction

In the fall of 2019, the Sites Project Authority (SPA) undertook a value planning effort that assessed the "right size" project based on overall objectives, participation levels, and expected permitting criteria. This assessment resulted in a project that utilize existing conveyance systems for water diversions and releases. Water will be diverted from the Sacramento River at the existing Red Bluff Pumping Plant and the Hamilton City Main Pump Station, and conveyed to Sites Reservoir via the Tehama Colusa Canal Authority canal (TCC) and the Glenn Colusa Irrigation District main canal (GCID); water releases will also occur through TCC and GCID facilities. Releases to the TCC will flow south towards its terminus where the project will construct the Dunnigan pipeline to discharge into the Colusa Basin Drain (CBD) or the Sacramento River. If releases are to the CBD, then water will be carried downstream to Knights Landing where discharge to the Sacramento River will be controlled by the Knights Landing Outfall Gates, or through Knights Landing Ridge Cut and the Wallace Weir to the Yolo Bypass. This value planning effort culminated in the development of the Sites Project Value Planning Alternatives Appraisal Report in April 2020.

2.0 Feasibility Design Development

In the summer of 2020, the SPA began development of feasibility level design in support of the Revised Draft Environmental Impact Report and Supplemental Draft Environmental Impact Statement (RDEIR-SDEIS) that included two project alternatives:

- Alternative 1 major project features consist of a 1.5 million-acre-foot (MAF) reservoir, realignment of Sites Lodoga Road across the proposed reservoir via bridges, and the Dunnigan Pipeline connecting the terminus of TCC to the CBD.
- Alternative 2 major project features consists of a 1.3 MAF reservoir, redirecting access between the towns of Stonyford and Sites through a new road alignment that wraps around the southern limit of the proposed reservoir, and the Dunnigan Pipeline connecting the terminus of the TCC to the Sacramento River.

The feasibility level designs for the above two alternatives were completed in the fall of 2020 and included developments of the basis of design technical memorandums (TM) and 10% design level project plans.

3.0 Value Engineering

In the winter of 2021, the SPA developed preliminary project schedules and constructability analysis for the two project alternatives to inform development of the RDEIR-SDEIS and support preparation of an updated project cost estimate. During development of the updated project cost estimate it became clear that there were several drivers that increased the project cost significantly from what was presented as part of the value planning efforts in 2019/2020. Concerns of project affordability led the SPA to review and adopt several value engineering (VE) proposals to mitigate the cost increase, which included the following:

- Replacing the dual I/O tunnel design with one large single tunnel.
- Replacing the vertical intake with a sloping structure.
- Removing the west bridge span of the Sites Lodoga realignment (Alternative 1) and replacing it with embankment fill.
- Removing the high-level emergency release structures in vicinity of Saddle Dam 3 and Saddle Dam 5, and accounting for additional releases at the proposed low-level emergency release structures.
- Relocated the Terminal Regulating Reservoir (TRR) features from the east side of GCID to the west side of GCID.

4.0 Design Considerations

Consideration and evaluations of the adopted VE proposals adhered to the design criteria established in the fall of 2020 and meets standard industry practice. Given that the project is in the early stages of design, updates to the design criteria may occur as the project progresses beyond feasibility level and in coordination with agencies such as the California Department of Water Resources Division of Safety of Dams (DSOD).

From: Hawk,Nina E [NHawk@mwdh2o.com]
Sent: 6/8/2021 4:30:38 PM
To: laurie.warner.herson@phenixenv.com
CC: Neudeck,Randall D [rneudeck@mwdh2o.com]; Alicia Forsythe [aforsythe@sitesproject.org]
Subject: FW: Catch up on Sites Envr Planning
Attachments: Confidentiality Agreement Sites-MWD.pdf

Hello Laurie,

I sent an email to Ali and see she is enjoying some much deserved time away (on vacation). I wanted to specifically request that MWD receive copies of the EIR and EIS chapters for review. Our understanding is some chapters have already been shared with regulatory agencies, including fishery agencies, and our team has not seen them.

Is there an easy share drive and/or link that can be provided for access? I have included a copy of the Confidentially Agreement for your ease that covers the sharing of such information (EIR and CEQA documents) which was executed for this purpose.

Thank you and any questions please let me know.

Look forward to hearing from you.

Nina E. Hawk
Bay Delta Initiatives Policy Manager
Mobile: (510) 299-8289
nhawk@mwdh2o.com
Metropolitan Water District of Southern California
1121 L Street Ste. 900, Sacramento, CA 95814

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, June 8, 2021 4:23 PM
To: Hawk,Nina E <NHawk@mwdh2o.com>
Subject: Automatic reply: Catch up on Sites Envr Planning

Thank you for your email. I am on vacation from June 5 to June 20. I will have limited access to email and cell reception.

If you need immediate help, please contact the following individuals:

For Sites Planning, Laurie Warner Herson at laurie.warner.herson@phenixenv.com

For Sites Permitting, John Spranza at John.Spranza@hdrinc.com

For Sites Water Operations, Erin Heydinger at Erin.Heydinger@hdrinc.com

I will return your message as soon as possible. Thank you!

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

---

From: Bruce Linquist [balinquist@ucdavis.edu]
Sent: 6/8/2021 5:03:26 PM
To: Spranza, John [john.spranza@hdrinc.com]; Huber, Anne [Anne.Huber@icf.com]; Tim Johnson [tjohnson@calrice.org]; pbuttner@calrice.org; Alicia Forsythe [aforsythe@sitesproject.org]; Diana.Roberts@icf.com; Laurie Warner Herson [laurie.warner.herson@phenixenv.com]; Williams, Nicole (Nicole.Williams@icf.com) [Nicole.Williams@icf.com]
Subject: Rice papers on Hg and As
Attachments: 2018 Tanner et al MeHg in Sac Valley rice fields.pdf; 2017 Tanner et al MeHg Sac Valley - JEQ.pdf; 2016 LaHue et al CA AWD.pdf; 2018 Carrijo et al FCR AWD yields and As.pdf

Hi John et al,
Attached are some papers related to Hg and As in rice. The first two are related to Hg. One is a review of CA literature and the other has actual data.

The arsenic papers have relatively little about the influence of water; however, from those you will see some values on rice grain As. Importantly, most of the As related papers are from a single location. The values you should be looking at are the treatments that were continuously flooded.

I hope this helps,
Bruce

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Friday, May 28, 2021 9:39 AM
To: Bruce Linquist <balinquist@ucdavis.edu>; Huber, Anne <Anne.Huber@icf.com>; Tim Johnson <tjohnson@calrice.org>; pbuttner@calrice.org; Alicia Forsythe <aforsythe@sitesproject.org>; Diana.Roberts@icf.com; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Williams, Nicole (Nicole.Williams@icf.com) <Nicole.Williams@icf.com>
Subject: RE: Sites Reservoir Project Agronomy and Water Quality Discussion: Doodle Poll

Hey folks, this is a friendly reminder to take the poll so I can get this scheduled.
Thanks.
John

John Spranza

D 916.679.8858 M 818.640.2487

From: Spranza, John
Sent: Wednesday, May 26, 2021 1:39 PM
To: balinquist@ucdavis.edu; Huber, Anne <Anne.Huber@icf.com>; Tim Johnson <tjohnson@calrice.org>; pbuttner@calrice.org; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Diana.Roberts@icf.com; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: RE: Sites Reservoir Project Agronomy and Water Quality Discussion: Doodle Poll

Hello,
Please use the link below to provide your availability for a meeting to discuss the topics identified in the email thread below.
Thanks.
John

https://doodle.com/poll/87z3nfcxeadv5hi7?utm_source=poll&utm_medium=link

John Spranza

D 916.679.8858 M 818.640.2487

From: Spranza, John
Sent: Tuesday, May 25, 2021 9:02 AM
To: balinquist@ucdavis.edu
Cc: Huber, Anne <Anne.Huber@icf.com>; Tim Johnson <tjohnson@calrice.org>; pbuttner@calrice.org; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Diana.Roberts@icf.com; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: Sites Reservoir Project Agronomy and Water Quality Discussion

Dr. Linquist,
I am part of the team that is leading the environmental permitting and planning effort for the Sites Reservoir Project. We're in the midst of preparing our Revised Draft EIR/Supplemental Draft EIS and have been meeting with environmental NGOs on the Project and Project effects.

Through our analysis efforts and discussions with Tim and Paul at the Rice Commission some concerns that have been raised in our NGO meetings are still outstanding and we wanted to see if you had any time in the near future to speak with us. We have the following topics we would like to discuss:

1. Optimal water temperatures for rice throughout the year. This comes into play in releases from Sites back into the TC Canal and the GCID Main Canal.
2. Rice and mercury effects.
3. Rice and arsenic effects.

I can send out a Doodle Poll to help schedule time if that would work best for you.

Thanks
John

John Spranza, MS, CCN
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Methylmercury Dynamics in Upper Sacramento Valley Rice Fields with Low Background Soil Mercury Levels

K. Christy Tanner,* Lisamarie Windham-Myers, Mark Marvin-DiPasquale, Jacob A. Fleck, Kenneth W. Tate, and Bruce A. Linquist

Abstract

Few studies have considered how methylmercury (MeHg, a toxic form of Hg produced in anaerobic soils) production in rice (*Oryza sativa* L.) fields can affect water quality, and little is known about MeHg dynamics in rice fields. Surface water MeHg and total Hg (THg) imports, exports, and storage were studied in two commercial rice fields in the Sacramento Valley, California, where soil THg was low (25 and 57 ng g^{-1}). The median concentration of MeHg in drainage water exiting the fields was 0.17 ng g^{-1} (range: <0.007–2.1 ng g^{-1}). Compared with irrigation water, drainage water had similar MeHg concentrations, and lower THg concentrations during the growing season. Significantly elevated drainage water MeHg and THg concentrations were observed in the fallow season compared with the growing season. An analysis of surface water loads indicates that fields were net importers of both MeHg (76–110 ng m^{-2}) and THg (1947–7224 ng m^{-2}) during the growing season, and net exporters of MeHg (35–200 ng m^{-2}) and THg (248–6496 ng m^{-2}) during the fallow season. At harvest, 190 to 700 ng MeHg m^{-2} and 1400 to 1700 ng THg m^{-2} were removed from fields in rice grain. Rice straw, which contained 120 to 180 ng MeHg m^{-2} and 7000–10,500 ng m^{-2} THg was incorporated into the soil. These results indicate that efforts to reduce MeHg and THg exports in rice drainage water should focus on the fallow season. Substantial amounts of MeHg and THg were stored in plants, and these pools should be considered in future studies.

Core Ideas

- MeHg dynamics were studied in two rice fields with soil THg near background levels.
- Surface water MeHg and THg imports and exports and soil and plant storage were quantified.
- Net surface water MeHg and THg import occurred in the growing season.
- Net surface water MeHg and THg export occurred in the fallow season.
- Annual MeHg and THg pools in straw and grain were similar to surface water loads.

The production of methylmercury (MeHg), a particularly toxic and bioaccumulative form of Hg produced by some anaerobic microbes, is a concern in flooded rice (*Oryza sativa* L.) fields (Compeau and Bartha, 1985; Gilmour et al., 1992, 2013; Chan et al., 2003; Fleming et al., 2006; Kerin et al., 2006; Parks et al., 2013; Windham-Myers et al., 2014a). Methylmercury can accumulate in rice grain, threatening human health (Horvat et al., 2003). Additionally, wildlife in rice fields can be affected by MeHg produced there, and wildlife in downstream ecosystems can be affected by MeHg exported in rice drainage water (Crump and Trudeau, 2009; Ackerman and Eagles-Smith, 2010; Alpers et al., 2014).

Research on rice field MeHg dynamics has been conducted primarily in areas of known Hg pollution, such as Guizhou Province, China (Zhang et al., 2010b; Li et al., 2014; Meng et al., 2014; Zhao et al., 2016) and Hg-affected areas of the California Central Valley (Eagles-Smith et al., 2014; Windham-Myers et al., 2014a). In Hg mining areas of Guizhou Province in inland China, human MeHg exposure through rice consumption exceeds that from fish consumption (Feng et al., 2008; Qiu et al., 2008; Hong et al., 2016; Zhang et al., 2010a). Many studies have compared total Hg (THg) and MeHg concentrations in rice grain and soil at sites with soil THg content ranging over four orders of magnitude from 40 ng g^{-1} in Thailand (Zarcinas et al., 2004) to 34,600 ng g^{-1} near Hg mines in the Wanshan mining district, Guizhou, China (Zhang et al., 2010b).

In places where rice is the dominant land use, export of MeHg in rice drainage waters can potentially have large impacts on water quality. Methylmercury in surface water can bioaccumulate in wildlife, reaching levels in sport fish that are a concern for human health, and negatively affecting wildlife fitness (Chan et al., 2003; Crump and Trudeau, 2009; Ackerman et al., 2014). Little is known about Hg biogeochemical cycling in rice fields or soil and water fluxes (Rothenberg et al., 2014). Understanding of MeHg export is further complicated by MeHg degradation processes such as photodemethylation (Seller et al., 1996; Fleck et al., 2014), microbial demethylation (Spangler et al., 1973; Marvin-DiPasquale et al., 2003), and

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Abbreviations: MDL, method detection limit; MeHg, methylmercury; RL, reporting limit; THg, total mercury; TSS, total suspended solids.

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MeHg storage within fields (Bachand et al., 2014; Windham-Myers et al., 2014a).

Export of MeHg from rice fields is a concern in the Sacramento Valley, California, where rice is grown on 240,000 ha of the valley (USDA-NASS, 2016), and Hg and gold mining resulted in Hg contamination in the surrounding mountains (Churchill, 2000; Rytuba, 2003; Alpers et al., 2016). Downstream in the Sacramento-San Joaquin Delta (hereafter referred to as the "Delta"), MeHg concentrations are elevated and negative impacts of Hg on wildlife have been documented (Ackerman et al., 2014). Both field-scale and watershed-scale studies report rice field drainage waters have elevated MeHg concentrations and/or loads during the fallow season (Alpers et al., 2014; Bachand et al., 2014; Eagles-Smith et al., 2014; Tanner et al., 2017), when fields are flooded to decompose rice straw. However, the field-scale studies (Alpers et al., 2014; Eagles-Smith et al., 2014) report concentrations that are considerably higher than observed at the watershed scale (Tanner et al., 2017). This may be because field-scale studies were conducted in areas known to receive Hg-laden sediment from mining regions during flood events (Singer et al., 2013), whereas sediment transport from mining areas into the main Sacramento Valley rice-growing region is limited by dams (Slotton et al., 1995; Supplemental Fig. S1). Thus, there is a need to better understand MeHg export from rice fields in the Sacramento Valley rice-growing region.

We studied rice fields in the Sacramento Valley, where soil THg was lower than in previously studied fields in California. Research focused on surface water imports and exports of THg and MeHg throughout a full annual cycle, and storage of MeHg and THg in soil and plant pools. The hypothesis that MeHg and THg exports in surface water will be elevated in the fallow season compared with the growing season was tested by addressing the following objectives: (i) characterize Hg dynamics in rice fields that were typical of California rice production, (ii) measure the field-scale impact of rice production on Hg-related surface water quality. Findings here will help identify periods of high MeHg export from the fields that could be reduced by modifying management practices.

Materials and Methods

Site Description

Two commercial rice fields were studied, one in Butte county ("Butte," area: 22.1 ha) in the northeast Sacramento Valley and the other in Yolo county ("Yolo," area: 48.6 ha) in the southwest Sacramento Valley (Supplemental Fig. S1). The study period started before planting in May and continued through the end of the following fallow season in February of 2014–2015 and 2015–2016 for Butte and Yolo, respectively. Both fields had heavy clay soils preferred for rice production (Supplemental Table S1). The fields represent the two primary surface irrigation water sources for rice in the region: the Sacramento River (Yolo) and the Feather River (Butte). Yolo also received some recycled irrigation water from surrounding rice fields. Butte irrigation water was diverted from the Feather River downstream of Lake Oroville and stored in the Thermalito Afterbay before entering irrigation canals (Supplemental Fig. S1).

Field Management

Both fields were managed by commercial rice growers using common management practices and rice cultivars for California's Central Valley (University of California Davis Cooperative Extension, 2015). Dates of management events were determined by the growers (Supplemental Table S1). The fields were laser leveled to ensure uniform water height. Irrigation water was supplied to each field through a single inlet. Drainage water exited fields at the outlets through a rectangular weir. Butte had two outlets and Yolo had seven, but drainage occurred through a single outlet per field throughout most of the study (exceptions discussed below).

Soil tillage, field leveling, and seed-bed preparation occurred in April. In early May, fields were flooded prior to planting and pre-germinated rice seed was broadcast by airplane. No outflow occurred from Butte until 10 July, and water level was managed by adjusting inflow rates. Yolo was drained using all outlets 3 d after planting and reflooded 3 d later—a common practice to promote even stand establishment. Often the water level must be lowered to expose weeds for herbicide applications, either by turning off irrigation water and allowing the water to subside through evapotranspiration and percolation (Butte) or a combination of surface outflow drainage and subsidence (Yolo). When water was lowered, areas of shallow standing water were visible, and these conditions lasted no more than 3 d. In July, water inflow was adjusted to maintain a constant level of water in the field with a small amount of surface water drainage (referred to as maintenance flow). Three weeks prior to harvest in September the fields were drained (Supplemental Table S1).

After harvest, soils were tilled to incorporate rice straw and flooded to promote decomposition during the winter fallow (Linquist et al., 2006). Winter flood-up at Butte occurred on 28 October but was delayed at Yolo until 18 December due to water availability (Supplemental Table S1). Fields were drained again in January (Butte) and February (Yolo).

Sample Collection

Samples of irrigation water entering the field (inlet), and drainage water exiting the field through the outlet weir (outlet) were collected every 1 to 2 wk at the inlet and outlet of each field when flow was occurring. Inlets and outlets did not always have flows at the same time, so sampling was targeted to capture each flow period. Samples included initial inflow and outflows during both the growing and fallow seasons, as well as drainage events. There was no inflow or outflow between the preharvest drain and winter flood up, so no samples were collected. Butte received precipitation in November and December, whereas Yolo precipitation occurred from November through February (Supplemental Fig. S2). Precipitation occurring when fields were not flooded resulted in soil saturation and runoff in only one instance. This occurred at Butte in February, and a sample was collected to capture the event (Supplemental Fig. S2e and S2g). Precipitation in November and early December at Butte did not result in flooded conditions before the field was flooded in mid-December. To ensure that the study sites were not anomalous, outlets of four other commercial rice fields near each study site were sampled during the growing season and again in the fallow season (if flooded).

Four soil and plant sampling plots were established in each field, at least 30 m from field edges. Soil samples were collected four times in each field: (i) after spring tillage prior to flooding and planting (May), (ii) prior to drainage for harvest (August), (iii) after fall tillage but before winter flooding (October), and (iv) prior to draining the fields in late winter (February). Rice straw (stems and leaves) and grain samples were collected at harvest.

Sampling Methods and Mercury Analysis

All samples for MeHg and THg analysis were collected using trace-clean sampling techniques (USEPA, 1996). Soil samples were collected differently depending on whether the soil was flooded or dry and tilled. Flooded samples (August and February) were collected as 5-cm-diam., 15-cm-deep soil cores. At each sampling point, two cores were collected and composited. At Butte, these samples were subsampled into four depth intervals (0–2, 4–6, 8–10, and 12–14 cm). No significant effect of depth was found for MeHg or THg at Butte, so only the 0- to 5-cm subsample of Yolo samples was used for laboratory analysis. When dry soil was sampled following tillage (May and October, mixed to a depth of ~15 cm, subsampling by depth was not possible) five scoops (each ~150 cm^3) were collected from a 1-m^2 area and composited in a Ziploc bag. All soil samples were field frozen with dry ice for transport and subsequently stored at −80°C prior to subsampling and analysis. Soil samples were analyzed for MeHg, THg, bulk density, and loss on ignition (Marvin-DiPasquale et al., 2011). Briefly, samples (0.5 g) were digested with aqua regia overnight and analyzed for THg after heated oxidation with BrCl according to USEPA Method 1631 (USEPA, 2002), and quantified on an automated Tekran 2600 total Hg analyzer with a method detection limit (MDL) of 7 pg across matrices. Methylmercury samples were extracted with 25% KOH in methanol for 4 h at 60°C and were then distilled, ethylated (De Wild et al., 2002), and quantified on an automated MeHg analyzer (Brooks Rand, MERX unit) with a MDL of 0.2 pg across matrices. Quality assurance measures included analysis of certified reference materials, laboratory duplicates, and matrix spikes for all MeHg and THg analyses (Supplemental Tables S2, S3, and S4, respectively). Reporting limits (RLs) were 0.11 and 0.065 ng g^{-1} for THg and MeHg, respectively, and all sediment samples had concentrations greater than the RL. New polyethylene terephthalate (PETG) bottles were double bagged in the laboratory prior to water sample collection. Immediately before sample collection, plastic seals on bottles were removed, and bottles were rinsed three times with sample water. Samples were stored on ice until acidified in the field by adding 5 mL of 50% trace-metal-clean HCl. Field blanks and field duplicates were collected for quality assurance of sampling methods (Supplemental Tables S5 and S6). Duplicates were averaged for data analysis. Unfiltered water samples were analyzed for THg and MeHg as described by Marvin-DiPasquale et al. (2011). For surface water, the MDL was 0.007 ng L^{-1} for MeHg and 0.1 ng L^{-1} for THg. Reporting limits were 0.02 and 0.3 ng L^{-1} for MeHg and THg, respectively. For samples less than the MDL, estimated values based on instrument readings were used in statistical analysis. Water samples were also analyzed for total suspended solids (TSS) by USEPA Method 160.2 (USEPA, 1983). Briefly, a known volume of sample is filtered through a preweighed, 1.2-μm glass fiber filter, which is then dried at 105°C to a constant weight.

Rice yield was determined at physiological maturity by harvesting the total aboveground biomass from a 1-m^2 quadrant at each sampling point ($n = 4$), from which 10 to 15 tillers were collected and separated into straw and panicle portions for MeHg and THg analysis. Samples were stored in plastic bags, transported on dry ice, and stored at −80°C. We chose to analyze rough rice (unmilled rice with the husk intact) to better represent all material (and associated MeHg and THg) that was removed from the field at harvest. Rough rice and straw were lyophilized, ground to a fine powder using a coffee grinder cleaned with ethanol between samples (Drennan-Harris et al., 2013), and then analyzed for MeHg using the same approach as for soil (Marvin-DiPasquale et al., 2011). For THg analysis, plant samples were digested with concentrated HNO_3 in an autoclave at 138 kPa and 126°C for 3 h (Kleckner et al., 2017), before addition of BrCl and quantification (Marvin-DiPasquale et al., 2011). All plant tissues had THg concentrations above both the MDL (0.1 ng g^{-1}) and RL (0.23 ng g^{-1}). Three straw samples were less than the RL for MeHg in plant tissues (0.11 ng g^{-1}), but greater than the MDL (0.06 ng g^{-1}).

Irrigation and Drainage Water Volume

Irrigation water applications were measured by the irrigation districts by measuring water flow through a fully submerged inlet pipe with the Remote Tracker System (H2OTech, http://www.h2otechonline.com). This system has a measurement error of <5% (Davids et al., 2013).

To measure outlet flow through a rectangular weir, pressure transducers (Global Water Instrumentation, Model WL16) were installed on the outlet weir, as well as on the soil surface in the field, at a distance of more than four times the maximum head away from the weir. This arrangement allowed for the calculation of head over the weir, and thus flow rates (Aydin et al., 2011), while allowing the farmer to adjust weir height. Staff gauges were installed at inlets and outlets. Gauges were read manually during field visits and photographed daily to verify the logger data. In cases where there was a need to quickly drain the fields from multiple outlets, the volume of water exported during these events was determined by measuring the water height in the field and multiplying by the field area.

Methylmercury and Total Mercury Load Calculations

Loads of MeHg and THg in irrigation and drainage water were calculated by integration. The volume of water entering or leaving the field (measured daily to weekly at inlets and every 2 h at outlets) was multiplied by the temporally closest concentration measurement (at the inlet or outlet, respectively). Loads are reported on a per area basis to account for differences in field size. Net loads were calculated as the difference between surface water inflows (irrigation) and outflows (drainage). Export via percolation, seepage, and evapotranspiration is outside the scope of this study.

Methylmercury and THg pools in grain, straw, and soil were calculated as the product of the concentration and the mass in a 1-m^2 area. We did not want changes in soil pools to be an artifact of shrinking and swelling in response to wet–dry cycles; thus, pool sizes were calculated based on the (constant) mass of soil in the plow layer. We used the average annual soil bulk density at each plot and a volume of 0.15 m^3 (1-m^2 × 15-cm-deep plow layer) to calculate the mass of soil in the plow layer. Pools were calculated independently for each plot (n = 4 per field), then averages and SDs were calculated.

Statistical Analysis

Because data were collected as a longitudinal survey, autocorrelation potentially exists due to repeated measures and sampling at multiple (soil) depths. The data were analyzed using linear mixed effects regression modeling, the generally accepted method of dealing with potential autocorrelation (Pinheiro and Bates, 2000; Krupa et al., 2012; Bates et al., 2015). Soil and plant samples were collected at plots (n = 4 per field), and water samples were collected at weirs (an inlet and outlet for each field). Repeated measures and autocorrelation were accounted for by including random intercepts for plots or weirs (nested within field) in all models.

Statistical analysis was conducted using R (version 3.3.3; R Core Team, 2016). Tests with $p < 0.05$ were considered significant. Models were initially fitted with the parameterization described below. Parameters (first random effects, then fixed effects) were removed stepwise if not significant. Model assumptions of normalcy and homogeneity of variance were checked using standard diagnostic plots. Environmental data are often skewed, so natural log transformations of response variables were used when necessary to ensure that model assumptions were met. Packages lme4 (Bates et al., 2015), lmerTest (Kuznetsova et al., 2016) and lsmeans (Lenth, 2016) were used to fit and test linear mixed effects regressions, and to calculate least-squares means of model parameters for plotting. All values reported in the text are mean ± SD, unless otherwise noted.

To assess changes in soil THg, MeHg, and %MeHg (MeHg/THg × 100) content by depth, data from Butte in August and February were modeled as Model A: $Y = D + E + (D \times E) + (1|P)$, where Y is the response variable (THg, MeHg, or %MeHg in soil), D is the depth interval (0–2, 4–6, 8–10, or 12–14 cm), E is the sampling event (August or February), $(D \times E)$ is the interaction between D and E, and $(1|P)$ is a random intercept for plot. April and October soil samples could not be divided into meaningful depth intervals because they were collected after tillage events and were excluded from this analysis.

Differences in soil Hg content between fields and sampling events were tested using data from both fields and all four sampling events, but where measurements were made at multiple depths (at Butte in August and February), the 0- to 2- and 4- to 6-cm depths were averaged at each plot. These data were modeled as Model B: $Y = F + E + (F \times E) + (1|P)$, where F is the field (Butte or Yolo), and $F \times E$ is an interaction term. Other terms are defined above.

Water data was analyzed to identify differences in surface water %MeHg, MeHg, THg, and TSS concentration between fields, seasons, and sites. Because only one or two samples were collected at the inlet during the fallow season at each field, inlet samples were not separated by season. These data were modeled as $Y = S + F + (S \times F) + (1|W)$ (Model C), where S is the sampling weir and season (inlet, outlet-growing, or outlet-fallow), $(S \times F)$ is an interaction term, and $(1|W)$ is a random intercept for weir. Other terms are defined above.

Methylmercury, %MeHg, and THg concentration in plant tissues were modeled as Model D: $Y = F + T + (1|P)$, where T is plant tissue type (grain or straw). Other terms are defined above.

Results and Discussion

Soil Mercury and Methylmercury

Butte and Yolo soil THg content (25 ± 7 and 57 ± 4 ng g^{-1}, respectively) were similar to background soil THg reported for the United States and China (Shacklette and Boerngen, 1984; Mingcai and Qinghua, 1997; Obrist et al., 2016), and five to ten times lower than reported for fields in the Delta (Marvin-DiPasquale et al., 2014). Prior studies suggest that MeHg production can be limited when soil THg is <1000 ng g^{-1} (Rudd et al., 1983; Krabbenhoft et al., 1999), as is the case in Butte and Yolo. Total Hg content did not change significantly between sampling events (Supplemental Table S7).

Soil MeHg content was 0.7 ± 0.3 and 0.18 ± 0.04 ng g^{-1} at Yolo and Butte, respectively, and both MeHg and THg were significantly higher at Yolo than at Butte (Model B, Supplemental Table S7). Butte %MeHg in soil (0.8 ± 0.2%) was significantly lower than at Yolo (1.3 ± 0.5%). Methylmercury content increased significantly during the growing season from 0.17 ± 0.05 and 0.49 ± 0.09 ng g^{-1} prior to planting to 0.19 ± 0.06 and 1.0 ± 0.22 ng g^{-1} prior to harvest at Butte and Yolo, respectively (Supplemental Table S7). This increase indicates net MeHg production during the growing season, because the increase in soil MeHg storage was orders of magnitude larger than the amount of MeHg imported in surface water (Table 1, Supplemental Table S7).

Soil MeHg and THg content did not differ significantly by depth in either August or February sampling events in the Butte field (Model A, Supplemental Fig. S3). The lack of differences between depths is likely due to regular mixing of the plow layer from twice-annual tillage.

Surface Water Mercury Concentrations

Surface water MeHg and THg concentrations ranged over three orders of magnitude, from <0.007 to 2 and <0.1 to 70 ng L^{-1}, respectively (Fig. 1). Spikes in MeHg, THg, and TSS concentration were observed at the beginning of the fallow season at Butte, and the end of the fallow season at Yolo (Fig. 2). The cause of these spikes is unknown, and their implications are discussed further below. Both MeHg and THg concentrations were five and six times higher, respectively, in Yolo than Butte (Fig. 2, $p < 0.05$). Between-season trends were similar in both fields (no significant interaction, Model C). Outlet MeHg and THg concentrations were significantly higher than inlet during the winter fallow season but were not significantly different from (MeHg) and lower than (THg) the inlet during the growing season (Fig. 2). Percentage MeHg did not differ significantly between the fields. Growing season outlet %MeHg was significantly higher than both inlet and fallow season outlet (Fig. 2). The TSS concentrations showed similar patterns to THg in drainage water, particularly in the winter (Fig. 1), and differences in TSS between fields and among sites and seasons closely mirrored THg (Fig. 2).

Methylmercury and THg concentrations in outlets of neighboring fields were consistent with Butte and Yolo (Fig. 1). Butte and Yolo are located within the area studied by Tanner et al.

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Table 1. Surface water methylmercury (MeHg) and total Hg (THg) budgets for studied fields.

Parameter	Butte				Yolo			
	Water	MeHg	THg	%MeHg†	Water	MeHg	THg	%MeHg
	$m^3\ m^{-2}$	ng m^{-2}			$m^3\ m^{-2}$	ng m^{-2}		
Growing season								
Irrigation imports	2.61	82	2027	4.0	1.94	148	7809	1.9
Total export	0.42	5.7	80	7.1	0.32	38	585	6.5
Maintenance drainage‡	0.34	5.4	72	7.5	0.16	27	224	12
Early season drain	–	–	–	–	0.036	6.2	304	1.1
Harvest drain	0.08	0.33	7.7	4.3	0.12	5.2	57	9.1
Export – import	−2.19	−76	−1947	–	−1.62	−110	−7224	–
Fallow season								
Irrigation imports	0.41	4.7	479	0.98	0.36	14	960	1.5
Drainage exports	0.20	40	727	5.5	0.17	214	7456	2.9
Export – import	−0.21	35	248		−0.19	200	6496	
Annual								
Irrigation imports	3.02	87	2506	3.4	2.3	162	8769	1.8
Drainage exports	0.62	46	807	5.7	0.49	252	8041	3.1
Export – import	−2.35	−41	−1700		−1.81	90	−728	

† %MeHg = (MeHg/THg) × 100.

‡ Total export = mainenance drainage + early season drain + harvest drain.

(2017) who reported similar irrigation and drainage water MeHg concentrations and seasonal patterns.

Hydrologic Methylmercury and Total Mercury Budget

Consistent with our hypothesis, both fields were MeHg and THg sinks (net importers) during growing and sources (net exporters) during the fallow season (Table 1). During the growing season (May–September), only 16% of irrigation water applied was exported as drainage water. Because concentrations in irrigation and drainage water were not significantly different during the growing season, and there was net water loss due to evapotranspiration, the fields acted as MeHg and THg sinks. During the fallow season, 50% of irrigation water applied was exported as surface drainage water (remaining water was retained in saturated field soil and lost via percolation, seepage, and evaporation), but concentrations of MeHg and THg were 6 to 18 times higher in drainage compared with inflow water (Fig. 2). Thus, the fields were MeHg and THg sources during the

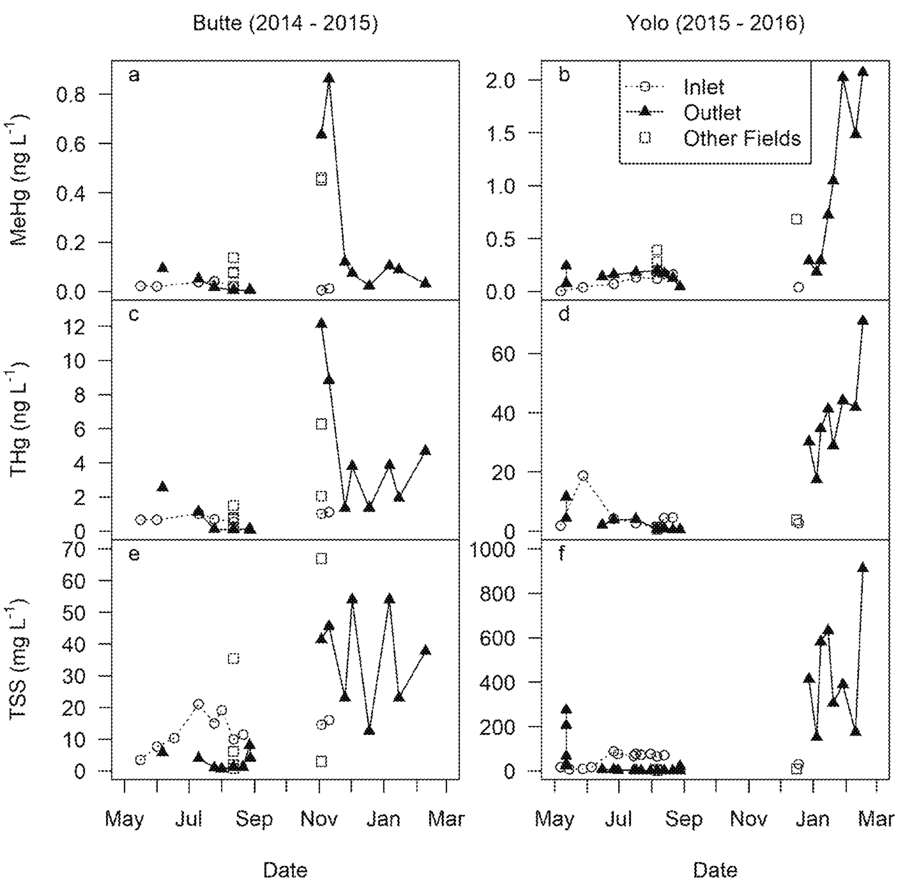

Fig. 1. Time series of surface water methylmercury (MeHg; a, b), total Hg (THg; c, d), and total suspended solids (TSS; e, f) data for Butte (left) and Yolo (right). Red squares show outlet water sampled from neighboring fields. Note the different y-axis scales between Butte and Yolo plots. Growing season (May–September) is on the left, and fallow season (November–March) on the right of each panel.

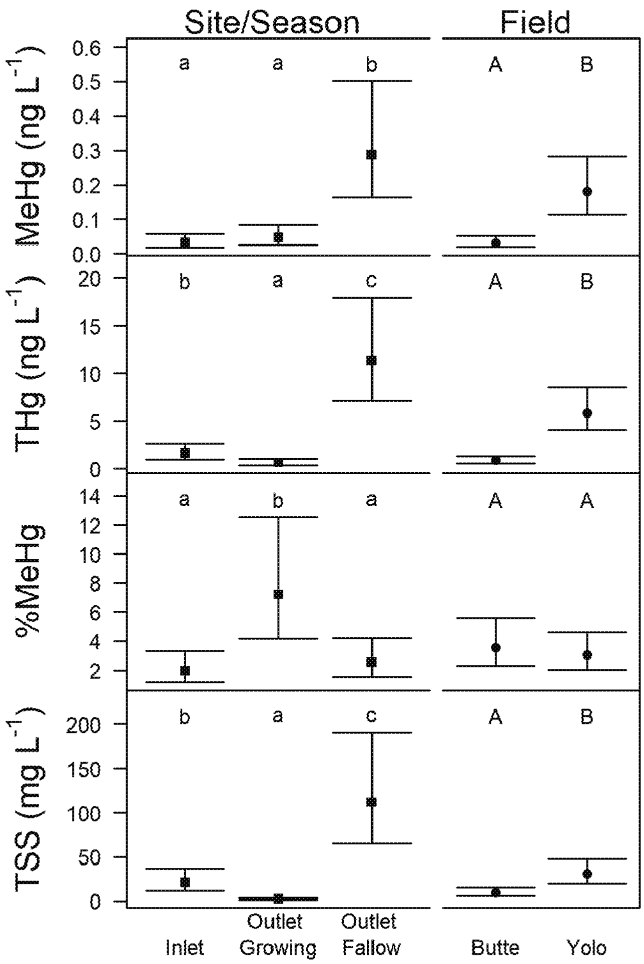

Fig. 2. Surface water least-squares means and SE of (from top to bottom) methylmercury (MeHg), total Hg (THg), percentage MeHg (%MeHg), and total suspended solids (TSS) from Model C. The effect of each factor (site and season [left] and field [right]) are shown, corrected for differences due to other factors. There were no statistically significant (site × season)] interactions. Inlet data were not divided by season because only one or two samples were collected at inlets during the fallow season.

fallow season. Annually, 85 to 86% of exported MeHg and 90 to 93% of exported THg occurred during the fallow season. Loads were consistently higher at Yolo than at Butte, with total annual imports being 1.7 and 3.5 times higher and total annual exports being 5.5 and 10 times higher for MeHg and THg, respectively.

Annually, both fields were net sinks for THg based on surface water budgets, with annual net import of 1700 and 730 ng m^{-2} for Butte and Yolo, respectively. Butte was a net MeHg sink, with an annual import of 41 ng m^{-2}, whereas Yolo was a net source of MeHg, with 90 ng m^{-2} exported annually. Considering the many factors that make rice fields ideal sites for Hg(II)-methylation, it is notable that one of the fields (Butte) was a net MeHg sink on an annual basis. Similarly, some fields in the Delta are MeHg sinks on an annual basis (Eagles-Smith et al., 2014), and others are sources (Bachand et al., 2014). This may indicate that MeHg degradation processes (i.e., microbial demethylation or photodemethylation) can reduce MeHg pools in rice fields, or that MeHg export in harvested rice grain is significant (discussed below).

Total Hg can enter ecosystems through wet deposition and plant uptake and be lost through evasion from the soil and plants (Eckley et al., 2016). It was not feasible to measure atmospheric exchange in this study. However, surface–air mercury fluxes are unlikely to drive differences between Butte and Yolo because controlling variables related to management (plant cover and soil moisture) and atmospheric conditions (wet deposition and air concentration; National Atmospheric Deposition Program, 2014) were similar between fields.

Rice Plant Mercury

Methylmercury content in rough rice from Yolo (0.7 ± 0.2 ng g^{-1}) was four times higher than in rice from Butte (0.16 ± 0.04 ng g^{-1}) (Model D, $p < 0.05$, Table 2). Total Hg in rough rice did not differ significantly between fields (Table 2, overall mean = 1.4 ± 0.4 ng g^{-1}). In previous studies, brown rice grain and husks were separated prior to Hg analysis, whereas rough rice (unprocessed grain with husk) was analyzed in this study. The rice husk is ~20% of the mass of rough rice (Gariboldi, 1974), and it has lower MeHg and higher THg concentrations than brown rice alone (Meng et al., 2010). If no MeHg was present in the husk, the concentration of MeHg in brown rice in this study would be at most 0.88 and 0.2 ng g^{-1} at Yolo and Butte, respectively (see the supplemental material for calculations). Mean brown rice THg concentrations could not have been >1.75 ng g^{-1} and were most likely lower than the reported rough rice concentration. In a comprehensive review, Rothenberg et al. (2014) found published values of rice MeHg content ranged from 0.86 to 63 ng g^{-1}, whereas THg content ranged from 1 to 510 ng g^{-1}, although lower concentrations have been reported more recently (Rothenberg et al., 2015). Keeping in mind the biases caused by analyzing rough rice rather than brown rice, the rice MeHg and THg concentrations reported here are still among the lowest published values.

Methylmercury in rice plants has been shown to originate in the soil (Strickman and Mitchell, 2017). Thus, low concentrations in rice grain and between-field differences reflect soil MeHg content at Butte and Yolo. However, concentrations of MeHg and THg in grain are weakly correlated ($R^2 \sim 0.2$), and concentrations of those species in soil (Horvat et al., 2003; Zhang et al., 2010b) as well as other factors such as rice cultivar (Li et al., 2013) or sources of Hg to the system (e.g., soil, source water, atmospheric deposition) (Zhang et al., 2010b; Meng et al., 2011) can also influence Hg uptake by rice plants.

Straw had 62% lower MeHg content than grain ($p < 0.05$), but five to eight times higher THg ($p < 0.05$). Grain and straw differed significantly in %MeHg, with grain ranging from 16 ± 9 (Butte) to 40 ± 13% (Yolo) and straw ranging from 1.2 ± 1.1 (Butte) to 2.7 ± 0.8% (Yolo) MeHg (Table 2). Higher %MeHg in grain compared to straw is consistent with previous studies (Meng et al., 2010, 2014). Total Hg content did not differ significantly between fields for straw (overall mean = 9 ± 3 ng g^{-1}).

Removal of rice grain from the field at harvest resulted in the export of 190 ± 50 to 700 ± 200 ng MeHg m^{-2} and 1400 ± 500 to 1700 ± 400 ng THg m^{-2} in Butte and Yolo, respectively (Table 2). Rice straw, which was tilled into the soil after harvest, contained 120 ± 80 to 180 ± 80 ng MeHg m^{-2} and 10,500 ± 3000 to 7000 ± 3000 ng THg m^{-2} in Butte and Yolo, respectively. Methylmercury and THg storage in rice plants is comparable in magnitude with annual surface water imports and exports (Table 1). Plant tissues differ in their primary source of Hg: grain Hg originates in the soil, whereas straw Hg is from the

Table 2. Methylmercury (MeHg) and total mercury (THg) in rice straw and grain. All values are means ± SD ($n = 4$).

Parameter	Butte		Yolo	
	MeHg	THg	MeHg	THg
Grain				
Concentration (ng g^{-1})	0.16 ± 0.04	1.2 ± 0.4	0.7 ± 0.2	1.7 ± 0.3
Pool (ng m^{-2})	190 ± 50	1400 ± 500	700 ± 200	1700 ± 400
%MeHg†	16 ± 9		40 ± 13	
Straw				
Concentration (ng g^{-1})	0.12 ± 0.09	10 ± 3	0.20 ± 0.06	8 ± 1.8
Pool (ng m^{-2})	120 ± 80	10,500 ± 3000	180 ± 80	7000 ± 3000
%MeHg	1.2 ± 1.1		2.7 ± 0.8	
Soil				
Concentration (ng g^{-1})	0.19 ± 0.06	28 ± 5.2	1.0 ± 0.2	57 ± 2.0
Pool (ng m^{-2})	24,000 ± 4600	3,600,000 ± 950,000	120,000 ± 23,000	6,500,000 ± 190,000
%MeHg	0.73 ± 0.26		1.8 ± 0.36	

† %MeHg = (MeHg/THg) × 100.

atmosphere (Yin et al., 2013). Thus, plant pools of Hg and their sources should be accounted for in mass balance studies of Hg species in rice fields.

Periods of Elevated Methylmercury and Total Mercury Export

Our results showed that MeHg and THg export from rice fields in the Sacramento Valley are primarily of concern during the winter fallow period. This is supported by significantly higher MeHg and THg concentrations in fallow season drainage water (Fig. 1), higher total export loads, and higher net export compared with the growing season (Table 1). Efforts to reduce export would be most effective in the fallow season.

Other studies of MeHg export from rice also found that net MeHg exports and concentrations were higher in the fallow season than the growing season (Alpers et al., 2014; Eagles-Smith et al., 2014; Tanner et al., 2017). There are several possible reasons for this. First, Bachand et al. (2014) found that crop transpiration during the growing season results in a net downward movement of surface water into the soil profile, and this may serve to trap MeHg, limiting its export during the growing season. As there are no transpiring plants during the fallow season, MeHg stored in the soil profile may be released into surface water via diffusion, where it may then be exported. Second, we found the pools of MeHg and THg accumulated in plants were 3 to 4 times and 1 to 12 times larger, respectively, than gross annual export in surface water. It is possible that plant uptake during the growing season limits MeHg and THg export. Grain is removed from the field at harvest; however, straw decomposes in the field during the fallow season and may be an important source of MeHg (120–180 ng m^{-2}) and THg (7000–10,500 g m^{-2}) for surface water export from the field (Windham-Myers et al., 2014a). Finally, decomposing rice straw may promote Hg(II)-methylation by providing labile organic carbon, if the Hg(II)-methylating microbes are limited by carbon (Marvin-DiPasquale et al., 2014; Windham-Myers et al., 2014b). However, the relationship between increased MeHg production and bioaccumulation or export is complex (Eagles-Smith et al., 2014; Zhu et al., 2015; Tanner et al., 2017).

One objective of this study was to identify periods of MeHg export that could be targeted for mitigation. Though we observed spikes in MeHg export, they accounted for a small fraction of annual exports or did not occur at the same time in both fields. Early growing season outlet MeHg and THg concentrations were somewhat elevated (Fig. 1), and the early-season draining event at Yolo accounted for 16 and 52% of growing season MeHg and THg exports, respectively. However, this export was only 2.4 and 3.8% of annual MeHg and THg exports annually. Field draining prior to harvest did result in a small pulse of export (5.8 and 14% of MeHg exports and 9.6 and 9.7% of THg exports during the growing season from Butte and Yolo, respectively), but this was a negligible percentage of annual export.

During the fallow season, concentrations and export were elevated, but within-season trends differed between fields. In Butte, both MeHg and THg concentrations were high at the start of the fallow season and decreased, whereas Yolo fallow season outlet concentrations started low and increased as the season progressed (Fig. 1). These data, combined with time series of MeHg concentrations in rice drainage water from previous studies, suggest that temporal patterns of MeHg concentration with in the fallow season are highly variable among fields (Alpers et al., 2014; Eagles-Smith et al., 2014).

More research is needed to understand fluctuations of MeHg concentrations in rice drainage water during the fallow season before management recommendations are identified. Furthermore, previous studies of MeHg export from rice systems included a flooded fallow season for straw decomposition (Eagles-Smith et al., 2014; Windham-Myers et al., 2014b; Tanner et al., 2017). Cropping systems with different annual cycles of dry and wet periods (such as the absence of a flooded fallow season, or production of multiple crops per year), likely have different seasonal patterns of MeHg export. Hydroperiod and management practices are important controlling variables of MeHg production (Marvin-DiPasquale et al., 2014) and export, and more studies will be needed to understand MeHg dynamics in these systems.

Conclusion

Surface water MeHg and THg budgets revealed clear differences between the growing and fallow seasons. During the growing season, drainage water and irrigation water had similar MeHg and THg concentrations. Due to irrigation water volumes being larger than drainage volumes, the fields were net sinks for

MeHg and THg in the growing season. In the fallow season, the fields were MeHg and THg sources because drainage water concentrations were elevated compared with irrigation water, whereas the volume of irrigation and drainage water were more similar. These results indicate that efforts to reduce MeHg and THg exports in rice drainage water should focus on the fallow season. Further, rice plants accumulated substantial amounts of MeHg and THg into their tissues annually, at a scale similar in magnitude to annual surface water loads. Plant tissue pools, and differences in MeHg and THg accumulation in straw and grain tissues, should be considered in future studies.

Supplemental Material

The supplemental information includes calculations of the impact of husk on rice grain MeHg and THg concentrations, a map of the study area (Supplemental Fig. S1), a time series of hydrological data (Supplemental Fig. S2), soil MeHg and THg by depth (Supplemental Fig. S3), comparison of studied fields (Supplemental Table S1), quality control and quality assurance data (Supplemental Tables S2–S6), and soil MeHg and THg concentrations and pools by sampling event (Supplemental Table S7).

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The Contribution of Rice Agriculture to Methylmercury in Surface Waters: A Review of Data from the Sacramento Valley, California

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Abstract

Methylmercury (MeHg) is a bioaccumulative pollutant produced in and exported from flooded soils, including those used for rice (*Oriza sativa* L.) production. Using unfiltered aqueous MeHg data from MeHg monitoring programs in the Sacramento River watershed from 1996 to 2007, we assessed the MeHg contribution from rice systems to the Sacramento River. Using a mixed-effects regression analysis, we compared MeHg concentrations in agricultural drainage water from rice-dominated regions (AgDrain) to MeHg concentrations in the Sacramento and Feather Rivers, both upstream and downstream of AgDrain inputs. We also calculated MeHg loads from AgDrains and the Sacramento and Feather Rivers. Seasonally, MeHg concentrations were higher during November through May than during June through October, but the differences varied by location. Relative to upstream, November through May AgDrain least-squares mean MeHg concentration (0.18 ng L^{-1}, range 0.15–0.23 ng L^{-1}) was 2.3-fold higher, while June through October AgDrain mean concentration (0.097 ng L^{-1}, range 0.6–1.6 ng L^{-1}) was not significantly different from upstream. June through October AgDrain MeHg loads contributed 10.7 to 14.8% of the total Sacramento River MeHg load. Missing flow data prevented calculation of the percent contribution of AgDrains in November through May. At sites where calculation was possible, November through May loads made up 70 to 90% of the total annual load. Elevated flow and MeHg concentration in November through May both contribute to the majority of the AgDrain MeHg load occurring during this period. Methylmercury reduction efforts should target elevated November through May MeHg concentrations in AgDrains. However, our findings suggest that the contribution and environmental impact of rice is an order of magnitude lower than previous studies in the California Yolo Bypass.

Core Ideas

- We studied the impact of rice production on MeHg at the watershed scale.
- MeHg concentration was elevated in agricultural drainage water during November through May.
- Watershed-scale MeHg loads were lower than expected based on field studies.

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In anoxic soils, a portion of the inorganic mercury (Hg) pool can be methylated, predominantly by sulfate- and iron-reducing bacteria (Compeau and Bartha, 1985; Gilmour et al., 1992; Fleming et al., 2006; Kerin et al., 2006), forming methylmercury (MeHg). Methylmercury binds strongly to thiols in proteins (Ballatori, 2002) and is extremely toxic to organisms, causing neurological problems and decreased reproductive success (Crump and Trudeau, 2009). Environmental levels of MeHg as low as 0.1 ng L^{-1} in freshwater ecosystems can have negative effects on high trophic-level organisms via bioaccumulation and biomagnification (Rudd, 1995; Watras et al., 1998; Chan et al., 2003). Humans are exposed to MeHg primarily through the consumption of fish and other wildlife from Hg-contaminated environments, resulting in negative health effects (Chan et al., 2003). Mercury and MeHg contamination of surface water is widespread. In the United States, fish consumption advisories have been issued in all 50 states and one US territory, including 1.8 million km of river and 6.6 million ha of lake (USEPA, 2011).

Wetlands provide anoxic soil conditions in which Hg-methylating microbes thrive, resulting in elevated MeHg production and bioaccumulation in a variety of wetland types (Marvin-DiPasquale et al., 2003; Hall et al., 2008). Unlike many crops, rice (*Oriza sativa* L.) is grown in flooded fields that are effectively agricultural wetlands. Rice is grown on approximately 150 million ha globally (Czech and Parsons, 2002), comprising a substantial portion of the world's estimated 1.2 billion ha of wetlands (Finlayson et al., 1999) and serving as important wildlife habitat (Czech and Parsons, 2002). Seasonal wet–dry cycles and inputs of labile organic carbon from root exudates and rice straw promote MeHg production and bioaccumulation in rice fields (Windham-Myers et al., 2009, 2014a; Ackerman and Eagles-Smith, 2010; Ackerman et al., 2010; Rothenberg and Feng, 2012). Many studies have found that MeHg can accumulate in rice grain and that rice can be the primary route of MeHg exposure for people living in Hg-contaminated inland rice-growing

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Abbreviations: AgDrain, agricultural drainage; AgDrain-E, drainage from agricultural areas east of the Sacramento River, also known as Sacramento Slough; AgDrain-W, drainage from agricultural areas west of the Sacramento River, also known as the Colusa Basin Drain; AgDrain-$W_{outfall}$, flows from AgDrain-W that enter the Sacramento River via the Knight's Landing Outfall Gates; AgDrain-$W_{diversion}$, flows diverted from AgDrain-W to the Yolo Bypass via Ridge Cut Slough; LSM, least-squares mean; MeHg, methylmercury.

areas (e.g., Feng et al., 2008; Meng et al., 2010, 2011; Zhu et al., 2015). In contrast, few studies have investigated export of MeHg in rice-field drainage water and its impact on downstream ecosystems, with the exception of studies in the California Yolo Bypass (Windham-Myers et al., 2014a). While it is clear that rice fields produce and export MeHg (Alpers et al., 2014), their effect has not been evaluated at a watershed scale.

MeHg concentration in stream channels and exposure to biota in those channels result from the interaction of sources, sinks, and transport processes in the watershed (Bradley et al., 2011). Though floodplains may also produce MeHg when temporarily flooded (Singer et al., 2016), at a watershed scale, the best predictor of MeHg concentration in a water body is the percent wetland cover upstream (Krabbenhoft et al., 1999). Methylmercury production may be decoupled from export (Bachand et al., 2014), and processes such as photodemethylation in open water (Seller et al., 1996) and particle settling can remove MeHg from the water column. As a result, MeHg concentrations can be lower than would be predicted from upstream MeHg inputs (Bradley et al., 2011).

The Sacramento River watershed (1.7 million ha) in California provides a good opportunity to study how rice contributes to watershed-scale MeHg concentrations and loads. Rice is grown on more than 240,000 ha and is the main crop in the low-lying central drainage area of the valley (USDA–NASS, 2016). Naturally enriched Hg conditions, plus a legacy of Hg and gold mining (which used elemental mercury to amalgamate the gold) in the mountains surrounding the valley, have resulted in elevated Hg concentrations in river sediments, water, and fish (Domagalski, 1998, 2001; Davis et al., 2008; Springborn et al., 2011; Singer et al., 2013; Domagalski et al., 2016; Donovan et al., 2016a, 2016b). Elevated MeHg concentrations in fish have led to fish consumption advisories and enactment of a Total Maximum Daily Load to reduce MeHg loads into the Sacramento–San Joaquin Delta (Delta Mercury Control Program, 2010).

The overall objective of this study was to evaluate the contribution from rice-producing areas to MeHg loads in the lower Sacramento River by compiling and analyzing historic surface water MeHg concentration and flow data. We evaluated MeHg concentrations and loads in major agricultural drains from rice-dominated areas and at mainstem sampling points in the Sacramento and Feather Rivers, both upstream and downstream of agricultural drain inputs. Furthermore, we evaluated seasonal trends to identify the time of year in which MeHg loads exported from rice fields may be of greatest concern, and long-term trends to see if changes in postharvest rice straw management practices have influenced MeHg concentrations.

Materials and Methods

The Sacramento Valley covers 1.7 million ha and is situated in the low-lying area between the Coast Ranges and Sierra Nevada of California. It is 240 km long from north to south and ranges from 32 km wide in the north to 72 km wide in the south (Bennett et al., 2011). The Sacramento Valley has a Mediterranean climate, with typically hot, dry conditions during April to September and a cool, rainy season from October through March

The Sacramento River watershed has both natural and anthropogenic Hg sources. Mineral springs (Youngs, 1994) and erodible surficial soils (US Bureau of Mines, 1965) in the Coast Range to the west and Cascade Mountains to the northeast are naturally Hg enriched. Mercury mining occurred in the Coast Range to the west (Jasinksi, 1995). Between 1846 and 1981, an estimated 34.5 million kg of Hg was released into the environment, partially as Hg vapor during ore processing (Churchill, 2000). Most of the Hg mining occurred in the Cache Creek watershed and farther south; thus, runoff from mine wastes in these areas enters the Yolo Bypass downstream of the current study area (Domagalski, 1998). Beginning in 1848, elemental Hg was used by the gold mining industry in the Klamath and Sierra Nevada mountain ranges, drained by the upper Sacramento River and Feather River, respectively (Domagalski, 1998; Churchill, 2000). Combined Hg losses from gold mining totaled 5.8 million kg, with 97% of losses occurring before 1935 and 80 to 90% of losses occurring in the Sierra Nevada (Churchill, 2000). While Hg losses were substantial, it is unclear to what degree rice-growing areas in the central Sacramento Valley have been contaminated with Hg. Reservoirs limit downstream transport of MeHg and total Hg (Slotton et al., 1995). Domagalski (1998) measured total Hg in riverbed sediments: sites in the central Sacramento River had 40 to 70 ng Hg g^{-1}, while sites within and downstream of the Feather River had 140 to 370 ng Hg g^{-1}. To our knowledge, there are no published Hg concentration data for Sacramento Valley rice soils. Atmospheric deposition has not been measured directly for the Sacramento Valley. However, the San Francisco Estuary to the south received 19 μg Hg m^{-2} yr^{-1} as dry deposition and 4.2 μg Hg m^{-2} yr^{-1} as wet deposition in 1999 to 2000 (Tsai and Hoenicke, 2001).

Within the Sacramento Valley, there are two main waterways: The Sacramento River on the western side of the valley and the Feather River on the east. Additional watershed inflows occur along the eastern and western edge of the valley, including the Yuba and Bear rivers. Both of the main rivers flow from north to south and converge near the southern end of the Valley's primary rice-growing region, north of the city of Sacramento (Fig. 1). After confluence with the Feather River, the Sacramento is joined by the American River and continues south to the Sacramento–San Joaquin Delta. Surface water hydrology is highly manipulated, with a number of constructed waterways used to direct irrigation water (supply and drainage) and to mitigate flooding.

Drainage from rice agriculture (hereafter, "rice"), and to a lesser extent nonagricultural wetlands, makes up the majority of water in agricultural drainage canals. Rice is planted during late April through May. Most fields are water-seeded, whereby pregerminated rice seed is dropped from an airplane onto flooded fields (Linquist et al., 2015). Water management during the first month of the growing season is highly variable, with the water level and outflow adjusted for seedling establishment and herbicide application. Later in the growing season, maintenance flow is established where irrigation water is applied to rice in excess of evapotranspiration demand in part to limit salinity build up (Grattan et al., 2002; Scardaci et al., 2002). Excess water is exported from rice fields as drainage water. Fields are drained in August or September, 3 to 4 wk before harvest. Irrigation of other crops in the watershed is managed to match evapotranspiration demand closely so that little or no drainage water is produced. Drainage water from managed wetlands is also present; however, wetland cover within the drainage area is approximately one fourth that of rice (Fig. 1) (US Fish and Wildlife Service, 2016). Water-export data from wetlands managed for wildlife is limited, but rates of outflow

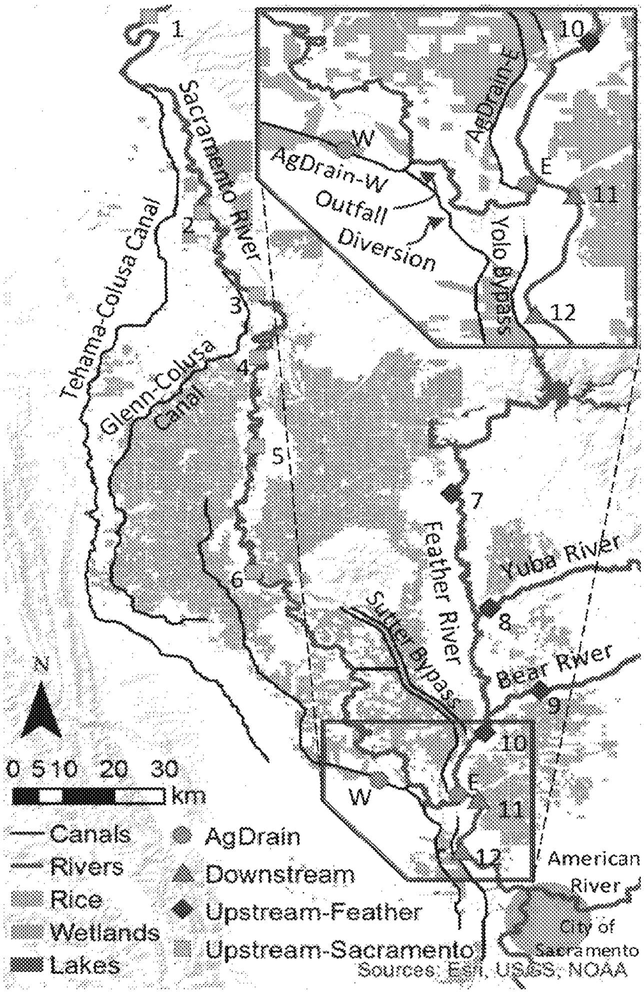

Fig. 1. Map of the study area. Site labels correspond to site identification field in Table 1. Rice area was obtained from the California Department of Water Resources (2013). Wetland area is from the National Wetland Inventory (US Fish and Wildlife Service, 2016). Water ways are depicted according to the National Hydrography Dataset (USDA–NRCS et al., 2013). AgDrain, agricultural drainage.

are also managed to prevent salinity build up (this management objective is similar to those of rice growers). Periods of high water export from managed wetlands are the drawdown of seasonal wetlands (March–May) and areas flooded during the summer (July–August) (S. Emmons, personal communication, 2016).

Drainage water from agricultural fields and other wetlands is collected by two major agricultural drains, hereafter referred to as "AgDrain-E" and "AgDrain-W." AgDrain-E collects drainage water from the eastern valley area (e.g., Sutter Bypass) between the Sacramento and Feather Rivers and discharges into the Sacramento River immediately upstream of the confluence of the Sacramento and Feather Rivers (Fig. 1). Low flows during summer in AgDrain-E are made up primarily of rice drainage water; however, during high winter flows, large volumes of floodwater from the Sutter Bypass floodplain are mixed with rice drainage water. AgDrain-W collects drainage water from the area west of the Sacramento River. Flows from AgDrain-W are divided immediately downstream of the sampling location, with some water directed into the Sacramento River (AgDrain-$W_{outfall}$) and the remainder diverted to the Yolo Bypass floodplain (AgDrain-$W_{diversion}$) (Fig. 1). Drainage from AgDrain-E and the Feather River enter the Sacramento River 25 km downstream of AgDrain-$W_{outfall}$.

We categorized sampling sites into "site groups" based on their location with respect to the two main AgDrains (Fig. 1): Sampling sites located at the mouths of AgDrain-E and AgDrain-W are referred to as "AgDrain" sites. "Upstream-Sacramento" and "Upstream-Feather" sites were located on the Sacramento and Feather Rivers, respectively, upstream of where AgDrains empty into the Sacramento River. Upstream sites serve as control sites because they represent river water that has been minimally influenced by rice. All Upstream-Sacramento sites were upstream of rice drainage water inputs, while Upstream-Feather site 5 may have been influenced by rice drainage water from rice grown east of the Feather River and north of the Bear River. Upstream sites also represent irrigation source water: sites 1 and 3 on the Sacramento River were located close to the Tehama–Colusa and the Glenn–Colusa Canals, respectively, which are major agricultural diversions that provide irrigation water to the western side of the Sacramento Valley. "Downstream" sites were located downstream of the confluence of the Sacramento River, Feather Riverm and AgDrains, but upstream of the Sacramento urban area and the confluence with the American River (Fig. 1). Downstream sites represent Sacramento River water that has been influenced by Sacramento Valley rice drainage.

Data Sources

We used data from programs that monitored aqueous, unfiltered MeHg concentrations in the Sacramento River watershed from 1996 to 2007. Programs include the USGS National Water Quality Assessment Program (Domagalski et al., 2000) dataset from 1996 to 1998 (I); three programs conducted by the Sacramento River Watershed Program (2005, 2008), including data from 2000 to 2003 (II), 2004 (IV), and 2006 to 2007 (V); and one dataset from the CALFED Bay-Delta Program (Foe et al., 2008), including data from 2003 to 2006 (III) (Supplemental Table S1). Samples were collected either as grab samples or as depth-integrated samples at the midpoint of the channel cross-section. Detection limits ranged from 0.0114 to 0.0234 ng L^{-1} (Supplemental Table S1). Methylmercury concentrations were below the detection limit in 1.6% of samples. Nondetects were equally distributed among Upstream-Sacramento, Upstream-Feather, AgDrain, and downstream samples (n = 4, 2, 3, and 2, respectively). If the lab value was reported, it was used in the analysis; otherwise undetected MeHg concentrations were treated as 0.5 × detection limit in data analysis. Sampling sites varied among programs, and sampling frequency ranged from monthly to quarterly. A number of sites were omitted from the analysis due to lack of relevance to the study questions or lack of data. These sites included small, seasonal creeks, sites on the Sacramento River distantly upstream or downstream of rice, and sites with fewer than 10 samples. For sites included in this analysis, the number of samples available by site and program is shown in Table 1.

Both precipitation and burned rice area were tested as possible explanatory variables. Precipitation from storm events may influence MeHg concentration by dilution or flushing MeHg from areas where it is produced (Balogh et al., 2006). Precipitation data were obtained from the California Irrigation Management Information System (California Department of Water Resources, 2014b). Data from two weather stations that represented the study area within the watershed were averaged for analysis (station identifications 12 and 3). Precipitation totals from 3, 5, and

Table 1. The number of methylmercury (MeHg) samples collected by each sampling program at sites used in this analysis. AgDrain, agricultural drainage water from rice-dominated regions.

Site	Site ID†	Samples in each program‡					Total number of samples
		I	II	III	IV	V	
Upstream-Sacramento							
Sacramento River above Bend Bridge	1	–	17	30	4	18	69
Sacramento River at Woodson Bridge	2	–	–	31	–	–	31
Sacramento River at Hamilton City	3	–	17	31	4	18	70
Sacramento River at Ord Ferry Bridge	4	–	–	22	–	–	22
Sacramento River at Butte City	5	–	–	30	–	–	30
Sacramento River at Colusa	6	29	17	30	4	18	98
Upstream-Feather							
Feather River at Gridley	7	–	–	31	–	–	31
Yuba River at Marysville	8	–	18	31	4	18	71
Bear River below Wheatland	9	–	–	30	–	–	30
Feather River at Nicolaus	10	–	18	31	4	18	71
AgDrains							
Colusa Basin Drain at Knights Landing	W	25	16	31	4	18	94
Sacramento Slough at Karnack	E	23	16	28	4	18	89
Downstream							
Sacramento River at Verona	11	27	–	—	–	–	27
Sacramento River at Veteran's Bridge	12	–	–	—	–	17	17

† Site locations are denoted in Fig. 1 using site identification (Site ID).

‡ See Supplemental Table S1 for more information about the sampling programs.

7 d before MeHg sample collection were tested as predictors of MeHg concentration. Burning of rice straw removes carbon from fields, possibly influencing microbial activity (Windham-Myers et al., 2014b; Zhu et al., 2015). Burned rice area data were obtained from the California Rice Commission (2016).

Flow data for load estimations were obtained from the California Data Exchange Center, the California Water Data Library (California Department of Water Resources, 2014a, 2016), and the National Water Information System (USGS, 2016) databases (Supplemental Table S2). Mean daily flow was used when available; otherwise, hourly or quarter-hourly flow measurements were averaged to obtain mean daily flow. Missing flow data prevented load calculation at key sites, including AgDrain-$W_{diversion}$, AgDrain-$W_{outfall}$ during the 2005 water year (October 2004–September 2005), and AgDrain-E during winter.

Data Analysis

Season was included in the analysis as a categorical variable because seasonal variation occurs in rice management as well as climate. We wanted to identify times of the year when concentrations were elevated to inform future studies. We plotted MeHg concentration data from all years by day and month and defined two seasons based on periods with relatively higher or lower MeHg concentrations.

Linear mixed-effects regression analysis was used to assess differences in MeHg concentration, allowing us to account for the fact that sites were measured repeatedly but not always concurrently. Site and year were used as random effects in the model. Fixed effects tested included season (June–October or November–May), site group (Upstream-Sacramento, Upstream-Feather, AgDrain, or downstream), time (as a continuous variable), fraction of rice area burned, and precipitation, as well as site group × season, site group × time, and site group × fraction of rice area burned interaction terms. Models were fitted using the lme4 package (Bates et al., 2015) in R (R Core Team, 2014). We selected the final model using backward stepwise regression. Beginning with the fullest model, first random effects, then fixed effects, were dropped stepwise if nonsignificant ($p > 0.05$). The p-values for random effects were calculated using likelihood ratio tests, whereas significance of fixed effects was determined using F tests with denominator degrees of freedom, calculated by Satterthwaite's approximation. Post hoc Tukey-corrected differences of least-squares means (LSM) were used to identify significant differences among categorical fixed effects; differences significantly different from zero ($p < 0.05$) were considered significant. Model selection and tests for differences between fixed effects were done using the lmerTest package (Kuznetsova et al., 2016). Assumptions of normalcy and homogeneity of variance were assessed using standard diagnostic plots. A natural log transformation was used on MeHg, but not on other variables. This transformation successfully corrected for heteroscedasticity and normalized the residuals of the model.

Beale's ratio estimator was used to calculate MeHg loads (Beale, 1962; Richards, 1998) because it was found to be unbiased and accurate in a number of studies comparing load calculation methods (Dolan et al., 1981; Beirman et al., 1988). The mean daily load (concentration × flow) for days on which concentration was measured was multiplied by the ratio of average flow during the period of interest to the average flow on days when concentration was measured, then multiplied by a bias correction factor (Supplemental Eq. S1 and S2).

At each site, loads were calculated separately for monitoring programs I, II, and V. Programs III and IV were combined because samples were collected concurrently and program IV did not have enough data for a separate load calculation. Additionally, loads were calculated using data from all programs combined. Separate calculations were done for the November through May and June through October seasons.

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Upstream-Sacramento and Upstream-Feather loads were calculated at sites 6 and 10, respectively. These sites were located immediately upstream of AgDrain inputs but downstream of other known MeHg inputs, including the Bear and Yuba Rivers (Fig. 1). Additionally, these sites had the most complete datasets (Table 1).

Results and Discussion

A total of 681 unfiltered water MeHg concentration measurements were compiled from the various programs and used in this study. Only three sites were sampled by all five programs, two of which were the main agricultural drainage canals that discharge directly into the Sacramento River (AgDrain-E and AgDrain-W), while the third was Upstream-Sacramento site 6.

Methylmercury concentrations ranged from below the detection limits (0.02–0.0114) to 1.97 ng L^{-1}, and only three samples in the dataset were above 1 ng L^{-1} (Fig. 2). Waterways with MeHg concentrations above 0.1 ng L^{-1} are potentially negatively impacted (Rudd, 1995), and 57% of samples in this study had concentrations below this level. Twenty percent of samples were below 0.06 ng L^{-1}, the regulatory standard for the Sacramento–San Joaquin Delta.

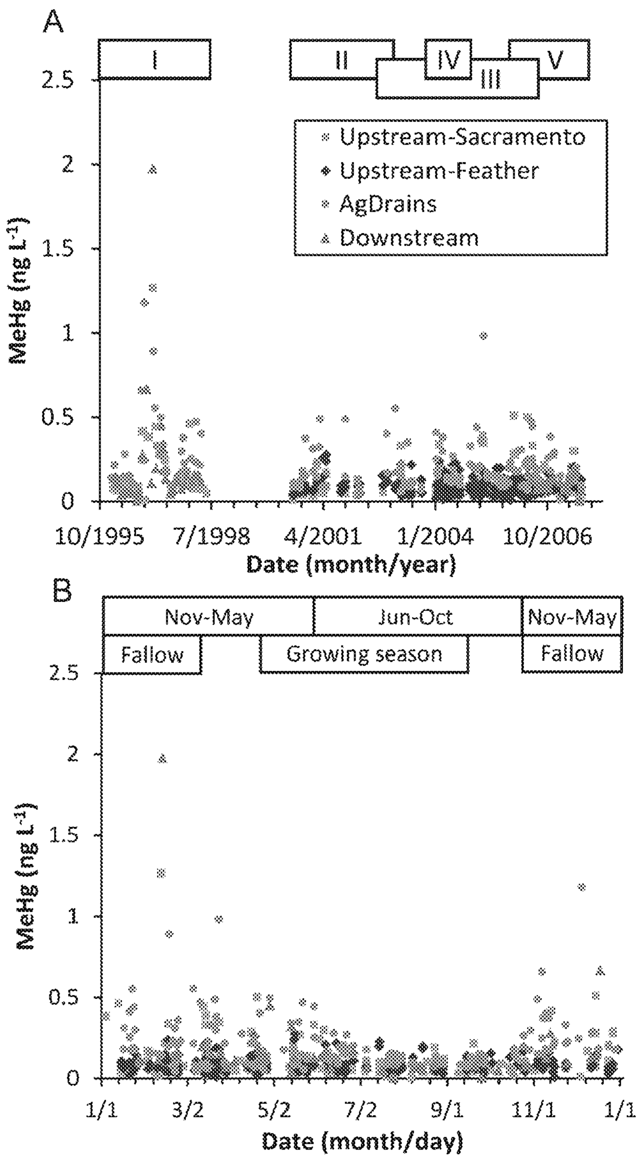

Fig. 2. (A) Time series of methylmercury (MeHg) concentrations throughout the study period. Bars at the top indicate when each sampling program occurred (Supplemental Table S1). (B) MeHg concentrations plotted by day of year. The figure shows data from the whole study period. Bars at top show the rice-growing season and winter fallow, and June to October and November to May seasons as defined in this study.

Methylmercury Concentrations

Despite changes in rice straw management during the study period, mixed-effects regression analysis did not detect a significant change in MeHg concentration over time (Fig. 2A), and there was no interaction between time and location (The results of variable selection for the mixed-effects model are shown in Supplemental Table S3). During the study period, straw removal practices changed as a result of the Connelly–Areias–Chandler Rice Straw Burning Reduction Act of 1991 (California Environmental Protection Agency, 1991), which mandated that rice straw burning in the Sacramento Valley be phased down starting in 1992 and be allowed only under specified conditions for disease control by 2001. The practice of burning rice straw was replaced by incorporating rice straw into soil during winter, followed by flooding to facilitate its decomposition (Linquist et al., 2006). The percentage of area where rice straw was incorporated during winter increased from <15% in 1992 to >80% by 2001 (California Air Resources Board, 2003). Rice straw is a source of labile organic carbon that may increase Hg methylation in rice fields (Windham-Myers et al., 2014a; Zhu et al., 2015); thus, an increase in AgDrain MeHg concentration over time was expected due to this shift from burning to incorporation and flooding during the study period. However, the fraction of rice area burned did not significantly affect MeHg concentration and did not interact with site group. This result is consistent with a recent controlled, replicated experiment testing the effect of straw removal from rice fields (Eagles-Smith et al., 2014). Other sources of variation in MeHg concentration may obscure any effect of rice straw management on MeHg concentration at the valley scale.

We did not detect a significant effect of precipitation on MeHg concentrations. Elevated MeHg concentrations were found in early 1997, 1 mo after a rain on snow event that caused major flooding throughout the region (samples were not collected during the event) (Fig. 2A). Although Balogh et al. (2006) reported elevated MeHg concentrations during high flows, concentration changes in response to storm events can be complex, depending on the transported material, as well as watershed characteristics (Richards and Holloway, 1987). The sampling frequency in this dataset may be too low to detect any MeHg concentration changes in response to precipitation.

Plotting all data by month and day revealed a seasonal pattern in which MeHg concentrations were consistently lower from June to October (range: less than detection limit to 0.3 ng L^{-1}), while concentrations from November through May were higher and more variable (less than detection limit to 1.98 ng L^{-1}) (Fig. 2B). We hereafter refer to these seasons as June to October (153 d) and November to May (212 d), respectively. Mixed effects regression revealed a strong seasonal effect, with November to May concentrations 65% higher than June to October concentrations ($F_{1,644} = 62.3$, $p < 0.001$); however, there was an interaction between site group and season ($F_{3,634} = 11.8$, $p < 0.001$; Fig. 3). The final model includes these significant fixed effects, as well as site group because it was part of a significant interaction (Supplemental Table S3). Significant random effects for both site and year were also included.

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With respect to water management and inputs into these systems, June to October includes runoff from rice fields in the form of maintenance flow and the final drain in preparation for harvest (August). November to May corresponds to the flooding of rice and managed wetlands (October and November) and subsequent runoff and final drains from rice (February) and natural wetlands (April and May). For the years studied, 92 ± 6% of the annual rainfall occurred in November to May. During high rainfall years or large storm events, regional flooding occurs, resulting in runoff from other agricultural fields (and urban areas), and river water may be diverted into bypasses, both resulting in comingling of water sources, particularly for AgDrain-E.

Methylmercury concentrations did not differ between Upstream-Sacramento and Upstream-Feather in November to May (LSM = 0.079 and 0.077 ng L^{-1}, respectively; $p = 0.3$) or June to October (0.060 and 0.075 ng L^{-1}, respectively; $p = 0.9$) (Fig. 3), indicating that rice on the east and west sides of the Valley receive similar MeHg inputs in irrigation water. Upstream-Feather MeHg concentrations did not differ between seasons ($p = 0.8$) (Fig. 3), but Upstream-Sacramento had slightly but significantly higher MeHg concentrations during November to May ($p = 0.002$).

During June to October, AgDrain MeHg concentrations (LSM = 0.097 ng L^{-1}) appeared elevated compared with other site groups; however, there were no significant differences ($p > 0.05$) in MeHg concentrations among site groups. In contrast, November to May AgDrain MeHg concentrations (LSM = 0.18 ng L^{-1}; $p < 0.05$) were significantly higher than November to May Upstream-Sacramento and Upstream-Feather concentrations. Previous studies also reported elevated MeHg concentrations in rice drainage water relative to irrigation water (Alpers et al., 2014; Zhao et al., 2016).

Similar to AgDrains, downstream MeHg concentrations were significantly higher than upstream during November to May, and there was no significant difference between AgDrain and downstream MeHg concentrations during either June to October or November to May. However, the flows and loads of AgDrain, upstream, and downstream sites must be considered when determining the degree to which AgDrains were influencing downstream MeHg concentrations.

In this study, Ag Drains exhibited a much stronger seasonal pattern than upstream sites, suggesting that rice and wetlands influence concentrations. Studies in the Yolo Bypass reported a similar seasonal pattern (Bachand et al., 2014; Marvin-DiPasquale et al., 2014; Windham-Myers et al., 2014b). While MeHg is produced in rice fields throughout the year (Marvin-DiPasquale et al., 2014), transpiration during the growing season results in the downward movement of surface water, causing MeHg to be transported into and stored in the rootzone (Bachand et al., 2014). The absence of transpiration during the fallow season allows MeHg to be released into surface water via diffusion (Bachand et al., 2014). Additionally, rice plants can store a significant amount of MeHg during the growing season (Windham-Myers et al., 2014b). Other studies have reported that MeHg stored in dry sediment may be quickly mobilized into the water column on flooding (Kelly et al., 1997; Rumbold and Fink, 2006; Alpers et al., 2014) or proposed that methylation may occur shortly after inundation (Singer et al., 2016). Thus, the early growing season drainage events, in addition to the fallow season, may be periods of MeHg export from rice. (e.g., Fig. 2B).

Methylmercury Loads

Using all available data, June to October MeHg loads for AgDrain-$W_{outfall}$, AgDrain-E, Upstream-Sacramento, and Upstream-Feather were (mean ± SD) 0.14 ± 0.03, 0.23 ± 0.03, 2.2 ± 0.3, and 0.88 ± 0.3 g d^{-1}, respectively (Fig. 4). The downstream MeHg load is expected to be the sum of all upstream

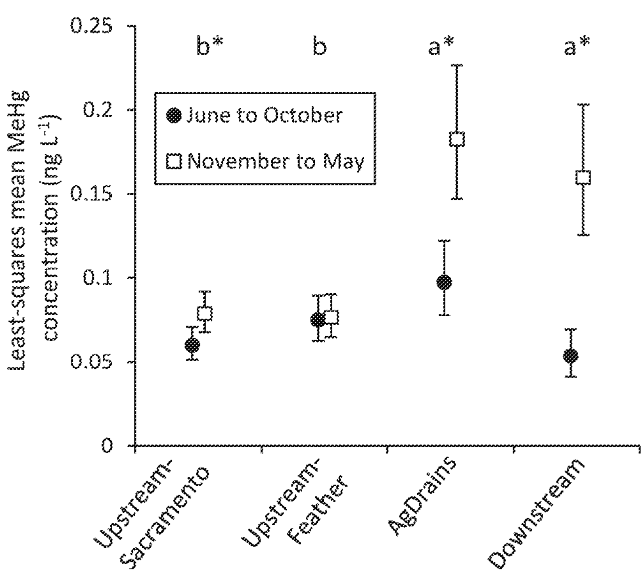

Fig. 3. Least-squares mean ± SE of methylmercury (MeHg) concentrations based on mixed-effects modeling for site groups and seasons. There is a significant interaction between site group and season. Site groups that were not significantly different during November to May have the same letter. Site groups did not differ significantly during June to October. Asterisks (*) indicate a significant difference between seasons at each site group. See Supplemental Table S4 for *p*-values of pairwise comparisons. AgDrain, agricultural drainage.

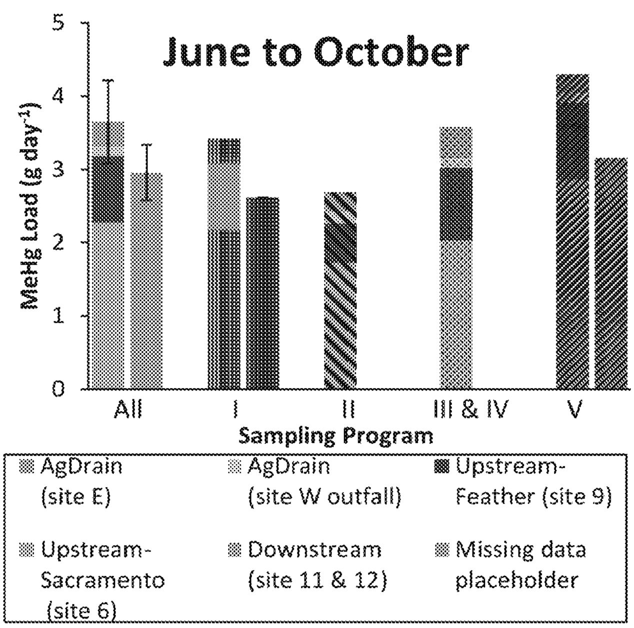

Fig. 4. June to October methylmercury (MeHg) loads by sampling program (indicated by *x*-axis groups and shading) and site (indicated by color in legend). Loads from tributary sources are shown as a stacked bar and are expected to equal downstream load. "All" represents loads calculated using data from all sampling programs. Error bars represent the standard deviation of sampling program estimates. Data was not available for Upstream-Feather, so a placeholder (gray) was used with the value from "All." Color and shading is consistent with Fig. 5. AgDrain, agricultural drainage.

tributary loads: Upstream-Sacramento, Upstream-Feather, AgDrain-$W_{outfall}$, and AgDrain-E. The downstream load (2.5 ± 0.6 g d^{-1}) was 73% of the total June to October tributary load (3.4 ± 0.4 g d^{-1}). Although the downstream load was within the range of variability of the tributary load, the downstream load was less than the tributary load in both programs where it was measured (I and V), possibly suggesting MeHg loss. June to October load estimates differed among datasets by less than a factor of two (Fig. 4). AgDrain loads accounted for 10.7% of the total June to October upstream tributary load, or 14.8% of the downstream load.

November to May loads made up 70 to 90% of the total annual load (within sites), and estimates differed among programs by approximately a factor of four (Fig. 5). November to May MeHg loads for AgDrain-$W_{outfall}$, Upstream-Sacramento, Upstream-Feather, and downstream were 0.22 ± 0.1, 7.3 ± 4, 1.7 ± 0.8, and 24 ± 17 g d^{-1}, respectively. November to May loads for AgDrain-E were not possible to estimate due to gaps in flow data and floodwater being diverted into and out of the river at a number of locations.

Sampling frequency in this study was lower than recommended for accurate load calculation (Dolan et al., 1981). Low sampling frequency is problematic because it reduces the likelihood of accurately capturing loads during storm events. This is particularly evident for November to May downstream loads, where removal of one elevated sample concentration (1.98 ng L^{-1}, 13 Feb. 1997, see Fig. 2A) decreases the downstream load estimate by 40%. This sample was taken more than a month after a major flood event, during an extended period of high flow, and elevated MeHg concentrations were also observed at other sites (quality control data did not suggest this was a result of contamination [Domagalski, 1998]). It is possible that higher concentrations occurred during the peak of this or other storm events, but samples were not collected then. Therefore, uncertainty surrounding storm event loads limits our confidence in November to May loads. There are typically no storm events and MeHg concentrations are less variable

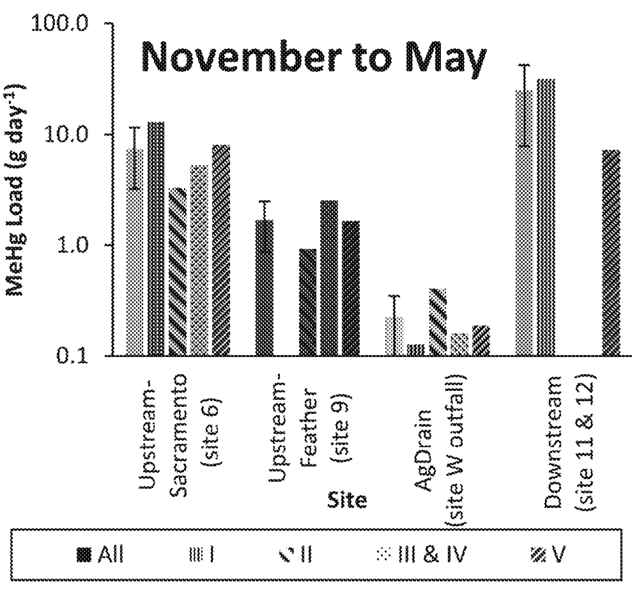

Fig. 5. November to May methylmercury (MeHg) loads by site (indicated by color and *x*-axis groups) and sampling program (indicated by shading in legend). Note the log scale *y*-axis. "All" represents loads calculated using data from all sampling programs. Error bars represent standard deviation of sampling program estimates. Color and shading is consistent with Fig. 4. AgDrain, agricultural drainage.

during June to October (Fig. 2B), so the variation in MeHg concentration can be captured using fewer samples; thus, the sampling frequency is likely adequate for June to October loads.

The true MeHg load at a site should be expected to show considerable interannual variation, with larger loads occurring in years with high flow (Hill, 1986). It is important to consider whether the years measured in this study are representative of historical flow regimes. Hill (1986) recommends using data from 6 to 7 yr to obtain robust estimates of average annual loads. With the exception of downstream, loads presented here were based on 7 to 9 yr of data, suggesting that this study adequately captures the interannual load variation at these sites. Flow during the study period was greater than averages of historical average flows at all sites except AgDrain-W in June to October (Supplemental Table S5 and Supplemental Fig. S1), suggesting that loads during this study may have been higher than historical average loads.

Full accounting of rice field loads requires the total MeHg load from AgDrain-W, which is the sum of AgDrain-$W_{outfall}$ (reported above) and AgDrain-$W_{diversion}$ (not calculated because of missing flow data). However, AgDrain-$W_{diversion}$ flow data from 2007 and 2012 shows that AgDrain-$W_{outfall}$ carried 36 ± 9% of November to May flows and 73 ± 7% of June to October flows from AgDrain-W. Through discussions with irrigation district managers, we determined that management of AgDrain-W flows have not changed since the beginning of the study period (Bair, personal communication, 2016). Based on the fraction of flows carried by AgDrain-$W_{outfall}$, the total AgDrain-W load was 0.61 ± 0.17 g d^{-1} in November to May and 0.19 ± 0.02 g d^{-1} in June to October.

Windham-Myers et al. (2014a) reported MeHg loads exported from rice fields in the Yolo Bypass. If these loads are extrapolated to other rice-growing regions and multiplied by the total area of rice in the Sacramento Valley (240,000 ha), the predicted MeHg loads are 12± 7 and 26 ± 24 g d^{-1} in June to October and November to May, respectively—an order of magnitude higher than the results of this study. This substantial difference may result from two potential sources. First, there are known site differences between the field-scale study site in the Yolo Bypass and typical Sacramento Valley rice-growing areas. For example, MeHg concentrations in irrigation source water were an order of magnitude higher in the Yolo Bypass than in irrigation source water (Upstream-Sacramento and Upstream-Feather) in this study. The Yolo Bypass is known to accumulate Hg-laden sediment during storm events (Springborn et al., 2011), while much of the rice land is not in the path of storm flows that would deliver Hg-laden sediment. Secondly, differences may result from scale-dependent factors. Bradley et al. (2011) found that MeHg loads exported from wetland sources overestimated the watershed-scale load because MeHg was lost through sink processes (including photo- and microbial demethylation and particle settling) during transport. Windham-Myers et al. (2014a) showed that rice fields are net MeHg sources; however, aqueous MeHg exported from rice fields in Sacramento Valley must be transported through a network of canals before it reaches the Sacramento River. Future research should seek to determine the degree to which MeHg is lost during canal transport and to quantify MeHg budgets for Sacramento Valley rice fields.

Rice Field Drainage Contribution

Elevated November to May downstream concentrations and the large November to May downstream load relative to the upstream tributary loads suggest that the uncalculated November to May AgDrain-E was considerably larger than AgDrain-W. However, AgDrain-E carries a mixture of floodwater and rice drainage water, as well as drainage from wetlands. Determining the MeHg load from rice requires further research on the effect of floodplains on MeHg and the contribution of managed wetlands.

It is misleading to consider only MeHg loads exported from rice because fields receive MeHg in irrigation water and atmospheric sources. Irrigation source water (upstream) had a MeHg concentration of 60 to 70% of that of AgDrain water (Fig. 3). Due to evapotranspiration and percolation losses, the volume of drainage water is $\leq$40% of irrigation water applied to a rice field during the growing season (Linquist et al., 2015). Thus, growing season increases in MeHg concentrations between irrigation and drainage water during the growing season were of a similar magnitude to that expected from evapoconcentration alone. The June to October AgDrain MeHg load contributed to the Sacramento River may be similar to the MeHg load diverted from the river for irrigation. During November to May (the fallow season), upstream MeHg concentrations were 43% of AgDrain, while drainage water exports are expected to be a larger fraction of irrigation water applied (no transpiration is expected in fallow rice fields), resulting in increased MeHg exports relative to imports. This is consistent with Bachand et al. (2014), who found that rice fields might store MeHg during the growing season but release it during the winter fallow. Wet and dry atmospheric deposition may be important sources of MeHg and total Hg (Munthe et al., 1995, Conaway et al., 2010) and have been shown to influence runoff fluxes from catchments (Hultberg and Munthe, 1995). However, atmospheric deposition data is not available for the Sacramento Valley. Deposition studies would help quantify the degree to which rice fields are MeHg sources or sinks.

Elevated November to May AgDrain MeHg concentrations and November to May AgDrain-W loads being fourfold higher than June to October loads both indicate that November to May is the period of higher concern for MeHg export from rice fields. Without knowledge of the full annual cycle of MeHg production in and export from a system, studies risk missing important periods of MeHg export. If the environmental management objective is to reduce annual loads of MeHg, control efforts should focus on the November to May period, when MeHg concentrations in AgDrains are elevated. Finally, this study indicates that care should be taken when extrapolating the impact of rice production on MeHg in surface water at the field to valley scale. While the seasonal patterns of MeHg concentrations and exports were similar to those observed at the field scale, there were substantial differences in the magnitudes of concentrations and loads.

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Alternate wetting and drying in high yielding direct-seeded rice systems accomplishes multiple environmental and agronomic objectives

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ABSTRACT

Rice (*Oryza sativa* L.) cultivation is critically important for global food security, yet it also represents a significant fraction of agricultural greenhouse gas (GHG) emissions and water resource use. Alternate wetting and drying (AWD) of rice fields has been shown to reduce both methane (CH_4) emissions and water use, but its effect on grain yield is variable. In this three-year study we measured CH_4 and nitrous oxide (N_2O) emissions, rice grain total arsenic (As) concentrations, yield response to N rate, and grain yield from two AWD treatments (drill-seeded and water-seeded) and a conventionally managed water-seeded treatment (control). Grain yields (average = 10 Mg ha^{-1}) were similar or higher in the AWD treatments compared to the control and required similar or lower N rates to achieve these yields. Furthermore, AWD reduced growing season CH_4 emissions by 60–87% while maintaining low annual N_2O emissions (average = 0.38 kg N_2O–N ha^{-1}); N_2O emissions accounted for <15% of the annual global warming potential (GWP) in all treatments. Fallow season emissions did not vary by treatment and accounted for 22–53% of annual CH_4 emissions and approximately one third of annual GWP on average. The AWD treatments reduced annual GWP by 57–74% and growing season yield-scaled GWP by 59–88%. Milled grain total As, which averaged 0.114 mg kg^{-1} in the control, was reduced by 59–65% in the AWD treatments. These results show that AWD has the potential to mitigate GHG emissions associated with rice cultivation and reduce rice grain total As concentrations without sacrificing grain yield or requiring higher N inputs; however future research needs to focus on adapting AWD to field scales if adoption of this technology is to be realized.

1. Introduction

Agriculture in the 21st century is expected to double food production to meet the demand from a growing population while simultaneously reducing its environmental footprint in the face of challenges like widespread soil degradation, water scarcity, and climate change (Foley et al., 2011). Agriculture is responsible for over half of global anthropogenic non-CO_2 greenhouse gas (GHG) emissions, due predominately to nitrous oxide (N_2O) emissions from N fertilization and methane (CH_4) emissions from livestock and rice (*Oryza sativa* L.) cultivation (Smith et al., 2014). Rice is the dominant staple crop in much of the world and is critically important for global food security (Maclean et al., 2002), yet rice cultivation is a significant source of CH_4 emissions (Linquist et al., 2012), accounting for 9–11% of GHG emissions from agriculture (Smith et al., 2014). Furthermore, increases in rice production over the last half-century relied heavily on irrigated rice production, which is increasingly constrained by water scarcity (Cassman, 1999). Alternative management techniques are therefore needed to reduce the environmental burden associated with rice cultivation without jeopardizing rice production and global food security.

Alternate wetting and drying (AWD) of rice paddies, in which fields are drained and re-flooded one or more times during the growing season, has been promoted as a strategy to decrease irrigation water use and reduce GHG emissions from rice cultivation while maintaining or improving yields (Richards and Sander, 2014). It has principally been promoted in Asia, with the most widespread adoption to date occurring in Bangladesh, the

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Philippines, and Vietnam (Lampayan et al., 2015). While AWD has been shown to reduce CH_4 emissions by 48–93% (Linquist et al., 2015a; Pandey et al., 2014; Qin et al., 2010; Xu et al., 2015), it can result in increased N_2O emissions, producing a trade-off between CH_4 and N_2O emissions (Ahn et al., 2014; Yang et al., 2012). However, in most cases this trade-off does not eliminate the overall reduction in global warming potential (GWP) associated with AWD (Linquist et al., 2015a; Pandey et al., 2014; Xu et al., 2015). The effect of AWD management on rice grain yield is less clear. In studies conducted in China, Belder et al. (2004) found that AWD had no significant impact on grain yield, while Xu et al. (2015) observed yield decreases of up to 16%. This variability is likely due in part to differences in AWD water management between studies, as AWD treatments may vary widely in their severity (Zhang et al., 2009; Linquist et al., 2015a), timing (Bouman and Tuong, 2001; Linquist et al., 2015a), and soil moisture monitoring methodology (e.g. field water tubes (Lampayan et al., 2015), moisture sensors (Linquist et al., 2015a), or tensiometers (Zhang et al., 2009)). However, AWD may also affect grain yield by altering N cycling in rice systems (Dong et al., 2012). In flooded rice systems, fertilizer N loss from coupled nitrification-denitrification at the interface of the aerobic and anaerobic soil layers is generally minimal (Buresh et al., 2008). Without careful timing of AWD water management however, the introduction of aerobic cycles may lead to increased nitrification and subsequent N loss (including as N_2O emissions) through denitrification upon re-flooding (Cai et al., 1997; Hussain et al., 2015).

While the effects of AWD on grain yield may vary, AWD has been shown to have agronomic benefits other than the aforementioned reduction in CH_4 emissions, such as lower grain arsenic (As) concentrations and reduced water inputs (Hu et al., 2013; Lampayan et al., 2015; Linquist et al., 2015a). There is increasing pressure to reduce water use in rice systems, as current water use levels are unsustainable in many rice-growing regions (Steffen et al., 2015). Water savings of 10–44% have been reported with AWD, mostly due to the elimination of unproductive flows such as lateral seepage and deep percolation (Lampayan et al., 2015; Linquist et al., 2015a; Rejesus et al., 2011). Concerns have also been raised about As accumulation in rice grains, especially among populations that have high rice consumption due to cultural practices or dietary constraints (Gilbert-Diamond et al., 2011; Williams et al., 2007; Zhu et al., 2008). Arsenic may be naturally present at high levels in some soils (Smith et al., 2013), or it may enter agricultural systems through historical pesticide usage or high-As irrigation water (Smith et al., 1998). Under the reduced conditions typically associated with flooded rice cultivation, the more mobile As(III) form predominates over the strongly adsorbed As(V) form, resulting in higher soil solution As concentrations and greater uptake by rice plants (Zhao et al., 2010). Decreased grain As accumulation has been shown with AWD (Linquist et al., 2015a), since drying events alter the redox potential of the soil and reduce the mobility and uptake of As.

The reductions in CH_4 emissions, rice grain As concentrations, and irrigation water use, as well as the observed variability in rice grain yield associated with AWD, highlight both the value of AWD and the importance of evaluating it across a wide range of agricultural environments. In this study we sought to compare rice grain yield, yield response to N rate, CH_4 and N_2O emissions, and rice grain total As concentrations for conventional flood irrigation and two AWD treatments in high-yielding California irrigated rice systems. We hypothesized that with appropriate AWD management (careful timing of prolonged flooded periods and rewetting events), grain yield could be maintained at similar N rates while reducing grain total As concentrations and the GWP from rice cultivation.

2. Materials and methods

2.1. Study site description

This study was conducted at the Rice Experiment Station (39°27′47″N, 121°43′35″W) in Biggs, CA from June 2012 to March 2015, which comprised three growing seasons and two fallow seasons. Historical management in these fields consisted of continuously flooded rice cultivation during the growing season and a flooded period during the winter fallow. The soils at the study site are an Esquon-Neerdobe complex, classified as fine, smectitic, thermic, Xeric Epiaquerts and Duraquerts, with approximately 29% sand, 26% silt, and 45% clay, a pH of 5.3, 1.06% organic C, and 0.08% total N (Pittelkow et al., 2012). The soil total As, Cd, Fe, Mn, and Zn were 0.99 ppm, 0.08 ppm, 30800 ppm, 424 ppm, and 58.8 ppm, respectively. To measure these elements, the soil was digested using Aqua Regia; the cations were measured by flame atomic absorption and the total As was measured by hydride generation-inductively coupled plasma atomic emission spectrometry. Over the duration of the experiment, the area received an average of approximately 405 mm of rainfall annually (~30 mm during the growing season), with a mean winter air temperature of ~12 °C and a mean summer air temperature of ~23 °C (CIMIS 2015).

2.2. Treatments

Three water management treatments – drill-seeded with AWD (DS-AWD), water-seeded with AWD (WS-AWD), and water-seeded with conventional flood irrigation (control, WS-C) – were implemented in all three years on 0.3 ha field plots in a randomized complete block design with three replicates. The treatment layout in the main plots was maintained over the course of this experiment, so that each plot had the same water management treatment for three years. Bunds were compacted with heavy machinery in order to minimize lateral seepage, but as some lateral seepage could not be avoided, drainage ditches were constructed between plots to prevent flooded plots from affecting drained plots and vice versa. The volumetric water content (θ_V) was measured throughout the season for all three replicates of both AWD treatments using EC-10 soil moisture sensors placed vertically to a depth of 10 cm (Decagon Devices, Inc., Pullman, WA). For both WS treatments a continuous flood was initiated immediately after broadcast seeding (Table 1), which was done to simulate the conventional practice of aerial seeding in California. Pre-germinated seed is typically broadcast into flooded fields by airplane, but given the scale of this experiment, pre-germinated seed was broadcast onto dry fields with a tractor-mounted seeder and the fields were then promptly flooded. The WS-C treatment was continuously flooded (10–15 cm deep) until physiological maturity (Fig. 1A). The WS-AWD treatment was managed identically to the WS-C treatment (continuously flooded) until constant ceptometer measurements indicated that canopy closure was achieved (51 days after planting on average). This initial flooded period was included in the WS-AWD treatment since the timing of flooding is critically important for weed control (Tuong et al., 2005), and having complete canopy coverage reduces the potential for weed problems associated with draining a field; this also coincides with when complete fertilizer N uptake is observed in WS rice systems that are managed as outlined here (Linquist et al., 2006). After this point the floodwater was allowed to subside (via evapotranspiration and percolation), the soils were dried until the average θ_V of the three replicates reached 0.35 $m^3 m^{-3}$, and the plots were then re-flooded to the same 10–15 cm floodwater depth maintained in the WS-C treatment. Floodwater was held during anthesis and grain fill, as water stress at these times can result in yield reductions of 60–75% (Boonjung and Fukai, 1996); as a result,

Table 1
Dates of important management practices for the 2012–2014 rice growing seasons.

Management	2012			2013			2014		
	WS-C[a]	*WS-AWD*	*DS-AWD*	*WS-C*	*WS-AWD*	*DS-AWD*	*WS-C*	*WS-AWD*	*DS-AWD*
Planted	6 June	6 June	6 June	23 May	23 May	23 May	21 May	21 May	21 May
Fertilized	1 June	1 June	2 July	21 May	21 May	20 June	19 May	19 May	16 June
Flooded	7 June	7 June	–	25 May	25 May	–	25 May	25 May	–
Flushed	–	–	8 June	–	–	25 May	–	–	25 May
	–	–	20 June	–	–	6 June	–	–	6 June
DS Flood	–	–	20 July	–	–	20 June	–	–	16 June
AWD Flood	–	14 Aug.	13 Aug.	–	23 July	23 July	–	22 July	21 July
	–	28 Aug.	27 Aug.	–	15 Aug.	15 Aug.	–	13 Aug.	13 Aug.
	–	15 Sept.	14 Sept.	–	–	–	–	–	–
	–	1 Oct.	1 Oct.	–	–	–	–	–	–
Drained	NR[b]	NR	NR	14 Sept.	14 Sept.	20 Sept.	7 Sept.	7 Sept.	16 Sept.
Harvest	7 Nov.	7 Nov.	7 Nov.	11 Oct.	11 Oct.	11 Oct.	1 Oct.	1 Oct.	9 Oct.
Winter flood	19 Nov.	19 Nov.	19 Nov.	18 Nov.	19 Nov.	19 Nov.	21 Oct.	21 Oct.	21 Oct.

[a] The treatments are: water-seeded with conventional continuous flood irrigation (WS-C), water-seeded with alternate wetting and drying (WS-AWD), and drill-seeded with alternate wetting and drying (DS-AWD).
[b] Dates not recorded are indicated by "NR".

only two drain events comprised AWD water management in this experiment (Fig. 1B). Typical management for DS systems involves multiple flush irrigations (and/or rainfall) for stand establishment. In this experiment the DS-AWD treatment was flush irrigated twice after planting dry seed with a tractor-pulled drill seeder (Fig. 1C; Table 1); N fertilizer was applied approximately one month after planting and a flood was initiated immediately thereafter (also typical of DS systems). The initial flood period was maintained for 25–28 days to ensure complete fertilizer N uptake before the drying event and to achieve full canopy coverage as in the WS treatments. Water management in the DS-AWD treatment after canopy closure was the same as in the WS-AWD treatment, though the DS-AWD plots were drained for harvest a week later due to delayed maturity (Fig. 1; Table 1).

2.3. Field management

Fields were planted with the rice variety M206 in all years of the experiment at the standard grower rates of 112 kg ha^{-1} (DS) and 168 kg ha^{-1} (WS). Weed control was achieved using herbicide applications typical for these systems. In 2013 and 2014, N-trial subplots (3 by 6 m) were established in each main plot with N rates of 0, 60, 120, 180, and 240 kg N ha^{-1}, and the location of these subplots was changed between years. Fertilizer was surface-applied as urea and lightly incorporated into the soil in the WS plots prior to planting, while in the DS plots urea was broadcast approximately four weeks after planting and immediately prior to the extended flood period (Table 1; Fig. 1). All plots received 50 kg P_2O_5 ha^{-1} and 50 kg K_2O ha^{-1} prior to planting. The initial flood (or flush for DS-AWD) was initiated on May 25th in 2013 and 2014, and the fields were drained for harvest on September 14th or 20th in 2013 and September 7th or 16th in 2014, with the earlier dates corresponding to the WS plots and the later dates corresponding to the DS plots (Table 1). Grain yields were measured using a small plot combine (the harvest area was approximately 10 m^2) and adjusted to the standard 14% moisture content. Prior to the combine harvest, whole plant subsamples were taken from each N-trial plot, oven-dried, and the grain and the straw were separated for calculation of the harvest index. Following harvest the rice straw was lightly incorporated in all plots and the plots were subsequently flooded for the winter fallow season to facilitate rice straw decomposition (Linquist et al., 2006). Further management details and dates can be found in Table 1.

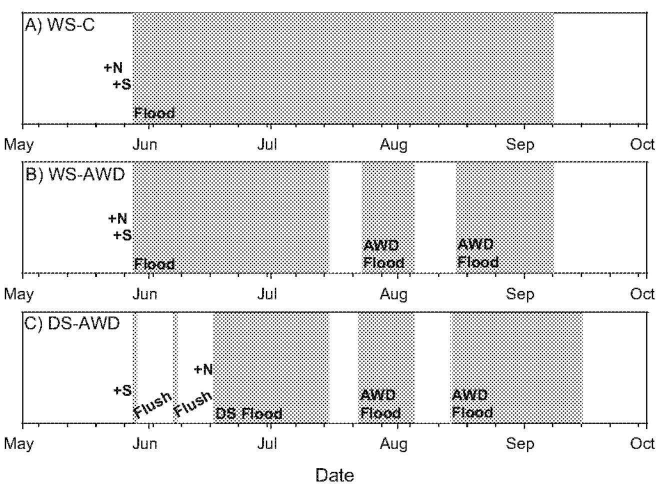

Fig. 1. Growing season water management for the three treatments: A) water-seeded with conventional continuous flood irrigation (WS-C), B) water-seeded with alternate wetting and drying (WS-AWD), and C) drill-seeded with alternate wetting and drying (DS-AWD). Gray shading indicates periods during which fields are flooded. Seeding and nitrogen fertilization are indicated by "+S" and "+N" respectively.

2.4. Soil analyses

During the 2014 growing season, soil samples were taken weekly from the 0 and 180 kg N ha^{-1} subplots in each main plot over a 5-week period that immediately followed N fertilization in the DS-AWD plots and included the first floodwater drain in the AWD plots. Samples were homogenized and stored on ice for less than 24 h before measurement of total soil extractable N (NH_4^+–N and NO_3^-–N). Three sub-samples (20 g) of each soil sample were added to 100 mL of 2 M KCl and mixed for one hour on a mechanical shaker. The solution was filtered through Whatman No. 42 filter paper (GE Healthcare UK Limited, Buckinghamshire, UK) and stored at 4 °C prior to colorimetric analysis for NH_4^+–N and NO_3^-–N on a spectrophotometer (Keeney and Nelson, 1982).

As field measurement of soil water potential was not practical due to the shrink-swell characteristics of the smectitic clays, a soil-moisture release curve was measured in the laboratory from 0 to 50 kPa on homogenized sieved soils using pressure cells according to methods adapted from Dane et al. (2002). In brief, a composite sample from all nine field plots was re-packed into three replicate cores, saturated for at least 48 h, and inserted into pressure cells connected to a pressurized gas cylinder at the top and a 100 kPa ceramic plate and a volumetric cylinder at the bottom; the volume of water released by the cores was measured as the pressure was increased in 5 kPa steps and enough time passed between pressure steps for hydraulic equilibrium to be achieved. The mean soil θ_V was just above 0.35 $m^3 m^{-3}$ at a water potential of −50 kPa (unpublished results), which is consistent with published estimates of soil-water characteristics for similarly textured soils (Saxton and Rawls, 2006).

2.5. Arsenic analysis

Milled rice grain samples were ground to a fine powder using a UDY Cyclone Sample Mill (UDY Corporation, Fort Collins, CO). Samples were mixed with 5 mL of HNO_3, 2 mL 25% HCl, and 1.5 mL H_2O and digested in a Milestone Ultrawave microwave system pressurized to 40 bar, slowly ramping to 260 °C and holding for 25 min (pressure in the chamber during digestion will reach 130 bar), cooled, and diluted to 15 mL volume with deionized water. This method has been shown to recover all of the organic As by hydrolysis, while cooler temperatures may not hydrolyze DMA-As. Total As in the digests was measured using hydride generation. An aliquot of the digest was transferred to a separate tube, and 3 mL of 5% potassium iodide/5% ascorbic acid, 2.5 mL of 1.73 M sulfamic acid, and 1.5 mL concentrated HCl were mixed with 4 mL of the sample to reduce all arsenate to arsenite. Using a mixing block, the pre-reduced solutions are combined with 0.5% sodium borohydride in 0.05% sodium hydroxide in order to analyze for total As using a flow injection hydride generation system with inductively coupled plasma-atomic emission spectrometry. NIST and other standard reference materials with certified total As concentrations were analyzed with all batches of samples, as were blanks; testing of the recovery of As from spiked samples and blanks was also conducted. All quality assurance checks were within the normal variance range of the standards.

2.6. Greenhouse gas measurements and flux calculations

Greenhouse gas samples were taken daily to weekly during the 2013 and 2014 growing seasons, and daily to monthly during the winter fallow seasons. During periods of high variability, such as floodwater drain events, sampling was conducted every day or every other day. Closed vented flux chambers were used for gas sampling, which consisted of a permanent base installed prior to each field season, a variable-height extension to accommodate rice plants, and a sealed chamber with a vent tube for pressure equalization (Adviento-Borbe et al., 2013; Pittelkow et al., 2012). Gas samples (25 mL) were taken through silicon septa at 21, 42, and 63 min and injected into pre-evacuated 12.5-mL glass vials (Labco Ltd., Buckinghamsire, UK). Four ambient gas samples were also taken at 0 min during each sampling event. Gas sampling was conducted between 09:00 and 12:00 h, as soil temperatures and gas fluxes are expected to be representative of their average daily values during this time period (Adviento-Borbe et al., 2013). In order to minimize the effects of intensive gas sampling on the rice plants, two collars were installed per main plot and sampling alternated between collars. Boardwalks were established prior to each field season so as to minimize soil compaction and prevent artificially inflated flux values. A more complete discussion of the sampling protocol for GHG flux measurements can be found in Adviento-Borbe et al. (2013).

All samples were analyzed for CH_4 and N_2O peak area on a GC-2014 gas chromatograph equipped with a ^{63}Ni electron capture detector set at 325 °C for N_2O concentrations and a flame-ionization detector (FID) for CH_4 concentrations (Shimadzu Scientific, Inst, Columbia, MD, USA). Nitrous oxide was separated by a stainless steel column packed with Hayesep D, 80/100 mesh at 75 °C. The detection limits of the GC instrument were 2.2 pg s^{-1} for CH_4 and 0.3 pg s^{-1} for N_2O. Results of the GC analyses were accepted if voltage output produced a linear relationship with the gas concentrations of CH_4 and N_2O standards with $r^2 > 0.99$ (1, 3.05, and 9.95 ppm for N_2O; 1.8, 10.18, 19.7, 100, 503, and 1020 ppm for CH_4); the peak area for each gas sample was then converted to a concentration based on this linear relationship. Fluxes were estimated from the linear increase of gas concentration over time, and gas concentrations were converted to elemental mass per unit area (g $ha^{-1} d^{-1}$) using the Ideal Gas Law with the chamber volume measured at each sampling event, the chamber air temperature measured as each gas sample was taken, and an atmospheric pressure of 0.101 MPa. Fluxes of CH_4 and N_2O were computed as:

$$F = \frac{\Delta C}{Dt} \times \frac{V}{A} \times \alpha \quad (1)$$

where F is the gas flux rate (g N_2O–N or CH_4–C $ha^{-1} d^{-1}$), $\Delta C/\Delta t$ denotes the increase or decrease (N_2O only) of gas concentration in the chamber (g $L^{-1} d^{-1}$), V is the chamber volume (L), A is area covered by the chamber (ha), and α is a conversion coefficient for elemental C ($\alpha = 0.749$) or N ($\alpha = 0.636$). For N_2O, a t-test was used to determine if each gas flux was significantly different from zero at $p < 0.05$. Similar to other studies (Adviento-Borbe et al., 2013; Linquist et al., 2015a; Pittelkow et al., 2012), gas fluxes with a linear correlation below a predetermined threshold ($r^2 \geq 0.9$) were treated as missing data, and those that were below the GC detection limits were set to zero flux for data analysis. Individual flux values were integrated across all time points with linear interpolation to calculate cumulative seasonal emissions (spring tillage to harvest), cumulative fallow season emissions (non-growing season emissions), and cumulative annual emissions.

2.7. Data analysis

All data met the assumptions of normality and homogeneity of variance without transformation. Growing season GWP, fallow season GWP, and annual GWP were calculated for a 100-yr time horizon using radiative forcing potentials with climate-carbon feedbacks relative to CO_2 of 34 and 298 for CH_4 and N_2O respectively (Myhre et al., 2013). Yield-scaled GWP (GWP_Y) was calculated as the ratio of growing season GWP (kg CO_2-eq ha^{-1}) to grain yield (Mg ha^{-1}). We used PROC MIXED in SAS® software Version 9.4 for analysis of variance on cumulative growing season, fallow season, and annual CH_4 emissions, N_2O emissions, and GWP with an adjusted Tukey means separation (SAS Institute Inc., 2013). The year was included as a repeated effect as the treatment layout was maintained over the course of this experiment. The same model was used for analysis of variance and means separation on grain total As concentrations, rice grain yield, and yield-scaled GWP, though grain yield was analyzed separately for each year due to a significant year by treatment interaction. The water management treatment (DS-AWD, WS-AWD, WS-C) was included as a fixed effect, block and the block by treatment interaction were included as random effects, and other interactions were included to the degree that it minimized the corrected Akaike Information Criteria (AICC).

3. Results and discussion

3.1. Water management and grain yield

The yield potential was the same for all water management treatments (10–11 Mg ha^{-1}) in both years that the yield response to N rate was evaluated (Fig. 2). Rice grain yields at the conventional N rate of 180 kg N ha^{-1} were similar for all water management

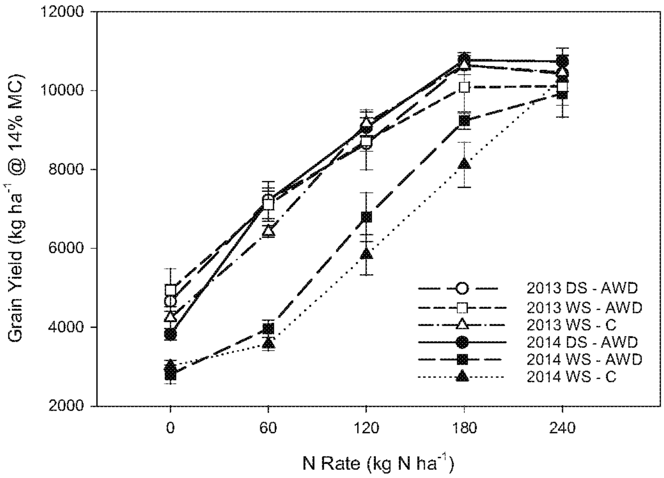

Fig. 2. Nitrogen response curves for the three water management treatments (water-seeded with conventional continuous flood irrigation (WS-C), water-seeded with alternate wetting and drying (WS-AWD), and drill-seeded with alternate wetting and drying (DS-AWD)) during the 2013 and 2014 growing seasons. Grain yields are standardized to 14 percent moisture content and error bars represent the standard error of the mean grain yield at each N application rate.

treatments in 2012 and 2013 (average = 9.86 and 10.46 Mg ha^{-1} respectively), whereas in 2014 the grain yield in the DS-AWD treatment was significantly higher (10.78 Mg ha^{-1}) than in the WS-C treatment (8.12 Mg ha^{-1}; Table 2). The reported effect of AWD on grain yield is highly variable: while some studies have shown that AWD can decrease rice grain yield (Linquist et al., 2015a; Xu et al., 2015), many other studies have shown no change in yield (Belder et al., 2004; Dong et al., 2012; Pandey et al., 2014; Yao et al., 2012) or even an increase in yield with AWD (Liu et al., 2013). This variable yield response to AWD is not surprising given the wide range of water management regimes that are classified as AWD, and the importance of AWD severity and timing in determining grain yields (Boonjung and Fukai, 1996). For example, a field experiment in China showed that allowing sandy loam soils to dry to −15 kPa prior to rewetting increased grain yield by 11%, but yield was reduced by 32% when fields were allowed to dry to −30 kPa before rewetting (Zhang et al., 2009). Similarly, the practice of "safe AWD" promoted by the International Rice Research Institute uses a water level of −15 cm (>−10 kPa) in perforated field water tubes as the threshold for rewetting in order to avoid a yield penalty (Bouman et al., 2007). This threshold has been supported by many field observations (Dong et al., 2012; Pandey et al., 2014; Yao et al., 2012), though in rare cases yield reductions have been observed with even less severe drying regimes (Lagomarsino et al., 2016). Yield reductions have frequently been observed with more severe drying regimes (Bouman and Tuong, 2001; Linquist et al., 2015a; Xu et al., 2015).

In this study the AWD treatments involved rewetting when the θ_V dropped to 0.35 m^3 m^{-3}; in contrast, the yield decrease with AWD reported by Linquist et al. (2015a) involved rewetting fields at a θ_V of 0.16–0.24 m^3 m^{-3}. No yield decline was observed in our study as a result of this higher minimum soil water content (Table 2). While soil θ_V is a relatively easy measurement for management decisions, soil water potential better describes the soil water status with respect to plant uptake and stress (Hillel, 2004). The soil θ_V at rewetting in our study corresponded to a lower soil water potential (−50 kPa) and thus a more severe AWD regime than that in many studies that reported a yield loss with AWD (Bouman and Tuong, 2001; Xu et al., 2015; Zhang et al., 2009). Differences in varietal response to AWD management may offer one explanation for this contradiction, as observed by Xu et al. (2015) in response to the same intermittent irrigation treatments. Nonetheless, this variable yield response to soil water potential is a significant obstacle to AWD adoption, as it makes it difficult to determine a precise threshold soil water potential for rewetting in order to prevent a yield penalty. Furthermore, soil water status can be highly heterogeneous even within fields at the scale of commercial rice production, which may result in variable yields. Targeted research is needed to adapt AWD regimes to local production environments and field scales in order to reduce risk-related barriers to AWD adoption.

3.2. Nitrogen management

The agronomic and economic performance of an AWD production system is tied not only to optimal grain yields, but also to the N rates required to achieve these yields. The N response curves were similar for all treatments in 2013, with yield increases observed until 180 kg N ha^{-1}, and no further increase in yield at higher N rates (Fig. 2). In 2014 however, both WS treatments showed yield increases up to 240 kg N ha^{-1}, while the DS-AWD treatment obtained its maximum yield at 180 kg N ha^{-1} (Fig. 2). Although the yield potential was the same for all treatments in each year, in 2014 the WS treatments thus required approximately 60 kg N ha^{-1} more fertilizer to achieve this yield (Fig. 2; Table 2). Bufogle et al. (1997) reported increased fertilizer N recovery in DS systems, but more recent work in California with similar early-maturing medium grain varieties (M-202, M206) has shown no significant differences in optimal N rates between DS and WS systems (Pittelkow et al., 2012; Pittelkow et al., 2014a). Lower grain yields in the WS treatments were observed even in the zero N subplots (Fig. 2), suggesting that indigenous soil N may have been lost from the WS treatments by denitrification or by nitrate leaching with deep percolation. Denitrification can be a significant

Table 2
Rice grain yield, growing season GWP, and yield-scaled GWP at the conventional N rate of 180 kg N ha^{-1} for the 2012–2014 growing seasons.

Treatment[b]	Yield[a]			Growing Season GWP			GWP-Y		
	(Mg ha^{-1})			(kg CO_2-eq ha^{-1})			(kg CO_2-eq Mg^{-1})		
	2012	2013	2014	2013	2014	Mean	2013	2014	Mean
WS–C	9.94[c] a	10.7 *a*	8.12 *b*	5518	6553	6035 *a*	516	818	667 *a*
	(0.919)	(0.241)	(0.568)	(1143)	(884)		(101)	(137)	
WS–AWD	10.6 *a*	10.1 *a*	9.24 *ab*	2387	2334	2361 *b*	245	257	251 *b*
	(0.409)	(0.670)	(0.219)	(574)	(797)		(67.6)	(94.1)	
DS–AWD	9.04 *a*	10.7 *a*	10.8 *a*	819	987	903 *b*	77.0	91.5	84.3 *b*
	(1.02)	(0.123)	(0.195)	(67.1)	(231)		(6.63)	(20.9)	

[a] Grain yield was analyzed separately for each year due to a significant year by treatment interaction.
[b] The treatments are: water-seeded with conventional continuous flood irrigation (WS-C), water-seeded with alternate wetting and drying (WS-AWD), and drill-seeded with alternate wetting and drying (DS-AWD).
[c] The standard error of the mean for each value is indicated in parentheses and values followed by the same letter are not significantly different at $p < 0.05$.

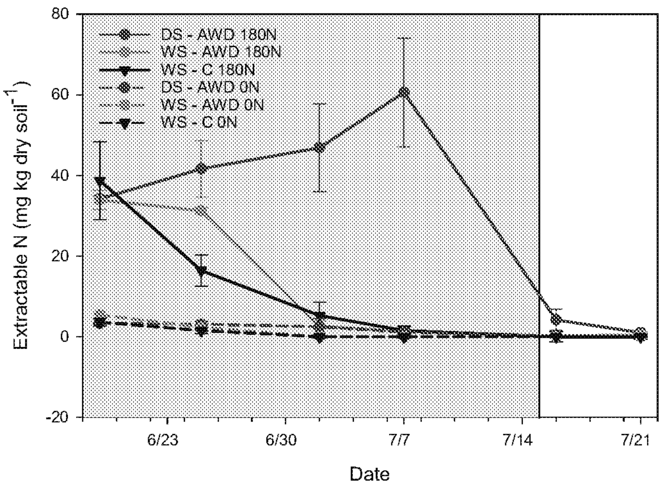

Fig. 3. Total soil extractable N content (NH_4^+–N and NO_3^-–N) during the 2014 growing season in the 0 N and 180 N subplots for all three main plot treatments. Error bars represent the standard error of the mean. The treatments are: water-seeded with conventional continuous flood irrigation (WS-C), water-seeded with alternate wetting and drying (WS-AWD), and drill-seeded with alternate wetting and drying (DS-AWD). Fertilizer N application was done on 6/16 in the drill-seeded plots and on 5/19 in the water-seeded plots. Gray or white shading indicate dates during which the AWD plots were flooded or drained respectively.

loss pathway under flooded conditions if relatively high nitrate concentrations are present before flooding (Buresh et al., 2008). Nitrate leaching can also be an important loss pathway in rice fields where high water losses from deep percolation are observed (Chowdary et al., 2004), though previous studies in conventionally irrigated California rice systems have shown that nitrate leaching is minimal and that combined losses from deep percolation and lateral seepage represent less than 15 percent of total water inputs (Liang et al., 2014; Linquist et al., 2015b).

The introduction of aerobic cycles with AWD has the potential to increase N losses due to increased nitrification and subsequent denitrification (Cai et al., 1997; Cai et al., 1999). It is therefore critical that soil inorganic N levels are low prior to initiating AWD water management in order to avoid these types of losses. Soil extractable N levels were measured in the 0 N and 180 N subplots of all treatments during the 2014 growing season (Fig. 3). Soil N levels in the 180 N subplots dropped to almost zero before the floodwater completely subsided (approximately 49 and 29 days after N fertilization in the WS and DS treatments respectively). This synchronization of water management with soil N levels resulted in minimal N losses during the aerobic drying cycles, as evidenced by negligible N_2O emissions during the drying cycles (Fig. 4). Importantly, neither AWD system (DS or WS) required increased N rates to achieve optimal yields relative to the conventional (WS-C) treatment.

3.3. *Greenhouse gas emissions and global warming potential*

Methane dominated the annual GWP of all three water management treatments during both years (94% on average), with its contribution ranging from 86% (DS-AWD) to 99% (WS-C; Table 3). During the growing season, daily CH_4 emissions in the WS-C plots increased to 87 kg CO_2-eq. ha^{-1} by August 5th in 2013 and to 80 kg CO_2-eq. ha^{-1} by July 16th in 2014, after which point emissions began to decline (Fig. 4 A–B). Growing season CH_4 emissions in the WS-C treatment were 133 kg CH_4-C ha^{-1} when averaged between years (Table 3), which is in good agreement with the global 100 kg CH_4-C ha^{-1} average reported in a meta-analysis by Linquist et al. (2012). Growing season CH_4 emissions ranging from 11 to 338 kg CH_4-C ha^{-1} have been reported for California rice systems (Pittelkow et al., 2013; Pittelkow et al., 2014a; Simmonds et al., 2015).

The DS-AWD and WS-AWD treatments reduced growing season CH_4 emissions by 87% and 60% respectively (Table 3), due to the introduction of aerobic conditions by the first AWD drain event and negligible subsequent CH_4 emissions (Fig. 4 C–F). A significant portion of growing season CH_4 emissions, 10% on average, comes from a spike in CH_4 emissions during the end-of-season drain (Adviento-Borbe et al., 2015). While this was observed both years in the WS-C treatment, minimal CH_4 emission spikes were observed in the AWD treatments (Fig. 4). The reduction in growing season CH_4 emissions in the AWD treatments can therefore be attributed to negligible CH_4 emissions following the first drying event and greatly reduced end-of-season CH_4 spikes (Fig. 4; Table 3). The 66% reduction in growing season CH_4 emissions observed in the DS-AWD treatment relative to the WS-AWD treatment can likely be attributed to intermittent aerobic conditions in the DS plots during flush irrigation for crop establishment (Fig. 4; Table 3); a similar 47% reduction in growing season CH_4 emissions over WS systems was seen in continuously flooded DS California rice systems (Pittelkow et al., 2014a).

While AWD consistently decreases growing season CH_4 emissions, N_2O emissions usually increase and can negate the reduction in GWP from reduced CH_4 emissions (Akiyama et al., 2005; Lagomarsino et al., 2016). Although nitrification is normally minimal in conventionally flooded fields, limiting N_2O loss as a by-product of both nitrification and denitrification, the introduction of aerobic periods could allow for nitrification of fertilizer NH_4^+ and thus greater denitrification losses (Buresh et al., 2008). Coordination of water management and N application timing is therefore required to prevent high N_2O emissions from offsetting reductions in GWP. In this experiment, all plots were flooded after N application and remained flooded until soil extractable N levels dropped to approximately zero (Fig. 3); as a result subsequent N_2O emissions were negligible (Fig. 4A–F). Some N_2O peaks were observed after the first two flush irrigation events for crop establishment in the DS-AWD treatment in 2014 (Fig. 4F), though these peaks accounted for only 11% of growing season GWP (Table 3). In contrast, N_2O fluxes were negligible (with the system possibly acting as a sink) during the growing season in the WS-AWD and WS-C treatments (Table 3).

Fallow season emissions can account for a significant fraction of annual GHG emissions from rice systems. No significant differences in fallow season CH_4 emissions were observed among treatments in this study, indicating that the effects of AWD on CH_4 emissions do not extend beyond the growing season (Table 3). Although CH_4 emissions during this flooded winter fallow period were generally low and relatively constant, spikes were observed during the spring drain for most treatment-year combinations (Fig. 4 G–H). Fallow season CH_4 emissions accounted for 22% of annual CH_4 emissions in the WS-C treatment; this compares to an average of 20% and a 5–55% range reported in similar California rice systems (Adviento-Borbe et al., 2013; Fitzgerald et al., 2000; Pittelkow et al., 2013; Pittelkow et al., 2014a). Due to lower growing season CH_4 emissions, fallow season emissions accounted for 27% and 53% of annual CH_4 emissions in the WS-AWD and DS-AWD treatments respectively (Table 3). Fallow season N_2O emissions peaked after floodwater was drained in the spring and were similar between treatments, comprising 68% of annual N_2O emissions in the DS-AWD treatment and 100% of annual N_2O emissions in the WS treatments (Fig. 4 G–H; Table 3). Fallow season emissions comprised 36% of annual GWP on average, ranging from 22% in the WS-C treatment to 55% in the DS-AWD treatment. In comparison, Adviento-Borbe et al. (2013) reported

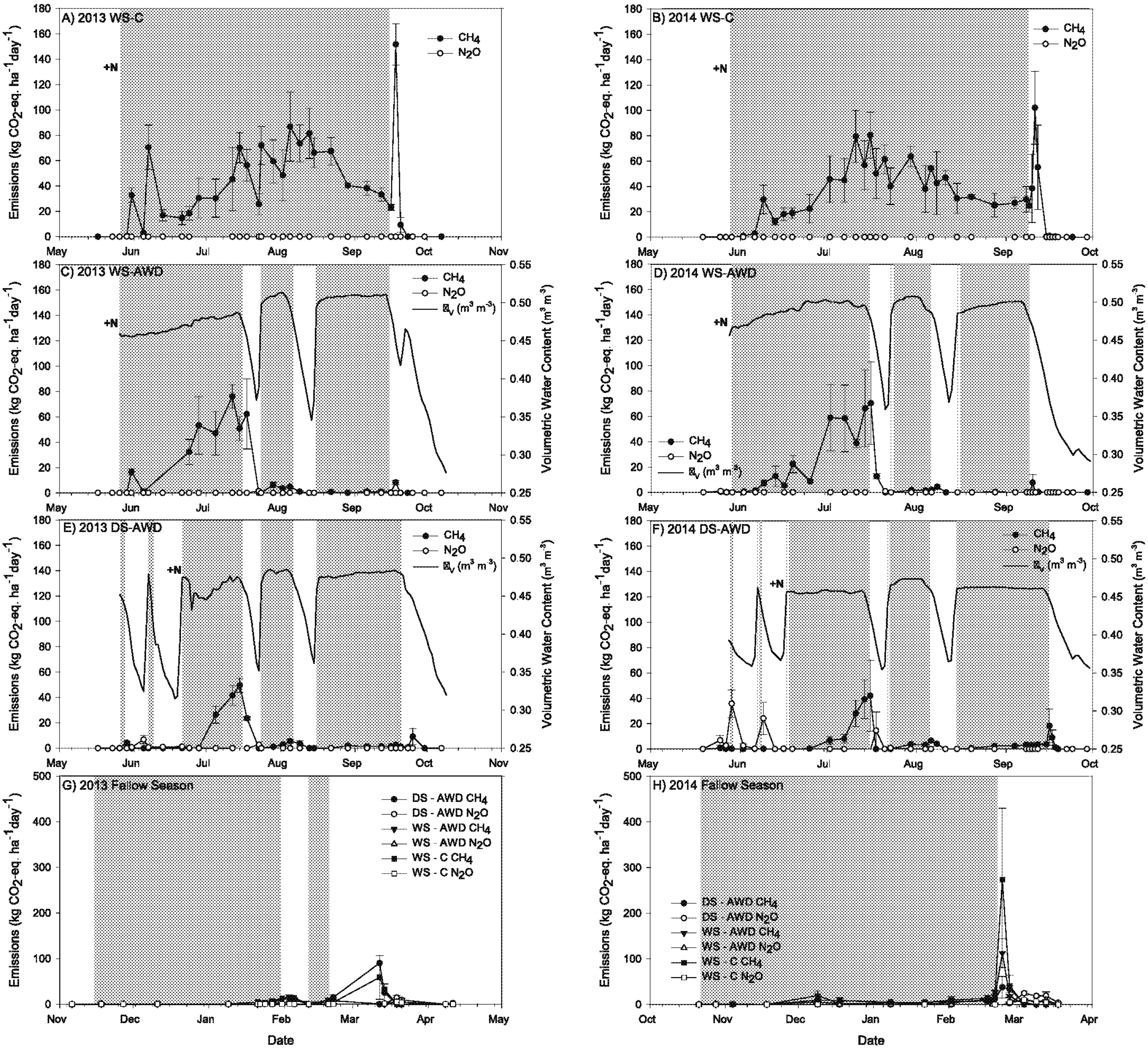

Fig. 4. Methane (CH_4) and nitrous oxide (N_2O) emissions during the growing season (A–F) and winter fallow period (G–H) for 2013–2014 and 2014–2015. Error bars represent the standard error of the mean and "N" indicates fertilization with urea. The treatments are: water-seeded with conventional continuous flood irrigation (WS-C), water-seeded with alternate wetting and drying (WS-AWD), and drill-seeded with alternate wetting and drying (DS-AWD). The average volumetric water content (θ_V) of each AWD treatment is also shown throughout the growing season and gray shading indicates periods during which fields are flooded. Note that the scale for the fallow season plots is different in order to accommodate the spike in CH_4 emissions during the spring drain.

that fallow season emissions accounted for approximately 13% of GWP in conventional flooded California rice systems.

Annual CH_4 emissions were reduced by 57–78% in the AWD treatments, with the greatest reduction corresponding to the DS-AWD treatment (Table 3). Annual N_2O emissions represented only 0.6%, 2.0%, and 14% of annual GWP in the WS-C, WS-AWD, and DS-AWD treatments respectively; except for the DS-AWD treatment, the N_2O emissions as a percent of annual GWP were lower than the 10–18% reported for conventional flooded systems (Linquist et al., 2012; Pittelkow et al., 2014b). As CH_4 was therefore the dominant GHG emitted from all treatments, a 57–74% decrease in annual GWP was observed with AWD (Table 3). Given the growing global food demand, it is increasingly important to evaluate agricultural GHG emissions with respect to crop productivity (Pittelkow et al., 2014b). The yield-scaled GWP was reduced by 59–88% with AWD as a result of similar grain yields among all treatments (Table 2). These reductions in GWP are similar to those reported by other studies, though the magnitude of the reduction depends on the specific AWD regime (Linquist et al., 2015a; Pandey et al., 2014; Xu et al., 2015).

3.4. Rice grain arsenic

Milled rice grain total As concentrations in the WS-C treatment were similar between years (average = 0.114 mg kg^{-1}; Table 4), and comparable to the average grain total As concentration of 0.13 mg kg^{-1} reported for California, but lower than the reported U.S. average of 0.19 mg kg^{-1} (Zavala and Duxbury, 2008). Brown

Table 3
Growing season, fallow season, and annual cumulative CH_4 emissions, N_2O emissions, and GWP for 2013 and 2014, with growing season emissions measured in the 180 kg N ha^{-1} subplots.

Treatment[a]	Growing Season		Fallow Season		Annual		
	CH_4 (kg CH_4-C ha^{-1})	N_2O (kg N_2O-N ha^{-1})	CH_4 (kg CH_4-C ha^{-1})	N_2O (kg N_2O-N ha^{-1})	CH_4 (kg CH_4-C ha^{-1})	N_2O (kg N_2O-N ha^{-1})	GWP (kg CO_2-eq ha^{-1})
2013							
WS-C	122[b]	−0.022	17.1	0.126	139	0.103	6354
	(25.3)	(0.012)	(9.36)	(0.047)	(21.4)	(0.048)	(951)
WS-AWD	53.0	−0.038	7.81	0.199	60.8	0.161	2835
	(12.6)	(0.003)	(1.93)	(0.042)	(13.0)	(0.038)	(572)
DS-AWD	17.0	0.103	15.4	0.387	32.4	0.490	1702
	(2.10)	(0.069)	(8.10)	(0.162)	(6.00)	(0.231)	(373)
2014							
WS-C	145	−0.025	65.7	0.126	210	0.101	9596
	(19.7)	(0.020)	(21.5)	(0.051)	(38.9)	(0.034)	(1783)
WS-AWD	51.7	−0.028	36.6	0.149	88.3	0.122	4067
	(17.6)	(0.001)	(8.12)	(0.013)	(24.8)	(0.012)	(1132)
DS-AWD	18.4	0.320	25.5	0.422	44.0	0.743	2345
	(6.27)	(0.139)	(2.82)	(0.079)	(8.13)	(0.217)	(303)
Means							
WS-C	133[c] *a*	−0.024 *a*	41.4 *a*	0.126 *a*	175 *a*	0.102 *a*	7975 *a*
WS-AWD	52.3 *b*	−0.033 *a*	22.2 *a*	0.174 *a*	74.5 *ab*	0.142 *a*	3451 *ab*
DS-AWD	17.7 *b*	0.212 *a*	20.5 *a*	0.405 *a*	38.2 *b*	0.616 *a*	2023 *b*

[a] The treatments are: water-seeded with conventional continuous flood irrigation (WS-C), water-seeded with alternate wetting and drying (WS-AWD), and drill-seeded with alternate wetting and drying (DS-AWD).
[b] The standard error of the mean for each value is indicated in parentheses.
[c] For each emissions category values followed by the same letter are not significantly different at $p < 0.05$.

rice grain total As concentrations were 31% higher on average (WS-C average = 0.143 mg kg^{-1}; Table 4), which is consistent with other studies showing preferential accumulation of As in the rice bran and a higher percentage of inorganic As in brown rice (Meharg et al., 2008; Zhao et al., 2010). Although the U.S. Food and Drug Administration noted that the As levels found in rice samples were too low to cause any short-term adverse health effects, the effects of long-term exposure are less clear (FDA, 2013). The FDA has not yet set regulatory limits for rice grain As, but the Food and Agriculture Organization of the United Nations and the World Health Organization have set voluntary recommended inorganic As limits for polished (milled) rice at 0.2 mg kg^{-1} (Codex Alimentarius Commission, 2014). While the total grain As values in our study are below this limit regardless of the treatment, it is nevertheless important to have agronomic strategies to reduce rice grain As concentrations. Aerobic periods introduced by AWD would favor the oxidation of As(III) to As(V), which is less mobile and thus less bioavailable for uptake and incorporation into the rice grain (Arao et al., 2009; Zhao et al., 2010). The DS-AWD treatment reduced grain total As concentrations by 57% for brown rice and by 59% for milled rice, while the WS-AWD reduced grain total As by 63% and 65% for brown and milled rice respectively (Table 4). This reduction has been confirmed by other studies and suggests that AWD may be a viable option to reduce rice grain As concentrations (Hu et al., 2013; Linquist et al., 2015a).

Results from this study and others indicate that the timing of AWD drain events may have an important effect on grain As concentration. This study suggests that late-season drain events have a greater impact on lowering grain As concentration than early-season drains, as evidenced by the similar grain total As concentrations in the DS-AWD and WS-AWD treatments despite primarily aerobic soils in the DS-AWD treatment during the first month of the season and flooded anaerobic soils in the WS-AWD treatment (Fig. 1; Table 4). Early season AWD followed by continuous flooding similarly resulted in grain total As levels comparable to continuous flooding (Linquist et al., 2015a). Arao et al. (2009) also showed that flooding late in the season (after heading in this case) increased inorganic As levels more than flooding early in the season (before heading). Root and shoot total As generally decrease from early tillering to grain fill, which suggests at least some early season uptake and translocation (Hu et al., 2013). Nevertheless, intermittent irrigation following the

Table 4
Grain total As concentrations for milled and brown rice samples harvested during the 2013 and 2014 growing seasons.

	Grain total arsenic (mg kg^{-1})					
Treatment[a]	2013		2014		Means	
	Brown Rice	*Milled Rice*	*Brown Rice*	*Milled Rice*	*Brown Rice*	*Milled Rice*
WS-C	0.136[b]	0.103	0.149	0.125	0.143[c] *a*	0.114 *a*
	(0.016)	(0.018)	(0.017)	(0.015)		
WS-AWD	0.054	0.037	0.051	0.041	0.053 *b*	0.039 *b*
	(0.005)	(0.002)	(0.004)	(0.004)		
DS-AWD	0.056	0.043	0.067	0.050	0.061 *b*	0.046 *b*
	(0.004)	(0.001)	(0.006)	(0.005)		

[a] The treatments are: water-seeded with conventional continuous flood irrigation (WS-C), water-seeded with alternate wetting and drying (WS-AWD), and drill-seeded with alternate wetting and drying (DS-AWD).
[b] The standard error of the mean for each value is indicated in parentheses.
[c] For each category values followed by the same letter are not significantly different at $p < 0.05$.

start of reproductive growth decreased brown rice As concentrations relative to continuous flooding by almost as much as season-long intermittent irrigation (Hu et al., 2013).

4. Conclusions

In this experiment it was found that AWD has the potential to minimize the environmental impacts of rice cultivation while maintaining optimal agronomic performance in high-yielding California rice systems. While other studies have shown that AWD can reduce GHG emissions, water use, and grain As, this has frequently come at the expense of reduced grain yield. In contrast, the AWD treatments in this study significantly reduced GHG emissions and grain total As with no reduction in grain yield. Despite these potential benefits, there are significant obstacles to the adoption of AWD in California and across the U.S.—principally limited information on AWD management at large scales and the risk of yield loss with improper management. With research focused on adapting AWD to field scales, adoption of AWD has the potential to accomplish multiple agronomic and environmental objectives, and should be considered as a viable option for GHG mitigation and rice grain As reduction.

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Impacts of variable soil drying in alternate wetting and drying rice systems on yields, grain arsenic concentration and soil moisture dynamics

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ABSTRACT

Continuously flooded rice systems are a major contributor to global rice production and food security. Allowing the soil to dry periodically during the growing season (such as with alternate wetting and drying irrigation - AWD) has been shown to decrease methane emissions, water usage, and heavy metal accumulation in rice grain. However, the effects of AWD on rice yields are variable and not well understood. A two-year study was established to quantify the impacts of a range of treatments differing in AWD severity (degree of soil drying between flooding events) on yield (as well as factors that may affect yields), soil hydrology in the soil profile, and grain arsenic (As) concentrations relative to a continuously flooded control (CF). Three AWD treatments of increasing severity were imposed between full canopy cover (around 45 days after sowing) and 50% heading: AWD-Safe (field was reflooded when the perched water table reached 15 cm below the soil surface) and AWD35 and AWD25 (field was reflooded when the soil volumetric water content at 0–15 cm depth reached 35% and 25%, respectively). During the drying periods, the 0–15 cm soil layer in the AWD-Safe remained saturated, whereas in AWD35 and AWD25 the soil dried to the desired volumetric water contents. In contrast, soil moisture at 25–35 cm below the soil surface was similar across all treatments. Yield was not reduced in any of the AWD treatments, compared to the CF control. There were no consistent differences in yield components, ^{13}C discrimination, and N dynamics. Results suggest that the availability of water and the presence of roots at the 25–35 cm soil depth during the drying periods ensured that the crop did not suffer drought stress and thus yields were maintained. Grain As concentration in the AWD-Safe treatment was similar to that in the CF control but decreased by 56–68% in AWD35 and AWD25. AWD-Safe is often promoted as a means of practicing AWD without reducing yields; however, in this study this practice did not reduce grain As concentration because the soil did not reach an unsaturated state. These findings demonstrate that knowledge of surface and subsurface hydrology, and the root system are important for understanding the potential of AWD.

1. Introduction

Rice is a staple crop for almost four billion people and the demand for rice is expected to grow through 2025 in response to increasing population (Bouman, 2007). About 75% of global rice production is grown in irrigated lowlands (IRRI, 2017), where the fields are usually continuously flooded throughout the growing season. While continuously flooded rice systems are highly productive, they are associated with a number of issues including high water use (Bouman et al., 2007b), high methane emissions (Linquist et al., 2012), and heavy metal accumulation in the grain [e.g. Zhang et al. (2010) for mercury; Zhao et al. (2010) for arsenic]. Therefore, the development of systems that maintain or increase yields while reducing these negative impacts are important for meeting sustainable intensification goals (Godfray and Garnett, 2014).

Alternate wetting and drying (AWD) has been proposed as an irrigation practice that has the potential to achieve these goals in rice systems. With AWD, fields are subjected to intermittent flooding, where

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irrigation is interrupted and water is allowed to subside via evapotranspiration and percolation until the soil reaches an aerobic state, after which the field is reflooded. Compared to continuously flooded rice systems, AWD has been shown to reduce water use by 23–33% (Carrijo et al., 2017), reduce greenhouse gas emissions (methane plus nitrous oxide) by 45–90% (Linquist et al., 2015a), and reduce methylmercury and total arsenic concentration in rice grain by 38–60% (Rothenberg et al., 2016; Tanner et al., 2018) and 50% (Das et al., 2016), respectively.

While the negative impacts of continuously flooded rice systems can be addressed with the implementation of AWD, in many cases yields are reduced. Based on a meta-analysis, Carrijo et al. (2017) found that the degree of soil drying during the drying events (termed AWD severity) was critical to ensuring that yields were maintained. They reported that compared to continuous flooding, yields were not reduced with mild AWD (soil water potential at root depth > −20 kPa or perched water did not drop below 15 cm from the soil surface) but were reduced on average by 23% with severe AWD (soil water potential at root depth < −20 kPa).

Yield reductions observed using severe AWD may be due to a number of factors. First, it may be water stress. The sensitivity of rice to unsaturated soil conditions can be attributed at least in part to its shallow root system (Parent et al., 2010). Second, AWD may result in increased N losses due to nitrification and denitrification (Pandey et al., 2014), which can lead to reduced plant N uptake. Third, allowing the soil to dry early in the season can promote weed growth (de Vries et al., 2010), leading to increased competition and lower yields. Finally, drying events can increase blast (*Magnaporthe oryzae*) pressure, a major disease of rice which reduces yields (Bidzinski et al., 2016).

There is a high degree of variation across AWD studies with respect to how yields respond to AWD (Carrijo et al., 2017). Lacking in most studies is an understanding of soil hydrology and rooting patterns throughout the rooting depth. Deep roots may be critical for water extraction during the drying periods in AWD (Ludlow and Muchow, 1990) provided that sufficient water is available at depth. Also, at issue is the question of how do AWD benefits (i.e. reductions in methane and heavy metal accumulation) vary with changes in AWD severity. Few studies have evaluated these effects despite the wide range of AWD severities reported in the literature. Therefore, the objective of this study was to establish a range of treatments differing in AWD severity to quantify impacts on yield (as well as factors that may affect yields such as yield components, N uptake, root traits, carbon isotope discrimination), soil hydrology throughout the rooting depth, and grain As concentrations.

2. Material and methods

2.1. Study site characteristics

A two-year field experiment was conducted at the Rice Experiment Station (39°27′47″N, 121°43′35″W) in Biggs, CA during the summers of 2015 and 2016. The soil at the site was a Vertisol, comprised of fine, smectitic, thermic, Xeric Epiaquerts and Duraquerts, with a soil texture of 29% sand, 26% silt and 45% clay, a pH of 5.3, 1.06% organic C and 0.08% total N (Pittelkow et al., 2012). The concentrations of total As and Cd in the soil were 3.85 mg kg^{-1} and 0.2 mg kg^{-1} respectively. Total As in the soil was measured through digestion with nitric, sulfuric and perchloric acids up to 310 °C on a programmed heating block. The digested solution was reduced so that all arsenic species were transformed to arsenite and quantified by inductively coupled plasma (ICP) atomic emission at 194 nm using hydride vapor generation (Tracy et al., 1990). Total Cd in soil was obtained through digestion with nitric acid and hydrogen peroxide in a closed vessel microwave system (Sah and Miller, 1992), followed by quantification using ICP-mass spectrometry. The climate at the site is Mediterranean with a mean annual precipitation of 472 mm and average daily temperatures of 15.5 °C (CIMIS, 2017). The total precipitation and average daily temperature during each growing season was 5.2 mm and 22.6 °C in 2015 and 10.1 mm and 21.7 °C in 2016 (CIMIS, 2017), respectively.

Table 1
Summary of management practices in 2015 and 2016.

Crop development and general management practices				
	2015		2016	
	Date	DAS	Date	DAS
Fertilization[a]	May 18th	−2	May 23rd	−1
Sowing	May 20th	0	May 24th	0
Initial flood	May 22nd	2	May 26th	2
Canopy cover ≥60%	Jul 1st	42	Jul 11th	48
50% heading	Aug 11th	83	Aug 12th	87
Pre-harvest drain	Sep 7th	110	Sep 19th	118
Harvest	Sep 30th	133	Oct 20th	149

Water management in AWD treatments						
	2015			2016		
	Date	DAS	Duration[c]	Date	DAS	Duration
Start of 1st drying period[b]	Jul 7th	48		Jul 12th	49	
AWD-Safe reflooded				Jul 15th	52	3
AWD35 reflooded	Jul 16th	57	9	Jul 19th	56	7
AWD25 reflooded	Jul 19th	60	12	Jul 22nd	59	10
Start of 2nd drying period	Jul 27th	68		Jul 26th	63	
AWD-Safe reflooded				Jul 29th	66	3
AWD35 reflooded	Aug 3rd	75	7	Aug 2nd	70	7
AWD25 reflooded	Aug 9th	81	13	Aug 5th	73	10

[a] Except for N fertilization in the microplots in 2016, which was done immediately prior to the initial flooding of the field.
[b] The start day of a drying period was considered the day when the perched water table was at the soil surface.
[c] Duration refers to the number of days from the start of a drying period to reflooding. DAS = days after sowing.

2.2. Treatments and experimental design

In 2015, two AWD treatments (AWD35 and AWD25) were compared to a continuously flooded (CF) control irrigation treatment, and an additional AWD treatment (AWD-Safe) was added in 2016. The plots were comprised of 0.3 ha basins, which were precision leveled and had no slope. The basins were separated by levees and drain ditches below the field soil level were constructed between basin levees to prevent lateral seepage between basins. Treatment position within the experimental field was re-randomized in each year. In both years, treatments were arranged in a randomized complete block design with three replications. More detailed information about the treatments and other management practices are reported in Table 1.

In the CF treatment, the field was flooded from sowing to about 3 weeks before harvest. In the AWD treatments two drying periods were imposed where the irrigation was interrupted and the floodwater (i.e. perched water table) was allowed to subside until a certain point before being reflooded. In AWD35 and AWD25 the field was reflooded when the soil moisture at 0–15 cm soil depth reached 35% and 25% volumetric water content, respectively. In AWD-Safe the field was reflooded when the perched water table reached 15 cm below the soil surface (Lampayan et al., 2015). Except for the two drying periods, irrigation, nutrient and pest management in the AWD treatments was similar to the CF control. The first drying period began in all AWD treatments when canopy cover across all plots reached a minimum of 60% (on average 45 days after planting). This was done to suppress weeds that may germinate in unsaturated soil (Rao et al., 2007) and ensure that most of the fertilizer N had been taken up to avoid N losses via coupled nitrification-denitrification (Linquist et al., 2006; LaHue et al., 2016). Canopy cover was monitored weekly (until the start of the AWD cycles) using a line quantum sensor attached to a datalogger (model Li-1400, Li-cor Inc., Lincoln, NE, USA) and was calculated as in Eq. (1):

$$Canopy\ cover(\%) = 100 \times \frac{incident\ light - transmitted\ light}{incident\ light} \tag{1}$$

where incident light is the radiation (μmol s^{-1} m^{-2}) measured above the canopy and the transmitted light is the radiation (μmol s^{-1} m^{-2}) measured below the canopy. The second drying period began in all AWD treatments approximately one week after the AWD25 treatment was reflooded (from the first drying period). All AWD treatments were reflooded from the second drying period before 50% heading. In both years, there was no precipitation during the drying periods.

2.3. Field management

In both years, 504 kg ha^{-1} of fertilizer (34-9-5-1.8 N-P-K-S) was banded at a soil depth of 5–7 cm prior to planting. This fertilizer was a blend of mono-ammonium phosphate, urea, ammonium sulfate and muriate of potash, which provided a total of 171, 45, 25 and 2 kg ha^{-1} of N, P_2O_5, K_2O and S, respectively. Seeds of the medium grain variety M-206 were broadcasted onto the dry soil at the rate of 168 kg ha^{-1}, after which the basins were flooded. Herbicides were applied as necessary during the first six weeks of crop development, as is common practice in farmers' fields and were similar for all treatments. About 3 weeks before harvest all plots were drained and allowed to dry in preparation for harvest.

2.4. Soil moisture measurements

In both years, soil volumetric water content at 0–15 cm depth was monitored throughout the season using soil sensors (Decagon Devices 10HS, Inc., Pullman, WA) connected to data loggers. The 10 cm-long sensor probes were installed vertically in the soil, with their centers being positioned at 7.5 cm soil depth. The sensor had a volume of influence of 1 L, which spanned from 0.5 to 14.5 cm soil depth. In 2015, two sensors per plot were used in all plots, whereas in 2016 one sensor per plot was used in all AWD treatments and one sensor was used in a CF plot. In all plots, sensors were installed at least 6 m from basin edges.

Soil water potential, perched water table, and soil gravimetric water content were measured only during the drying periods in 2016. Sensors were installed and measurements were taken at least 6 m from plot edges. Soil water potential was measured at 0–15 cm depth using electrical resistance sensors (Watermark 200SS, Irrometer Co Inc., Riverside, CA). The 8.3 cm-long sensor probes were installed vertically in the soil, with their centers being positioned at 7.5 cm soil depth. One sensor per plot was used in all AWD treatments and one sensor was used in a CF plot. The perched water table was measured using 5 cm diameter polyvinyl chloride tubes perforated with holes approximately 1 cm in diameter and spaced 2 cm apart. The tubes were inserted into the soil after drilling a hole of the exact same diameter and the water level inside the tube was measured with a ruler. All plots were equipped with one 20 cm deep tube (30 cm long with 20 cm below the soil surface), and two of the AWD25 plots contained one 50 cm deep tube (60 cm long with 50 cm below the soil surface). In the AWD35 plots the perched water table eventually dropped below the 20 cm tube depth and thus could not be measured. For these situations, the perched water table in the AWD35 plots was estimated to be the same as what was concomitantly measured in the 50 cm deep tubes in the AWD25 plots or, if a concomitant measurement was not taken, values were interpolated assuming a linear change between the two closest measurements in time (using both measurements from the 20 cm deep tubes and 50 cm deep tubes). Soil gravimetric water content (GWC) was measured immediately before each reflooding event in all AWD treatments, and, by means of comparison, two similar measurements were made in the CF control coinciding with the two drying periods imposed in the AWD treatments. Soil GWC was determined by taking four samples per plot to a depth of 35 cm using a 1.7 cm diameter soil core. Samples were sectioned and pooled into three soil depths (0–15 cm, 15–25 cm and 25–35 cm) and dried at 105 °C until constant weight. Soil gravimetric water content, GWC (%), was calculated as in Eq. (2):

$$GWC = 100 \times \left(\frac{W - D}{D}\right) \tag{2}$$

where: W = sample wet weight (g), D = sample dry weight (g).

2.5. Root measurements

Root measurements were taken in 2016 prior to and after the imposition of the two drying periods, so that all plots were flooded when roots were sampled. Four soil samples per plot were taken to a depth of 35 cm using a 1.7 cm diameter soil core, sectioned and pooled into the three soil depths (0–15 cm, 15–25 cm and 25–35 cm). Samples were washed to remove soil using a 0.1 mm mesh screen and roots were manually separated from organic material. Roots were scanned and analyzed using WinRHIZO software (Regent Instruments Inc., Québec City, QC, Canada) and finally dried at 60 °C and weighed. For each sample, total root length was determined. Root length density (RLD, cm root cm^{-3} soil) and specific root length (SRL, cm mg^{-1}) were calculated for each soil depth as in Eqs. (3) and (4), respectively:

$$RLD = \frac{RL}{4 \times \left(\frac{1.7}{2}\right)^2 \times \pi \times CL} \tag{3}$$

where: RL = total root length present in the sample, given by WinRHIZO (cm), and CL = sample core length (cm).

$$SRL = \frac{RL}{RM} \tag{4}$$

where: RM = oven-dried root mass present in the sample (mg).

2.6. Yield, yield components and $\Delta^{13}C$

When plants were mature, a small plot combine (2.18 m wide) was used to harvest four sample areas of approximately 13 m^2 within each treatment plot. The sample areas were at least 5 m distant from the border of the plot. Grain moisture was measured for each sample, yields were corrected to 14% moisture and the average of the four samples was considered the plot yield. Yield components were obtained by manually harvesting a 1 × 1 m (1 m^2) subplot and subsampling approximately 20% of the fresh biomass. Panicles and tillers in the subsample were counted. The number of spikelets per panicle and percentage of unfilled grains per panicle were obtained from 30 panicles representative of the subsample. Grains were oven-dried at 65 °C, weighed and adjusted to 14% moisture for the estimation of yield. Straw was oven-dried at 65 °C, weighed and the harvest index was obtained as the mass ratio of grain to total aboveground biomass. In 2016 only, grain size was determined by weighing 1000 grains and correcting for 14% moisture.

To determine if the crop experienced drought, carbon isotope composition analysis was performed on the straw dry matter obtained from the subplot used for yield component analysis. Straw samples were ground first in a laboratory mill (Model 4, Thomas Wiley, Philadelphia, PA, USA) fit with a 4 mm screen, and then in a ball mill to pass a 250 μm sieve, after which they were submitted to the Stable Isotope Laboratory at UC Davis for analysis. Carbon isotope discrimination ($\Delta^{13}C$) was calculated according to Farquhar et al. (1989) and assuming a carbon isotope composition of the air of −8%.

2.7. Field measurements for N uptake determination

Microplots (2.25 m^2) were established to quantify plant N uptake, and its partitioning between fertilizer- and soil-derived N. Immediately prior to the initial flooding of the field, microplots received 180 kg ha^{-1} of N (approximately the same rate as that applied to plots) in the form of ammonium sulfate enriched with 1.1% of ^{15}N. A solution was prepared by diluting ammonium sulfate enriched at 10 atom% into water, and 615 mL was applied uniformly to each microplot using a sprinkling can. Except for N fertilization, management in the microplots was the same as in the plots.

When plants were mature, the above ground biomass of all plants within a 0.5 m^2 area in the center of each microplot was manually harvested and a subsample of approximately 50% (fresh weight basis) was oven-dried at 65 °C until constant weight. Grains were separated from straw so that grain and straw yield were recorded separately. Straw was ground first in a laboratory mill (Model 4, Thomas Wiley, Philadelphia, PA, USA) fit with a 4 mm screen, and then in a ball mill to pass a 250 μm sieve, while grains were ground in the ball mill only. In the center of the harvested area, a 1.7 cm diameter soil core was used to take samples (five per microplot) at 0–15 cm and 15–30 cm soil depth. This same procedure was conducted outside the microplot (approximately 10 m away) for the determination of ^{15}N natural abundance. Soil samples were either air-dried (2015) or oven-dried at 60 °C (2016) until constant weight, after which they were homogenized using mortar and pestle and then ground in a ball mill to pass a 250 μm sieve. In addition, bulk density was determined using a 4.5 cm diameter soil core (one per microplot) taken inside the harvested area at the 0–15 cm and 15–30 cm soil depths. Bulk density samples were oven-dried at 105 °C until constant weight. Grain, straw and soil samples, in addition to a sample of the ^{15}N enriched fertilizer solution, were analyzed for N concentration and ^{15}N atom% concentration at the Stable Isotope Laboratory at UC Davis.

^{15}N atom% excess (AE, %) in grain, straw, soil and fertilizer was calculated as in Eq. (5):

$$AE_{grain,straw,soil,fertilizer} = AC_{grain,straw,soil,fertilizer} - AC_{nat} \tag{5}$$

where AC is ^{15}N atom% concentration (%) and AC_{nat} is ^{15}N natural abundance (%), which was determined as the average ^{15}N atom% concentration (%) of all plots soil samples (0–15 and 15–30 cm) collected outside the microplot area.

Total N (TN, kg ha^{-1}) in grain, straw and soil was calculated as in Eqs. (6) and (7):

$$TN_{grain,straw} = N_{grain,straw} \times Y_{grain,straw} \tag{6}$$

$$TN_{soil} = N_{soil} \times BD \times SD \times 10000 \tag{7}$$

where N is N concentration (g g^{-1}), Y is yield (kg ha^{-1}), BD is soil bulk density (kg m^{-3}), and SD is soil layer depth (m).

Fertilizer N recovery (FNR, %) in grain, straw and soil was calculated as in Eq. (8):

$$FNR_{grain,straw,soil} = 100 \times \frac{AE_{grain,straw,soil}}{AE_{fertilizer}} \times \frac{TN_{grain,straw,soil}}{180} \tag{8}$$

Fertilizer use efficiency (FUE, %) was calculated as in Eq. (9):

$$FUE = FNR_{grain} + FNR_{straw} \tag{9}$$

Fertilizer loss (Loss, %) was calculated as in Eq. (10):

$$Loss = 100 - (FNR_{grains} + FNR_{straw} + FNR_{soil}) \tag{10}$$

Plant total N uptake (N_{total}, kg ha^{-1}) was calculated as in Eq. (11):

$$N_{total} = TN_{grain} + TN_{straw} \tag{11}$$

Plant N uptake derived from the fertilizer ($N_{fertilizer}$, kg ha^{-1}) was calculated as in Eq. (12):

$$N_{fertilizer} = \frac{(FNR_{grain} + FNR_{straw}) \times 180}{100} \tag{12}$$

Plant N uptake derived from the soil (N_{soil}, kg ha^{-1}) was calculated as in Eq. (13):

$$N_{soil} = N_{total} - N_{fertilizer} \tag{13}$$

2.8. Grain total As concentration

Rice grains were dehulled, polished, and ball milled to pass a 250 μm sieve. Samples of 0.5 g (two analytical replicates per plot) were digested in glass digestion tubes by adding 5 mL of nitric acid (trace metal grade, 67–70%, Fisher Chemical, USA) and allowing it to dissolve overnight at room temperature. Samples were further digested in a heating block at 105 °C until the cessation of a brown fog, and then at 120 °C until complete dryness. The ash was re-dissolved with 10 mL of 0.28 M nitric acid and filtered using a syringe filter (0.45 μm), taking care to discard the first 1 mL of the filtrate. The extract was then diluted 5-fold with 18.2 MΩ cm water (Barnstead Nanopure).

Total As in samples was quantified by inductively coupled plasma mass spectrometry (ICP-MS 7900, Agilent Technologies, Santa Clara, CA, USA) with a detection limit of 0.01 μg L^{-1}. As was monitored at m/z of 75 and selenium was also monitored (m/z 77, 78 and 82) to check for polyatomic $^{40}Ar^{35}Cl$ interferences on m/z 75. No interferences were observed. Every 10 samples, one blank, one fortified sample, and one certified reference material (1568b, National Institute of Standards and Technology, Gaithersburg, MD, USA) were included as quality control samples. All quality control elements were within the standard quality control criteria, as defined in the FDA Elemental Analysis Manual (FDA, 2012).

2.9. Data analysis

All statistical analyses were performed in R software (R Core Team, 2016). For all measurements with the exception of RLD and SRL, a linear model was fit for each year of experiment including block and treatment as fixed effects. An analysis of variance was conducted followed by means separation using the Fisher Least Significant Difference method. Analyses on RLD and SRL were done by fitting a linear mixed effects model with block, treatment and time (and the interaction between treatment and time) as fixed effects and plot as a random effect, and an analysis of variance was followed by means separation using the Tukey test.

3. Results

3.1. Soil moisture dynamics during the drying periods

The duration of the drying periods in the AWD treatments (i.e. from the day the perched water table was at the soil surface until the field was reflooded) varied from 3 days in AWD-Safe to 13 days in AWD25 (Table 1). From sowing to maturity (pre-harvest drain), volumetric water content (VWC) in the 0–15 cm soil profile in the CF control averaged 47% in 2015 and 50% in 2016 (Fig. 1). In the AWD-Safe treatment, the minimum VWC was 41% and 44% in the first and second drying periods of 2016, respectively. In both years, the minimum VWC in the AWD35 and AWD25 treatments was close to what was targeted and ranged from 30 to 33% in AWD35 and 24 to 28% in AWD25.

Soil water potential (SWP) at 0–15 cm depth never dropped below zero in the CF, as expected (Fig. 2a). Similarly, in the AWD-Safe treatment the SWP never dropped below zero even during the two drying periods. In contrast, negative SWP values were observed in the AWD35 and AWD25 treatments beginning four days after the start of each drying period (i.e. perched water table at the soil surface). The minimum SWP, measured immediately before the first and second

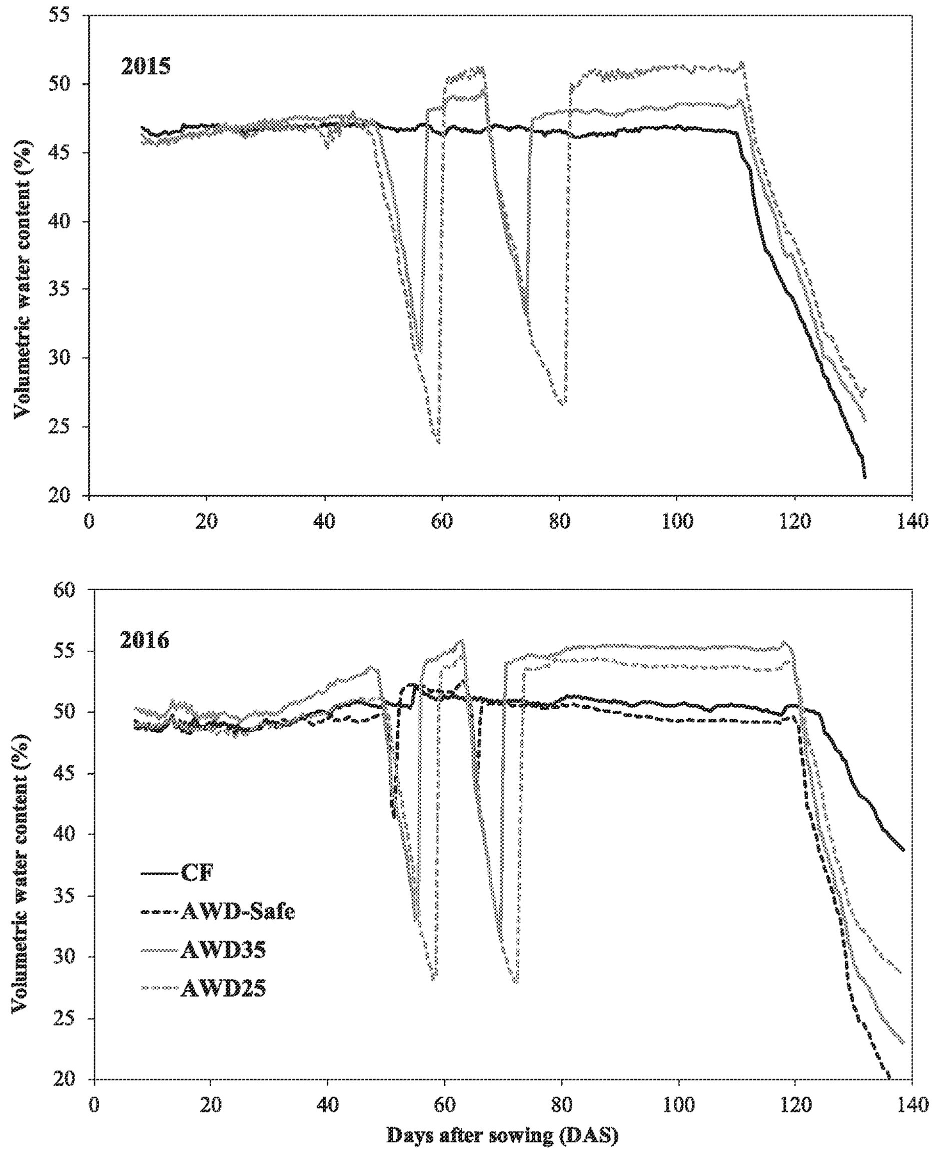

Fig. 1. Volumetric water content measured throughout the season at 0–15 cm depth. Average standard error across all measurements was 0.84%, 0.77%, and 0.85% in CF, AWD35 and AWD25, respectively, in 2015, and 1.1%, 1.4%, and 1.7% in AWD-Safe, AWD35 and AWD25 in 2016.

reflooding events was, respectively, −32 kPa and −35 kPa in AWD35, and −69 kPa and −73 kPa in AWD25.

The perched water table, measured when the drying periods were imposed in the AWD treatments in 2016, averaged 13 cm above the soil in CF (Fig. 2b). The AWD-Safe was reflooded when the perched water table was −19 cm (first drying period) and −20 cm (second drying period), thus slightly lower than the targeted value of −15 cm. The AWD25 was reflooded when the perched water table was −38 cm and −43 cm at the end of the first and second drying periods, respectively. The estimated perched water table in the AWD35 treatment was −31 cm and −34 cm at the end of the first and second drying periods, respectively.

While SWP and VWC were measured only at 0–15 cm, gravimetric water content (GWC) was measured at deeper soil layers immediately before each reflooding event. At 0–15 cm soil depth, GWC followed the same trend as VWC, increasing in the order: AWD25 < AWD35 < AWD-Safe < CF, although the difference between AWD-Safe (44 and 42% at the end of the first and second drying period) and CF (47% at the end of both periods) was not significant (Fig. 3). Differences between the treatments became less evident with increasing soil depth and were not significant at 25–35 cm, with GWC ranging across treatments from 26 to 30% and from 25 to 29% at the end of the first and second period, respectively. In addition, GWC changes with soil depth were different between the treatments. For example, in the CF, AWD-Safe and AWD35 treatments, GWC decreased with soil depth, with the decline being highest in the CF treatment and lowest in the AWD35 treatment. In contrast, GWC increased slightly with soil depth in the AWD25 treatment.

3.2. Crop parameters

The AWD treatments did not impact yield in either year compared to the CF control (Table 2). Averaged across treatments, yields were 13.7 t ha^{-1} in 2015 and 11.3 t ha^{-1} in 2016. Similarly, there were no consistent differences in the measured yield components between treatments (Table S1, Supplementary Material). On average, respectively for 2015 and 2016, there were 880 and 559 tillers per m^2, 873 and 553 panicles per m^2, 85 and 91 grains per panicle, 14% and 8% unfilled grains, and a harvest index of 50% and 51%. In 2016, the 1000-grain weight at 14% moisture was 30 g.

Carbon isotope discrimination analysis showed similar $\Delta^{13}C$ values across the treatments in both years. Averaging across treatments, $\Delta^{13}C$

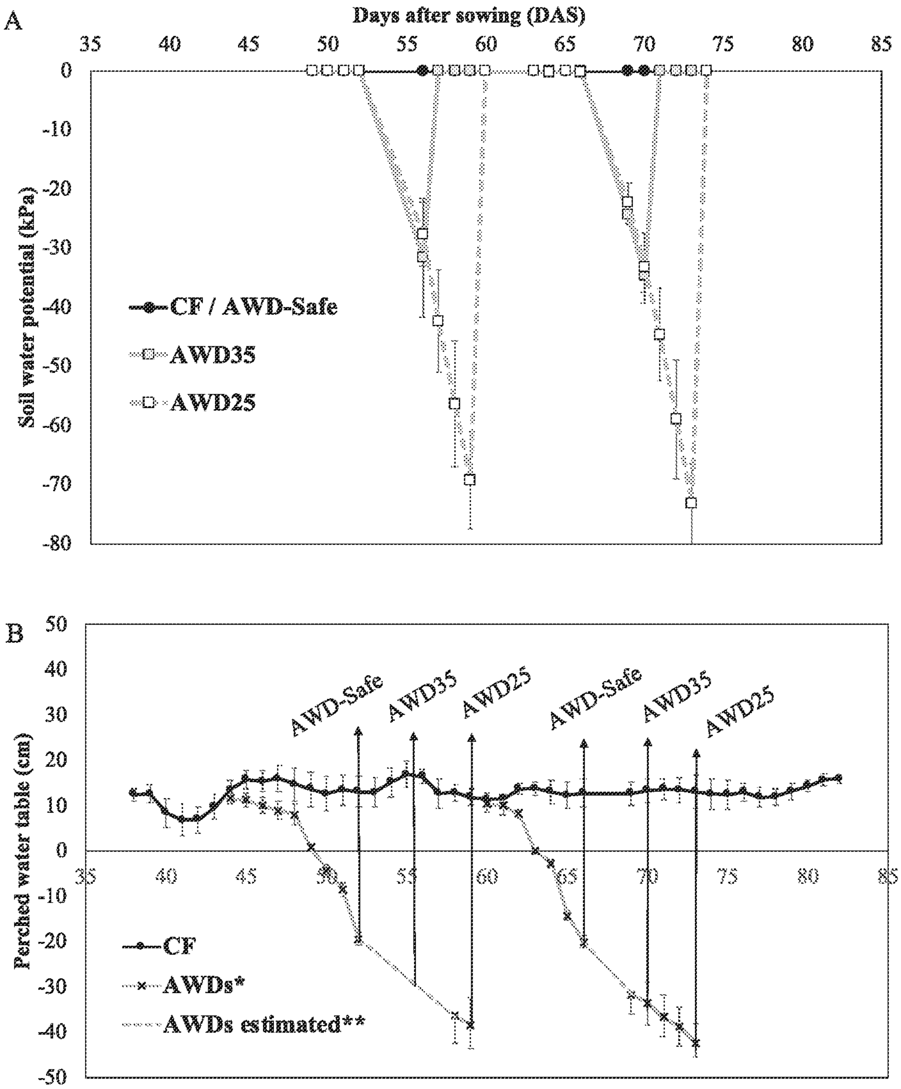

Fig. 2. Soil water potential at 0–15 cm soil depth (A) and perched water table (B) measured throughout the AWD cycles in 2016. Arrows indicate reflooding events. Bars represent standard errors of means.

*AWDs: values above −20 cm are averages of all AWD plots (n = 9), measured using the 20 cm deep tubes, and values below −20 cm are averages of two AWD25 plots, measured using the 50 cm deep tubes. **AWDs estimated: values were obtained by interpolation.

values were 20.5‰ (ranging from 20.4 to 20.6‰) in 2015, and 20‰ (ranging from 19.4 to 20.2‰) in 2016 (Table S1, Supplementary Material).

In both years, there were no differences in plant total N uptake between treatments (Table 3). Similarly, in both years, plant N contributions from soil and fertilizer, FUE and the total amount of fertilizer N unaccounted for (Loss) were the same among treatments. Averaged across treatments, N recovery in soil at the 0–15 cm depth was 22% in

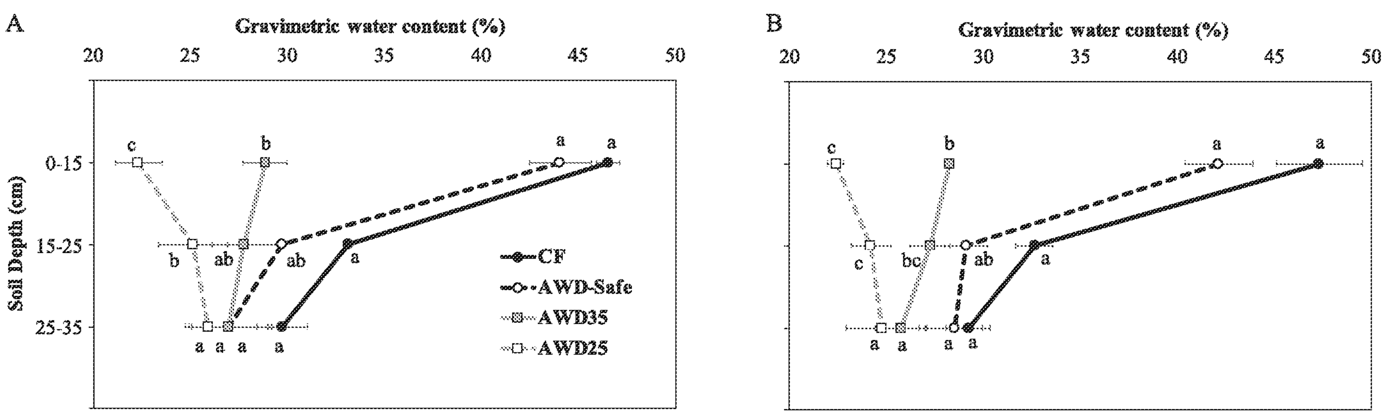

Fig. 3. Soil gravimetric water content at the end of the first (A) and second (B) drying periods in 2016. Measurements in AWD treatments were made immediately prior to reflooding. Measurements in CF were made coinciding with each drying period for comparison. Bars represent standard errors of the means. For each soil depth and drying period, different letters indicate significant differences ($p < 0.05$) between the treatments.

Table 2
Yield (adjusted to 14% moisture) in 2015 and 2016. There was not an AWD-Safe treatment in 2015. Numbers in parenthesis are standard errors. Different letters in a column indicate significant differences ($p < 0.05$) between treatments.

	Yield (t ha^{-1})	
Treatment	2015	2016
CF	13.8 (0.08) a	11.4 (0.08) a
AWD35	13.5 (0.15) a	11.4 (0.09) a
AWD25	13.7 (0.43) a	11.1 (0.28) a
AWD-Safe		11.4 (0.18) a

Table 3
Plant (straw + grain) total N uptake (N_{total}), based on N analysis. Fertilizer-derived N uptake ($N_{fertilizer}$), soil-derived N uptake (N_{soil}), fertilizer use efficiency (FUE) and fertilizer losses (Loss) are based on ^{15}N analysis. Numbers in parenthesis are standard errors of means (n = 3). Within each year, different letters in a column indicate significant differences ($p < 0.05$) between treatments.

Treatment	Year	N_{total} (kg ha^{-1})	$N_{fertilizer}$ (kg ha^{-1})	N_{soil} (kg ha^{-1})	FUE (%)	Loss (%)
CF	2015	157 (11) a	59 (8) a	98 (4) a	33 (5) a	49 (6) a
AWD35		158 (8) a	51 (6) a	107 (5) a	28 (3) a	44 (5) a
AWD25		144 (18) a	42 (4) a	102 (15) a	23 (2) a	48 (6) a
CF	2016	139 (20) a	33 (1.3) a	106 (22) a	18 (0.7) a	41 (3) a
AWD35		124 (4) a	33 (2.7) a	91 (4) a	19 (1.5) a	42 (12) a
AWD25		140 (3) a	34 (0.3) a	106 (2) a	19 (0.2) a	30 (16) a
AWD-Safe		157 (4) a	40 (2.3) a	117 (5) a	22 (1.3) a	33 (9) a

2015 and 43% in 2016, and at the 15–30 cm depth was 3% in 2015 and 1% in 2016 (data not shown).

Root length density (RLD) and specific root length (SRL) were determined before and after the imposition of the two drying periods. There was no difference between treatments in the initial RLD and SRL measurements taken before the drying periods were imposed (Table 4). After the AWD treatments were imposed, the RLD at 0–15 cm and 15–25 cm soil depth was similar in all treatments; however, at the deepest soil layer measured (25–35 cm) RLD was higher in AWD-Safe (1.6 cm cm^{-3}) than in CF and AWD25 (both being 0.8 cm cm^{-3}), while plants in AWD35 had an intermediate RLD (1.4 cm cm^{-3}). Across all treatments, final RLD at 25–35 cm represented only 6% of total RLD, whereas 89% of total RLD was found in the top 15 cm of the soil. The SRL after the imposition of the treatments was not different between the treatments in any of the soil depths measured.

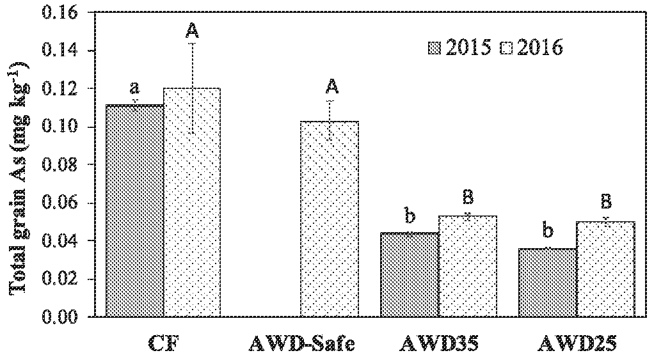

Fig. 4. Grain arsenic concentration in polished rice. Bars represent standard errors of means. Different lower and upper-case letters indicate significant differences ($p < 0.05$) between the treatments in 2015 and 2016, respectively.

3.3. Grain arsenic concentration

In both years, the AWD35 and AWD25 treatments provided similar reductions in grain As concentration (61% and 68% in 2015, 56% and 58% in 2016, respectively) compared to CF (Fig. 4). In contrast, the AWD-Safe treatment had similar grain As concentration as the CF control.

4. Discussion

4.1. Soil moisture dynamics and crop parameters

This study evaluated a range of AWD severities. In the least severe treatment (AWD-Safe) the soil at 0–15 cm depth remained near saturation (i.e. SWP close to 0) and required a drying period of 3 days. In the AWD35 treatment the SWP (0–15 cm) reached −34 kPa and required a drying period of 7 days. In the most severe drying treatment (AWD25), the SWP (0–15 cm) reached −71 kPa and required a drying period of 11 days. Carrijo et al. (2017) in their analysis of factors affecting yields under AWD classified drying periods as severe (below −20 kPa) and mild (greater than −20 kPa). Based on this, both AWD35 and AWD25 are considered severe drying periods, which usually lead to yield penalties (Carrijo et al., 2017). Despite this, yields and yield components were not affected in our study.

One concern with introducing aerobic periods is the potential for nitrogen losses via nitrification and subsequent denitrification. However, N dynamics were not affected by the different water management treatments as plant total N uptake, including the partitioning between fertilizer- and soil-derived N, were similar among treatments in each year (Table 3). Others (e.g., Reis et al., 2018; LaHue et al.,

Table 4
Root length density and specific root length at different soil depths measured prior to (initial) and after (final) the two AWD drying cycles in 2016 (i.e. all measurements taken during flooded soil conditions). Numbers in parenthesis are standard errors of means. Within each root trait, different letters in a column indicate significant differences ($p < 0.05$) between the treatments.

		Initial			Final		
Soil depth (cm)		0–15	15–25	25–35	0–15	15 –25	25–35
Root length density (cm cm^{-3})	CF	6.9 (1.4) a	1.5 (0.5) a	1.5 (0.6) a	17 (6.7) a	1.5 (0.3) a	0.8 (0.03) b
	AWD-Safe	4.0 (0.8) a	1.4 (0.7) a	1.5 (0.3) a	20.7 (2.5) a	1.5 (0.4) a	1.6 (0.2) a
	AWD35	4.4 (0.2) a	1.1 (0.2) a	1.7 (0.5) a	18.9 (1.2) a	1 (0.1) a	1.4 (0.2) ab
	AWD25	6.2 (2) a	1.4 (1) a	1.2 (0.2) a	20 (0.9) a	1 (0.1) a	0.8 (0.04) b
Specific root length (cm mg^{-1})	CF	15.4 (1.1) a	18.1 (4.7) a	14.6 (0.8) a	17.7 (5.5) a	11.7 (0.9) a	12.8 (2.3) a
	AWD-Safe	16.1 (1.5) a	13.4 (2.0) a	21.7 (6.3) a	27.3 (3.9) a	13.6 (1.6) a	19.7 (1.9) a
	AWD35	16.9 (2.0) a	27.3 (8.4) a	17.2 (2.3) a	20.3 (2.3) a	16.6 (6.9) a	21.5 (1.2) a
	AWD25	14.8 (1.0) a	21.3 (4.3) a	14.7 (1.0) a	24.3 (3.4) a	12.5 (2.7) a	14.3 (4.7) a

2016) reported similar findings, and LaHue et al. (2016) attributed the lack of difference in total N uptake on the fact that the drying and reflooding events occurred when there was little mineral N in the soil. Indeed, the decision to delay the first drying event until canopy coverage (about 45 days after planting) was to ensure low soil mineral N levels during the dry down period. Dong et al. (2012) found that AWD triggered N losses via nitrification and denitrification compared to a flooded control; however, those losses were quantitatively insignificant and did not affect total plant N uptake or fertilizer use efficiency. Fertilizer N losses were similar between years and ranged from 30 to 49% (Table 3). These losses are roughly comparable to the 50% reported by Bird et al. (2001), also in California rice systems. Further, the small fraction of ^{15}N recovered at 15–30 cm soil depth suggest that fertilizer loss by leaching was negligible. Rice soils in California are typically heavy clays with low percolation, and nitrate leaching has been shown to be negligible (Liang et al., 2014). These results indicate that if AWD as practiced here is implemented, no additional input of N fertilizer is required.

Carbon isotope composition analysis can be used as an indicator of water stress since stressed tissues often show higher ^{13}C composition and thus lower discrimination against the heavier isotope (lower $\Delta^{13}C$ values) as a result of a decrease in stomatal conductance (Lambers et al., 2008). Lower discrimination, represented by $\Delta^{13}C$ values, have been reported as a result of drought stress in rice (Centritto et al., 2009; Kondo et al., 2004). Carbon isotope discrimination analysis performed on the vegetative plant tissues showed no differences between treatments. Thus, our results indicate that plants in the AWD treatments did not encounter drought stress, supporting the fact that there was no yield reduction, compared to CF.

Unique and important for understanding the results of this study is the quantification of soil moisture below what is typically considered the rice root zone (0–15 cm). The analysis of GWC in the soil profile during the drying periods indicated that differences in soil moisture across treatments became less with soil depth and at the deepest depth examined (25–35 cm) were not significantly different from each other. Assuming that the soil in the CF treatment was saturated at 25–35 cm during the time the AWD treatments were drying (which all happened after the CF treatment had been flooded for at least 48 days), this soil layer was also saturated in the AWD treatments. Thus, even though during the drying periods in AWD35 and AWD25 the soil was dry at the surface (0–15 cm), it was moist at deeper soil layers.

If deeper soil layers played a major role in supplying water during the drying periods in AWD, there should be a sufficient amount of roots in these layers to meet transpiration demands. We found that while 88% of total RLD were in the 0–15 cm depth, in all treatments there were roots down to 35 cm deep. In upland rice, Kondo et al. (2000) found that maximum water extraction rates per unit length of root can be as high as 0.08 mL/day/cm in parts of the roots exposed to moist soil. Assuming that the same rates can be achieved in lowland systems such as the one in this study, the amount of deep roots (25–35 cm) present in the AWD35 and AWD25 treatments could take up more than 9 mm/day when functioning at maximum rates. Thus, despite representing only 6% of the total RLD, the amount of roots present at 25–35 cm soil depth may have been sufficient to maintain water extraction near normal transpiration rates (Linquist et al., 2015b; Montazar et al., 2017).

These results suggest that while AWD-Safe is indeed a safe practice that can be applied in a range of environments without causing yield reductions (Lampayan et al., 2015), more severe AWD drying periods are possible in certain circumstances. Understanding the hydrology and rooting patterns at deeper soil depths is critical to know whether rice can tolerate drier surface level conditions. Our results suggest that yields were maintained in AWD due to the availability of water at deeper soil layers and the presence of roots in this layer. This may have been caused by a shallow groundwater table and/or by groundwater capillary rise as it has been found to be a significant source of water in aerobic rice systems (Bouman et al., 2007a). This area of the Sacramento Valley has a shallow water table that is less than 1 m below the soil surface (CA DWR, 2017).

4.2. Grain arsenic concentration

The accumulation of As in rice grain is enhanced in CF systems because anaerobic soil conditions increase the bioavailability of As in the soil by: [1] favoring the reduction of As^{5+} to As^{3+}, which is more mobile in the soil, and [2] favoring the reduction of Fe^{3+} to Fe^{2+}, dissolving iron plaques containing As and allowing As to enter the soil solution (Meharg and Zhao, 2012). Further, the reduction of Fe^{3+} to Fe^{2+} also favors the movement of Fe^{2+} from the bulk soil to aerated portions of the root surface causing the formation of new iron plaques that can accumulate As (Yamaguchi et al., 2014). Thus, the potential of AWD to reduce grain As concentration is due to improved soil aeration caused by the introduction of drying periods (Bakhat et al., 2017). The AWD-Safe treatment did not decrease grain As concentration compared to CF likely because the soil moisture at 0–15 cm depth was maintained near saturation throughout the drying periods (Fig. 2A), suggesting that the soil was not aerated enough to decrease soil As bioavailability. Other studies (Arao et al., 2009; Linquist et al., 2015b; Das et al., 2016; LaHue et al., 2016) that reported reductions in grain As concentrations with AWD had AWD treatments that were more severe than the AWD-Safe treatment used here. However, Norton et al. (2017) recently reported a 14–26% decrease in grain As concentrations under AWD-Safe practices. Importantly, depending on the soil and field characteristics, AWD-Safe may cause the SWP to drop to lower levels (down to ≈ -15 kPa) than those seen here (Lampayan et al., 2015), but SWP was not reported by Norton et al. (2017). A more direct determinant of soil As availability is soil redox potential (Eh) (Masscheleyn et al., 1991). For example, Honma et al. (2016) reported that total dissolved As concentration in soil was very low (7.7 $\mu g\ L^{-1}$) when soil Eh was above -100 mV. Establishing relationships between soil Eh and soil moisture may help determine how AWD can be most effective in decreasing As uptake.

While AWD-Safe did not impact grain As concentration in our study, both AWD35 and AWD25 decreased grain As concentration by a similar magnitude of 56%–68% (Fig. 4). In a soil containing four times more As, two AWD treatments that were more severe than the AWD35 and AWD25 treatments decreased grain As concentration by a similar magnitude of 46%–66% (Linquist et al., 2015b). A similar decrease in grain As concentration was observed with an AWD reflooded at 40% of saturated VWC in a soil containing even higher As concentration (Das et al., 2016). These findings suggest that, independent of soil As content, drying the soil further than what was achieved in the AWD35 treatment does not necessarily promote further decrease in grain As concentration.

Although only total As concentrations were determined in this study, it is important to consider As species composition in rice grain since the inorganic forms are more toxic than the methylated (organic) forms (Mandal and Suzuki, 2002). Because demethylation reactions are favored by aerobic conditions, inorganic species usually compose a greater fraction of total As concentration in aerated soils compared to flooded soils, and this pattern is usually reflected in the grain (Meharg and Zhao, 2012). Consequently, reductions in total As observed here with AWD35 and AWD25 may translate into less pronounced reductions in inorganic As, as it has been observed by others (Das et al., 2016).

5. Conclusions

Despite other studies showing that severe AWD, such as the ones imposed here (AWD35 and AWD25), decrease yield compared to continuously flooded systems, yields were not reduced and plants did not encounter water stress. This was likely because water was available deeper in the soil profile (25–35 cm) and the roots in this layer provided sufficient water uptake to maintain plant transpiration. In addition to maintaining yields, the AWD35 and AWD25 treatments decreased grain arsenic concentration by 56–68%. In the AWD-Safe treatment, the least severe of the AWD treatments imposed here, yields were also maintained compared to CF, corroborating with what other studies have observed; however, grain As concentration did not decrease because the soil did not become sufficiently aerobic. These results show that if AWD is to serve as a mitigation practice for grain As accumulation, soils may need to dry further than what was achieved with AWD-Safe. Importantly, these outcomes are not necessarily universal and soil water thresholds observed here may be different depending on the soil type and texture. Understanding the surface and subsurface hydrology and root distribution will help determine the appropriate level of drying severity for AWD practices.

Acknowledgments

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.fcr.2018.02.026.

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From: Hawk,Nina E [NHawk@mwdh2o.com]
Sent: 6/9/2021 8:55:45 AM
To: Laurie Warner Herson [laurie.warner.herson@phenixenv.com]
CC: Neudeck,Randall D [rneudeck@mwdh2o.com]; Alicia Forsythe [aforsythe@sitesproject.org]
Subject: RE: Catch up on Sites Envr Planning

Good Morning Laurie,

Thanks for the confirmation and we look forward to getting the links to the portal. We will keep an eye out.

Have a great day!

Nina E. Hawk
Bay Delta Initiatives Policy Manager
Mobile: (510) 299-8289
nhawk@mwdh2o.com
Metropolitan Water District of Southern California
1121 L Street Ste. 900, Sacramento, CA 95814

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

From: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Sent: Wednesday, June 9, 2021 6:13 AM
To: Hawk,Nina E <NHawk@mwdh2o.com>
Cc: Neudeck,Randall D <rneudeck@mwdh2o.com>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Catch up on Sites Envr Planning

Hi Nina,

I reached out to Jerry yesterday and he confirmed that we will be providing access to all admin RDEIR/SDEIS chapters and appendices through the participant portal. I am working with staff this morning to set up the files and Jerry will be sending out a link later to the all RC participants with cc to AB members.

Thank you for your patience as we set this up –

Laurie

From: Hawk,Nina E <NHawk@mwdh2o.com>
Sent: Tuesday, June 8, 2021 4:31 PM
To: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Cc: Neudeck,Randall D <rneudeck@mwdh2o.com>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: FW: Catch up on Sites Envr Planning

Hello Laurie,

I sent an email to Ali and see she is enjoying some much deserved time away (on vacation). I wanted to specifically request that MWD receive copies of the EIR and EIS chapters for review. Our understanding is some chapters have already been shared with regulatory agencies, including fishery agencies, and our team has not seen them.

Is there an easy share drive and/or link that can be provided for access? I have included a copy of the Confidentially Agreement for your ease that covers the sharing of such information (EIR and CEQA documents) which was executed for this purpose.

Thank you and any questions please let me know.

Look forward to hearing from you.

Nina E. Hawk
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THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, June 8, 2021 4:23 PM
To: Hawk,Nina E <NHawk@mwdh2o.com>
Subject: Automatic reply: Catch up on Sites Envr Planning

Thank you for your email. I am on vacation from June 5 to June 20. I will have limited access to email and cell reception.

If you need immediate help, please contact the following individuals:

For Sites Planning, Laurie Warner Herson at laurie.warner.herson@phenixenv.com

For Sites Permitting, John Spranza at John.Spranza@hdrinc.com

For Sites Water Operations, Erin Heydinger at Erin.Heydinger@hdrinc.com

I will return your message as soon as possible. Thank you!

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

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From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/9/2021 9:51:22 AM
To: Bruce Linquist [balinquist@ucdavis.edu]; Huber, Anne [Anne.Huber@icf.com]; Tim Johnson [tjohnson@calrice.org]; pbuttner@calrice.org; Alicia Forsythe [aforsythe@sitesproject.org]; Diana.Roberts@icf.com; Laurie Warner Herson [laurie.warner.herson@phenixenv.com]; Williams, Nicole (Nicole.Williams@icf.com) [Nicole.Williams@icf.com]
Subject: RE: Rice papers on Hg and As

Thank you very much for sending these!

John Spranza

D 916.679.8858 M 818.640.2487

From: Bruce Linquist <balinquist@ucdavis.edu>
Sent: Tuesday, June 8, 2021 5:03 PM
To: Spranza, John <John.Spranza@hdrinc.com>; Huber, Anne <Anne.Huber@icf.com>; Tim Johnson <tjohnson@calrice.org>; pbuttner@calrice.org; Alicia Forsythe <aforsythe@sitesproject.org>; Diana.Roberts@icf.com; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Williams, Nicole (Nicole.Williams@icf.com) <Nicole.Williams@icf.com>
Subject: Rice papers on Hg and As

Hi John et al,
Attached are some papers related to Hg and As in rice. The first two are related to Hg. One is a review of CA literature and the other has actual data.

The arsenic papers have relatively little about the influence of water; however, from those you will see some values on rice grain As. Importantly, most of the As related papers are from a single location. The values you should be looking at are the treatments that were continuously flooded.

I hope this helps,
Bruce

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Friday, May 28, 2021 9:39 AM
To: Bruce Linquist <balinquist@ucdavis.edu>; Huber, Anne <Anne.Huber@icf.com>; Tim Johnson <tjohnson@calrice.org>; pbuttner@calrice.org; Alicia Forsythe <aforsythe@sitesproject.org>; Diana.Roberts@icf.com; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Williams, Nicole (Nicole.Williams@icf.com) <Nicole.Williams@icf.com>
Subject: RE: Sites Reservoir Project Agronomy and Water Quality Discussion: Doodle Poll

Hey folks, this is a friendly reminder to take the poll so I can get this scheduled.
Thanks.
John

John Spranza

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From: Spranza, John
Sent: Wednesday, May 26, 2021 1:39 PM
To: balinquist@ucdavis.edu; Huber, Anne <Anne.Huber@icf.com>; Tim Johnson <tjohnson@calrice.org>; pbuttner@calrice.org; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Diana.Roberts@icf.com; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: RE: Sites Reservoir Project Agronomy and Water Quality Discussion: Doodle Poll

Hello,
Please use the link below to provide your availability for a meeting to discuss the topics identified in the email thread below.
Thanks.
John

https://doodle.com/poll/87z3nfcxeadv5hi7?utm_source=poll&utm_medium=link

John Spranza

D 916.679.8858 M 818.640.2487

From: Spranza, John
Sent: Tuesday, May 25, 2021 9:02 AM
To: balinquist@ucdavis.edu
Cc: Huber, Anne <Anne.Huber@icf.com>; Tim Johnson <tjohnson@calrice.org>; pbuttner@calrice.org; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Diana.Roberts@icf.com; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: Sites Reservoir Project Agronomy and Water Quality Discussion

Dr. Linquist,
I am part of the team that is leading the environmental permitting and planning effort for the Sites Reservoir Project. We're in the midst of preparing our Revised Draft EIR/Supplemental Draft EIS and have been meeting with environmental NGOs on the Project and Project effects.

Through our analysis efforts and discussions with Tim and Paul at the Rice Commission some concerns that have been raised in our NGO meetings are still outstanding and we wanted to see if you had any time in the near future to speak with us. We have the following topics we would like to discuss:

1. Optimal water temperatures for rice throughout the year. This comes into play in releases from Sites back into the TC Canal and the GCID Main Canal.
2. Rice and mercury effects.
3. Rice and arsenic effects.

I can send out a Doodle Poll to help schedule time if that would work best for you.

Thanks
John

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

HDR

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California American Water
Sites Reservoir Evaluation Meeting

Location:	Teams Meeting
Date:	July 1, 2021
Time:	10:30 am – 12:00 pm
Attendees - Sites:	Jerry Brown
Attendees - CalAm:	Ian Crooks, Kent Hodgkinson, Candace Coleman
Attendees - WY:	Charles Duncan, Lindsay Smith, Polly Boissevain, Amy Kwong

AGENDA ITEMS

1. INTRODUCTIONS, REVIEW AGENDA **10:30 — 10:40: Charles Duncan**

2. PROJECT OVERVIEW/OBJECTIVES **10:40 — 10:50: Ian Crooks**

3. SITES RESERVOIR STORAGE **10:50 — 11:20: Jerry Brown**

    a. How much supply is available by year type?

    b. Under what year types will water be stored and subsequently diverted from Sites?

    c. What does the modeling indicate in terms of long-term supplies (quantity and reliability)?

    d. What climate change considerations were included in the modeling?

    e. Confirm how water will be delivered for diversion from the Sac River?

    f. When would a decision from CalAm be required regarding its participation or agreement to proceed with an option for future participation?

    g. Who are the other project participants and how much water is allocated to each?

    h. What is the projected cost for water?

    i. What is the status of the project? When is water expected to be available from Sites? What are the obstacles you see to meeting these goals?

4. AG DISTRICTS – WET YEAR SUPPLY **11:20 — 11:40: Jerry Brown**

    a. Which Ag Districts have committed to purchasing storage capacity at Sites and can you provide us with their contact information?

    b. Has any modeling been done to indicate the quantity and reliability of water by year type?

5. DISCUSSION/SITES QUESTIONS FOR CAL AM **11:40 — 11:50: All**

6. ACTION ITEMS, NEXT STEPS **11:50 — 12:00: Lindsay Smith**

From: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Sent: 6/11/2021 9:52:12 AM
To: Eric Leitterman [ELeitterman@valleywater.org]
CC: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: RE: Sites South of Delta/SWP Modeling

Hi Eric,

Apologies for the delay on this and thanks for the reminder. I thought I had sent this out but looked back and could not find it. Here is the table, where an X indicates model runs that have been performed and are available.

	Project Size/Level of Federal Investment	Historic hydrology	2035 Central Tendency Climate Change	2030 WSIP Climate Change	2070 WSIP Climate Change
No Action	No project	X	X	X	X
Alternative 1A	1.5 MAF No federal funding	X	X		
Alternative 1B	1.5 MAF 7% federal funding	X	X	X	X
Alternative 2	1.3 MAF No federal funding	X	X		
Alternative 3	1.5 MAF 25% federal funding	X	X		

I will also send this out to the full workgroup after next week's meeting.

Thanks!
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

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From: Eric Leitterman <ELeitterman@valleywater.org>
Sent: Wednesday, May 26, 2021 1:51 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Sites South of Delta/SWP Modeling

Hi Erin

Did you ever send out the table of alternatives you mentioned your email below? I can't find it in my records and may have missed it.

ERIC LEITTERMAN
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Water Supply Division

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Clean Water · Healthy Environment · Flood Protection

From: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Sent: Monday, April 19, 2021 10:08 AM
To: 'fhernandez@cityofamericancanyon.org' <fhernandez@cityofamericancanyon.org>; Dwayne Chisam <DChisam@avek.org>; 'Robert Cheng' <RCheng@cvwd.org>; pvasileva@cvwd.org; Mark Krause <MKrause@dwa.org>; Paul Weghorst <weghorst@irwd.com>; Kellie Welch <welch@irwd.com>; 'Randall Neudeck' <rneudeck@mwdh2o.com>; 'CWang (cwang@mwdh2o.com)' <cwang@mwdh2o.com>; Bradshaw,Dee <VBradshaw@mwdh2o.com>; Sheehan,Rebecca D <RSheehan@mwdh2o.com>; Dan Bartel <dbartel@rrbwsd.com>; 'Bob Tincher' <bobt@sbvmwd.com>; Heather Dyer <heatherd@sbvmwd.com>; Jeff Davis <jdavis@sgpwa.com>; Eric Leitterman <ELeitterman@valleywater.org>; 'Dirk Marks' <dmarks@scvwa.org>; 'AFlores (AFlores@zone7water.com)' <AFlores@zone7water.com>; Xie, Lillian <lxie@zone7water.com>; cchilmakuri@swc.org; leckhart@sgpwa.com; Rob Kunde <rkunde@wrmwsd.com>
Cc: Jerry Brown <jbrown@sitesproject.org>; JP Robinette <JRobinette@BrwnCald.com>; Alicia Forsythe <aforsythe@sitesproject.org>; steve.micko@jacobs.com; Thayer, Reed/SAC <Reed.Thayer@jacobs.com>; Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Subject: RE: Sites South of Delta/SWP Modeling

Good morning,

Thank you for your participation in last week's modeling meeting. Attached is the PowerPoint presentation. I will also be following up with a table describing the alternatives that have been modeled and the associated hydrology. Please reach out if you would like any of the data or available results we discussed. For those of you who have already requested information, I will be getting back to you shortly.

Best,
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

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-----Original Appointment-----
From: Heydinger, Erin
Sent: Wednesday, March 31, 2021 5:13 PM
To: Heydinger, Erin; fhernandez@cityofamericancanyon.org; Dwayne Chisam; Robert Cheng; pvasileva@cvwd.org; Mark Krause; Paul Weghorst ; Kellie Welch; Randall Neudeck; CWang (cwang@mwdh2o.com); Bradshaw,Dee; Sheehan,Rebecca D; Dan Bartel; Bob Tincher; Heather Dyer; Jeff Davis; ELeitterman@valleywater.org; Dirk Marks; AFlores (AFlores@zone7water.com); Xie, Lillian; cchilmakuri@swc.org; leckhart@sgpwa.com; Rob Kunde
Cc: Jerry Brown; JP Robinette (JRobinette@BrwnCald.com); Alicia Forsythe; steve.micko@jacobs.com; Thayer,

Reed/SAC; Leaf, Rob/SAC
Subject: Sites South of Delta/SWP Modeling
When: Tuesday, April 13, 2021 2:00 PM-4:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

Good afternoon – the meeting agenda is attached. Thanks!

Thanks for your responses to the Doodle poll. This invite is to discuss Sites modeling assumptions for Delta and South of Delta participants. **Please RSVP** so we can ensure we do not exceed the quorum limit. Agenda coming soon.

Microsoft Teams meeting

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(833) 255-2803,,895164312# United States (Toll-free)
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From: Leaf, Rob/SAC [Rob.Leaf@jacobs.com]
Sent: 6/11/2021 10:06:49 AM
To: Sumer, Derya [dsumer@usbr.gov]
CC: Alicia Forsythe [aforsythe@sitesproject.org]; steve.micko@jacobs.com; Heydinger, Erin [erin.heydinger@hdrinc.com]; Whittington, Chad/SAC [Chad.Whittington@jacobs.com]
Subject: RE: Sites - 2021 Water Estimate
Attachments: [EXTERNAL] RE: Sites - 2021 Water Estimate

Derya,

Please see the attached for more information re this analysis.

Rob

From: Leaf, Rob/SAC
Sent: Friday, June 4, 2021 11:02 AM
To: dsumer@usbr.gov
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Micko, Steve/SAC <Steve.Micko@jacobs.com>; 'Heydinger, Erin' <Erin.Heydinger@hdrinc.com>; Whittington, Chad/SAC <Chad.Whittington@jacobs.com>
Subject: FW: Sites - 2021 Water Estimate

Derya,

We presented the attached to a group of NGOs that had expressed interest in seeing what was behind the following statement:
"If Sites Reservoir were operational today, California would have nearly 1,000,000-acre feet more water available to them to help get through challenging drought conditions."
https://3hm5en24txyp2e4cxyxaklbs-wpengine.netdna-ssl.com/wp-content/uploads/2021/04/If-Sites-Was-Operational-in-2021-Fact-Sheet.pdf

The email chain below shows who was invited and received the attached information.

The first 14 slides were on that topic. The remaining slides were follow-up to some prior NGO meetings regarding the Trinity and what our analysis to date shows and what the Sites water rights application will include.

We are providing additional information on follow-up to the meeting with the NGOs and we can share that information with you when we have it prepared.

Rob

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Friday, May 28, 2021 4:33 PM
To: dobegi@nrdc.org; Ron Stork <RStork@friendsoftheriver.org>; Greg Reis <reis@bayecotarium.org>; brandon.dawson@sierraclub.org; Chris Shutes <blancapaloma@msn.com>; jon@baykeeper.org; bobker@bay.org; bobker@sbcglobal.net; barry@westernwaterstrategies.com; john@goldengatesalmon.org; rzwillinger@defenders.org; Jerry Brown <jbrown@sitesproject.org>; Heydinger, Erin <erin.heydinger@hdrinc.com>; Leaf, Rob/SAC <Rob.Leaf@jacobs.com>; Micko, Steve/SAC <Steve.Micko@jacobs.com>; Deirdre Des Jardins <ddj@cah2oresearch.com>
Subject: [EXTERNAL] RE: Sites - 2021 Water Estimate

Hi all – Thank you for taking the time to chat with the Sites Team this afternoon. Attached is a PDF file of the PowerPoint presentation. We will be getting the Daily Divertible and Storage Flow Tool out to this group next week sometime.

I hope everyone has a safe and wonderful holiday weekend as we honor those who gave so much to our country.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

-----Original Appointment-----
From: Alicia Forsythe
Sent: Monday, May 24, 2021 11:55 AM
To: Alicia Forsythe; dobegi@nrdc.org; Ron Stork; Greg Reis; brandon.dawson@sierraclub.org; Chris Shutes; jon@baykeeper.org; bobker@bay.org; bobker@sbcglobal.net; barry@westernwaterstrategies.com; john@goldengatesalmon.org; rzwillinger@defenders.org; Jerry Brown; Heydinger, Erin; Leaf, Rob/SAC; Steve Micko (Steve.Micko@jacobs.com)
Cc: Deirdre Des Jardins
Subject: Sites - 2021 Water Estimate
When: Friday, May 28, 2021 1:00 PM-2:30 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

Based on the doodle poll, this date works for the majority of the group.

Agenda to follow.

Ali

Microsoft Teams meeting

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From: Heydinger, Erin [erin.heydinger@hdrinc.com]
Sent: 6/11/2021 8:57:17 AM
To: dobegi@nrdc.org; Ron Stork [RStork@friendsoftheriver.org]; Greg Reis [reis@bayecotarium.org]; brandon.dawson@sierraclub.org; Chris Shutes [blancapaloma@msn.com]; jon@baykeeper.org; bobker@bay.org; bobker@sbcglobal.net; barry@westernwaterstrategies.com; john@goldengatesalmon.org; rzwillinger@defenders.org; Deirdre Des Jardins [ddj@cah2oresearch.com]
CC: Jerry Brown [jbrown@sitesproject.org]; steve.micko@jacobs.com; Alicia Forsythe [aforsythe@sitesproject.org]; Leaf, Rob/SAC [Rob.Leaf@jacobs.com]; Whittington, Chad/SAC [Chad.Whittington@jacobs.com]
Subject: [EXTERNAL] RE: Sites - 2021 Water Estimate
Attachments: Sites_Project_2009-2020_Fill_Release_Storage_Estimates_Documentation_20210610_v1.docx; Sites_Project_2009-2020_Fill_And_Release_Estimates_20210601_v1.xlsx

Flag: Follow up

Good morning,

As a follow-up to our discussion on the Sites 2021 Water Estimate, I've attached the fill and release estimate tool for WY 2009 – 2020 (developed by the Jacobs team) and documentation of the tool's purpose, methods, assumptions, and results. Thank you for taking the time to walk through this with us. We are more than happy to answer any follow-up questions you may have.

Have a great weekend,
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

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-----Original Appointment-----
From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Monday, May 24, 2021 11:55 AM
To: Alicia Forsythe; dobegi@nrdc.org; Ron Stork; Greg Reis; brandon.dawson@sierraclub.org; Chris Shutes; jon@baykeeper.org; bobker@bay.org; bobker@sbcglobal.net; barry@westernwaterstrategies.com; john@goldengatesalmon.org; rzwillinger@defenders.org; Jerry Brown; Heydinger, Erin; Leaf, Rob/SAC; Steve Micko (Steve.Micko@jacobs.com)
Cc: Deirdre Des Jardins
Subject: Sites - 2021 Water Estimate
When: Friday, May 28, 2021 1:00 PM-2:30 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

Based on the doodle poll, this date works for the majority of the group.

Agenda to follow.

Ali

Microsoft Teams meeting

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Sites Project Annual Fill, Release, and Storage Estimates for Water Years 2009 – 2020

Overview

A simple analysis to estimate annual Sites diversion, release, and storage values for Water Years (WY) 2009 – 2020 was conducted using correlations between modeled results and historic information and annual mass balance calculations. Fill values were estimated using the Daily Divertible & Storable Flow Tool's simulation of DEIRS Alternative 1B and historical flow information at Bend Bridge. Releases were estimated based on the correlation between CalSim II simulated releases and the historic Sacramento Valley Water Supply Index (WSI HIST). This approach was used to evaluate potential Sites Project operations for recent years that are not covered by the CalSim II simulation period.

Assumptions and Analysis Performed

Sites fills, releases, and end-of-September storage conditions were computed in a spreadsheet using simple mass balance calculations, the Daily Divertible & Storable Flow Tool, and historical information. The analysis included operational assumptions and conveyance constraints consistent with DEIRS Alternative 1B.

Sites Storage

The starting storage for WY 2009 was assumed as 600 TAF based on an analysis of Sites operations for WY 1922 – 2008 using the Sites fill "regression method" and Sites release function that are described in the following sections. The analysis showed that Sites Reservoir would fill to near capacity after the above normal and wet years of 2005 and 2006. Then, in the drier years of 2007 and 2008, a high level of Sites releases would bring storage down to almost 600 TAF. For the analysis of WY 2009 – 2020, the starting storage only influences storage conditions and releases through the end of WY 2013, when deadpool storage is reached regardless of the storage volume in WY 2009. Fills and releases were constrained by available storage. The physical storage capacity of Alternative 1B is 1.5 MAF. Evaporation was estimated using a rating curve between storage and evaporation developed for the CalSim II simulation of Alternative 1B for WY 1922 – 2003.

Sites Fill

Daily Divertible Flow Tool (WY 2009 – 2018)

For WY 2009 – 2018, the annual diversions to fill Sites Reservoir were determined by the Daily Divertible & Storable Flow Tool's simulation of Alternative 1B. The Divertible Flow Tool estimates the daily diversion potential for Sites Project in WY 2009 – 2018 based on water availability and intake/conveyance constraints and diversion criteria. It was developed in 2018 to supplement CalSim II by representing the effects of operations criteria on a daily timestep, allow for relative comparisons between monthly and daily approaches, and provide results for more recent years. The Daily Divertible Flow Tool simulates each year as a separate event and does not include storage or release operations.

Regression Method (WY 2019 – 2020)

The Daily Divertible Flow Tool does not simulate results for 2019 – 2020. Fills for these years were estimated based on a regression between historical full natural flows for the Sacramento River at Bend Bridge (CDEC; SBB FNF) and CalSim II results for diversions to fill Sites Project under Alternative 1B. It was determined that Sites diversions were typically about 9% of the November through March volume of full natural flow at Bend Bridge when it was greater than 1,150 TAF. When the November through March volume of full natural flow at Bend Bridge was less than 1,150 TAF, Sites diversions were typically zero. A function was established to reflect these observations in the estimates of Sites fills for WY 2019 – 2020. Figure 1 shows the correlation between SBB FNF and Sites diversions using CalSim results and the extrapolation method used by the Sites Fill Function from WY 1922 – 2003.

Sites Fill Function:

- For WY 2009 – 2018:
  - Sites fills are equal to Alternative 1B results from the Daily Divertible & Storable Flow Tool.
- For WY 2019 – 2020:
  - Sites fills are equal to 9% of the November through March volume of full natural flow of the Sacramento River at Bend Bridge (SBB FNF; CDEC).
    - When SBB FNF (Nov-Mar) is less than 1,150 TAF for a given year, Sites fills is zero
  - Sites fills are also constrained by available storage capacity based on annual mass balance calculations.

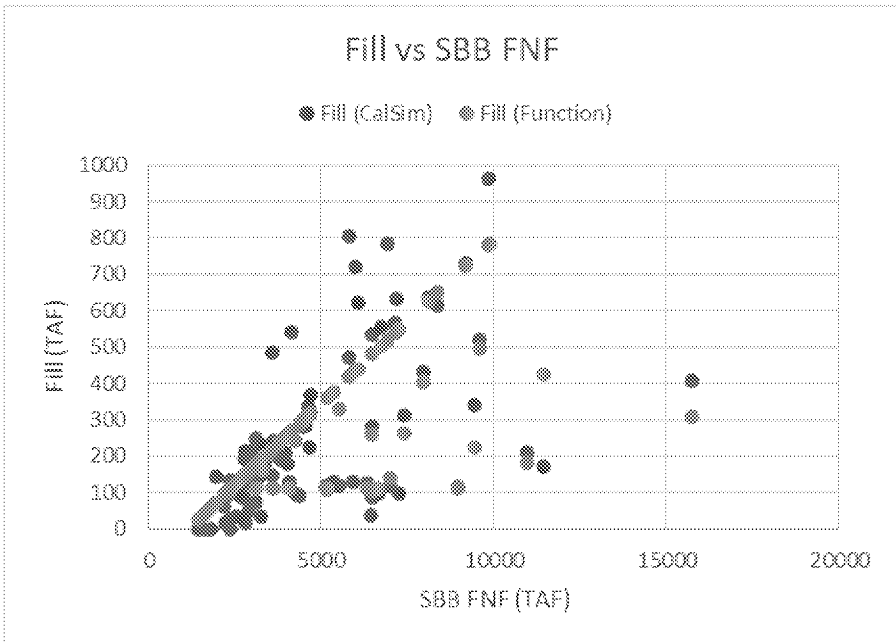


Figure 1. Sites Fill vs SBB FNF correlation between CalSim II and Fill Function results.

Sites Release

Sites releases were estimated based on a "similar years" relationship developed from CalSim II results for total releases from Sites Project under Alternative 1B using the historical Sacramento Valley Water Supply Index (WSI HIST) as an indicator of wetness. A release function was developed by evaluating the correlation between CalSim II simulated releases and the WSI HIST from WY 1922 – 2003. Figure 2 shows the correlation between the Sacramento Valley WSI and Sites release using CalSim II results and the release function described below.

- For WSI HIST < 7.25:
    - Release = 180 TAF per WSI unit below 8.5
- For 7.25 < WSI HIST < 9.75:
    - Release = 60 TAF per WSI unit below 11.0
- For WSI HIST > 9.75:
    - Release = 75 TAF
- Releases may not exceed storage availability based on annual mass balance calculations (previous year's storage plus the current year's fill minus dead pool storage).

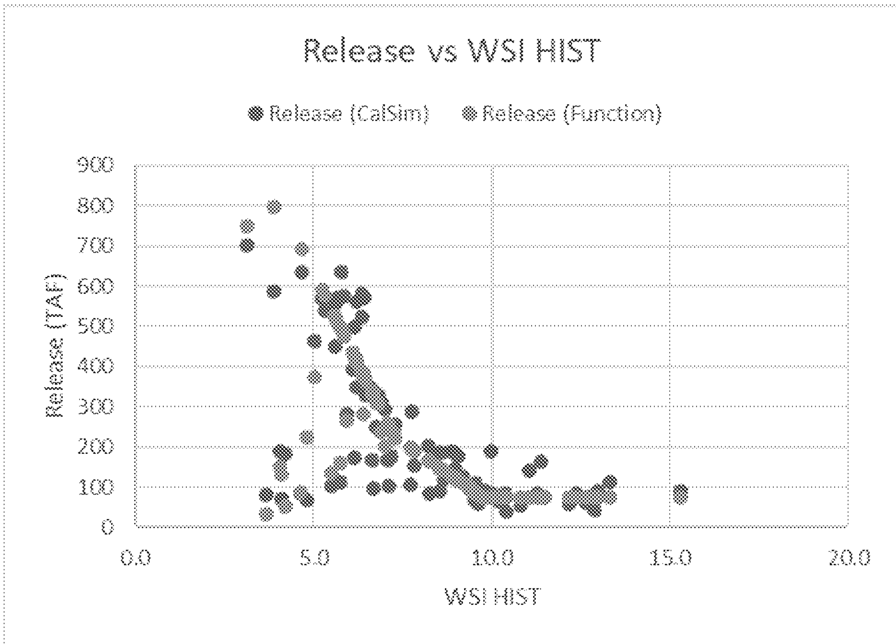


Figure 2. Sites Release vs WSI HIST correlation between CalSim and Release Function results.

Results

Table 1 shows the annual estimates for Sites fills, releases, and end-of-September (EOS) storages for Alternative 1B using the approach described above. In this 12-year period, the estimated average annual fill and release values are 269 TAF and128 TAF respectively. The estimated average end-of-September storage in Sites Reservoir is 510 TAF. These results reflect Sites operations during a relatively dry period, with 5 out of the 12 years being classified as dry or critically dry years. Despite the dry conditions, the tool estimates that Sites Reservoir would have nearly reached full capacity in WY 2019, after only a couple of wet years. The fills in wet years allow for releases during drier years. As illustrated by Figure 3, estimated Sites releases typically are highest during drier years when sufficient storage is available. For example, Sites Reservoir released 430 TAF in the dry year of 2020 while still maintaining 970 TAF in storage.

Table 1. Annual Sites Fills, Releases, and End-Of-September Storage for Alternative 1B (TAF).

Water Year	Year Type	Diversions to Fill Sites	Total Sites Releases	Total Sites Storage (EOS)
2009	D	90	490	170
2010	BN	110	160	100
2011	W	590	80	600
2012	BN	190	290	470
2013	D	170	480	130
2014	C	0	20	100
2015	C	50	30	110
2016	BN	230	220	110
2017	W	1,070	80	1,090
2018	BN	140	240	950
2019	W	480	80	1,320
2020	D	110	430	970
Average		269	216	510

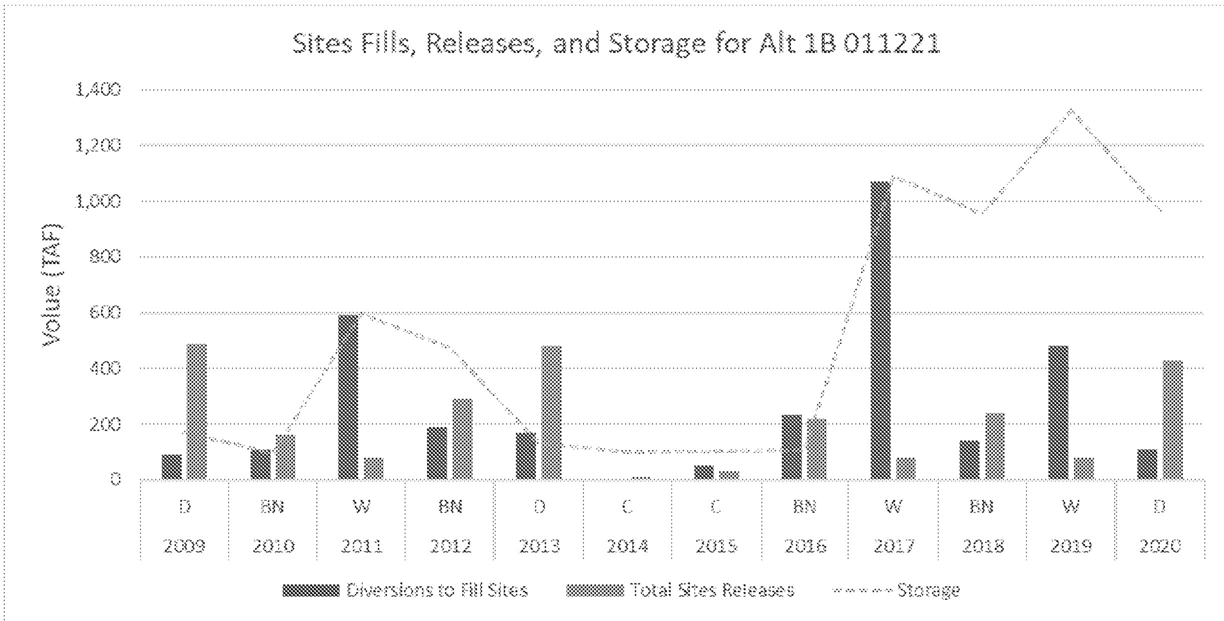


Figure 3. Sites Fills, Releases, and End-Of-September Storage for Alternative 1B (TAF).

File Provided Natively

From: Jerry Brown [jbrown@sitesproject.org]
Sent: 6/11/2021 5:47:19 PM
To: Daniel G Keppen [dan@familyfarmalliance.org]
Subject: Follow-up Material

Dan – good talking to you. As discussed https://www.acwa.com/wp-content/uploads/2017/06/2017-06-05-ACWA-Integrated-Storage-Final-Report.pdf - is ACWA's June 2017 integration report where the water supply benefits of several proposed storage projects were analyzed in conjunction with SWP/CVP operations. Also an analysis was done looking at the water supply benefits new delta conveyance. Figure 4 is a good summary level graph of the results of the analysis. Also Figure 27 shows the available surplus flow by water year type. It was determined that an average of ~2MAF is available for water supply, assuming current climate conditions. Note that the climate models used to inform the Prop 1 WSIP climate change analysis show that Sites' performance improves 5%-10% with climate change so this total average surplus flow would presumably be improved as well. The storage projects have changed and mostly been downsized since then. Also, the conveyance project has been downsized since then. So the total performance shown in figure 4 is going to be reduced but the figures are still proportionally accurate.

Let me know if you need anything else. Thank you for your help.

Jerry

Sites-SWP-CVP Operations

Carriage Water Considerations

June 14, 2021

Sites

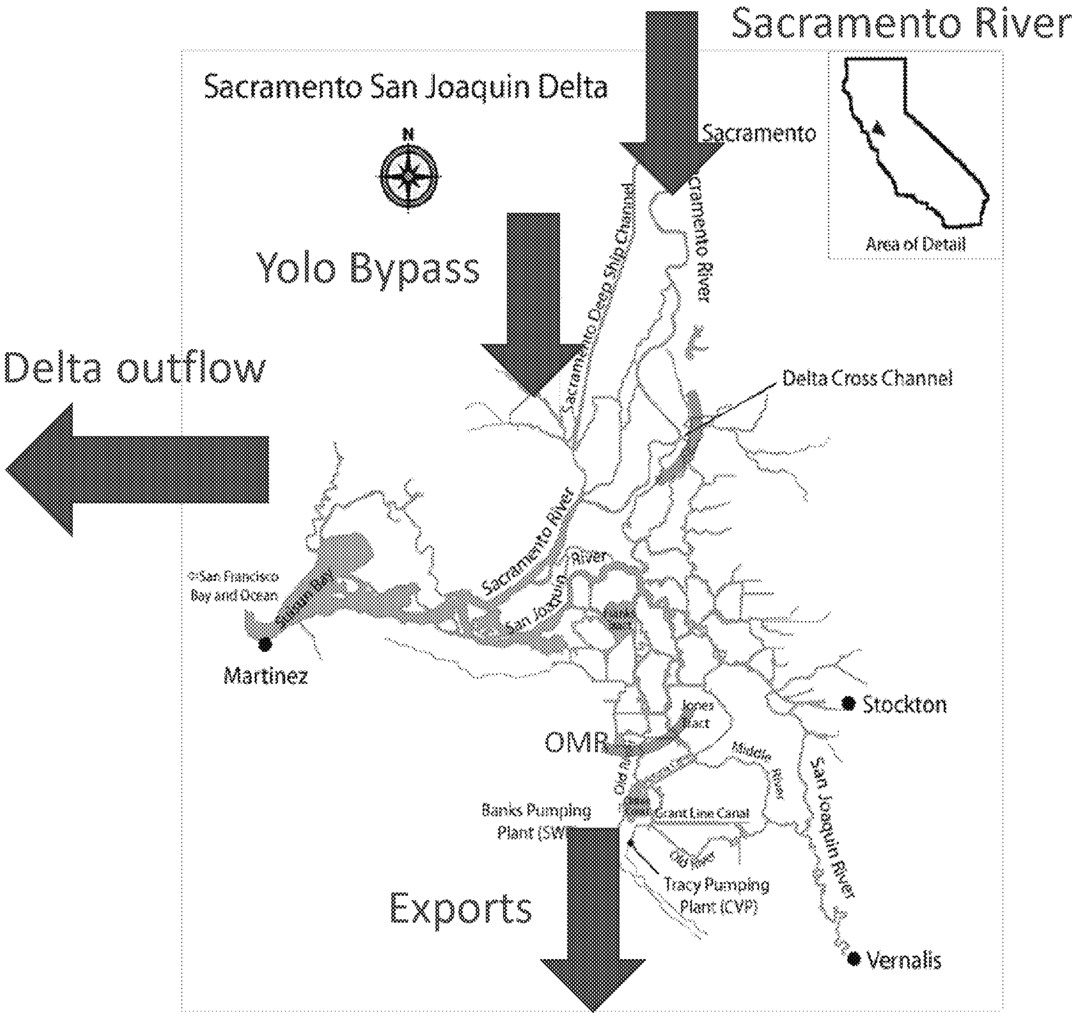
Agenda

- Provide operation context:
  - Sites affect on Delta flows
- Describe conceptual approach for estimating Sites carriage water
  - Assumptions
  - Approach
  - Next steps

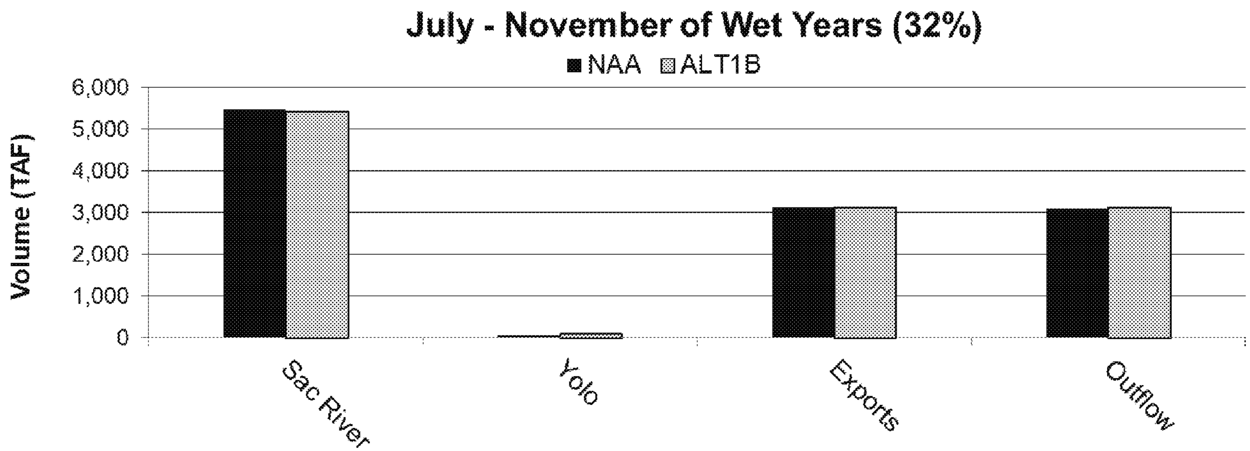
Operational Context

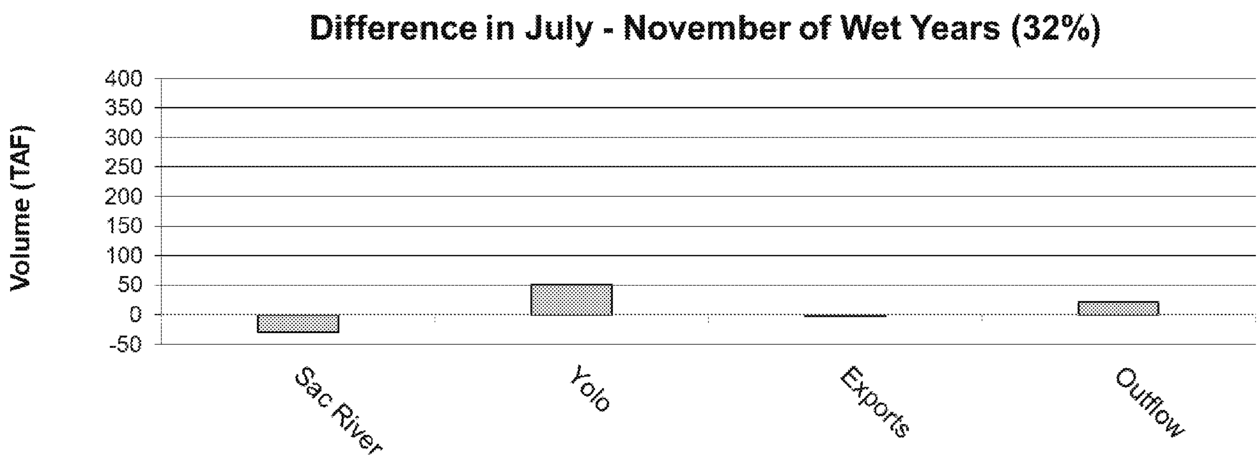
Sites

Sites and the Delta

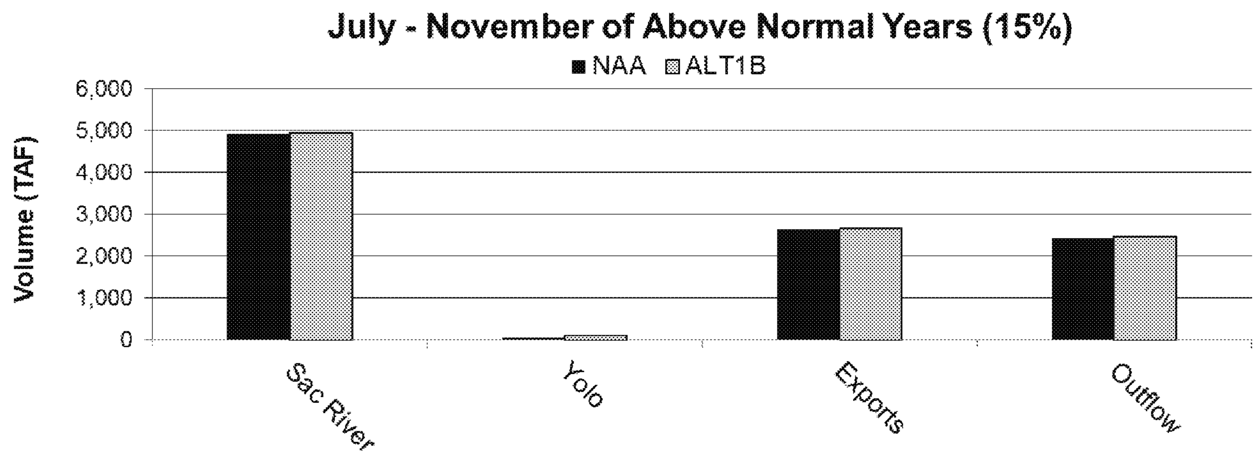


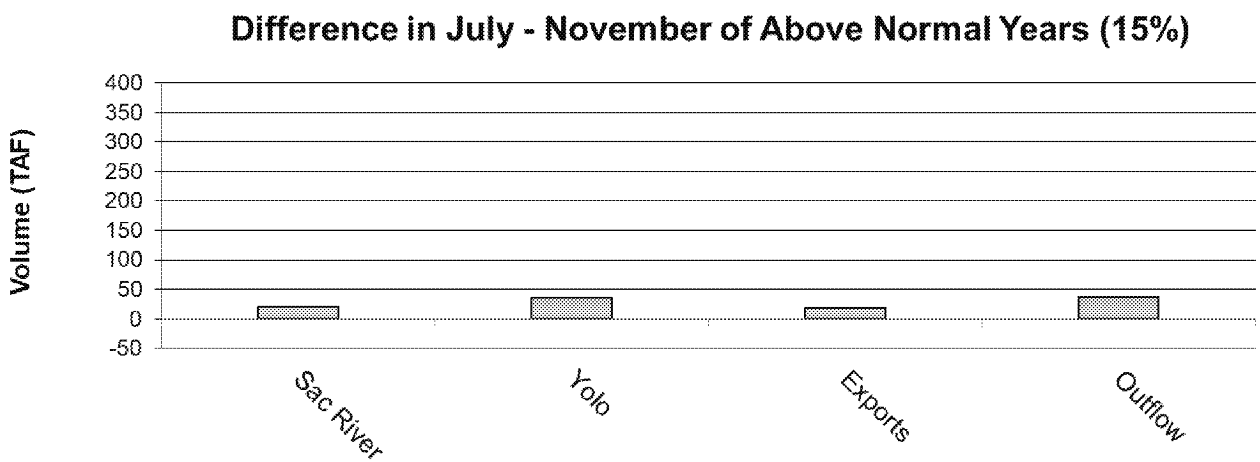
Sites and the Delta: Jul – Nov of Wet Years





Sites and the Delta : Jul – Nov of Above Normal Years





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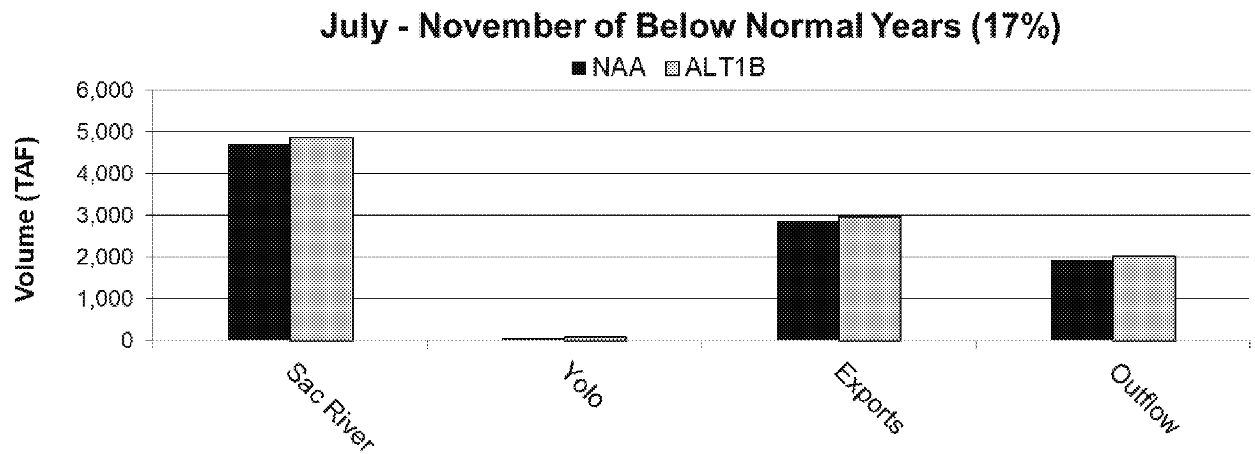
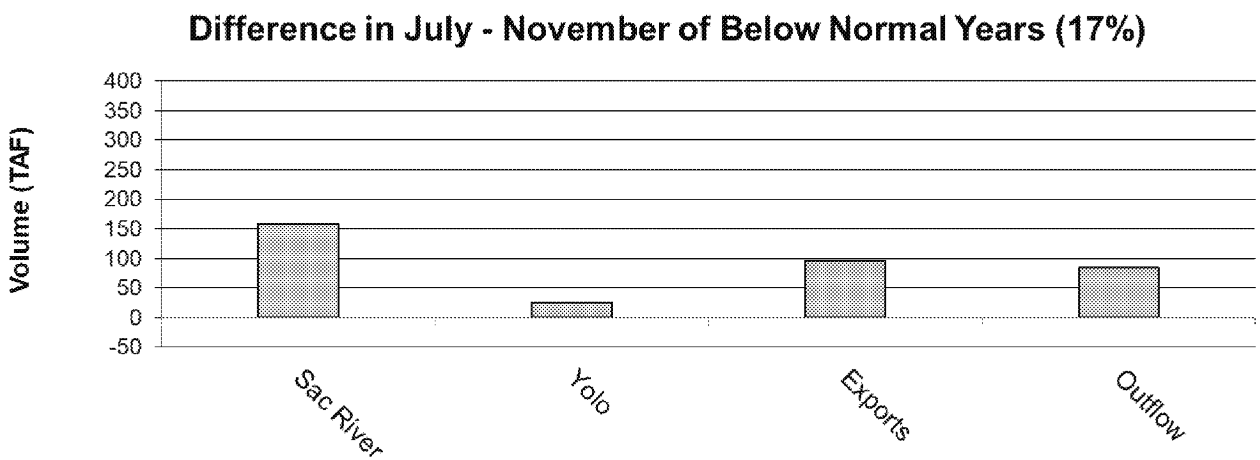
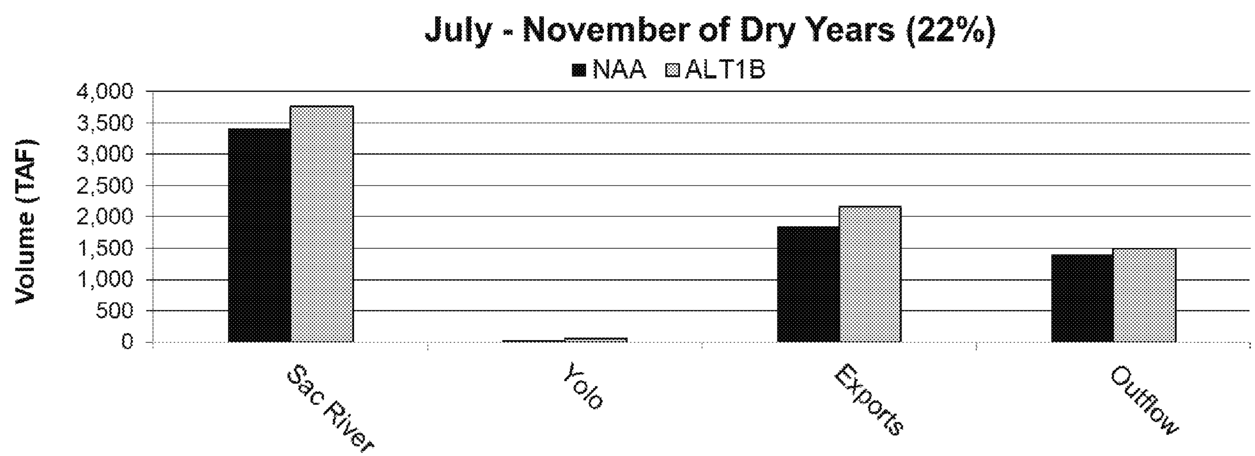
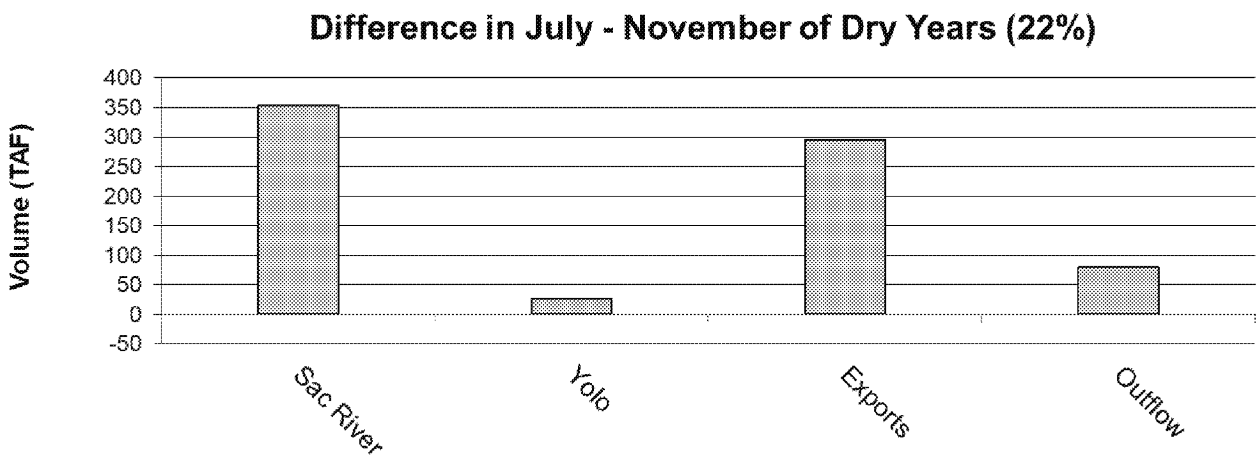
Sites and the Delta : Jul – Nov of Below Normal Years



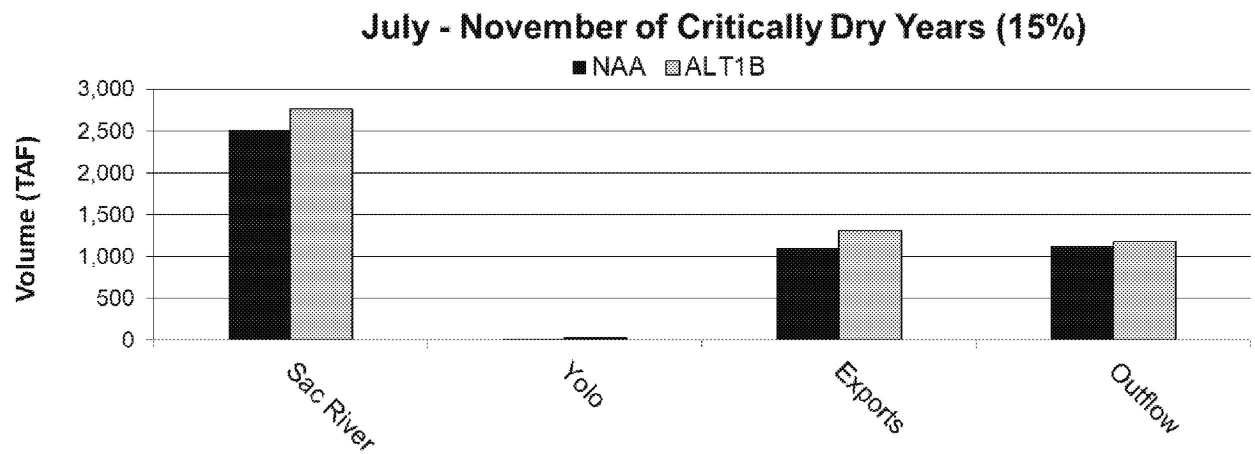


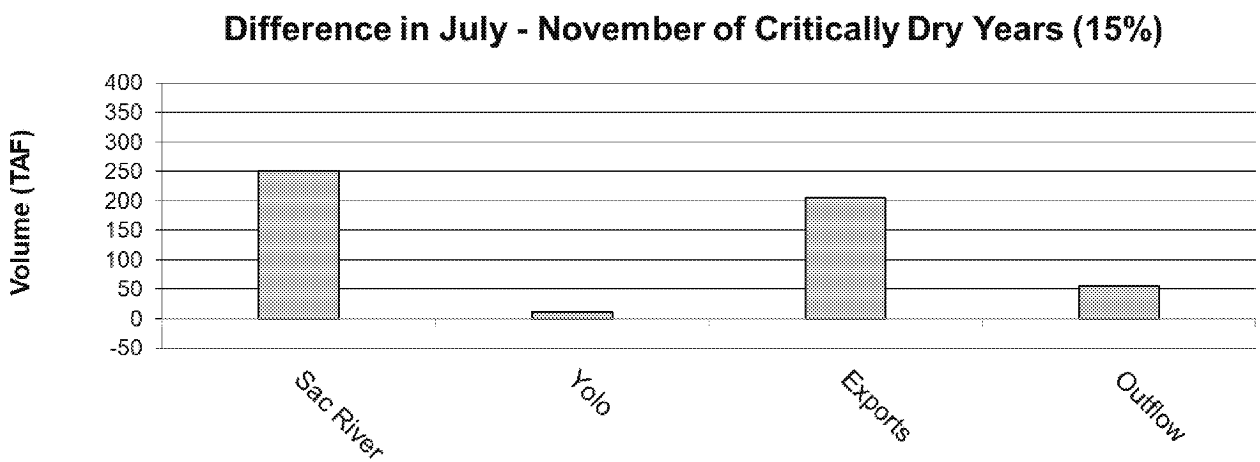
Sites and the Delta : Jul – Nov of Dry Years





Sites and the Delta : Jul – Nov of Critically Dry Years





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Conceptual Approach

Sites

Sites Operations and the Delta

- Sites operations can be organized into 3 three categories

Year Category	Sacramento River at Freeport Flow	Yolo Bypass Flow
Export	Sites releases water to Sacramento River for export to South of Delta storage partners	Limited or no change
Export and Outflow	Sites releases water to Sacramento River for export to South of Delta storage partners	Sites releases water to Yolo Bypass, ultimately increasing Delta outflow
Outflow	Limited or no change	Sites releases water to Yolo Bypass, ultimately increasing Delta outflow

Assumptions

- Carriage water is calculated each year
- Sites attains credit for Delta water quality benefits associated with releases to Yolo Bypass
- Losses in Yolo Bypass are estimated at 13%
- Currently, potential benefits to operations at San Luis reservoir are not considered

Carriage Water Estimation

- Estimation of carriage water cost:
  - Similar to non-project transfers
  - Incremental increase to Delta outflow to maintain Delta salinity conditions
- Estimation of carriage water Benefit:
  - Increase to SWP/CVP export and/or storage as a result of increased Delta outflow
- Costs and benefits may be considered in a single year

Next Steps

- Develop conceptual framework with DSM2 and CalSim II modeling to assess:
  - Water quality changes in Export, Export and Outflow, and Outflow years (DSM2)
  - Change in Delta flows associated with water quality changes (DSM2)
  - Long-term Sites operations as a result of carriage water cost refinements (DSM2 and CalSim II)

Discussion

Sites

Schedule Update
March 2021

Date:	May 15, 2021
From:	Jeff Campbell
Quality Review by:	Marcus Maltby

1.0 Schedule Update

The Sites Reservoir Project Master Schedule is updated on a bimonthly basis. The included schedule update is a result of adjustments and revisions made to the previous master schedule based on conversations and input from Service Area Integration Leads for activities occurring during the Amendment 2 work period. All markups provided by integration leads are retained as backup on the Sites Reservoir Project SharePoint site here. This update was completed on May 15, 2021.

2.0 Decisions Summary

No major decisions impacting the project were discussed during this schedule update period.

3.0 Attachments

Attachment 1 – Program Summary Schedule

Attachment 2 – Program Detail Schedule

Attachment 3 – Critical Path Schedule

Attachment 4 – Engineering Detail Schedule

Attachment 5 – Environmental Detail Schedule

Attachment 6 – Operations Detail Schedule

Attachment 7 – Permitting Detail Schedule

Attachment 8 – Right of Entry Detail Schedule

Attachment 1: Program Summary Schedule

SITES PROJECT

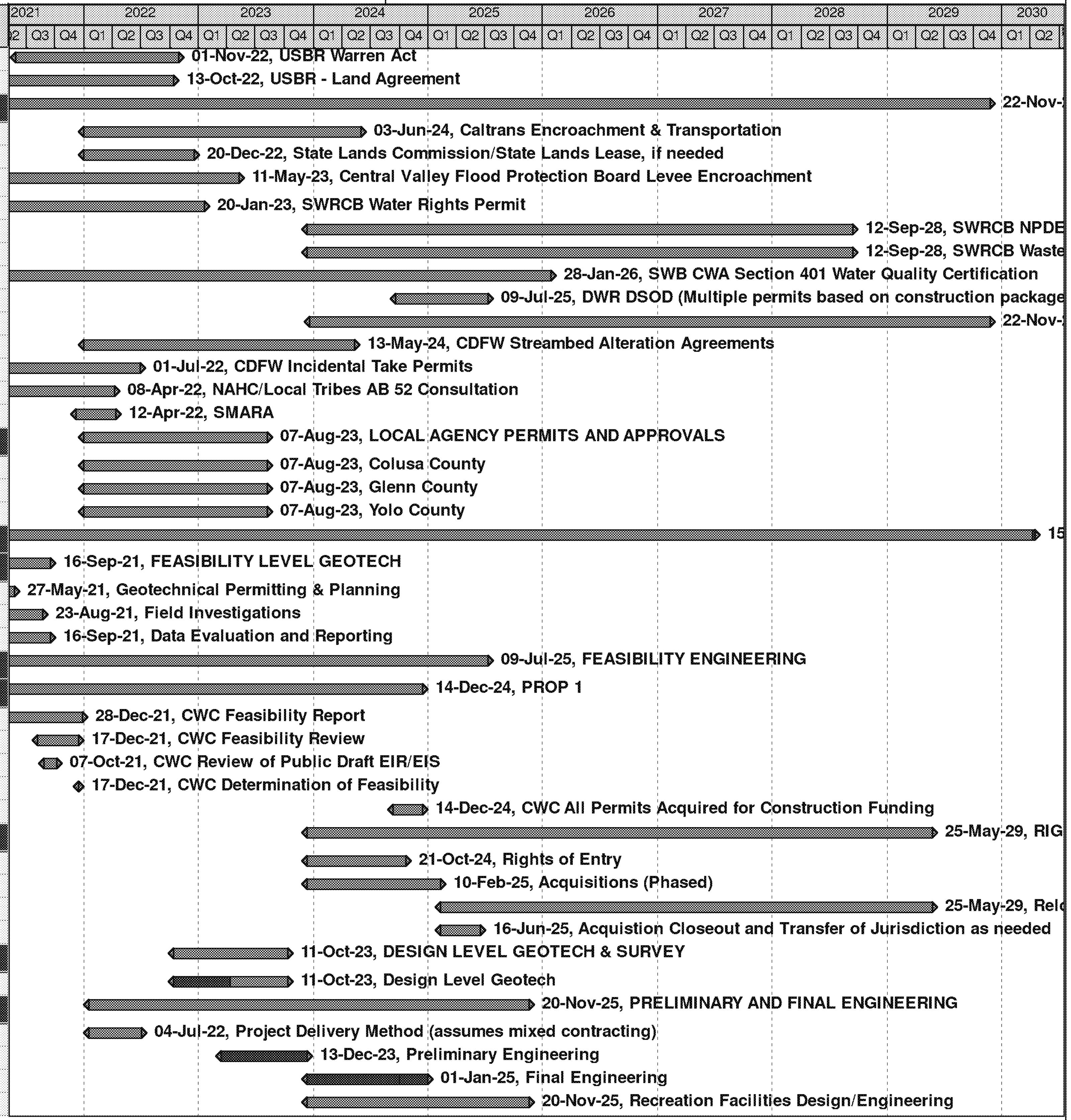
Date: 10-Jun-21

Activity ID	Activity Name	Remaining Duration	Start	Finish
SITES PROJECT		2301	11-Feb-20 A	15-Apr-30
MILESTONES		2219	26-Aug-21 A	15-Apr-30
MS-011-DE	Release Revised Draft EIR/ Supplemental Draft EIS for Public I	0		26-Aug-21
MS-003-LF	Local Funding (Go/No-go #3)	0		29-Sep-21
MS-020-CS	WIIN Construction Start Date (12/16/21)	0		23-Dec-21
MS-004-P2	Ph 2 Amendment 2	0		30-Dec-21*
MS-006-Ph2-:	Phase 2-2a Amendment Complete	0		30-Dec-21
MS-250-FE	Final EIR/EIS	0		12-Oct-22
MS-450-RD	ROD Signed	0		10-Nov-22
WP3-010	Phase 3 Amendment Complete	0		30-Jun-23
MS-010-D	Final Design Complete	0		02-Oct-24
MS-500-CS	Construction Starts	0	02-Jan-25	
MS-510-CC	Construction Complete	0		06-Jun-29
MS-600-PB	Public Beneficial Occupancy - Sites Program	0		15-Apr-30
OPERATIONS MODELING		760	01-Sep-20 A	16-May-24
	Full Operations Analysis	0	23-Nov-20 A	03-May-21
	BA/ITP Documentation	42	01-Nov-20 A	30-Jun-21
	Operations Plan, Ver 1	143	01-Nov-20 A	24-Nov-21
	Operational Agreements	410	23-Sep-20 A	22-Dec-22
	Bridging Analysis for CWC/WSIP Benefits	21	01-Sep-20 A	01-Jun-21
	Final Sites-Reclamation Operating Agreement	290	02-Nov-20 A	29-Jun-22
	Final Sites-DWR Operating Agreement	291	02-Nov-20 A	30-Jun-22
	Operations Plan, Version 2	370	27-Aug-21	26-Jan-23
	Annual Operating Plan Process and Procedures	519	25-Nov-21	21-Nov-23
	Member Portal/Accounting System	300	03-Jan-22	16-Mar-23
	Operations Support	649	22-Nov-21	16-May-24
EIR/EIS		953	01-Sep-20 A	12-Feb-25
	Project Description Chapter	0	22-Sep-20 A	03-May-21
	Revised Draft EIR/Supplemental Draft EIS	82	01-Sep-20 A	26-Aug-21
	Public Review	43	27-Aug-21	28-Oct-21
	Begin Preparation of the Admin Final EIR/EIS	48	07-Oct-21	17-Dec-21
	Environmental Feasibility Report For CWC	39	27-Sep-21	22-Nov-21
	Final EIR/Final EIS	213	07-Dec-21	12-Oct-22
	NOD, Findings of Fact, Statement of Overriding Considerations, Mitigation Monitoring	32	21-Sep-22	04-Nov-22
	Authority Certifies EIR and Approves Project and File NOD	1	04-Nov-22	07-Nov-22
	ROD	21	13-Oct-22	10-Nov-22
	Additional NEPA/CEQA Review, if needed	570	14-Nov-22	12-Feb-25
FEDERAL PERMITS AND AGREEMENTS		844	01-Sep-20 A	12-Sep-24
	Phase 1 Environmental Site Assessments	421	31-Dec-21	11-Aug-23
	U.S. Army Corps of Engineers CWA 404, Rivers and Harbors Act Section 10	506	01-Sep-20 A	11-May-23
	U.S. Army Corps of Engineers Rivers and Harbors Act Section 14, Section 408	844	01-Sep-20 A	12-Sep-24
	U.S. EPA and U.S. Army Corps of Engineers LEDPA Review	461	02-Nov-20 A	06-Feb-23
	Advisory Council on Historic Preservation NHPA Section 106	238	01-Sep-20 A	15-Apr-22
	USFWS and NMFS ESA Section 7	230	01-Sep-20 A	05-Apr-22
	USFWS Bald Eagle Protection Act	528	01-Sep-20 A	13-Jun-23
	U.S. Coast Guard Navigability Determination	239	03-Jan-22	15-Dec-22

Critical Remaining Work
Milestone
Summary

SITES MASTER SUMMARY SCHEDULE

Activity ID	Activity Name	Remaining Duration	Start	Finish
	USBR Warren Act	356	01-Jun-21	01-Nov-22
	USBR - Land Agreement	363	02-Nov-20 A	13-Oct-22
	STATE PERMITS AND AGREEMENTS	2199	11-Feb-20 A	22-Nov-29
	Caltrans Encroachment & Transportation	605	03-Jan-22	03-Jun-24
	State Lands Commission/State Lands Lease, if needed	242	03-Jan-22	20-Dec-22
	Central Valley Flood Protection Board Levee Encroachment	501	01-Sep-20 A	11-May-23
	SWRCB Water Rights Permit	428	01-Sep-20 A	20-Jan-23
	SWRCB NPDES and CWA Section 402 (Multiple permits based on construction packa	1234	14-Dec-23	12-Sep-28
	SWRCB Waste Discharge Requirements (Multiple permits based on constr. package	1234	14-Dec-23	12-Sep-28
	SWB CWA Section 401 Water Quality Certification	1203	11-Feb-20 A	28-Jan-26
	DWR DSOD (Multiple permits based on construction packages and/or ROW access)	210	19-Sep-24	09-Jul-25
	Cal OSHA Permits (Multiple permits based on construction packages and/or ROW ac	1541	21-Dec-23	22-Nov-29
	CDFW Streambed Alteration Agreements	591	03-Jan-22	13-May-24
	CDFW Incidental Take Permits	292	01-Sep-20 A	01-Jul-22
	NAHC/Local Tribes AB 52 Consultation	233	01-Sep-20 A	08-Apr-22
	SMARA	86	07-Dec-21	12-Apr-22
	LOCAL AGENCY PERMITS AND APPROVALS	400	03-Jan-22	07-Aug-23
	Colusa County	400	03-Jan-22	07-Aug-23
	Glenn County	400	03-Jan-22	07-Aug-23
	Yolo County	400	03-Jan-22	07-Aug-23
	MITIGATION	2301	09-Dec-20 A	15-Apr-30
	FEASIBILITY LEVEL GEOTECH	96	25-Mar-20 A	16-Sep-21
	Geotechnical Permitting & Planning	19	25-Mar-20 A	27-May-21
	Field Investigations	79	07-Sep-20 A	23-Aug-21
	Data Evaluation and Reporting	96	04-Jan-21 A	16-Sep-21
	FEASIBILITY ENGINEERING	1058	01-Sep-20 A	09-Jul-25
	PROP 1	910	05-Oct-20 A	14-Dec-24
	CWC Feasibility Report	164	05-Oct-20 A	28-Dec-21
	CWC Feasibility Review	131	09-Aug-21	17-Dec-21
	CWC Review of Public Draft EIR/EIS	30	27-Aug-21	07-Oct-21
	CWC Determination of Feasibility	0	17-Dec-21	17-Dec-21
	CWC All Permits Acquired for Construction Funding	66	12-Sep-24	14-Dec-24
	RIGHT OF WAY (ROW)	1417	14-Dec-23	25-May-29
	Rights of Entry	218	14-Dec-23	21-Oct-24
	Acquisitions (Phased)	298	14-Dec-23	10-Feb-25
	Relocation Assistance, as needed	1119	11-Feb-25	25-May-29
	Acquistion Closeout and Transfer of Jurisdiction as needed	90	11-Feb-25	16-Jun-25
	DESIGN LEVEL GEOTECH & SURVEY	260	13-Oct-22	11-Oct-23
	Design Level Geotech	260	13-Oct-22	11-Oct-23
	PRELIMINARY AND FINAL ENGINEERING	1001	20-Jan-22	20-Nov-25
	Project Delivery Method (assumes mixed contracting)	118	20-Jan-22	04-Jul-22
	Preliminary Engineering	195	16-Mar-23	13-Dec-23
	Final Engineering	275	14-Dec-23	01-Jan-25
	Recreation Facilities Design/Engineering	506	14-Dec-23	20-Nov-25



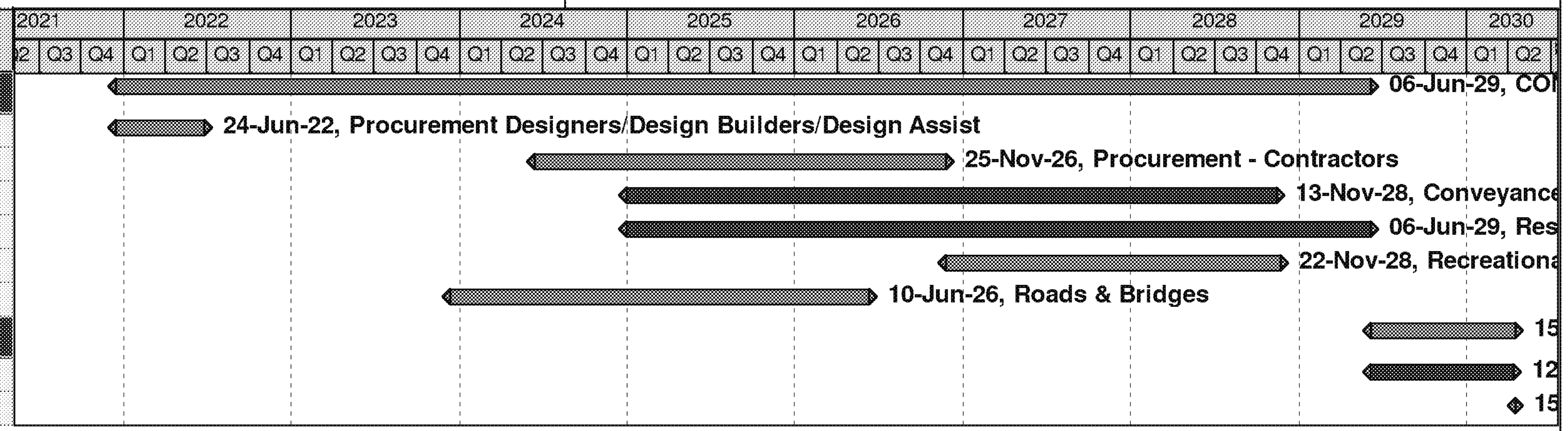
Critical Remaining Work
Milestone
Summary

SITES MASTER SUMMARY SCHEDULE

SITES PROJECT

Date: 10-Jun-21

Activity ID	Activity Name	Remaining Duration	Start	Finish
	CONSTRUCTION	1948	17-Dec-21	06-Jun-29
	Procurement Designers/Design Builders/Design Assist	135	17-Dec-21	24-Jun-22
	Procurement - Contractors	639	14-Jun-24	25-Nov-26
	Conveyance Features	1008	02-Jan-25	13-Nov-28
	Reservoir Features	1155	02-Jan-25	06-Jun-29
	Recreational Features	520	26-Nov-26	22-Nov-28
	Roads & Bridges	650	14-Dec-23	10-Jun-26
	OPERATIONS	223	07-Jun-29	15-Apr-30
	Early Operations (Commissioning)	222	07-Jun-29	12-Apr-30
	Full Operations Begins	0	15-Apr-30	15-Apr-30

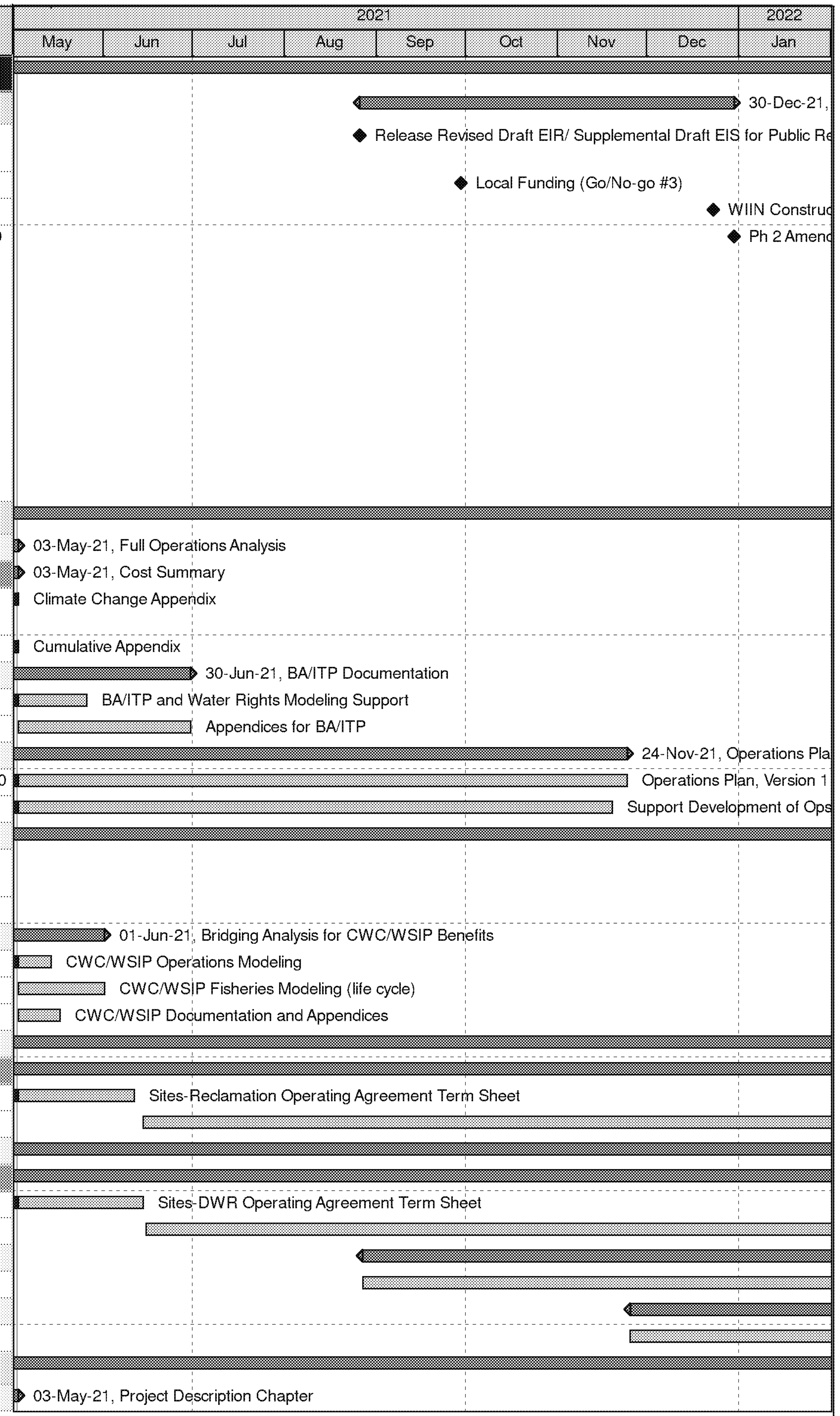


Critical Remaining Work
Milestone
Summary

SITES MASTER SUMMARY SCHEDULE

Attachment 2: Program Detail Schedule

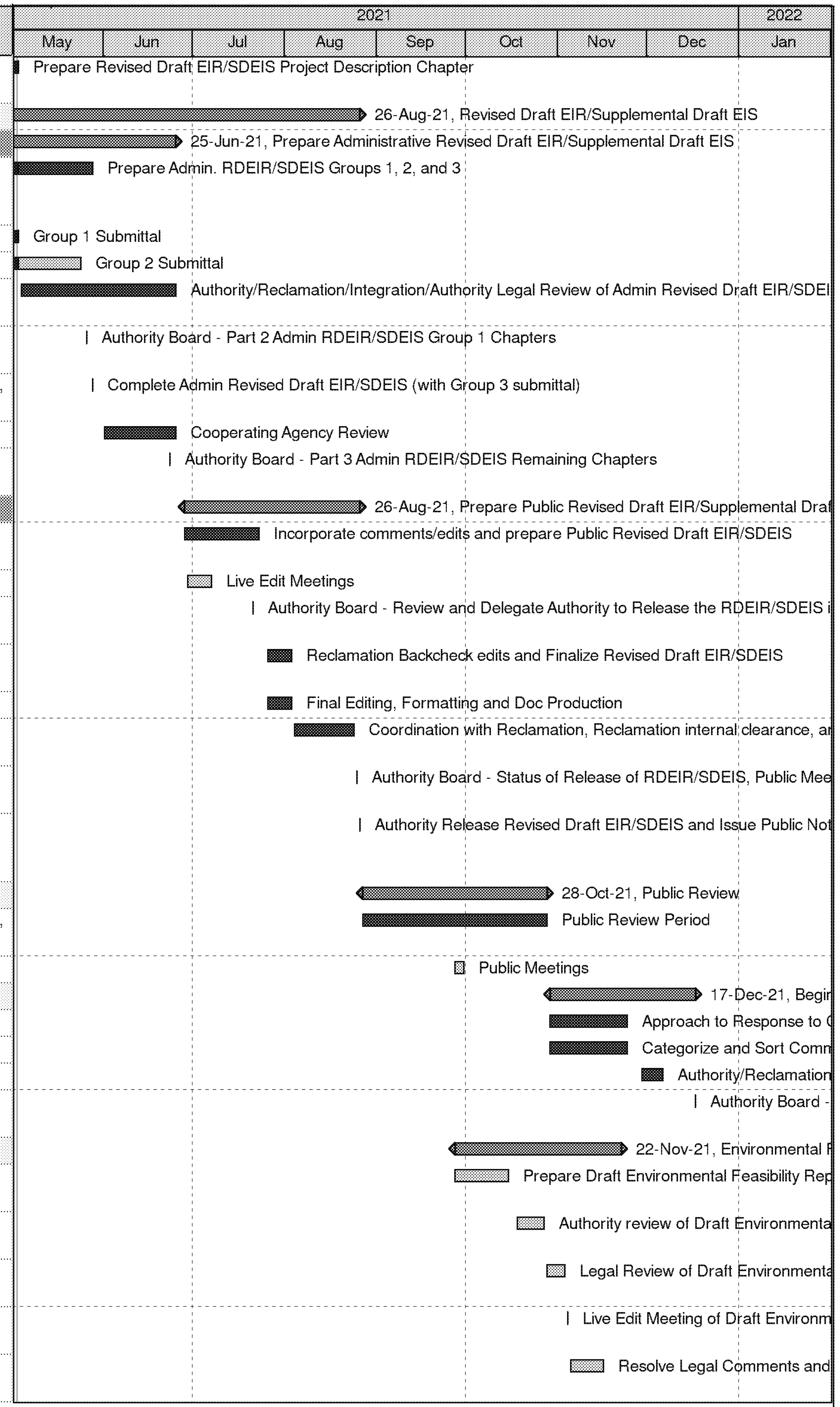
Activity ID	Activity Name	Remaining Duration	% Complete	Start	Finish	Total Float	Predecessors	Successors
SITES PROJECT		1058	34.02%	02-Jan-20 A	09-Jul-25	1243		
MILESTONES		84	0%	26-Aug-21	30-Dec-21	487		
MS-011-DE	Release Revised Draft EIR/ Supplemental Draft EIS for Public Review	0	0%		26-Aug-21	339	EIR-080	MS-250-FE
MS-003-LF	Local Funding (Go/No-go #3)	0	0%		29-Sep-21	575	MS-002-LF	WP3-010
MS-020-CS	WIIN Construction Start Date (12/16/21)	0	0%		23-Dec-21	124	CES-280, CES-090	MS-006-Ph2-2a
MS-004-P2	Ph 2 Amendment 2	0	0%		30-Dec-21*	1	OP-490, PS-030, INV-00-30, INV-033, RA-010, GC-020, CON-040, PC-010, PC-020, MS-004-P1b, TM-F107, FED-050, EM-00-10, GSR-040, ENG-230, FF-030, TM-D97, TM-D99, TM-F99, TM-H99, TM-I98, TM-I99, TM-D98, EIR-580, CWC-010, TM-F97, TM-F98, GS-30, GS-C50, ORA-010, WP-00-2A, A3WP-1120, PA-450, AR-030, PS-020, RA-00-1B, RCB-20-268, POF-003, A3WP-1140, A3WP-1150, AR-040, TM-E99, TM-E97, TM-E98, ENG-430, MB-010	DB-100, STA-100, FO-1090
OPERATIONS MODELING		639	45.01%	01-Sep-20 A	21-Nov-23	1662		
Full Operations Analysis		0	100%	23-Nov-20 A	03-May-21	4		
Cost Summary		0	100%	23-Nov-20 A	03-May-21	4		
OP-$-460	Climate Change Appendix	0	100%	23-Nov-20 A	03-May-21	0	OP-1100	OP-$-455, OP-470, EIR-025, OP-460
OP-$-455	Cumulative Appendix	0	100%	23-Nov-20 A	03-May-21	4	OP-$-460	EIR-027
BA/ITP Documentation		42	51.04%	01-Nov-20 A	30-Jun-21	1165		
OP-450	BA/ITP and Water Rights Modeling Support	18	70.97%	01-Nov-20 A	26-May-21	1165	OP-1030	OP-360
OP-360	Appendices for BA/ITP	42	0%	03-May-21	30-Jun-21	1165	OP-450, MS-007-PD, PDE-60	CES-200
Operations Plan, Ver 1		143	17.69%	01-Nov-20 A	24-Nov-21	2158		
OP-470	Operations Plan, Version 1	143	17%	01-Nov-20 A	24-Nov-21	68	OP-$-460	OP-475, CFS-010, CFS-020
OP-475	Support Development of Ops Plan Ver 1 Documentation	140	23.91%	01-Mar-21 A	19-Nov-21	2161	OP-470	OP-490
Operational Agreements		410	0%	23-Sep-20 A	22-Dec-22	1891		
OP-480 ($$$)	Support Operational Agreements	410	0%	23-Sep-20 A	22-Dec-22	1668	OP-446, OP-0240	OP-490, FO-1040
OP-490	Support for Operational Agreements Documentation	410	0%	19-Nov-20 A	22-Dec-22	1891	OP-480 ($$$), OP-475	MS-004-P2, FO-1040
Bridging Analysis for CWC/WSIP Benefits		21	55.48%	01-Sep-20 A	01-Jun-21	68		
CFS-010	CWC/WSIP Operations Modeling	10	84.62%	01-Sep-20 A	14-May-21	68	OP-0230, OP-470	CFS-020
CFS-020	CWC/WSIP Fisheries Modeling (life cycle)	21	0%	03-May-21	01-Jun-21	68	CFS-010, OP-0230, OP-446, OP-470	CFS-030
CFS-030	CWC/WSIP Documentation and Appendices	11	0%	03-May-21	17-May-21	68	CFS-020	CWC-403
Final Sites-Reclamation Operating Agreement		290	0%	02-Nov-20 A	29-Jun-22	363		
Reclamation Term Sheet		290	0%	02-Nov-20 A	29-Jun-22	363		
OP-1110	Sites-Reclamation Operating Agreement Term Sheet	29	19%	02-Nov-20 A	11-Jun-21	363	OP-1030	OP-1120, OP-1005
OP-1005	Final Sites-Reclamation Operating Agreement	261	0%	14-Jun-21	29-Jun-22	363	POF-004, OP-1110	OP-1015
Final Sites-DWR Operating Agreement		291	0%	02-Nov-20 A	30-Jun-22	362		
DWR Term Sheet		291	0%	02-Nov-20 A	30-Jun-22	362		
OP-1120	Sites-DWR Operating Agreement Term Sheet	30	92.52%	02-Nov-20 A	14-Jun-21	362	OP-1030, OP-1110, OP-00-1A	OP-1015
OP-1015	Final Sites-DWR Operating Agreement	261	0%	15-Jun-21	30-Jun-22	362	POF-004, OP-1005, OP-1120	FD-110
Operations Plan, Version 2		370	0%	27-Aug-21	26-Jan-23	1659		
FO-1050	Operations Plan, Version 2	370	0%	27-Aug-21	26-Jan-23	1659	EIR-080, FO-1040	FO-1060
Annual Operating Plan Process and Procedures		519	0%	25-Nov-21	21-Nov-23	1446		
FO-1060	Annual Operating Plan Processes and Procedures	519	0%	25-Nov-21	21-Nov-23	1446	EIR-100, FO-1050	FO-1070
EIR/EIS		312	64.09%	22-Sep-20 A	01-Aug-22	0		
Project Description Chapter		0	100%	22-Sep-20 A	03-May-21	19		



Actual Work | Critical Remaining Work | Summary
Remaining Work | Milestone

Sites Project Detailed Planning Schedule

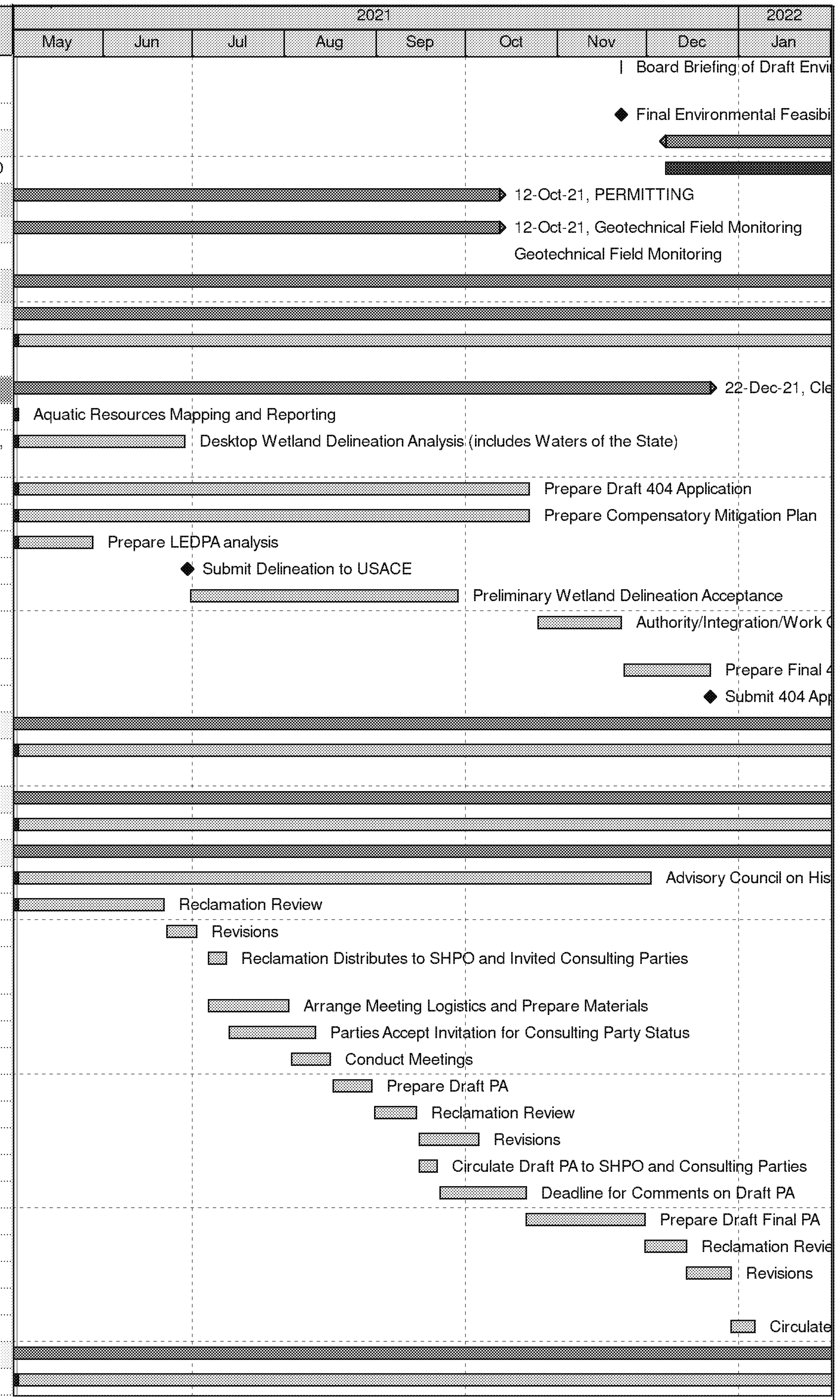
Activity ID	Activity Name	Remaining Duration	% Complete	Start	Finish	Total Float	Predecessors	Successors
EIR-021	Prepare Revised Draft EIR/SDEIS Project Description Chapter	0	100%	22-Sep-20 A	03-May-21	19	WP2-130, OP-1100, PDE-50, PDE-55, EIR-470	EIR-030, FED-020, ENG-290, ENG-265, EIR-480, EIR-485
Revised Draft EIR/Supplemental Draft EIS		82	0%	13-Jan-21 A	26-Aug-21	0		
Prepare Administrative Revised Draft EIR/Supplemental Draft EIS		33	0%	13-Jan-21 A	25-Jun-21	17		
EIR-020	Prepare Admin. RDEIR/SDEIS Groups 1, 2, and 3	20	71.83%	13-Jan-21 A	28-May-21	0	WP2-120, OP-0230, OP-0240, OP-0250, OP-0260, PDE-55, EB-00-00, OP-320, ENG-510, EIR-018	EIR-030, EIR-590
EIR-025	Group 1 Submittal	1	96.88%	13-Jan-21 A	03-May-21	0	OP-$-460, OP-460	EIR-030, EIR-125, EIR-035
EIR-027	Group 2 Submittal	16	50%	13-Jan-21 A	24-May-21	4	OP-$-455	EIR-030, EIR-135
EIR-035	Authority/Reclamation/Integration/Authority Legal Review of Admin Revised Draft EIR/SDEIS	38	0%	04-May-21	25-Jun-21	0	EIR-025, EIR-085	EIR-040, EIR-590, ENG-239, EIR-060
EIR-125	Authority Board - Part 2 Admin RDEIR/SDEIS Group 1 Chapters	1	0%	26-May-21	26-May-21	0	EIR-025, EIR-085	EIR-030
EIR-030	Complete Admin Revised Draft EIR/SDEIS (with Group 3 submittal)	1	0%	28-May-21	28-May-21	0	EIR-021, EIR-501, EIR-018A, EIR-019A, EIR-020, EIR-025, EIR-027, EIR-125	EIR-135, EIR-590, 404-001, FED-090
EIR-590	Cooperating Agency Review	19	0%	01-Jun-21	25-Jun-21	0	EIR-035, EIR-030, EIR-020	EIR-040
EIR-135	Authority Board - Part 3 Admin RDEIR/SDEIS Remaining Chapters	1	0%	23-Jun-21	23-Jun-21	1	EIR-027, EIR-030, EIR-005	EIR-060
Prepare Public Revised Draft EIR/Supplemental Draft EIS		43	0%	28-Jun-21	26-Aug-21	0		
EIR-040	Incorporate comments/edits and prepare Public Revised Draft EIR/SDEIS	19	0%	28-Jun-21	23-Jul-21	0	EIR-035, EIR-590	EIR-045, EIR-050
EIR-045	Live Edit Meetings	6	0%	29-Jun-21	07-Jul-21	2	EIR-040	EIR-050, EIR-060
EIR-060	Authority Board - Review and Delegate Authority to Release the RDEIR/SDEIS in August	1	0%	21-Jul-21	21-Jul-21	2	EIR-035, EIR-135, EIR-045	EIR-050
EIR-050	Reclamation Backcheck edits and Finalize Revised Draft EIR/SDEIS	7	0%	26-Jul-21	03-Aug-21	0	EIR-045, EIR-040, EIR-060	EIR-067, EIR-150
EIR-067	Final Editing, Formatting and Doc Production	7	0%	26-Jul-21	03-Aug-21	0	EIR-026, EIR-050	EIR-075, EIR-150
EIR-075	Coordination with Reclamation, Reclamation internal clearance, and public noticing	15	0%	04-Aug-21	24-Aug-21	0	EIR-067	EIR-080, EIR-150
EIR-150	Authority Board - Status of Release of RDEIR/SDEIS, Public Meeting Schedule	1	0%	25-Aug-21	25-Aug-21	0	EIR-067, EIR-050, EIR-026, EIR-075	EIR-090, EIR-080
EIR-080	Authority Release Revised Draft EIR/SDEIS and Issue Public Notices	1	0%	26-Aug-21	26-Aug-21	0	EIR-075, EIR-150	EIR-090, CWC-450, MS-011-DE, FO-1050, FO-1020, FO-1030, FO-1040
Public Review		43	0%	27-Aug-21	28-Oct-21	0		
EIR-090	Public Review Period	63	0%	27-Aug-21	28-Oct-21	0	EIR-080, EIR-150, EIR-487	EIR-530, EIR-100, EIR-092, EIR-095
EIR-530	Public Meetings	4	0%	27-Sep-21	30-Sep-21	3	EIR-090	EIR-100, EIR-110
Begin Preparation of the Admin Final EIR/EIS		33	0%	29-Oct-21	17-Dec-21	154		
EIR-100	Approach to Response to Comments	18	0%	29-Oct-21	24-Nov-21	0	EIR-090, EIR-530	EIR-105, FO-1080, FO-106
EIR-095	Categorize and Sort Comments by Topic	18	0%	29-Oct-21	24-Nov-21	0	EIR-090	EIR-105
EIR-105	Authority/Reclamation/Legal Review	6	0%	29-Nov-21	06-Dec-21	0	EIR-100, EIR-092, EIR-095	EIR-140, EIR-210
EIR-140	Authority Board - Summary of Comments received in the RDEIR/SDEIS and Approach to Responses	1	0%	17-Dec-21	17-Dec-21	213	EIR-105, EIR-110	EIR-210
Environmental Feasibility Report For CWC		39	0%	27-Sep-21	22-Nov-21	8		
EIR-110	Prepare Draft Environmental Feasibility Report for CWC	14	0%	27-Sep-21	15-Oct-21	3	EIR-530	EIR-540, EIR-00-SR, FO-1080, EIR-140
EIR-540	Authority review of Draft Environmental Feasibility Report for CWC	8	0%	18-Oct-21	27-Oct-21	3	EIR-110	EIR-560
EIR-560	Legal Review of Draft Environmental Feasbility Report for CWC	5	0%	28-Oct-21	03-Nov-21	3	EIR-540	EIR-117
EIR-117	Live Edit Meeting of Draft Environmental Feasibility Report for CWC	1	0%	04-Nov-21	04-Nov-21	3	EIR-560	EIR-570, EIR-580
EIR-580	Resolve Legal Comments and prepare Final Feasibility Report for CWC	7	0%	05-Nov-21	16-Nov-21	3	EIR-117	EIR-120, MS-004-P2, EIR-570



Actual Work | Critical Remaining Work | Summary | Remaining Work | Milestone

Sites Project Detailed Planning Schedule

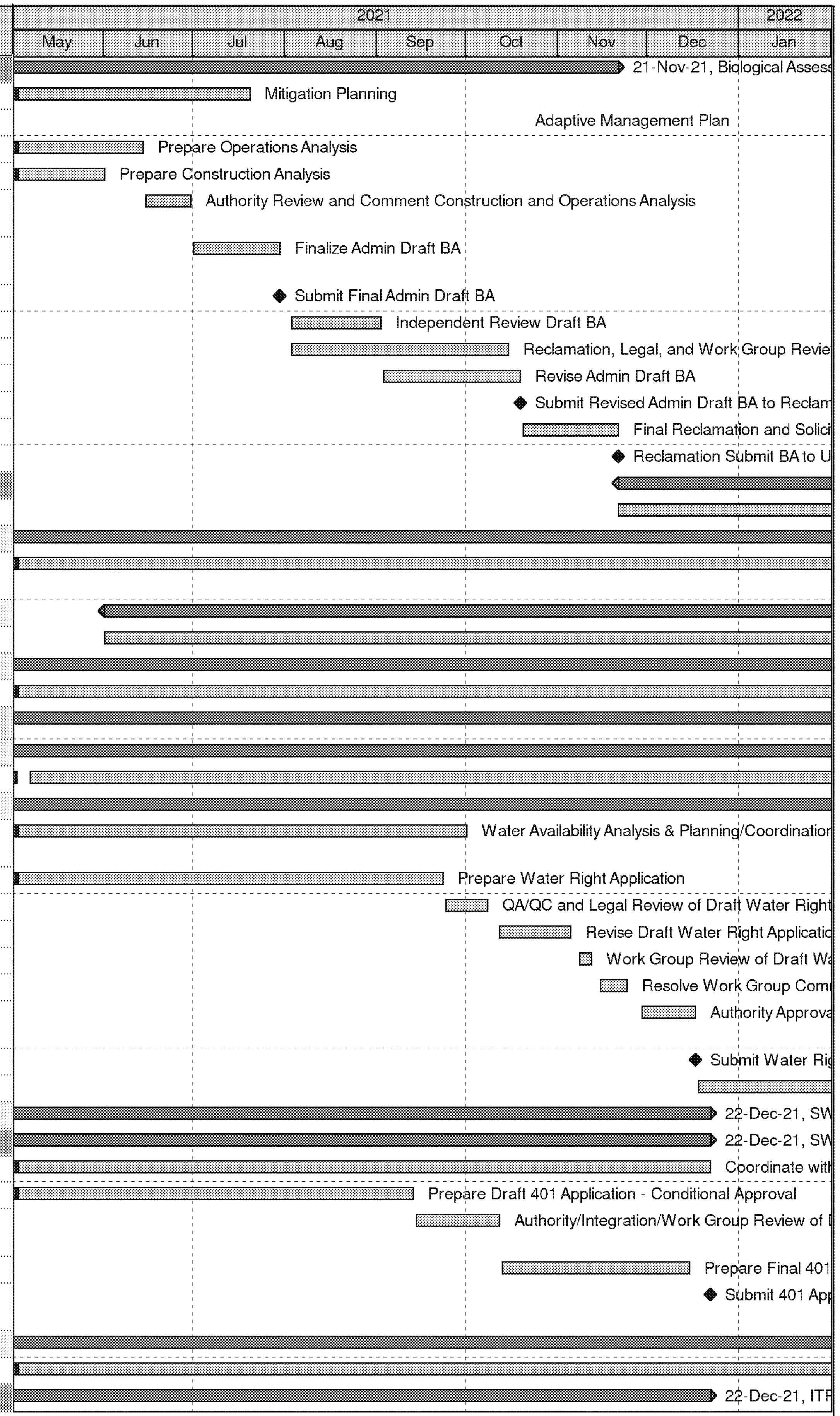
Activity ID	Activity Name	Remaining Duration	% Complete	Start	Finish	Total Float	Predecessors	Successors
EIR-570	Board Briefing of Draft Environmental Feasibility Report for CWC	1	0%	22-Nov-21	22-Nov-21	0	EIR-117, EIR-580	EIR-120
EIR-120	Final Environmental Feasibility Report Submittal to CWC	0	0%		22-Nov-21	8	EIR-580, EIR-00-SR, EIR-570	CWC-500, CWC-490
Final EIR/Final EIS		163	0%	07-Dec-21	01-Aug-22	0		
EIR-210	Preparation of Final EIR/EIS	163	0%	07-Dec-21	01-Aug-22	0	EIR-105, EIR-140	WR-125, EIR-212, STA-140
PERMITTING		113	100%	01-Sep-20 A	12-Oct-21	64		
Geotechnical Field Monitoring		113	100%	01-Sep-20 A	12-Oct-21	64		
GSR-015	Geotechnical Field Monitoring	113	100%	01-Sep-20 A	12-Oct-21	64	GPP-00-00	ENG-404, ENG-406
FEDERAL PERMITS AND AGREEMENTS		528	26.85%	01-Sep-20 A	13-Jun-23	980		
U.S. Army Corps of Engineers CWA 404, Rivers and Harbors Ac		506	100%	01-Sep-20 A	11-May-23	701		
FED-020	U.S. Army Corps of Engineers CWA 404, Rivers and Harbors Act Section 10	529	3%	04-Feb-21 A	11-May-23	429	EIR-021, 404-025	FED-030
Clean Water Act Section 404		161	100%	01-Sep-20 A	22-Dec-21	1046		
404-015	Aquatic Resources Mapping and Reporting	0	100%	01-Sep-20 A	03-May-21	1103	404-010, 404-003	404-030
404-010	Desktop Wetland Delineation Analysis (includes Waters of the State)	40	50%	01-Sep-20 A	28-Jun-21	410	ENG-220, 404-001	404-020, 404-015, 404-025, 408-00-00
404-050	Prepare Draft 404 Application	121	10%	04-Feb-21 A	22-Oct-21	1046	404-003, 404-025	404-060, 404-035, 404-035
404-035	Prepare Compensatory Mitigation Plan	121	5%	04-Feb-21 A	22-Oct-21	1046	404-050, 404-050	404-060
404-001	Prepare LEDPA analysis	20	0%	05-Feb-21 A	28-May-21	410	VP-070, 404-003, EIR-030	404-010, 404-025
404-020	Submit Delineation to USACE	0	0%		29-Jun-21	1062	404-010	404-030
404-030	Preliminary Wetland Delineation Acceptance	90	0%	30-Jun-21	28-Sep-21	1534	404-020, 404-015	404-060
404-060	Authority/Integration/Work Group Review of Draft 404 Application	20	0%	25-Oct-21	22-Nov-21	1046	404-050, 404-035, 404-030	404-070
404-070	Prepare Final 404 Application	20	0%	23-Nov-21	22-Dec-21	1046	404-060	404-120
404-120	Submit 404 Application	0	0%		22-Dec-21	1046	404-070, 404-00-00	CWC-510
U.S. Army Corps of Engineers Rivers and Harbors Act Section		529	0%	04-Feb-21 A	11-May-23	429		
FED-030	U.S. Army Corps of Engineers Rivers and Harbors Act Section 14, Section 408	529	0%	04-Feb-21 A	11-May-23	429	FED-020	STA-030
U.S. EPA and U.S. Army Corps of Engineers LEDPA Review		461	0%	02-Nov-20 A	06-Feb-23	497		
FED-040	U.S. EPA and U.S. Army Corps of Engineers LEDPA Revie	461	0%	02-Nov-20 A	06-Feb-23	497	WP2-130	RC-100
Advisory Council on Historic Preservation NHPA Section 106		190	0%	01-Sep-20 A	04-Feb-22	969		
FED-050	Advisory Council on Historic Preservation NHPA Section 10	147	0%	01-Sep-20 A	02-Dec-21	19	106-001	MS-004-P2
106-022	Reclamation Review	35	0%	22-Mar-21 A	21-Jun-21	966	106-021	106-024
106-024	Revisions	9	0%	22-Jun-21	02-Jul-21	966	106-022	106-025, 106-032
106-025	Reclamation Distributes to SHPO and Invited Consulting Parties	5	0%	06-Jul-21	12-Jul-21	981	106-024	106-026, 106-033
106-032	Arrange Meeting Logistics and Prepare Materials	20	0%	06-Jul-21	02-Aug-21	966	106-024	106-042, 106-033
106-026	Parties Accept Invitation for Consulting Party Status	30	0%	13-Jul-21	11-Aug-21	1432	106-025	106-052
106-033	Conduct Meetings	10	0%	03-Aug-21	16-Aug-21	966	106-025, 106-032	106-042, 106-041
106-041	Prepare Draft PA	10	0%	17-Aug-21	30-Aug-21	966	106-033	106-042
106-042	Reclamation Review	10	0%	31-Aug-21	14-Sep-21	966	106-032, 106-033, 106-041	106-044, 106-052
106-044	Revisions	15	0%	15-Sep-21	05-Oct-21	978	106-042	106-061
106-052	Circulate Draft PA to SHPO and Consulting Parties	5	0%	15-Sep-21	21-Sep-21	966	106-026, 106-042	106-053
106-053	Deadline for Comments on Draft PA	30	0%	22-Sep-21	21-Oct-21	1398	106-052	106-061
106-061	Prepare Draft Final PA	25	0%	21-Oct-21	30-Nov-21	967	106-053, 106-044	106-062
106-062	Reclamation Review	10	0%	30-Nov-21	14-Dec-21	967	106-061	106-064
106-064	Revisions	10	0%	14-Dec-21	29-Dec-21	967	106-062	106-072
106-071	Consult with SHPO and Consulting Parties on Draft Final F	25	0%	29-Dec-21	04-Feb-22	969	106-072	106-073
106-072	Circulate Draft Final PA to SHPO and Consulting Parties	5	0%	29-Dec-21	06-Jan-22	967	106-064	106-071, 106-073
USFWS and NMFS ESA Section 7		230	0%	01-Sep-20 A	05-Apr-22	977		
FED-060	USFWS and NMFS ESA Section 7	189	20%	01-Sep-20 A	03-Feb-22	734	WP2-130	RC-100



Actual Work · Critical Remaining Work · Summary · Remaining Work · Milestone

Sites Project Detailed Planning Schedule

Activity ID	Activity Name	Remaining Duration	% Complete	Start	Finish	Total Float	Predecessors	Successors
Biological Assessment		140	0%	01-Sep-20 A	21-Nov-21	970		
BA-011	Mitigation Planning	55	0%	01-Sep-20 A	20-Jul-21	1001	BA-010, WP2-130	BA-057
BA-016	Adaptive Management Plan	118	0%	01-Sep-20 A	19-Oct-21	969	BA-015, WP2-130	BA-060
BA-025	Prepare Operations Analysis	30	0%	24-Feb-21 A	14-Jun-21	971	VP-095, BA-010, OP-320	BA-030, BA-029
BA-024	Prepare Construction Analysis	21	0%	25-Mar-21 A	01-Jun-21	980	BA-001, ENG-220, BA-022	BA-030, BA-029
BA-029	Authority Review and Comment Construction and Operations Analysis	12	0%	15-Jun-21	30-Jun-21	971	BA-025, BA-024	BA-030
BA-030	Finalize Admin Draft BA	21	0%	01-Jul-21	30-Jul-21	971	BA-010, BA-015, BA-024, BA-025, BA-029	BA-035, BA-032
BA-032	Submit Final Admin Draft BA	0	0%		30-Jul-21	971	BA-030	BA-035
BA-035	Independent Review Draft BA	31	0%	03-Aug-21	02-Sep-21	1404	BA-030, BA-032	BA-055, BA-057
BA-055	Reclamation, Legal, and Work Group Review	74	0%	03-Aug-21	15-Oct-21	1404	BA-035	BA-057, BA-075
BA-057	Revise Admin Draft BA	31	0%	03-Sep-21	19-Oct-21	969	BA-055, BA-035, BA-011	BA-075, BA-060
BA-060	Submit Revised Admin Draft BA to Reclamation	0	0%		19-Oct-21	969	BA-057, BA-016	BA-075
BA-075	Final Reclamation and Solicitor Office Review	33	0%	20-Oct-21	21-Nov-21	1400	BA-055, BA-057, BA-060	BA-1110, BA-100
BA-100	Reclamation Submit BA to USFWS & NMFS	0	0%		21-Nov-21	1400	BA-075, BA-000	BA-1110
BO Incidental Task Authorization		135	0%	21-Nov-21	05-Apr-22	1400		
BA-1110	BO Incidental Take Authorization	135	0%	21-Nov-21	05-Apr-22	1400	BA-075, BA-100	OS-1120, CWC-510
USFWS Bald Eagle Protection Act		528	0%	01-Sep-20 A	13-Jun-23	395		
FED-075	USFWS Bald Eagle Protection Act (includes Pre-Application Surveys)	528	0%	01-Sep-20 A	13-Jun-23	395	WP2-130	RC-100
USBR Warren Act		356	0%	01-Jun-21	01-Nov-22	1132		
FED-090	USBR Warren Act	356	0%	01-Jun-21	01-Nov-22	1132	EIR-030	EIR-450
USBR - Land Agreement		363	0%	02-Nov-20 A	13-Oct-22	290		
FED-100	USBR Land Agreements	363	16%	02-Nov-20 A	13-Oct-22	290	WP2-130	PD-100
STATE PERMITS AND AGREEMENTS		506	0%	01-Sep-20 A	11-May-23	701		
Central Valley Flood Protection Board Levee Encroachment		501	0%	01-Sep-20 A	11-May-23	417		
STA-030	Central Valley Flood Protection Board Levee Encroachmer	501	15%	01-Sep-20 A	11-May-23	417	WP2-130, FED-030	RC-100
SWRCB Water Rights Permit		197	0%	01-Sep-20 A	16-Feb-22	779		
WR-005	Water Availability Analysis & Planning/Coordination with SWRCB	107	10%	01-Sep-20 A	01-Oct-21	776	WP2-130	WR-025, WR-00-00
WR-025	Prepare Water Right Application	101	12%	01-Feb-21 A	23-Sep-21	776	WR-005	WR-035
WR-035	QA/QC and Legal Review of Draft Water Right Application	11	0%	24-Sep-21	08-Oct-21	776	WR-025	WR-045
WR-045	Revise Draft Water Right Application	19	0%	12-Oct-21	05-Nov-21	776	WR-035	WR-055
WR-055	Work Group Review of Draft Water Right Application	4	0%	08-Nov-21	12-Nov-21	776	WR-045	WR-065
WR-065	Resolve Work Group Comments	8	0%	15-Nov-21	24-Nov-21	776	WR-055	WR-075
WR-075	Authority Approval of Water Right Application, Submit to SWRCB	15	0%	29-Nov-21	17-Dec-21	776	WR-065	WR-085
WR-085	Submit Water Right Application	0	0%		17-Dec-21	776	WR-075	WR-095
WR-095	SWRCB Review of Water Right Application	60	0%	18-Dec-21	16-Feb-22	1126	WR-085	WR-105
SWB CWA Section 401 Water Quality Certification		161	0%	15-Jan-21 A	22-Dec-21	1046		
SWB CWA Section 401 Water Quality Certification - Conditional Ap;		161	0%	15-Jan-21 A	22-Dec-21	1046		
401-120	Coordinate with RWQCB and SWRCB - Conditional Apprc	161	5%	15-Jan-21 A	22-Dec-21	1046	404-003	401-130, 401-160
401-130	Prepare Draft 401 Application - Conditional Approval	93	0%	01-Mar-21 A	13-Sep-21	1051	WP2-130, 401-120	401-140
401-140	Authority/Integration/Work Group Review of Draft 401 - Conditional Approval	20	0%	14-Sep-21	12-Oct-21	1051	401-130	401-150
401-150	Prepare Final 401 Application - Conditional Approval	43	0%	13-Oct-21	15-Dec-21	1051	401-140	401-160
401-160	Submit 401 Application - Conditional Approval	0	0%		22-Dec-21	1046	401-150, 401-00-00, CES-270, CES-280, 401-120	CWC-510, 401-170
CDFW Incidental Take Permits		292	0%	01-Sep-20 A	01-Jul-22	915		
STA-110	CDFW Section 2081	292	0%	01-Sep-20 A	01-Jul-22	129	106-001	OS-1120, CES-010, STA-1:
ITP - CESA(Se 2081) Operations		161	0%	30-Sep-20 A	22-Dec-21	1046		



Actual Work | Critical Remaining Work | Summary
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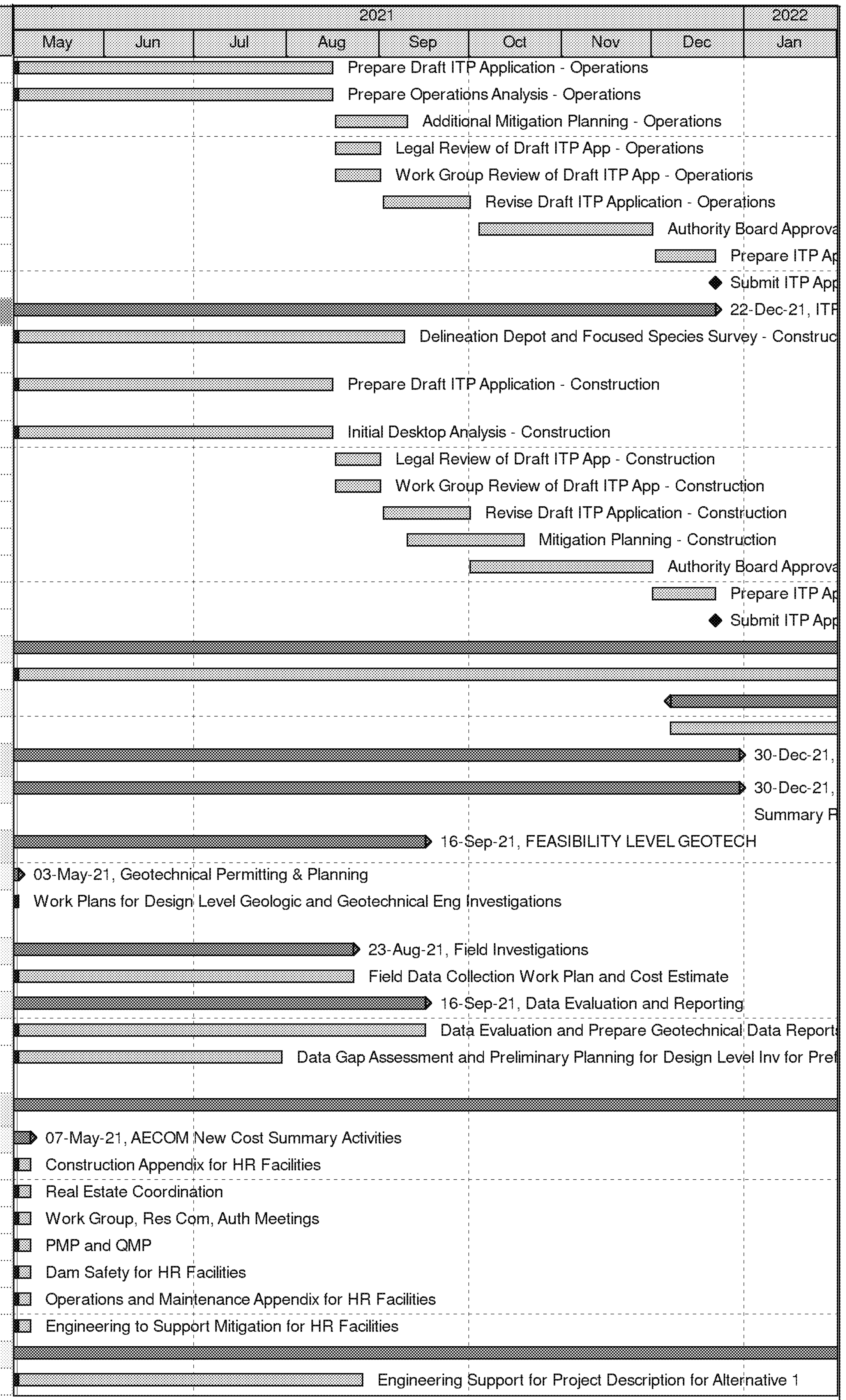
Sites Project Detailed Planning Schedule

Activity ID	Activity Name	Remaining Duration	% Complete	Start	Finish	Total Float	Predecessors	Successors
CES-210	Prepare Draft ITP Application - Operations	74	5%	30-Sep-20 A	16-Aug-21	1046	VP-095	CES-220, CES-230, CES-2
CES-190	Prepare Operations Analysis - Operations	74	5%	30-Sep-20 A	16-Aug-21	1115	OP-0230	CES-200, CES-00-10
CES-200	Additional Mitigation Planning - Operations	18	0%	17-Aug-21	10-Sep-21	1115	CES-190, CES-210, OP-360	CES-270
CES-220	Legal Review of Draft ITP App - Operations	16	0%	17-Aug-21	01-Sep-21	1511	CES-210	CES-240
CES-230	Work Group Review of Draft ITP App - Operations	16	0%	17-Aug-21	01-Sep-21	1511	CES-210	CES-240
CES-240	Revise Draft ITP Application - Operations	21	0%	02-Sep-21	01-Oct-21	1046	CES-230, CES-220	CES-250
CES-250	Authority Board Approval of ITP App - Operations	39	0%	04-Oct-21	01-Dec-21	1046	CES-240	CES-260
CES-260	Prepare ITP Application to CDFW - Operations	15	0%	02-Dec-21	22-Dec-21	1046	CES-250	CWC-510, CES-270
CES-270	Submit ITP Application to CDFW - Operations	0	0%		22-Dec-21	1046	CES-260, CES-00-10, CES-200	401-160
ITP - CESA(Se 2081) Construction		160	0%	01-Sep-20 A	22-Dec-21	119		
CES-020	Delineation Depot and Focused Species Survey - Construction	91	0%	01-Sep-20 A	09-Sep-21	145	CES-010	CES-025
CES-030	Prepare Draft ITP Application - Construction	74	10%	30-Sep-20 A	16-Aug-21	119	VP-095	CES-040, CES-060, CES-00-00
CES-010	Initial Desktop Analysis - Construction	74	20%	30-Sep-20 A	16-Aug-21	145	ENG-220, VP-095, STA-110, BA-001	CES-020
CES-040	Legal Review of Draft ITP App - Construction	16	0%	17-Aug-21	01-Sep-21	177	CES-030	CES-070
CES-060	Work Group Review of Draft ITP App - Construction	16	0%	17-Aug-21	01-Sep-21	177	CES-030	CES-070
CES-070	Revise Draft ITP Application - Construction	20	0%	02-Sep-21	01-Oct-21	118	CES-060, CES-040	CES-080
CES-025	Mitigation Planning - Construction	27	0%	10-Sep-21	19-Oct-21	145	CES-020	CES-090
CES-080	Authority Board Approval of ITP App - Construction	39	0%	01-Oct-21	01-Dec-21	118	CES-070	CES-090, CES-090
CES-090	Prepare ITP Application to CDFW - Construction	15	0%	01-Dec-21	22-Dec-21	118	CES-080, OP-446, CES-080, CES-0	CES-280, MS-020-CS
CES-280	Submit ITP Application to CDFW - Construction	0	0%		22-Dec-21	119	CES-090, CES-00-00	MS-020-CS, 401-160
NAHC/Local Tribes AB 52 Consultation		233	0%	01-Sep-20 A	08-Apr-22	129		
STA-120	NAHC/Local Tribes AB 52 Consultation	233	0%	01-Sep-20 A	08-Apr-22	129	STA-110	EIR-250
SMARA		86	0%	07-Dec-21	12-Apr-22	169		
STA-140	SMARA	86	0%	07-Dec-21	12-Apr-22	169	EIR-210	MS-250-FE
MITIGATION		166	0%	09-Dec-20 A	30-Dec-21	0		
Early Mitigation		166	0%	09-Dec-20 A	30-Dec-21	0		
EM-00-10	Summary Report for Early Mitigation/Geotech Mitigation	166	0%	09-Dec-20 A	30-Dec-21	0	PA-160	MS-004-P2
FEASIBILITY LEVEL GEOTECH		96	30.99%	04-Sep-20 A	16-Sep-21	103		
Geotechnical Permitting & Planning		0	100%	04-Sep-20 A	03-May-21	87		
GSR-010	Work Plans for Design Level Geologic and Geotechnical Eng Investigations	0	100%	04-Sep-20 A	03-May-21	87	WP2-130, GSR-000	GSR-020
Field Investigations		79	0%	07-Sep-20 A	23-Aug-21	87		
GSR-020	Field Data Collection Work Plan and Cost Estimate	79	0%	07-Sep-20 A	23-Aug-21	87	GSR-010, ENG-570	GSR-030, TM-I99
Data Evaluation and Reporting		96	55.18%	04-Jan-21 A	16-Sep-21	103		
GSR-030	Data Evaluation and Prepare Geotechnical Data Reports	96	39.62%	04-Jan-21 A	16-Sep-21	103	GSR-020	GSR-040
GSR-040	Data Gap Assessment and Preliminary Planning for Design Level Inv for Preferred Alt	63	72.96%	04-Jan-21 A	30-Jul-21	103	GSR-030	MS-004-P2
FEASIBILITY ENGINEERING		1058	42.76%	01-Sep-20 A	09-Jul-25	65		
AECOM New Cost Summary Activities		5	0%	01-Sep-20 A	07-May-21	158		
ENG-234	Construction Appendix for HR Facilities	5	0%	01-Sep-20 A	07-May-21	81	ENG-370	ENG-390
ENG-238	Real Estate Coordination	5	0%	01-Sep-20 A	07-May-21	81	ENG-370	ENG-390, RE-210
ENG-435	Work Group, Res Com, Auth Meetings	5	0%	01-Sep-20 A	07-May-21	158	ENG-380	ENG-392
TM-H97	PMP and QMP	5	0%	01-Sep-20 A	07-May-21	118	ENG-380	ENG-390
ENG-236	Dam Safety for HR Facilities	5	0%	01-Oct-20 A	07-May-21	81	ENG-400	ENG-235
ENG-235	Operations and Maintenance Appendix for HR Facilities	5	0%	01-Nov-20 A	07-May-21	81	ENG-370, ENG-236	ENG-390
ENG-237	Engineering to Support Mitigation for HR Facilities	5	0%	01-Nov-20 A	07-May-21	81	ENG-340	ENG-390
Engineering Support for Env and Permitting		292	47.85%	01-Sep-20 A	01-Jul-22	289		
ENG-233	Engineering Support for Project Description for Alternative	82	6.82%	01-Sep-20 A	26-Aug-21	8	RCB-20-038, PDE-40, WP2-130	ENG-370



Actual Work — Critical Remaining Work — Summary
Remaining Work — Milestone

Sites Project Detailed Planning Schedule

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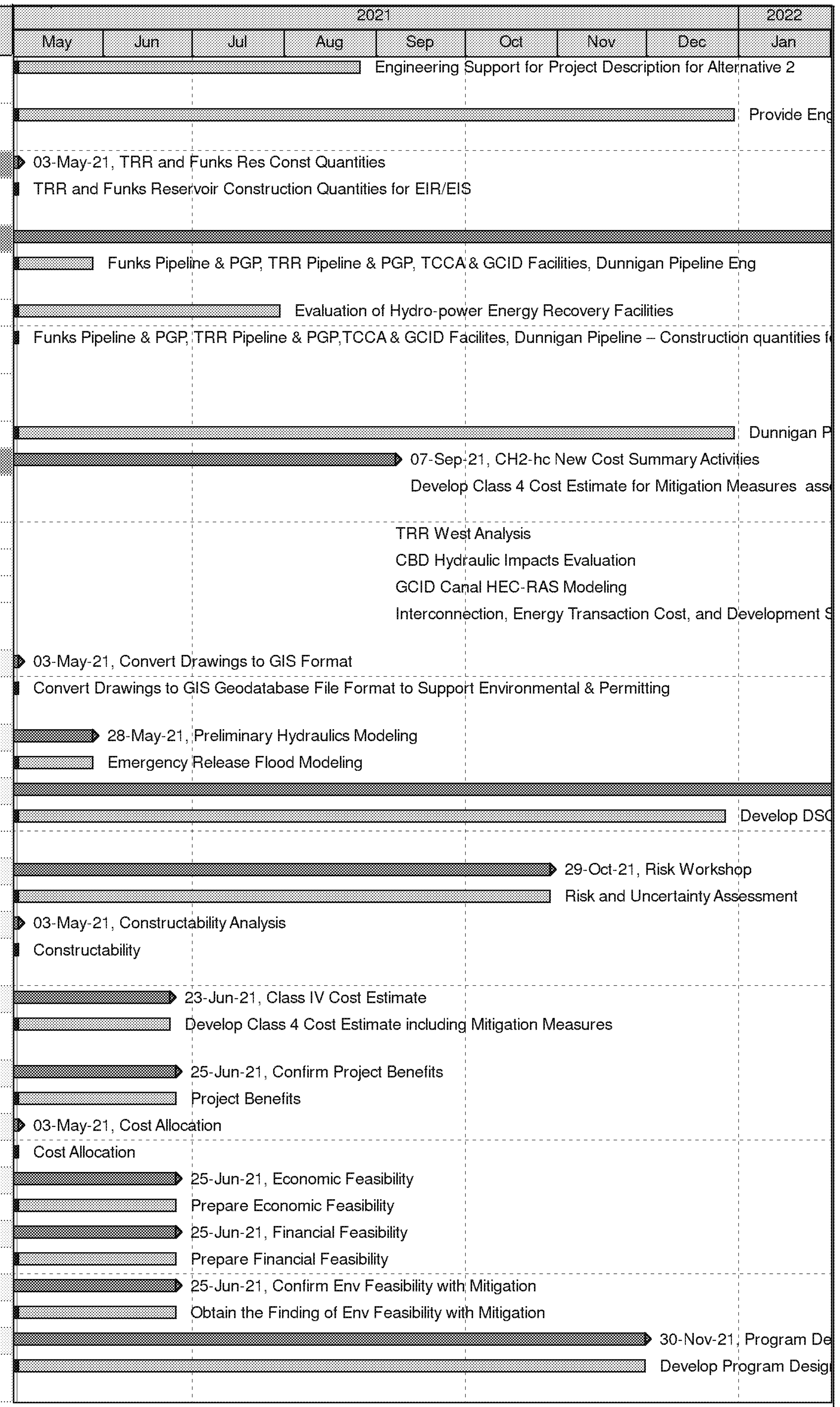
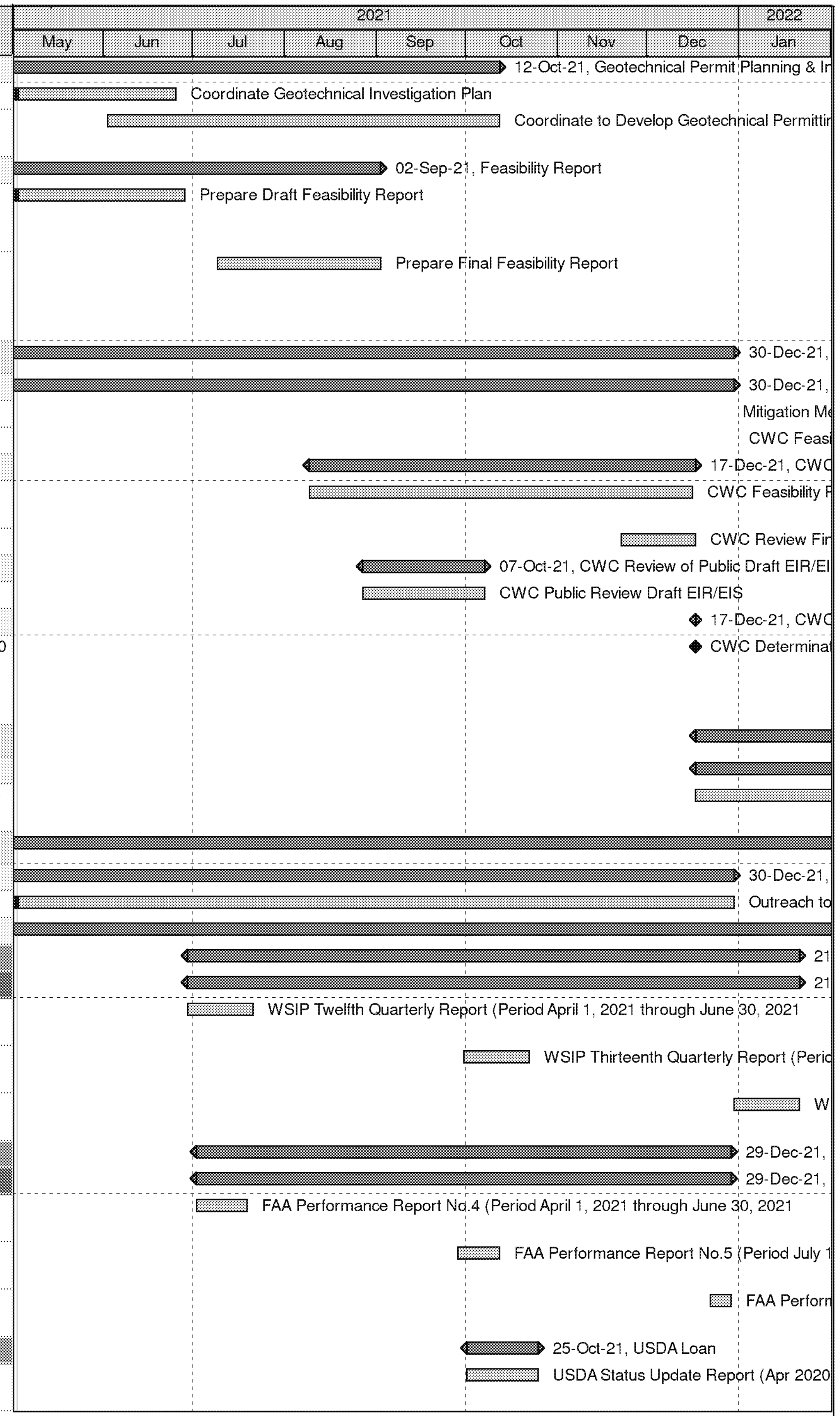
Activity ID	Activity Name	Remaining Duration	% Complete	Start	Finish	Total Float	Predecessors	Successors
ENG-239	Engineering Support for Project Description for Alternative 2	82	6.82%	01-Sep-20 A	26-Aug-21	8	RCB-20-038, PDE-40, WP2-130, EIR-035	ENG-370
ENG-230	Provide Engineering Support to Environmental and Permitting Team	166	47.47%	30-Sep-20 A	30-Dec-21	0	ENG-220	MS-004-P2
TRR and Funks Res Const Quantities		0	100%	02-Nov-20 A	03-May-21	20		
ENG-510	TRR and Funks Reservoir Construction Quantities for EIR/EIS	0	100%	02-Nov-20 A	03-May-21	20	ENG-501	ENG-550, ENG-570, EIR-020, ENG-592
Remaining Engineering		292	62.12%	01-Sep-20 A	01-Jul-22	289		
ENG-560	Funks Pipeline & PGP, TRR Pipeline & PGP, TCCA & GCID Facilities, Dunnigan Pipeline Eng	20	77.27%	01-Sep-20 A	28-May-21	146	ENG-501	CWC-500
ENG-580	Evaluation of Hydro-power Energy Recovery Facilities	63	66.67%	01-Sep-20 A	30-Jul-21	103	ENG-501	CWC-500
ENG-570	Funks Pipeline & PGP, TRR Pipeline & PGP,TCCA & GCID Facilites, Dunnigan Pipeline – Construction quantities for EIS/EIR	0	100%	09-Oct-20 A	03-May-21	165	ENG-510	GSR-020
ENG-550	OH Transmission Lines & Substations - Constr Quantities for EIR/EIS Summary	292	0%	02-Nov-20 A	01-Jul-22	289	ENG-510	DB-100
ENG-590	Dunnigan Pipeline CVFPB & USACE 408 Permit Support	166	0%	04-Jan-21 A	30-Dec-21	113	ENG-501, ENG-502	PH2-2a-1010
CH2-hc New Cost Summary Activities		92	0%	08-Sep-20 A	07-Sep-21	71		
ENG-266	Develop Class 4 Cost Estimate for Mitigation Measures associated with HC Facilities	92	0%	08-Sep-20 A	07-Sep-21	71	ENG-265	ENG-392
ENG-592	TRR West Analysis	89	0%	02-Nov-20 A	02-Sep-21	34	ENG-510	ENG-390
ENG-467	CBD Hydraulic Impacts Evaluation	89	0%	23-Nov-20 A	02-Sep-21	34	OP-0640	ENG-390
ENG-468	GCID Canal HEC-RAS Modeling	89	0%	23-Nov-20 A	02-Sep-21	34	OP-0610	ENG-390
ENG-591	Interconnection, Energy Transaction Cost, and Development Support Services	89	0%	31-Dec-20 A	02-Sep-21	34	ENG-530	ENG-390
Convert Drawings to GIS Format		0	100%	12-Sep-20 A	03-May-21	0		
ENG-220	Convert Drawings to GIS Geodatabase File Format to Support Environmental & Permitting	0	100%	12-Sep-20 A	03-May-21	0	ENG-200	ENG-230, BA-001, CES-010, 404-010, EIR-018, BA-024
Preliminary Hydraulics Modeling		20	83.87%	01-Sep-20 A	28-May-21	350		
ENG-466	Emergency Release Flood Modeling	20	83.87%	01-Sep-20 A	28-May-21	350	WP2-130	ENG-480, ENG-420
DSOD Engagement		1058	0%	01-Sep-20 A	09-Jul-25	65		
ENG-400	Develop DSOD Engagement Plan	163	0%	01-Sep-20 A	27-Dec-21	79	WP2-130	ENG-440, ENG-445, ENG-
ENG-440	DSOD Engagement	1058	0%	01-Sep-20 A	09-Jul-25	65	ENG-400, ENG-445	ENG-410, STA-080, ENG-4
Risk Workshop		126	0%	01-Oct-20 A	29-Oct-21	40		
ENG-290	Risk and Uncertainty Assessment	126	0%	01-Oct-20 A	29-Oct-21	40	ENG-210, EIR-021	CWC-403
Constructability Analysis		0	100%	01-Sep-20 A	03-May-21	8		
ENG-370	Constructability	0	100%	01-Sep-20 A	03-May-21	8	ENG-233, ENG-239	ENG-380, ENG-320, PA-220, ENG-234, ENG-235, ENG-238
Class IV Cost Estimate		37	32.73%	08-Sep-20 A	23-Jun-21	32		
ENG-265	Develop Class 4 Cost Estimate including Mitigation Measures	37	32.73%	08-Sep-20 A	23-Jun-21	32	EIR-021	ENG-300, ENG-320, ENG-380, ENG-266
Confirm Project Benefits		39	0%	01-Oct-20 A	25-Jun-21	32		
ENG-300	Project Benefits	39	0%	01-Oct-20 A	25-Jun-21	32	ENG-140, ENG-150, ENG-265	ENG-380
Cost Allocation		0	100%	01-Oct-20 A	03-May-21	32		
ENG-320	Cost Allocation	0	100%	01-Oct-20 A	03-May-21	32	ENG-265, ENG-370	ENG-350, ENG-360
Economic Feasibility		39	0%	01-Oct-20 A	25-Jun-21	32		
ENG-350	Prepare Economic Feasibility	39	0%	01-Oct-20 A	25-Jun-21	32	ENG-320	ENG-380
Financial Feasibility		39	0%	01-Oct-20 A	25-Jun-21	32		
ENG-360	Prepare Financial Feasibility	39	0%	01-Oct-20 A	25-Jun-21	32	ENG-320	ENG-380, ENG-340
Confirm Env Feasibility with Mitigation		39	0%	10-Oct-20 A	25-Jun-21	32		
ENG-340	Obtain the Finding of Env Feasibility with Mitigation	39	0%	10-Oct-20 A	25-Jun-21	32	ENG-360, ENG-410	ENG-380, ENG-237
Program Design/Construction/Permit Implementation Schedule		145	0%	01-Oct-20 A	30-Nov-21	32		
ENG-410	Develop Program Design/Construction/Permit Implementation Plan	145	0%	01-Oct-20 A	30-Nov-21	32	ENG-406, ENG-440	ENG-340



Actual Work | Critical Remaining Work | Summary
Remaining Work | Milestone

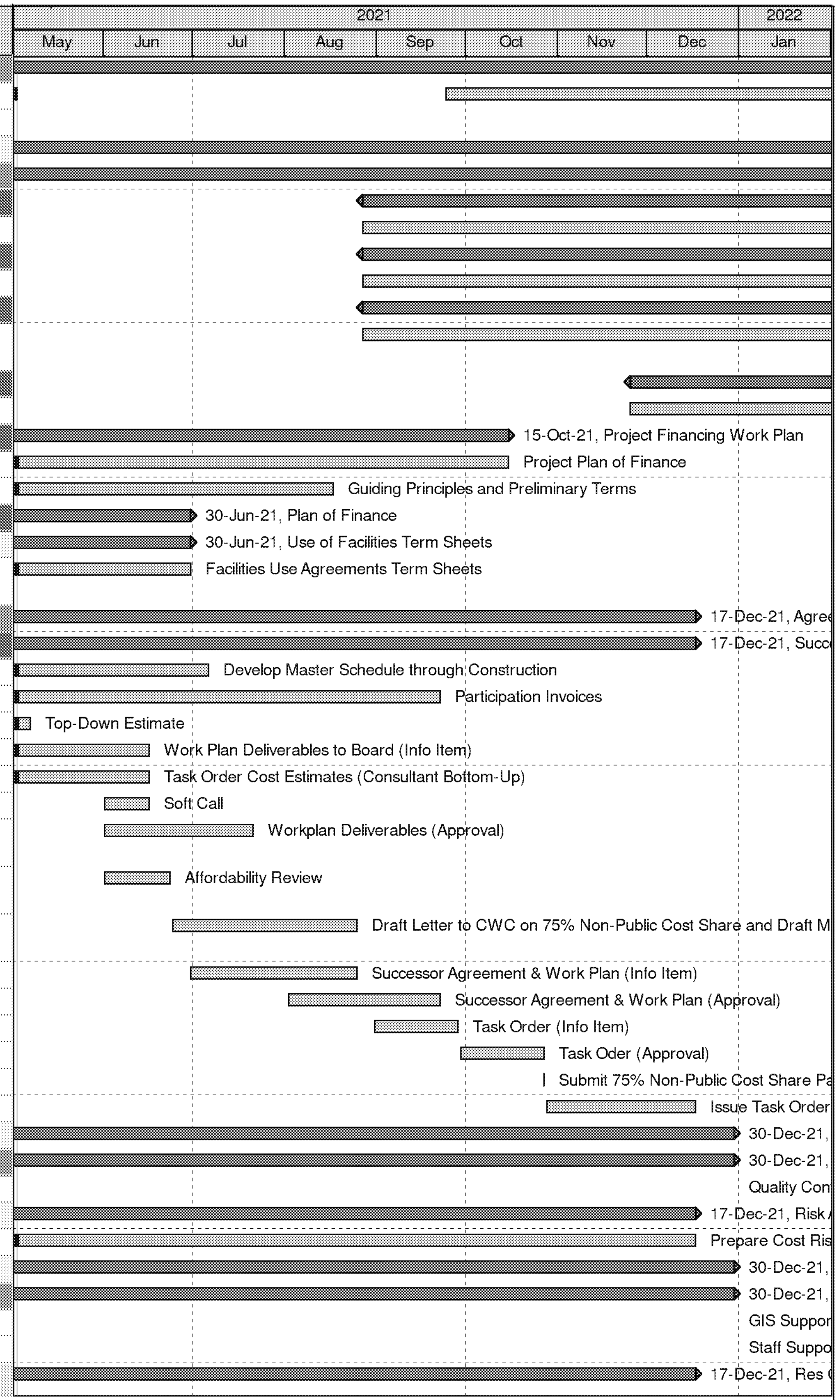
Activity ID	Activity Name	Remaining Duration	% Complete	Start	Finish	Total Float	Predecessors	Successors
Geotechnical Permit Planning & Invest Plan		113	57.18%	01-Sep-20 A	12-Oct-21	64		
ENG-404	Coordinate Geotechnical Investigation Plan	39	62.14%	01-Sep-20 A	25-Jun-21	64	WP2-130, GSR-015	CWC-500, ENG-406
ENG-406	Coordinate to Develop Geotechnical Permitting Plan	92	0%	02-Jun-21	12-Oct-21	64	WP2-130, ENG-404, GSR-015, ENG-440	ENG-410
Feasibility Report		87	48.38%	01-Sep-20 A	02-Sep-21	32		
ENG-380	Prepare Draft Feasibility Report	41	70.29%	01-Sep-20 A	28-Jun-21	33	ENG-210, ENG-350, ENG-340, ENG-360, ENG-370, ENG-265, ENG-300	ENG-390, ENG-385, CWC-010, ENG-435, TM-H97
ENG-390	Prepare Final Feasibility Report	40	0%	09-Jul-21	02-Sep-21	32	ENG-380, ENG-385, OP-0230, OP-446, ENG-234, ENG-235, ENG-237, ENG-238, TM-H97, ENG-467, ENG-468, ENG-591, ENG-592, ENG-385	ENG-392, 408-010, DLG-010, CWC-403
PROP 1		166	0%	05-Oct-20 A	30-Dec-21	0		
CWC Feasibility Report		166	0%	05-Oct-20 A	30-Dec-21	0		
CWC-010	Mitigation Measure Evaluation/Cost Estimate	164	0%	05-Oct-20 A	28-Dec-21	0	ENG-380	MS-004-P2
TM-F107	CWC Feasibility Report Permitting Support	166	0%	13-Oct-20 A	30-Dec-21	0	404-003	MS-004-P2
CWC Feasibility Review		131	0%	09-Aug-21	17-Dec-21	14		
CWC-403	CWC Feasibility Review	130	0%	09-Aug-21	16-Dec-21	15	ENG-390, CFS-030, CWC-450, ENG-290	CWC-500
CWC-490	CWC Review Final Environmental Feasibility Report	25	0%	22-Nov-21	17-Dec-21	14	EIR-120	CWC-500
CWC Review of Public Draft EIR/EIS		30	0%	27-Aug-21	07-Oct-21	11		
CWC-450	CWC Public Review Draft EIR/EIS	30	0%	27-Aug-21	07-Oct-21	11	EIR-080, CWC-420	CWC-403
CWC Determination of Feasibility		0	0%	17-Dec-21	17-Dec-21	14		
CWC-500	CWC Determination of Feasibility	0	0%		17-Dec-21*	14	EIR-120, ENG-404, OP-070, ENG-560, ENG-580, ENG-540, ENG-503, ENG-502, TM-H98, CWC-403, ENG-392, CWC-490	PD-100, DB-100, PDC-1000
CONSTRUCTION		135	0%	17-Dec-21	24-Jun-22	78		
Procurement Designers/Design Builders/Design Assist		135	0%	17-Dec-21	24-Jun-22	78		
PDC-1000	Procurement - Designers, Design Builders & Design Assists (CMAR)	135	0%	17-Dec-21	24-Jun-22	78	CWC-500	PD-100, DLG-010, MIT-015
PROJECT OPERATIONS AND FINANCES		639	6.21%	02-Jan-20 A	21-Nov-23	1662		
COMMUNICATIONS & GOVERNMENT AFFAIRS		166	0%	02-Jan-20 A	30-Dec-21	113		
GS-C60	Outreach to NGO's	166	50.89%	02-Jan-20 A	30-Dec-21	113	MS-004-Ph2	MS-006-Ph2-2a
FUNDING		251	0%	01-Sep-20 A	30-Jun-22	2010		
State Funding		140	0%	29-Jun-21	21-Jan-22	1328		
WSIP Early Funding Administration		140	0%	29-Jun-21	21-Jan-22	1328		
WSIP-1120	WSIP Twelfth Quarterly Report (Period April 1, 2021 through June 30, 2021	16	0%	29-Jun-21	21-Jul-21	158	WSIP-1110	WSIP-1130
WSIP-1130	WSIP Thirteenth Quarterly Report (Period July 1, 2021 through September 30, 2021	16	0%	30-Sep-21	22-Oct-21	158	WSIP-1120	WSIP-1140, PH2-2a-1000, MS-006-Ph2-2a
WSIP-1140	WSIP Fourteenth Quarterly Report (Period October 1, 2021 through December 31, 2021	15	0%	30-Dec-21	21-Jan-22	1328	WSIP-1130	MS-450-RD
Federal Funding		122	0%	02-Jul-21	29-Dec-21	1286		
Financial Assistance Agreement		122	0%	02-Jul-21	29-Dec-21	1286		
FAA-1040	FAA Performance Report No.4 (Period April 1, 2021 through June 30, 2021	11	0%	02-Jul-21	19-Jul-21	166	FAA-1030	FAA-1050
FAA-1050	FAA Performance Report No.5 (Period July 1, 2021 through September 30, 2021	10	0%	28-Sep-21	12-Oct-21	166	FAA-1040	FAA-1060, MS-006-Ph2-2a
FAA-1060	FAA Performance Report No.6 (Period October 1, 2021 through December 30, 2021	5	0%	22-Dec-21	29-Dec-21	1286	FAA-1050	FAA-1070, PH2-2a-1000
USDA Loan		16	0%	01-Oct-21	25-Oct-21	157		
USDA-1020	USDA Status Update Report (Apr 2020 - Sept 2021)	16	0%	01-Oct-21	25-Oct-21	157	USDA-1010	USDA-1030, PH2-2a-1000, MS-006-Ph2-2a



Actual Work | Critical Remaining Work | Summary
Remaining Work | Milestone

Sites Project Detailed Planning Schedule

Activity ID	Activity Name	Remaining Duration	% Complete	Start	Finish	Total Float	Predecessors	Successors
WIFIA Loan Application		190	0%	01-Sep-20 A	30-Jun-22	2010		
WL-00-010	WIFIA Loan Application	125	0%	01-Sep-20 A	29-Mar-22	2075	WL-005	WL-00-00
WL-00-00	WIFIA Loan Application Prep	125	0%	03-Jan-22	30-Jun-22	2010	WL-005, WL-00-010	WL-015
GROWTH		639	8.29%	01-Nov-20 A	21-Nov-23	1439		
Plan of Finance		639	8.29%	01-Nov-20 A	21-Nov-23	1439		
Final TCCA Facility Use Agreement		328	0%	27-Aug-21	22-Dec-22	243		
FO-1020	Final TCCA Facility Use Agreement	328	0%	27-Aug-21	22-Dec-22	243	EIR-080, POF-004	PD-100
Final GCID Facility Use Agreement		328	0%	27-Aug-21	22-Dec-22	243		
FO-1030	Final GCID Facility Use Agreement	328	0%	27-Aug-21	22-Dec-22	243	EIR-080, POF-004	PD-100
Final CBDA Facility Use Agreement		328	0%	27-Aug-21	22-Dec-22	1668		
FO-1040	Final CBDA Facility Use Agreement	328	0%	27-Aug-21	22-Dec-22	1668	EIR-080, POF-004, OP-480 ($$$), OP-490	FO-1050
Develop Organizational Operating Roles and Responsibilities		519	0%	25-Nov-21	21-Nov-23	1446		
FO-1070	Develop Organizational Operating Roles and Responsibiliti	519	0%	25-Nov-21	21-Nov-23	1446	FO-1060	OS-1150
Project Financing Work Plan		116	10%	01-Nov-20 A	15-Oct-21	91		
POF-002	Project Plan of Finance	116	10%	01-Nov-20 A	15-Oct-21	91	POF-010	POF-003
POF-003	Guiding Principles and Preliminary Terms	75	10%	01-Nov-20 A	17-Aug-21	91	POF-002, POF-001, POF-400	MS-004-P2
Plan of Finance		42	0%	01-Dec-20 A	30-Jun-21	325		
Use of Facilities Term Sheets		42	0%	01-Dec-20 A	30-Jun-21	325		
POF-004	Facilities Use Agreements Term Sheets	42	0%	01-Dec-20 A	30-Jun-21	325	ENG-190, WP2-130	OP-1005, OP-1015, FO-1020, FO-1030, FO-1040
Agreements		158	0%	01-Mar-21 A	17-Dec-21	8		
Successor Agreement & Work Plan		158	0%	01-Mar-21 A	17-Dec-21	8		
PA-220	Develop Master Schedule through Construction	45	63.71%	01-Mar-21 A	06-Jul-21	8	PA-160, ENG-370	PA-210, A3WP-1000
PA-450	Participation Invoices	100	0%	01-Mar-21 A	22-Sep-21	66	PA-400	MS-004-P2
A3WP-101	Top-Down Estimate	5	40%	01-Apr-21 A	07-May-21	8	A3WP-1000	A3WP-1020, A3WP-1030
A3WP-102	Work Plan Deliverables to Board (Info Item)	32	0%	29-Apr-21 A	16-Jun-21	8	A3WP-1010	A3WP-1050
A3WP-103	Task Order Cost Estimates (Consultant Bottom-Up)	32	0%	29-Apr-21 A	16-Jun-21	8	A3WP-1010	A3WP-1050
A3WP-108	Soft Call	12	0%	01-Jun-21	16-Jun-21	39	A3WP-1050, A3WP-1060	A3WP-1090
A3WP-1050	Workplan Deliverables (Approval)	36	0%	01-Jun-21	21-Jul-21	8	A3WP-1020, A3WP-1030	A3WP-1070, A3WP-1080, A3WP-1060
A3WP-1060	Affordability Review	17	0%	01-Jun-21	23-Jun-21	8	A3WP-1050	A3WP-1070, A3WP-1080, A3WP-1140
A3WP-1140	Draft Letter to CWC on 75% Non-Public Cost Share and Draft Materials	44	0%	24-Jun-21	25-Aug-21	85	A3WP-1060	MS-004-P2
A3WP-107	Successor Agreement & Work Plan (Info Item)	40	0%	30-Jun-21	25-Aug-21	8	A3WP-1050, A3WP-1060, PA-210	A3WP-1090
A3WP-109	Successor Agreement & Work Plan (Approval)	37	0%	02-Aug-21	22-Sep-21	8	A3WP-1070, A3WP-1080, PA-400	A3WP-1100
A3WP-110	Task Order (Info Item)	20	0%	31-Aug-21	28-Sep-21	8	A3WP-1090	A3WP-1110
A3WP-111	Task Oder (Approval)	20	0%	29-Sep-21	27-Oct-21	8	A3WP-1100	A3WP-1120, A3WP-1150
A3WP-115	Submit 75% Non-Public Cost Share Package to CWC	1	0%	27-Oct-21	27-Oct-21	42	A3WP-1110	MS-004-P2
A3WP-112	Issue Task Orders	34	0%	28-Oct-21	17-Dec-21	8	A3WP-1110, A3WP-1130	MS-004-P2
PROJECT CONTROLS		166	0%	02-Oct-20 A	30-Dec-21	113		
BC New Cost Summary Activities		166	0%	02-Oct-20 A	30-Dec-21	113		
TM-B97	Quality Control	166	0%	02-Oct-20 A	30-Dec-21	113	MS-005-Ph2-1b	PH2-2a-1010
Risk Assessment		158	0%	28-Dec-20 A	17-Dec-21	8		
RA-010	Prepare Cost Risk Update	158	0%	28-Dec-20 A	17-Dec-21	8	RA-005	MS-004-P2
SUPPORT		166	0%	04-Sep-20 A	30-Dec-21	113		
HDR New Cost Summary Activities		166	0%	04-Sep-20 A	30-Dec-21	113		
MGT-055	GIS Support	166	0%	04-Sep-20 A	30-Dec-21	113	MS-005-Ph2-1b	PH2-2a-1010
MGT-065	Staff Support	166	0%	04-Sep-20 A	30-Dec-21	113	MS-005-Ph2-1b	PH2-2a-1010
Res Comm/Authority Board		158	0%	21-Apr-21 A	17-Dec-21	8		

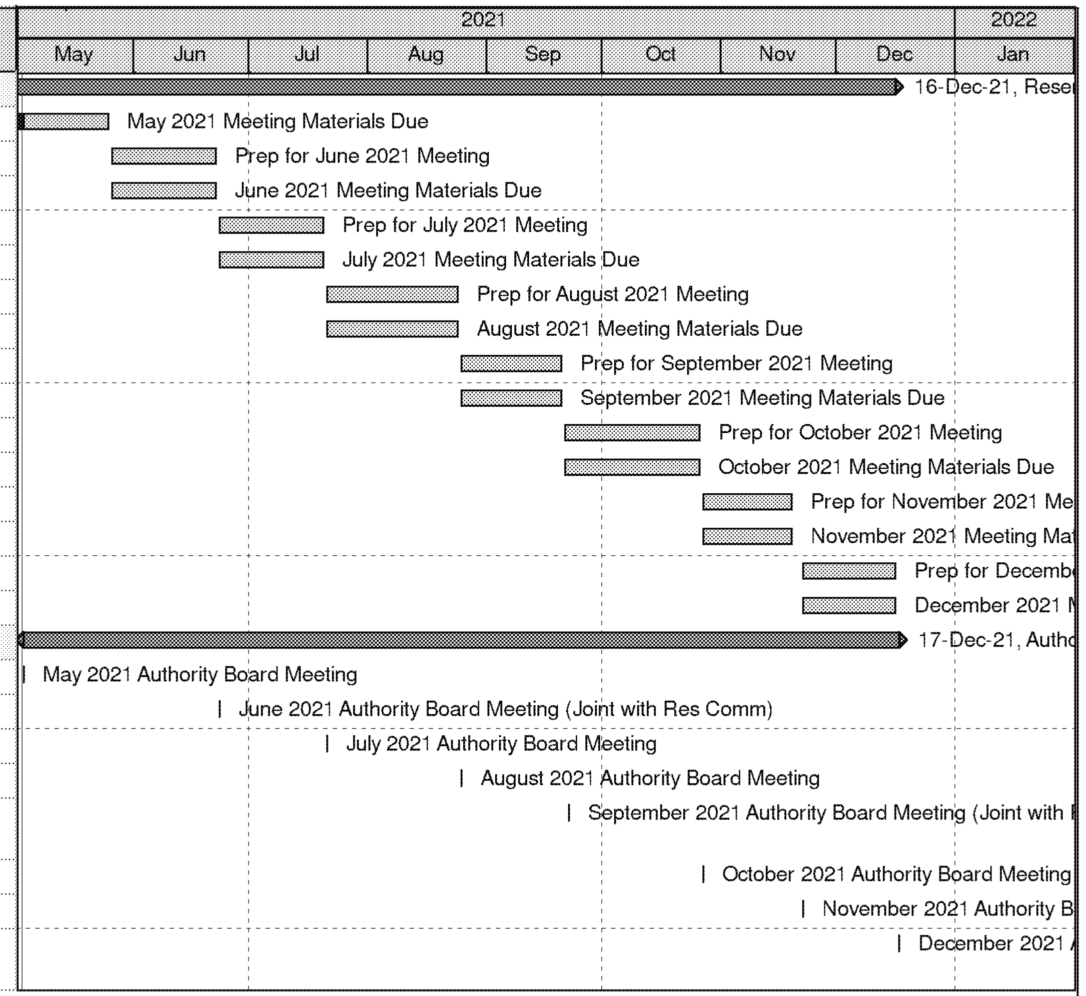


Actual Work | Critical Remaining Work | Summary
Remaining Work | Milestone

Sites Project Detailed Planning Schedule

Draft_0009901

Activity ID	Activity Name	Remaining Duration	% Complete	Start	Finish	Total Float	Predecessors	Successors
Reservoir Committee/Board Materials DUE		157	0%	21-Apr-21 A	16-Dec-21	1		
RCB-20-318	May 2021 Meeting Materials Due	17	32%	21-Apr-21 A	25-May-21*	1	RCB-20-298	RCB-20-338, RCB-20-328
RCB-20-348	Prep for June 2021 Meeting	19	0%	26-May-21	22-Jun-21*	1	RCB-20-338	RCB-20-208
RCB-20-338	June 2021 Meeting Materials Due	19	0%	26-May-21	22-Jun-21*	1	RCB-20-318	RCB-20-358, RCB-20-348
RCB-20-368	Prep for July 2021 Meeting	19	0%	23-Jun-21	20-Jul-21*	1	RCB-20-358	RCB-20-218
RCB-20-358	July 2021 Meeting Materials Due	19	0%	23-Jun-21	20-Jul-21*	1	RCB-20-338	RCB-20-378, RCB-20-368
RCB-20-388	Prep for August 2021 Meeting	25	0%	21-Jul-21	24-Aug-21*	1	RCB-20-378	RCB-20-228
RCB-20-378	August 2021 Meeting Materials Due	25	0%	21-Jul-21	24-Aug-21*	1	RCB-20-358	RCB-20-398, RCB-20-388
RCB-20-408	Prep for September 2021 Meeting	18	0%	25-Aug-21	20-Sep-21*	1	RCB-20-398	RCB-20-238
RCB-20-398	September 2021 Meeting Materials Due	18	0%	25-Aug-21	20-Sep-21*	1	RCB-20-378	RCB-20-418, RCB-20-408
RCB-20-428	Prep for October 2021 Meeting	25	0%	21-Sep-21	26-Oct-21*	1	RCB-20-418	RCB-20-248
RCB-20-418	October 2021 Meeting Materials Due	25	0%	21-Sep-21	26-Oct-21*	1	RCB-20-398	RCB-20-438, RCB-20-428
RCB-20-448	Prep for November 2021 Meeting	17	0%	27-Oct-21	19-Nov-21*	1	RCB-20-438	RCB-20-258
RCB-20-438	November 2021 Meeting Materials Due	17	0%	27-Oct-21	19-Nov-21*	1	RCB-20-418	RCB-20-458, RCB-20-448
RCB-20-468	Prep for December 2021 Meeting	17	0%	22-Nov-21	16-Dec-21*	1	RCB-20-458	RCB-20-268
RCB-20-458	December 2021 Meeting Materials Due	17	0%	22-Nov-21	16-Dec-21*	1	RCB-20-438	RCB-20-468
Authority Board Meetings		158	0%	03-May-21	17-Dec-21	8		
RCB-20-198	May 2021 Authority Board Meeting	1	0%	03-May-21	03-May-21	158	RCB-20-188, RCB-20-328	RCB-20-208
RCB-20-208	June 2021 Authority Board Meeting (Joint with Res Comm)	1	0%	23-Jun-21	23-Jun-21	123	RCB-20-198, RCB-20-348	RCB-20-218
RCB-20-218	July 2021 Authority Board Meeting	1	0%	21-Jul-21	21-Jul-21	105	RCB-20-208, RCB-20-368	RCB-20-228
RCB-20-228	August 2021 Authority Board Meeting	1	0%	25-Aug-21	25-Aug-21	81	RCB-20-218, RCB-20-388	RCB-20-238
RCB-20-238	September 2021 Authority Board Meeting (Joint with Res Comm)	1	0%	22-Sep-21	22-Sep-21	63	RCB-20-228, RCB-20-408	RCB-20-248
RCB-20-248	October 2021 Authority Board Meeting	1	0%	27-Oct-21	27-Oct-21	40	RCB-20-238, RCB-20-428	RCB-20-258
RCB-20-258	November 2021 Authority Board Meeting	1	0%	22-Nov-21	22-Nov-21	24	RCB-20-248, RCB-20-448	RCB-20-268
RCB-20-268	December 2021 Authority Board Meeting (Joint with Res Comm)	1	0%	17-Dec-21	17-Dec-21	8	RCB-20-258, RCB-20-468	MS-004-P2



Actual Work | Critical Remaining Work | Summary
Remaining Work | Milestone

Sites Project Detailed Planning Schedule

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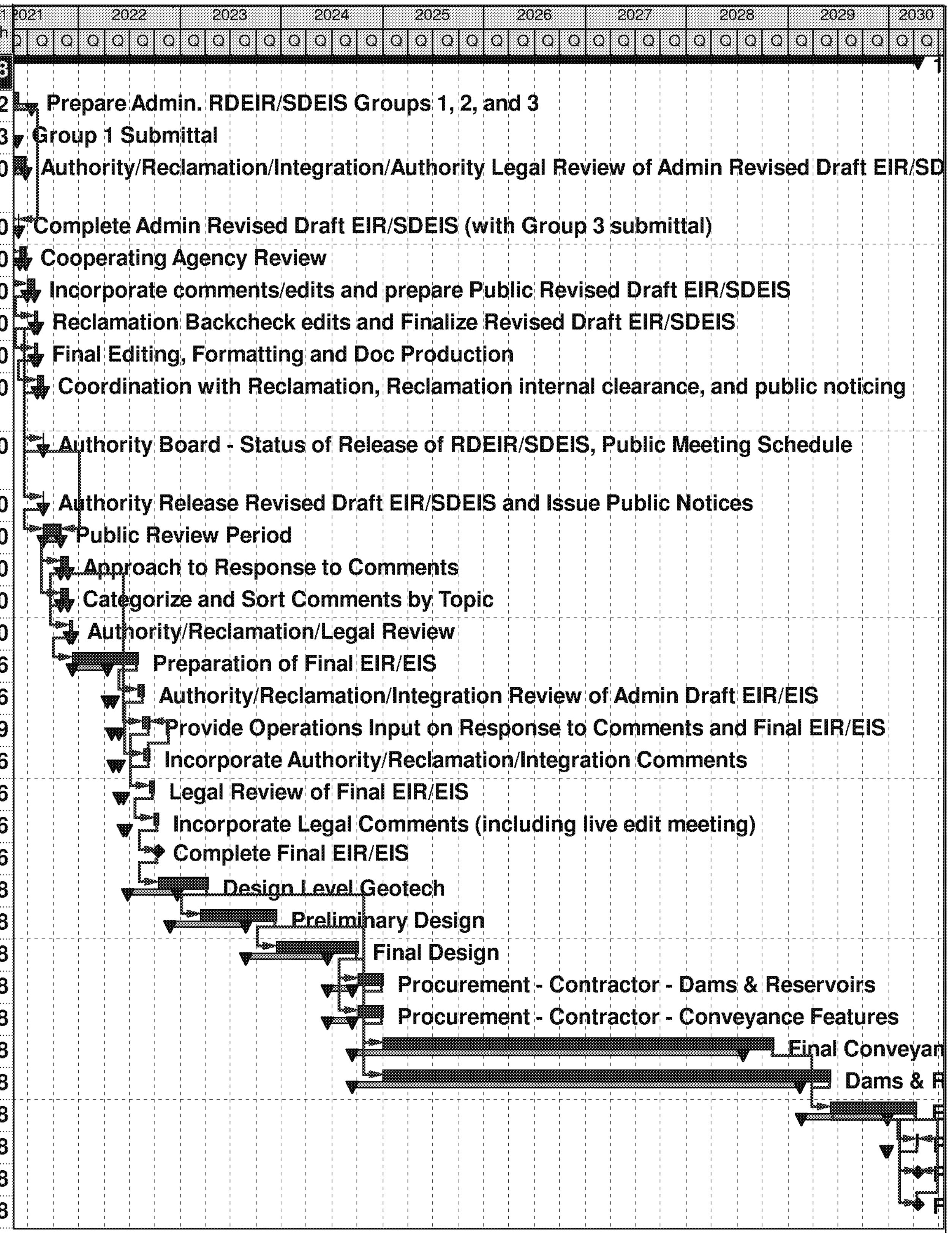
Attachment 3: Critical Path Schedule

Activity ID	Activity Name	Remaining Duration	Start	Finish	Total Float	Mar'21 Finish
SITES PROJECT		2301	13-Jan-21 A	15-Apr-30	0	-78
EIR-020	Prepare Admin. RDEIR/SDEIS Groups 1, 2, and 3	20	13-Jan-21 A	28-May-21	0	32
EIR-025	Group 1 Submittal	1	13-Jan-21 A	03-May-21	0	13
EIR-035	Authority/Reclamation/Integration/Authority Legal Review of Admin Revised Draft EIR/SDEIS	38	04-May-21	25-Jun-21	0	0
EIR-030	Complete Admin Revised Draft EIR/SDEIS (with Group 3 submittal)	1	28-May-21	28-May-21	0	0
EIR-590	Cooperating Agency Review	19	01-Jun-21	25-Jun-21	0	0
EIR-040	Incorporate comments/edits and prepare Public Revised Draft EIR/SDEI	19	28-Jun-21	23-Jul-21	0	0
EIR-050	Reclamation Backcheck edits and Finalize Revised Draft EIR/SDEIS	7	26-Jul-21	03-Aug-21	0	0
EIR-067	Final Editing, Formatting and Doc Production	7	26-Jul-21	03-Aug-21	0	0
EIR-075	Coordination with Reclamation, Reclamation internal clearance, and public noticing	15	04-Aug-21	24-Aug-21	0	0
EIR-150	Authority Board - Status of Release of RDEIR/SDEIS, Public Meeting Schedule	1	25-Aug-21	25-Aug-21	0	0
EIR-080	Authority Release Revised Draft EIR/SDEIS and Issue Public Notices	1	26-Aug-21	26-Aug-21	0	0
EIR-090	Public Review Period	63	27-Aug-21	28-Oct-21	0	0
EIR-100	Approach to Response to Comments	18	29-Oct-21	24-Nov-21	0	0
EIR-095	Categorize and Sort Comments by Topic	18	29-Oct-21	24-Nov-21	0	0
EIR-105	Authority/Reclamation/Legal Review	6	29-Nov-21	06-Dec-21	0	0
EIR-210	Preparation of Final EIR/EIS	163	07-Dec-21	01-Aug-22	0	-76
EIR-212	Authority/Reclamation/Integration Review of Admin Draft EIR/EIS	15	02-Aug-22	22-Aug-22	0	-76
FO-1080	Provide Operations Input on Response to Comments and Final EIR/EIS	20	17-Aug-22	13-Sep-22	0	-79
EIR-214	Incorporate Authority/Reclamation/Integration Comments	15	23-Aug-22	13-Sep-22	0	-76
EIR-220	Legal Review of Final EIR/EIS	10	14-Sep-22	27-Sep-22	0	-76
EIR-240	Incorporate Legal Comments (including live edit meeting)	10	28-Sep-22	12-Oct-22	0	-76
EIR-250	Complete Final EIR/EIS	0		12-Oct-22	0	-76
DLG-010	Design Level Geotech	130	13-Oct-22	12-Apr-23	0	-78
PD-100	Preliminary Design	195	16-Mar-23	13-Dec-23	0	-78
FD-110	Final Design	210	14-Dec-23	02-Oct-24	0	-78
FD-120	Procurement - Contractor - Dams & Reservoirs	65	03-Oct-24	01-Jan-25	0	-78
FD-130	Procurement - Contractor - Conveyance Features	65	03-Oct-24	01-Jan-25	147	-78
CC-100	Final Conveyance Construction	1008	02-Jan-25	13-Nov-28	147	-78
RC-100	Dams & Reservoir Construction	1155	02-Jan-25	06-Jun-29	0	-78
OPR-110	Early Operations (Commissioning)	222	07-Jun-29	12-Apr-30	0	-78
MIT-030	Post Construction Monitoring Begins	5	09-Apr-30	15-Apr-30	0	-78
MS-600-PB	Public Beneficial Occupancy - Sites Program	0		15-Apr-30	0	-78
OPR-120	Full Operations Begins	0		15-Apr-30	0	-78

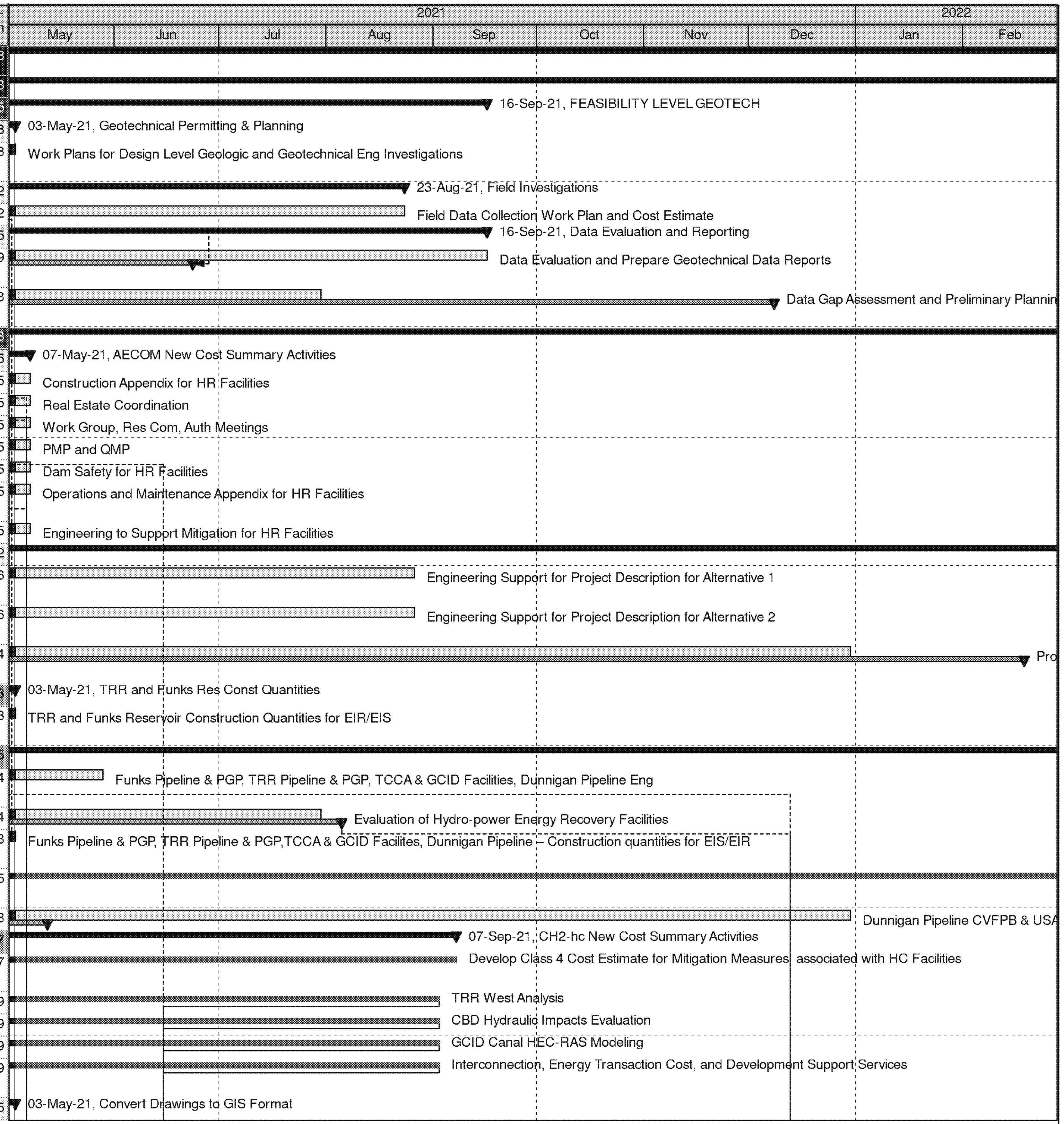


Critical Remaining Work
Mar'21 Update
Milestone
Summary

Sites Project - **Critical Path**

Attachment 4: Engineering Detail Schedule

Activity ID	Activity Name	Remaining Duration	% Complete	Start	Finish	Total Float	Mar'21 - Finish
Henry Luu		1058	39.6%	01-Sep-20 A	09-Jul-25	65	-278
SITES PROJECT		1058	39.6%	01-Sep-20 A	09-Jul-25	65	-278
FEASIBILITY LEVEL GEOTECH		96	30.99%	04-Sep-20 A	16-Sep-21	103	55
Geotechnical Permitting & Planning		0	100%	04-Sep-20 A	03-May-21	87	-98
GSR-010	Work Plans for Design Level Geologic and Geotechnical Eng Investigations	0	100%	04-Sep-20 A	03-May-21	87	-98
Field Investigations		79	0%	07-Sep-20 A	23-Aug-21	87	-82
GSR-020	Field Data Collection Work Plan and Cost Estimate	79	0%	07-Sep-20 A	23-Aug-21	87	-82
Data Evaluation and Reporting		96	55.18%	04-Jan-21 A	16-Sep-21	103	55
GSR-030	Data Evaluation and Prepare Geotechnical Data Reports	96	39.62%	04-Jan-21 A	16-Sep-21	103	-59
GSR-040	Data Gap Assessment and Preliminary Planning for Design Level Inv for Preferred Alt	63	72.96%	04-Jan-21 A	30-Jul-21	103	88
FEASIBILITY ENGINEERING		1058	42.76%	01-Sep-20 A	09-Jul-25	65	-278
AECOM New Cost Summary Activities		5	0%	01-Sep-20 A	07-May-21	158	-85
ENG-234	Construction Appendix for HR Facilities	5	0%	01-Sep-20 A	07-May-21	81	-85
ENG-238	Real Estate Coordination	5	0%	01-Sep-20 A	07-May-21	81	-85
ENG-435	Work Group, Res Com, Auth Meetings	5	0%	01-Sep-20 A	07-May-21	158	-85
TM-H97	PMP and QMP	5	0%	01-Sep-20 A	07-May-21	118	-85
ENG-236	Dam Safety for HR Facilities	5	0%	01-Oct-20 A	07-May-21	81	-85
ENG-235	Operations and Maintenance Appendix for HR Facilities	5	0%	01-Nov-20 A	07-May-21	81	-85
ENG-237	Engineering to Support Mitigation for HR Facilities	5	0%	01-Nov-20 A	07-May-21	81	-85
Engineering Support for Env and Permitting		292	47.85%	01-Sep-20 A	01-Jul-22	289	-92
ENG-233	Engineering Support for Project Description for Alternative 1	82	6.82%	01-Sep-20 A	26-Aug-21	8	-116
ENG-239	Engineering Support for Project Description for Alternative 2	82	6.82%	01-Sep-20 A	26-Aug-21	8	-116
ENG-230	Provide Engineering Support to Environmental and Permitting Team	166	47.47%	30-Sep-20 A	30-Dec-21	0	34
TRR and Funks Res Const Quantities		0	100%	02-Nov-20 A	03-May-21	20	-83
ENG-510	TRR and Funks Reservoir Construction Quantities for EIR/EIS	0	100%	02-Nov-20 A	03-May-21	20	-83
Remaining Engineering		292	62.12%	01-Sep-20 A	01-Jul-22	289	-225
ENG-560	Funks Pipeline & PGP, TRR Pipeline & PGP, TCCA & GCID Facilities, Dunnigan Pipeline Eng	20	77.27%	01-Sep-20 A	28-May-21	146	-54
ENG-580	Evaluation of Hydro-power Energy Recovery Facilitie	63	66.67%	01-Sep-20 A	30-Jul-21	103	4
ENG-570	Funks Pipeline & PGP, TRR Pipeline & PGP,TCCA & GCID Facilites, Dunnigan Pipeline – Construction quantities for EIS/EIR	0	100%	09-Oct-20 A	03-May-21	165	-83
ENG-550	OH Transmission Lines & Substations - Constr Quantities for EIR/EIS Summary	292	0%	02-Nov-20 A	01-Jul-22	289	-375
ENG-590	Dunnigan Pipeline CVFPB & USACE 408 Permit Sup	166	0%	04-Jan-21 A	30-Dec-21	113	-158
CH2-hc New Cost Summary Activities		92	0%	08-Sep-20 A	07-Sep-21	71	-137
ENG-266	Develop Class 4 Cost Estimate for Mitigation Measures associated with HC Facilities	92	0%	08-Sep-20 A	07-Sep-21	71	-137
ENG-592	TRR West Analysis	89	0%	02-Nov-20 A	02-Sep-21	34	-169
ENG-467	CBD Hydraulic Impacts Evaluation	89	0%	23-Nov-20 A	02-Sep-21	34	-169
ENG-468	GCID Canal HEC-RAS Modeling	89	0%	23-Nov-20 A	02-Sep-21	34	-169
ENG-591	Interconnection, Energy Transaction Cost, and Development Support Services	89	0%	31-Dec-20 A	02-Sep-21	34	-169
Convert Drawings to GIS Format		0	100%	12-Sep-20 A	03-May-21	0	-115

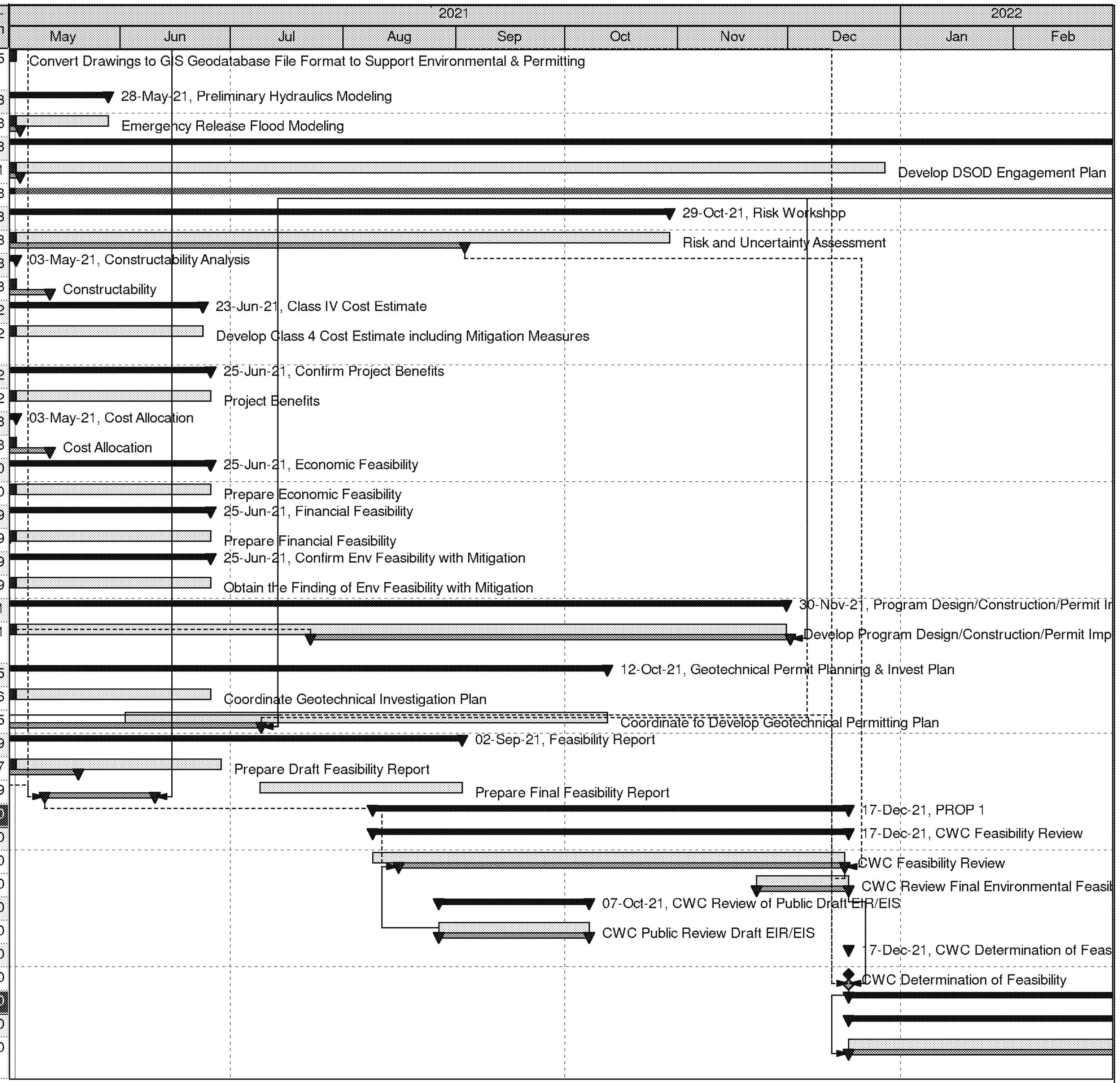


Remaining Level of Effort
Actual Level of Effort
Mar'21 Update
Actual Work
Remaining Work
Critical Remaining Work
Mar'21 Milestones
Milestone
Summary

Sites Project Authority

ENGINEERING

Activity ID	Activity Name	Remaining Duration	% Complete	Start	Finish	Total Float	Mar'21 - Finish
ENG-220	Convert Drawings to GIS Geodatabase File Format to Support Environmental & Permitting	0	100%	12-Sep-20 A	03-May-21	0	-115
Preliminary Hydraulics Modeling		20	83.87%	01-Sep-20 A	28-May-21	350	-18
ENG-466	Emergency Release Flood Modeling	20	83.87%	01-Sep-20 A	28-May-21	350	-18
DSOD Engagement		1058	0%	01-Sep-20 A	09-Jul-25	65	-278
ENG-400	Develop DSOD Engagement Plan	163	0%	01-Sep-20 A	27-Dec-21	79	-161
ENG-440	DSOD Engagement	1058	0%	01-Sep-20 A	09-Jul-25	65	-278
Risk Workshop		126	0%	01-Oct-20 A	29-Oct-21	40	-38
ENG-290	Risk and Uncertainty Assessment	126	0%	01-Oct-20 A	29-Oct-21	40	-38
Constructability Analysis		0	100%	01-Sep-20 A	03-May-21	8	8
ENG-370	Constructability	0	100%	01-Sep-20 A	03-May-21	8	8
Class IV Cost Estimate		37	32.73%	08-Sep-20 A	23-Jun-21	32	-82
ENG-265	Develop Class 4 Cost Estimate including Mitigation Measures	37	32.73%	08-Sep-20 A	23-Jun-21	32	-82
Confirm Project Benefits		39	0%	01-Oct-20 A	25-Jun-21	32	-42
ENG-300	Project Benefits	39	0%	01-Oct-20 A	25-Jun-21	32	-42
Cost Allocation		0	100%	01-Oct-20 A	03-May-21	32	8
ENG-320	Cost Allocation	0	100%	01-Oct-20 A	03-May-21	32	8
Economic Feasibility		39	0%	01-Oct-20 A	25-Jun-21	32	-60
ENG-350	Prepare Economic Feasibility	39	0%	01-Oct-20 A	25-Jun-21	32	-60
Financial Feasibility		39	0%	01-Oct-20 A	25-Jun-21	32	-39
ENG-360	Prepare Financial Feasibility	39	0%	01-Oct-20 A	25-Jun-21	32	-39
Confirm Env Feasibility with Mitigation		39	0%	10-Oct-20 A	25-Jun-21	32	-49
ENG-340	Obtain the Finding of Env Feasibility with Mitigation	39	0%	10-Oct-20 A	25-Jun-21	32	-49
Program Design/Construction/Permit Implementation Schedule		145	0%	01-Oct-20 A	30-Nov-21	32	1
ENG-410	Develop Program Design/Construction/Permit Implementation Plan	145	0%	01-Oct-20 A	30-Nov-21	32	1
Geotechnical Permit Planning & Invest Plan		113	57.18%	01-Sep-20 A	12-Oct-21	64	-65
ENG-404	Coordinate Geotechnical Investigation Plan	39	62.14%	01-Sep-20 A	25-Jun-21	64	-56
ENG-406	Coordinate to Develop Geotechnical Permitting Plan	92	0%	02-Jun-21	12-Oct-21	64	-65
Feasibility Report		87	48.38%	01-Sep-20 A	02-Sep-21	32	-59
ENG-380	Prepare Draft Feasibility Report	41	70.29%	01-Sep-20 A	28-Jun-21	33	-27
ENG-390	Prepare Final Feasibility Report	40	0%	09-Jul-21	02-Sep-21	32	-59
PROP 1		90	0%	09-Aug-21	17-Dec-21	8	0
CWC Feasibility Review		131	0%	09-Aug-21	17-Dec-21	14	0
CWC-403	CWC Feasibility Review	130	0%	09-Aug-21	16-Dec-21	15	0
CWC-490	CWC Review Final Environmental Feasibility Report	25	0%	22-Nov-21	17-Dec-21	14	0
CWC Review of Public Draft EIR/EIS		30	0%	27-Aug-21	07-Oct-21	11	0
CWC-450	CWC Public Review Draft EIR/EIS	30	0%	27-Aug-21	07-Oct-21	11	0
CWC Determination of Feasibility		0	0%	17-Dec-21	17-Dec-21	14	0
CWC-500	CWC Determination of Feasibility	0	0%		17-Dec-21*	14	0
CONSTRUCTION		135	0%	17-Dec-21	24-Jun-22	78	0
Procurement Designers/Design Builders/Design Assist		135	0%	17-Dec-21	24-Jun-22	78	0
PDC-1000	Procurement - Designers, Design Builders & Design Assists (CMAR)	135	0%	17-Dec-21	24-Jun-22	78	0



Remaining Level of Effort
Actual Level of Effort
Mar'21 Update
Actual Work
Remaining Work
Critical Remaining Work
Mar'21 Milestones
Milestone
Summary

Sites Project Authority

ENGINEERING

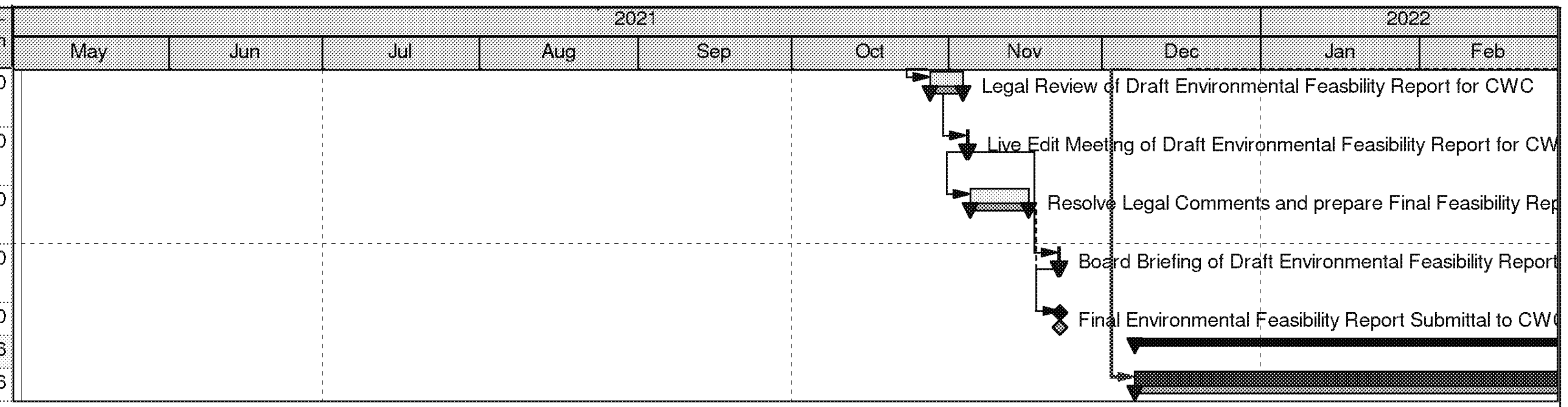
Attachment 5: Environmental Detail Schedule

Activity ID	Activity Name	Remaining Duration	% Complete	Start	Finish	Total Float	Mar'21 - Finish
Laurie Warner-Herson		312	64.09%	22-Sep-20 A	01-Aug-22	92	-76
SITES PROJECT		312	64.09%	22-Sep-20 A	01-Aug-22	92	-76
MILESTONES		0	0%	26-Aug-21	26-Aug-21	339	0
MS-011-DE	Release Revised Draft EIR/ Supplemental Draft EIS for Public Review	0	0%		26-Aug-21	339	0
EIR/EIS		312	64.09%	22-Sep-20 A	01-Aug-22	0	-76
Project Description Chapter		0	100%	22-Sep-20 A	03-May-21	19	-41
EIR-021	Prepare Revised Draft EIR/SDEIS Project Description Chapter	0	100%	22-Sep-20 A	03-May-21	19	-41
Revised Draft EIR/Supplemental Draft EIS		82	0%	13-Jan-21 A	26-Aug-21	0	0
Prepare Administrative Revised Draft EIR/Supplemental Draft E		39	0%	13-Jan-21 A	25-Jun-21	17	13
EIR-020	Prepare Admin. RDEIR/SDEIS Groups 1, 2, and 3	20	71.83%	13-Jan-21 A	28-May-21	0	32
EIR-025	Group 1 Submittal	1	96.88%	13-Jan-21 A	03-May-21	0	13
EIR-027	Group 2 Submittal	16	50%	13-Jan-21 A	24-May-21	4	-28
EIR-035	Authority/Reclamation/Integration/Authority Legal Review of Admin Revised Draft EIR/SDEIS	38	0%	04-May-21	25-Jun-21	0	0
EIR-125	Authority Board - Part 2 Admin RDEIR/SDEIS Group 1 Chapters	1	0%	26-May-21	26-May-21	0	0
EIR-030	Complete Admin Revised Draft EIR/SDEIS (with Group 3 submittal)	1	0%	28-May-21	28-May-21	0	0
EIR-590	Cooperating Agency Review	19	0%	01-Jun-21	25-Jun-21	0	0
EIR-135	Authority Board - Part 3 Admin RDEIR/SDEIS Remaining Chapters	1	0%	23-Jun-21	23-Jun-21	1	0
Prepare Public Revised Draft EIR/Supplemental Draft EIS		43	0%	28-Jun-21	26-Aug-21	0	0
EIR-040	Incorporate comments/edits and prepare Public Revised Draft EIR/SDEIS	19	0%	28-Jun-21	23-Jul-21	0	0
EIR-045	Live Edit Meetings	6	0%	29-Jun-21	07-Jul-21	2	0
EIR-060	Authority Board - Review and Delegate Authority to Release the RDEIR/SDEIS in August	1	0%	21-Jul-21	21-Jul-21	2	0
EIR-050	Reclamation Backcheck edits and Finalize Revised Draft EIR/SDEIS	7	0%	26-Jul-21	03-Aug-21	0	0
EIR-067	Final Editing, Formatting and Doc Production	7	0%	26-Jul-21	03-Aug-21	0	0
EIR-075	Coordination with Reclamation, Reclamation internal clearance, and public noticing	15	0%	04-Aug-21	24-Aug-21	0	0
EIR-150	Authority Board - Status of Release of RDEIR/SDEIS, Public Meeting Schedule	1	0%	25-Aug-21	25-Aug-21	0	0
EIR-080	Authority Release Revised Draft EIR/SDEIS and Issue Public Notices	1	0%	26-Aug-21	26-Aug-21	0	0
Public Review		43	0%	27-Aug-21	28-Oct-21	0	0
EIR-090	Public Review Period	63	0%	27-Aug-21	28-Oct-21	0	0
EIR-530	Public Meetings	4	0%	27-Sep-21	30-Sep-21	3	0
Begin Preparation of the Admin Final EIR/EIS		33	0%	29-Oct-21	17-Dec-21	154	0
EIR-100	Approach to Response to Comments	18	0%	29-Oct-21	24-Nov-21	0	0
EIR-095	Categorize and Sort Comments by Topic	18	0%	29-Oct-21	24-Nov-21	0	0
EIR-105	Authority/Reclamation/Legal Review	6	0%	29-Nov-21	06-Dec-21	0	0
EIR-140	Authority Board - Summary of Comments received in the RDEIR/SDEIS and Approach to Responses	1	0%	17-Dec-21	17-Dec-21	213	0
Environmental Feasibility Report For CWC		39	0%	27-Sep-21	22-Nov-21	8	0
EIR-110	Prepare Draft Environmental Feasibility Report for CW	14	0%	27-Sep-21	15-Oct-21	3	0
EIR-540	Authority review of Draft Environmental Feasibility Report for CWC	8	0%	18-Oct-21	27-Oct-21	3	0

Remaining Level of Effort
Actual Level of Effort
Actual Work
Remaining Work
Critical Remaining Work
Milestone
Summary
Mar'21 Milestone
Mar'21 Update

Sites Project Authority
ENVIRONMENTAL

Activity ID	Activity Name	Remaining Duration	% Complete	Start	Finish	Total Float	Mar'21 - Finish
EIR-560	Legal Review of Draft Environmental Feasbility Report for CWC	5	0%	28-Oct-21	03-Nov-21	3	0
EIR-117	Live Edit Meeting of Draft Environmental Feasibility Report for CWC	1	0%	04-Nov-21	04-Nov-21	3	0
EIR-580	Resolve Legal Comments and prepare Final Feasibility Report for CWC	7	0%	05-Nov-21	16-Nov-21	3	0
EIR-570	Board Briefing of Draft Environmental Feasibility Report for CWC	1	0%	22-Nov-21	22-Nov-21	0	0
EIR-120	Final Environmental Feasibility Report Submittal to CW	0	0%		22-Nov-21	8	0
Final EIR/Final EIS		163	0%	07-Dec-21	01-Aug-22	0	-76
EIR-210	Preparation of Final EIR/EIS	163	0%	07-Dec-21	01-Aug-22	0	-76



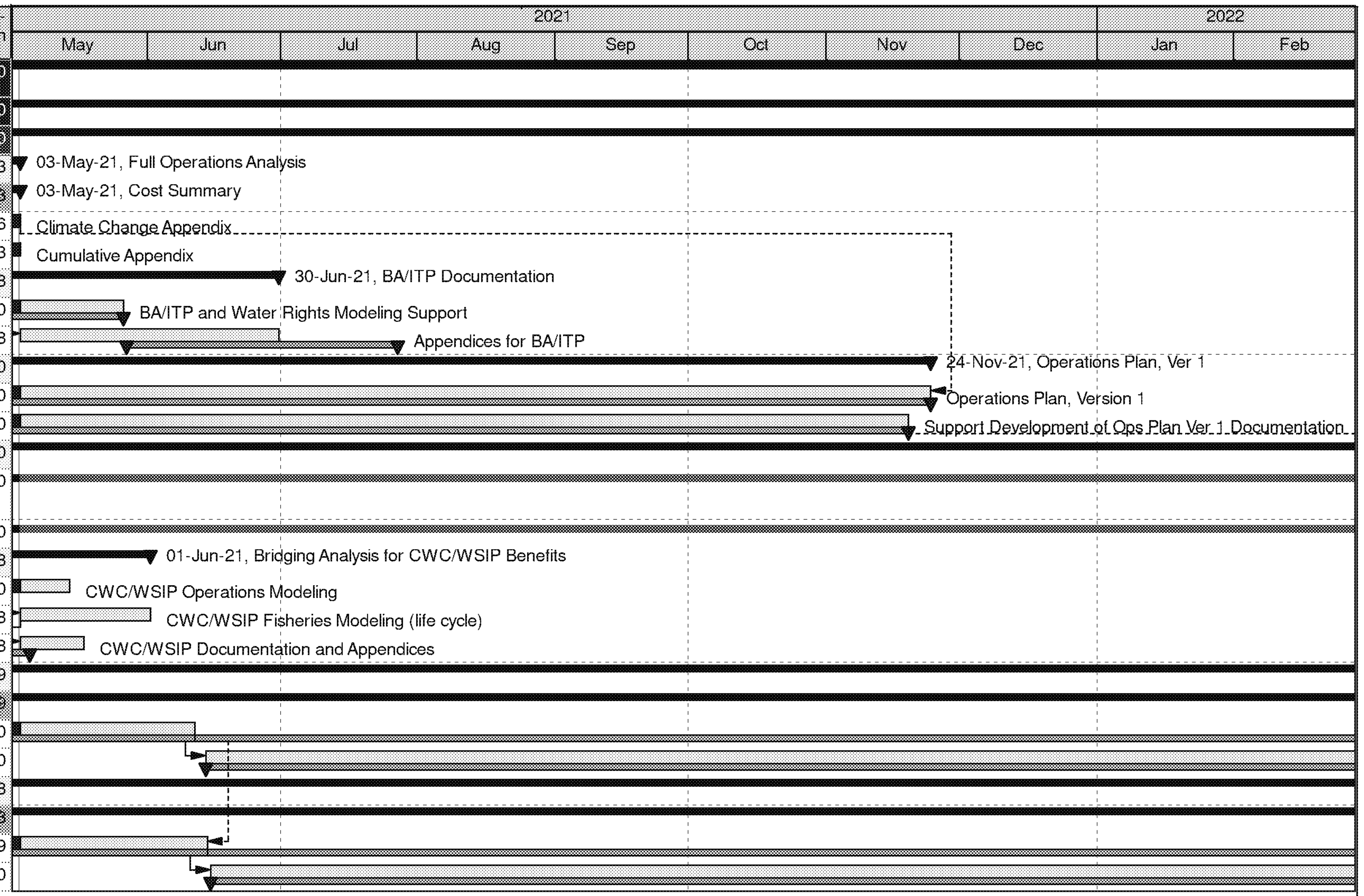
- Remaining Level of Effort
- Actual Level of Effort
- Actual Work
- Remaining Work
- Critical Remaining Work
- Milestone
- Summary
- Mar'21 Milestone
- Mar'21 Update

Sites Project Authority

ENVIRONMENTAL

Attachment 6: Operations Detail Schedule

Activity ID	Activity Name	Remaining Duration	% Complete	Start	Finish	Total Float	Mar'21 - Finish
Erin Heydinger		410	45.01%	01-Sep-20 A	22-Dec-22	1891	0
SITES PROJECT		410	45.01%	01-Sep-20 A	22-Dec-22	1891	0
OPERATIONS MODELING		410	45.01%	01-Sep-20 A	22-Dec-22	1891	0
Full Operations Analysis		0	100%	23-Nov-20 A	03-May-21	4	-3
Cost Summary		0	100%	23-Nov-20 A	03-May-21	4	-3
OP-$-460	Climate Change Appendix	0	100%	23-Nov-20 A	03-May-21	0	-16
OP-$-455	Cumulative Appendix	0	100%	23-Nov-20 A	03-May-21	4	-3
BA/ITP Documentation		42	51.04%	01-Nov-20 A	30-Jun-21	1165	18
OP-450	BA/ITP and Water Rights Modeling Support	18	70.97%	01-Nov-20 A	26-May-21	1165	0
OP-360	Appendices for BA/ITP	42	0%	03-May-21	30-Jun-21	1165	18
Operations Plan, Ver 1		143	17.69%	01-Nov-20 A	24-Nov-21	2158	0
OP-470	Operations Plan, Version 1	143	17%	01-Nov-20 A	24-Nov-21	68	0
OP-475	Support Development of Ops Plan Ver 1 Documentati	140	23.91%	01-Mar-21 A	19-Nov-21	2161	0
Operational Agreements		410	0%	23-Sep-20 A	22-Dec-22	1891	0
OP-480 ($$$)	Support Operational Agreements	410	0%	23-Sep-20 A	22-Dec-22	1668	0
OP-490	Support for Operational Agreements Documentation	410	0%	19-Nov-20 A	22-Dec-22	1891	0
Bridging Analysis for CWC/WSIP Benefits		21	55.48%	01-Sep-20 A	01-Jun-21	68	-18
CFS-010	CWC/WSIP Operations Modeling	10	84.62%	01-Sep-20 A	14-May-21	68	-20
CFS-020	CWC/WSIP Fisheries Modeling (life cycle)	21	0%	03-May-21	01-Jun-21	68	-28
CFS-030	CWC/WSIP Documentation and Appendices	11	0%	03-May-21	17-May-21	68	-8
Final Sites-Reclamation Operating Agreement		290	0%	02-Nov-20 A	29-Jun-22	363	29
Reclamation Term Sheet		290	0%	02-Nov-20 A	29-Jun-22	363	29
OP-1110	Sites-Reclamation Operating Agreement Term Sheet	29	19%	02-Nov-20 A	11-Jun-21	363	290
OP-1005	Final Sites-Reclamation Operating Agreement	261	0%	14-Jun-21	29-Jun-22	363	0
Final Sites-DWR Operating Agreement		291	0%	02-Nov-20 A	30-Jun-22	362	28
DWR Term Sheet		291	0%	02-Nov-20 A	30-Jun-22	362	28
OP-1120	Sites-DWR Operating Agreement Term Sheet	30	92.52%	02-Nov-20 A	14-Jun-21	362	289
OP-1015	Final Sites-DWR Operating Agreement	261	0%	15-Jun-21	30-Jun-22	362	0

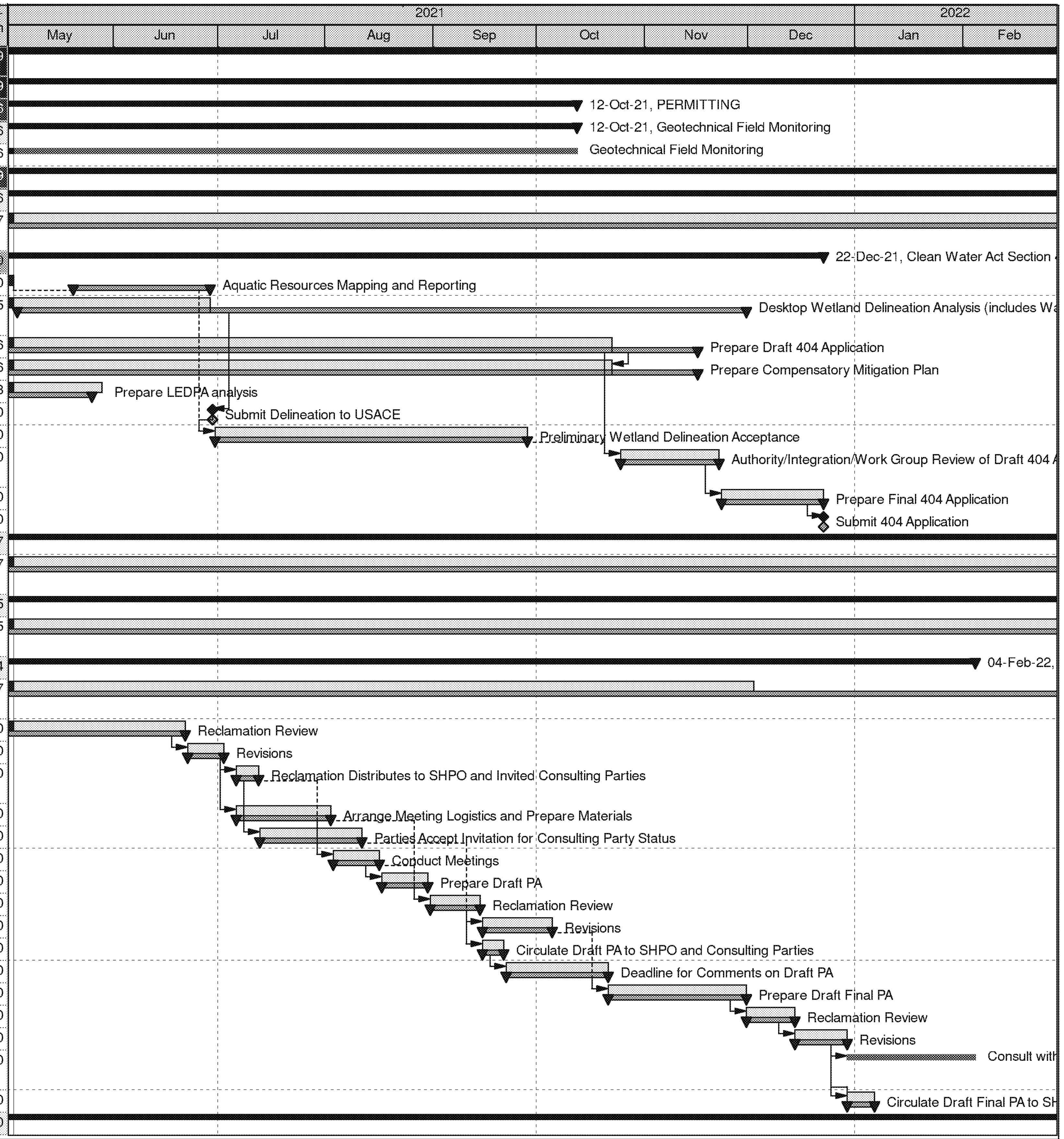


Remaining Level of Effort
Actual Level of Effort
Actual Work
Remaining Work
Critical Remaining Work
Milestone
Summary
Mar'21 Milestone
Mar'21 Update

Sites Project Authority
OPERATIONS

Attachment 7: Permitting Detail Schedule

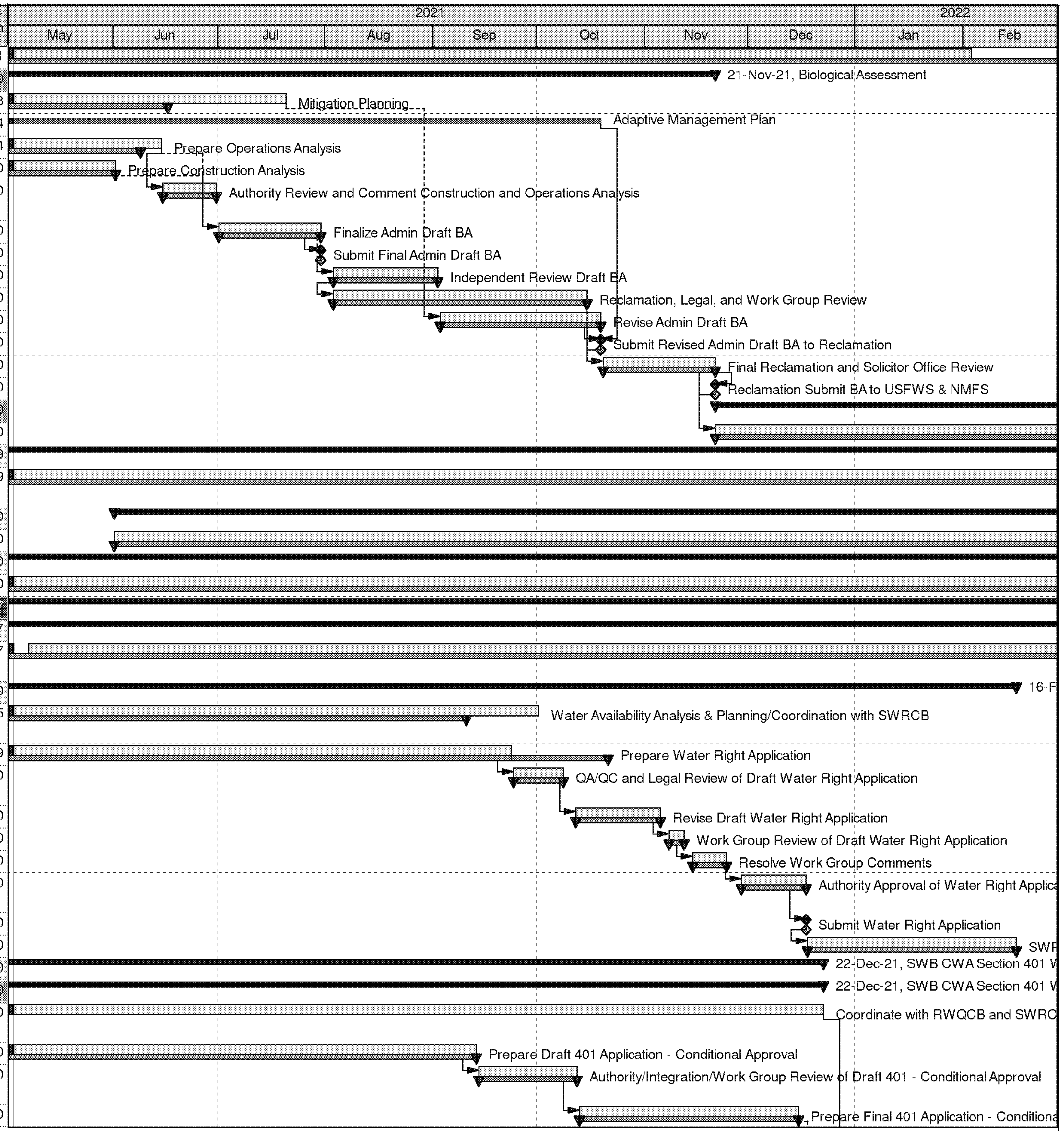
Activity ID	Activity Name	Remaining Duration	% Complete	Start	Finish	Total Float	Mar'21 - Finish
John Spranza		528	23.18%	01-Sep-20 A	13-Jun-23	980	39
SITES PROJECT		528	23.18%	01-Sep-20 A	13-Jun-23	980	39
PERMITTING		113	100%	01-Sep-20 A	12-Oct-21	64	26
Geotechnical Field Monitoring		113	100%	01-Sep-20 A	12-Oct-21	64	26
GSR-015	Geotechnical Field Monitoring	113	100%	01-Sep-20 A	12-Oct-21	64	26
FEDERAL PERMITS AND AGREEMENTS		528	26.85%	01-Sep-20 A	13-Jun-23	980	39
U.S. Army Corps of Engineers CWA 404, Rivers and Harbors Ac		506	100%	01-Sep-20 A	11-May-23	701	16
FED-020	U.S. Army Corps of Engineers CWA 404, Rivers and Harbors Act Section 10	529	3%	04-Feb-21 A	11-May-23	429	17
Clean Water Act Section 404		161	100%	01-Sep-20 A	22-Dec-21	1046	0
404-015	Aquatic Resources Mapping and Reporting	0	100%	01-Sep-20 A	03-May-21	1103	40
404-010	Desktop Wetland Delineation Analysis (includes Waters of the State)	40	50%	01-Sep-20 A	28-Jun-21	410	105
404-050	Prepare Draft 404 Application	121	10%	04-Feb-21 A	22-Oct-21	1046	16
404-035	Prepare Compensatory Mitigation Plan	121	5%	04-Feb-21 A	22-Oct-21	1046	16
404-001	Prepare LEDPA analysis	20	0%	05-Feb-21 A	28-May-21	410	-3
404-020	Submit Delineation to USACE	0	0%		29-Jun-21	1062	0
404-030	Preliminary Wetland Delineation Acceptance	90	0%	30-Jun-21	28-Sep-21	1534	0
404-060	Authority/Integration/Work Group Review of Draft 404 Application	20	0%	25-Oct-21	22-Nov-21	1046	0
404-070	Prepare Final 404 Application	20	0%	23-Nov-21	22-Dec-21	1046	0
404-120	Submit 404 Application	0	0%		22-Dec-21	1046	0
U.S. Army Corps of Engineers Rivers and Harbors Act Section		529	0%	04-Feb-21 A	11-May-23	429	17
FED-030	U.S. Army Corps of Engineers Rivers and Harbors Act Section 14, Section 408	529	0%	04-Feb-21 A	11-May-23	429	17
U.S. EPA and U.S. Army Corps of Engineers LEDPA Review		461	0%	02-Nov-20 A	06-Feb-23	497	45
FED-040	U.S. EPA and U.S. Army Corps of Engineers LEDPA Review	461	0%	02-Nov-20 A	06-Feb-23	497	45
Advisory Council on Historic Preservation NHPA Section 106		190	0%	01-Sep-20 A	04-Feb-22	969	44
FED-050	Advisory Council on Historic Preservation NHPA Section 106	147	0%	01-Sep-20 A	02-Dec-21	19	87
106-022	Reclamation Review	35	0%	22-Mar-21 A	21-Jun-21	966	0
106-024	Revisions	9	0%	22-Jun-21	02-Jul-21	966	0
106-025	Reclamation Distributes to SHPO and Invited Consulting Parties	5	0%	06-Jul-21	12-Jul-21	981	0
106-032	Arrange Meeting Logistics and Prepare Materials	20	0%	06-Jul-21	02-Aug-21	966	0
106-026	Parties Accept Invitation for Consulting Party Status	30	0%	13-Jul-21	11-Aug-21	1432	0
106-033	Conduct Meetings	10	0%	03-Aug-21	16-Aug-21	966	0
106-041	Prepare Draft PA	10	0%	17-Aug-21	30-Aug-21	966	0
106-042	Reclamation Review	10	0%	31-Aug-21	14-Sep-21	966	0
106-044	Revisions	15	0%	15-Sep-21	05-Oct-21	978	0
106-052	Circulate Draft PA to SHPO and Consulting Parties	5	0%	15-Sep-21	21-Sep-21	966	0
106-053	Deadline for Comments on Draft PA	30	0%	22-Sep-21	21-Oct-21	1398	0
106-061	Prepare Draft Final PA	25	0%	21-Oct-21	30-Nov-21	967	0
106-062	Reclamation Review	10	0%	30-Nov-21	14-Dec-21	967	0
106-064	Revisions	10	0%	14-Dec-21	29-Dec-21	967	0
106-071	Consult with SHPO and Consulting Parties on Draft Final PA	25	0%	29-Dec-21	04-Feb-22	969	0
106-072	Circulate Draft Final PA to SHPO and Consulting Part	5	0%	29-Dec-21	06-Jan-22	967	0
USFWS and NMFS ESA Section 7		230	0%	01-Sep-20 A	05-Apr-22	977	0



Remaining Level of Effort
Actual Level of Effort
Actual Work
Remaining Work
Critical Remaining Work
Milestone
Summary
Mar'21 Milestone
Mar'21 Update

Sites Project Authority
PERMITS

Activity ID	Activity Name	Remaining Duration	% Complete	Start	Finish	Total Float	Mar'21 - Finish
FED-060	USFWS and NMFS ESA Section 7	189	20%	01-Sep-20 A	03-Feb-22	734	31
Biological Assessment		140	0%	01-Sep-20 A	21-Nov-21	970	0
BA-011	Mitigation Planning	55	0%	01-Sep-20 A	20-Jul-21	1001	-23
BA-016	Adaptive Management Plan	118	0%	01-Sep-20 A	19-Oct-21	969	-84
BA-025	Prepare Operations Analysis	30	0%	24-Feb-21 A	14-Jun-21	971	-4
BA-024	Prepare Construction Analysis	21	0%	25-Mar-21 A	01-Jun-21	980	0
BA-029	Authority Review and Comment Construction and Operations Analysis	12	0%	15-Jun-21	30-Jun-21	971	0
BA-030	Finalize Admin Draft BA	21	0%	01-Jul-21	30-Jul-21	971	0
BA-032	Submit Final Admin Draft BA	0	0%		30-Jul-21	971	0
BA-035	Independent Review Draft BA	31	0%	03-Aug-21	02-Sep-21	1404	0
BA-055	Reclamation, Legal, and Work Group Review	74	0%	03-Aug-21	15-Oct-21	1404	0
BA-057	Revise Admin Draft BA	31	0%	03-Sep-21	19-Oct-21	969	0
BA-060	Submit Revised Admin Draft BA to Reclamation	0	0%		19-Oct-21	969	0
BA-075	Final Reclamation and Solicitor Office Review	33	0%	20-Oct-21	21-Nov-21	1400	0
BA-100	Reclamation Submit BA to USFWS & NMFS	0	0%		21-Nov-21	1400	0
BO Incidental Task Authorization		135	0%	21-Nov-21	05-Apr-22	1400	0
BA-1110	BO Incidental Take Authorization	135	0%	21-Nov-21	05-Apr-22	1400	0
USFWS Bald Eagle Protection Act		528	0%	01-Sep-20 A	13-Jun-23	395	39
FED-075	USFWS Bald Eagle Protection Act (includes Pre-Application Surveys)	528	0%	01-Sep-20 A	13-Jun-23	395	39
USBR Warren Act		356	0%	01-Jun-21	01-Nov-22	1132	0
FED-090	USBR Warren Act	356	0%	01-Jun-21	01-Nov-22	1132	0
USBR - Land Agreement		363	0%	02-Nov-20 A	13-Oct-22	290	40
FED-100	USBR Land Agreements	363	16%	02-Nov-20 A	13-Oct-22	290	40
STATE PERMITS AND AGREEMENTS		506	0%	01-Sep-20 A	11-May-23	701	-37
Central Valley Flood Protection Board Levee Encroachment		501	0%	01-Sep-20 A	11-May-23	417	-37
STA-030	Central Valley Flood Protection Board Levee Encroachment	501	15%	01-Sep-20 A	11-May-23	417	-37
SWRCB Water Rights Permit		197	0%	01-Sep-20 A	16-Feb-22	779	0
WR-005	Water Availability Analysis & Planning/Coordination with SWRCB	107	10%	01-Sep-20 A	01-Oct-21	776	-15
WR-025	Prepare Water Right Application	101	12%	01-Feb-21 A	23-Sep-21	776	19
WR-035	QA/QC and Legal Review of Draft Water Right Application	11	0%	24-Sep-21	08-Oct-21	776	0
WR-045	Revise Draft Water Right Application	19	0%	12-Oct-21	05-Nov-21	776	0
WR-055	Work Group Review of Draft Water Right Application	4	0%	08-Nov-21	12-Nov-21	776	0
WR-065	Resolve Work Group Comments	8	0%	15-Nov-21	24-Nov-21	776	0
WR-075	Authority Approval of Water Right Application, Submit to SWRCB	15	0%	29-Nov-21	17-Dec-21	776	0
WR-085	Submit Water Right Application	0	0%		17-Dec-21	776	0
WR-095	SWRCB Review of Water Right Application	60	0%	18-Dec-21	16-Feb-22	1126	0
SWB CWA Section 401 Water Quality Certification		161	0%	15-Jan-21 A	22-Dec-21	1046	0
SWB CWA Section 401 Water Quality Certification - Condition:		161	0%	15-Jan-21 A	22-Dec-21	1046	0
401-120	Coordinate with RWQCB and SWRCB - Conditional Approval	161	5%	15-Jan-21 A	22-Dec-21	1046	-190
401-130	Prepare Draft 401 Application - Conditional Approval	93	0%	01-Mar-21 A	13-Sep-21	1051	0
401-140	Authority/Integration/Work Group Review of Draft 401 - Conditional Approval	20	0%	14-Sep-21	12-Oct-21	1051	0
401-150	Prepare Final 401 Application - Conditional Approval	43	0%	13-Oct-21	15-Dec-21	1051	0

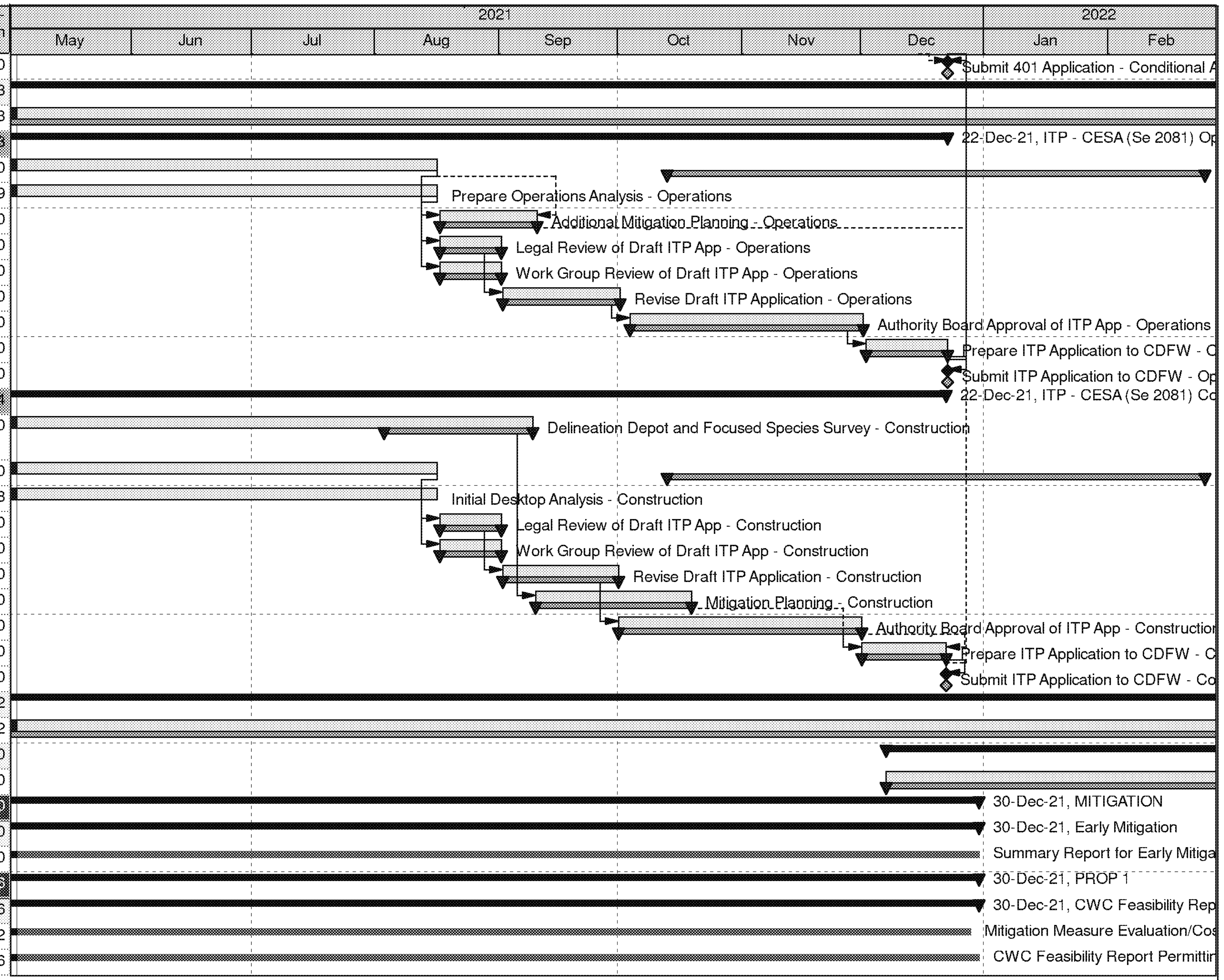


Remaining Level of Effort — Milestone
Actual Level of Effort — Summary
Actual Work — Mar'21 Milestone
Remaining Work — Mar'21 Update
Critical Remaining Work

Sites Project Authority

PERMITS

Activity ID	Activity Name	Remaining Duration	% Complete	Start	Finish	Total Float	Mar'21 - Finish
401-160	Submit 401 Application - Conditional Approval	0	0%		22-Dec-21	1046	0
CDFW Incidental Take Permits		292	0%	01-Sep-20 A	01-Jul-22	915	23
STA-110	CDFW Section 2081	292	0%	01-Sep-20 A	01-Jul-22	129	23
ITP - CESA (Se 2081) Operations		161	0%	30-Sep-20 A	22-Dec-21	1046	43
CES-210	Prepare Draft ITP Application - Operations	74	5%	30-Sep-20 A	16-Aug-21	1046	130
CES-190	Prepare Operations Analysis - Operations	74	5%	30-Sep-20 A	16-Aug-21	1115	-89
CES-200	Additional Mitigation Planning - Operations	18	0%	17-Aug-21	10-Sep-21	1115	0
CES-220	Legal Review of Draft ITP App - Operations	16	0%	17-Aug-21	01-Sep-21	1511	0
CES-230	Work Group Review of Draft ITP App - Operations	16	0%	17-Aug-21	01-Sep-21	1511	0
CES-240	Revise Draft ITP Application - Operations	21	0%	02-Sep-21	01-Oct-21	1046	0
CES-250	Authority Board Approval of ITP App - Operations	39	0%	04-Oct-21	01-Dec-21	1046	0
CES-260	Prepare ITP Application to CDFW - Operations	15	0%	02-Dec-21	22-Dec-21	1046	0
CES-270	Submit ITP Application to CDFW - Operations	0	0%		22-Dec-21	1046	0
ITP - CESA (Se 2081) Construction		160	0%	01-Sep-20 A	22-Dec-21	119	44
CES-020	Delineation Depot and Focused Species Survey - Construction	91	0%	01-Sep-20 A	09-Sep-21	145	0
CES-030	Prepare Draft ITP Application - Construction	74	10%	30-Sep-20 A	16-Aug-21	119	130
CES-010	Initial Desktop Analysis - Construction	74	20%	30-Sep-20 A	16-Aug-21	145	-148
CES-040	Legal Review of Draft ITP App - Construction	16	0%	17-Aug-21	01-Sep-21	177	0
CES-060	Work Group Review of Draft ITP App - Construction	16	0%	17-Aug-21	01-Sep-21	177	0
CES-070	Revise Draft ITP Application - Construction	20	0%	02-Sep-21	01-Oct-21	118	0
CES-025	Mitigation Planning - Construction	27	0%	10-Sep-21	19-Oct-21	145	0
CES-080	Authority Board Approval of ITP App - Construction	39	0%	01-Oct-21	01-Dec-21	118	0
CES-090	Prepare ITP Application to CDFW - Construction	15	0%	01-Dec-21	22-Dec-21	118	0
CES-280	Submit ITP Application to CDFW - Construction	0	0%		22-Dec-21	119	0
NAHC/Local Tribes AB 52 Consultation		233	0%	01-Sep-20 A	08-Apr-22	129	82
STA-120	NAHC/Local Tribes AB 52 Consultation	233	0%	01-Sep-20 A	08-Apr-22	129	82
SMARA		86	0%	07-Dec-21	12-Apr-22	169	0
STA-140	SMARA	86	0%	07-Dec-21	12-Apr-22	169	0
MITIGATION		166	0%	09-Dec-20 A	30-Dec-21	0	50
Early Mitigation		166	0%	09-Dec-20 A	30-Dec-21	0	50
EM-00-10	Summary Report for Early Mitigation/Geotech Mitigat	166	0%	09-Dec-20 A	30-Dec-21	0	50
PROP 1		166	0%	05-Oct-20 A	30-Dec-21	0	-16
CWC Feasibility Report		166	0%	05-Oct-20 A	30-Dec-21	0	-16
CWC-010	Mitigation Measure Evaluation/Cost Estimate	164	0%	05-Oct-20 A	28-Dec-21	0	-102
TM-F107	CWC Feasibility Report Permitting Support	166	0%	13-Oct-20 A	30-Dec-21	0	-16



Remaining Level of Effort ◆ Milestone
Actual Level of Effort Summary
Actual Work ◇ Mar'21 Milestone
Remaining Work Mar'21 Update
Critical Remaining Work

Sites Project Authority

PERMITS

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Attachment 8: Right of Entry Detail Schedule (No Activities Occurring in Amendment 2)

Project Description Team Meeting - Agenda

Affordable Water, Sustainably Managed

Our Core Values – Safety, Trust and Integrity, Respect for Local Communities, Environmental Stewardship, Shared Responsibility and Shared Benefits, Accountability and Transparency, Proactive Innovation, Diversity and Inclusivity
Our Commitment – To live up to these values in everything we do

Meeting Information:

Date:	June 16, 2021	**Location:**	Microsoft Teams
Start Time:	1:00 p.m.	**Finish Time:**	2:30 p.m.
Purpose:	Coordination on Project Description Development		

Meeting Participants:

Jeriann Alexander, Fugro
Jelica Arsenijevic, Sites Integration
Ellen Berryman, ICF
Robert Boling, HDR
Monique Briard, ICF
Jerry Brown, Sites Authority
Linda Fisher, Sites Integration
Michael Forrest, AECOM
Ali Forsythe, Sites Authority
Mike Hendrick, ICF
Jeff Herrin, AECOM
Erin Heydinger, HDR
Jim Lecky, ICF
Henry Luu, HDR
Conner McDonald, CMD West
Steve Micko, CH2M
Pete Rude, CH2M
Kevin Spesert, Sites Authority
John Spranza, Sites Integration
Ellen Unsworth, ICF
Laurie Warner Herson, Sites Integration
Nicole Williams, ICF

Agenda:

Discussion Topic	Topic Leader	Time Allotted
1. Introductions and Safety Moment	Mike F.	10 mins
2. Feasibility Cost Estimate a. Mitigation	John/Henry	10 mins
3. RDEIR/SDEIS Status a. System impact study b. Butte Sand and Gravel traffic impact	Laurie/Henry	35 mins
4. Geotech update	Henry/Jelica	10 mins
5. Open Topics from the Group	Group	20 mins
6. Action Items and Next Meeting	Team	5 mins

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/16/2021 8:36:22 AM
To: jeff.herrin@aecom.com
CC: Luu, Henry [Henry.Luu@hdrinc.com]; Laurie Warner Herson [laurie.warner.herson@phenixenv.com]; Alicia Forsythe [aforsythe@sitesproject.org]
Subject: Mitigation memo for use in FS
Attachments: 20210610_Updated Mitigation cost Estimate for 2021.docx

Hi Jeff,
Please see the attached draft memo that identifies the mitigation costing process that was implemented to reach the June 2021 revised mitigation planning cost. Please note that this cost is in 2019 dollars and I believe the escalation to 2021 dollars in approximately $579M.

Let me know if you have any questions or need additional information for use in the feasibility study.

John

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

HDR
2379 Gateway Oaks Drive, Suite 200
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Sites

Topic: **Updated Mitigation Cost Estimate 2021** **2021 June 10**

Subject: **Update of 2006 AECOM mitigation cost estimate**

Background and Purpose

In October 2016, AECOM, on behalf of the Sites Project Authority (Authority), prepared a technical memorandum (TM) that presented the results of a mitigation measure evaluation and cost estimate that was developed as a planning-level tool for assessing costs *associated with implementing select mitigation measures for the Sites Reservoir (Sites Reservoir Feasibility Study Technical Memorandum – Mitigation Measure Evaluation and Cost Estimate 2016*). The 2016 evaluation and cost estimate of $500 million dollars (M) were based on the mitigation measures and the project description for the North-of-the-Delta-Offstream Storage Preliminary Administrative Draft EIR (DWR 2013). The mitigation measures evaluated were for impacts associated with Sites Reservoir Alternative C.

In October 2019, the Authority pursued a value planning process to determine if further refinements to the Project were warranted. Between October 2019 and April 2020, the Authority considered previous input from state and federal agencies, non-governmental organizations, elected officials, landowners, and local communities, and decided to "right size" the Project to better meet the needs of Sites Storage Partners1, the statewide water supply and the environment. Multiple alternatives were considered during the value planning process that took into consideration the public and agency comments received on the 2017 Draft EIR/EIS (Sites Project Authority 2020).

The value planning process culminated in a Sites Project Value Planning Alternatives Appraisal Report (Value Planning Report) that was adopted by the Authority in April 2020 which included an updated mitigation cost estimate of $540M. In September 2020 the Authority approved to designate Alternative 1, which is based on Value Planning Alternative 7 (VP-7) as the Authority's preferred project alternative.

This memorandum (memo) summarizes the results of ICF International (ICF), HDR Engineering (HDR) and the Sites Project Authority's Environmental Planning and Permitting Manager's (EPP) update of AECOM's 2016 mitigation cost estimate using the Authority's revised preferred project alternative (collectively referred to as the mitigation team).

Methods

The mitigation team performed an evaluation of the cost and magnitude of the mitigation measures for resources that will be affected by project construction, operations, and maintenance. The resources evaluated were the same as those identified in AECOM's 2016 TM estimate, which included mitigation measure evaluation and cost estimate tables prepared in May 2016. The resources evaluated in the mitigation team's updated cost estimate included the following:

- Surface Water Quality,
- Aquatic Resources,
- Botanical Resources,
- Wildlife Habitat,
- Wetlands Habitat,
- Cultural Resources,
- Land Use,
- Paleontology, and
- Air Quality.

The mitigation measure evaluation and cost estimating process were built on the October 2016 TM and incorporated all applicable mitigation measures for these resources based on engineering, design, and planning work on the preferred alternative prior to April 15, of 2021. Assumptions used in the revised cost estimate were based on the following:

- Effects requiring mitigation were taken from the April/May 2021 Administrative Draft Revised Environmental Impact Report /Supplemental Environmental Impact Statement (REIR/SEIS)
- Outreach to experts in mitigation banking for current pricing of mitigation (banks, easements, etc.)
- Assumed presence of all listed and rare species with a moderate or greater potential to occur as defined in the 2021 Administrative Draft REIR/SEIS due to lack of access for species and vegetation surveys
- Assumed mitigation ratio of 2:1 for permanent effects and 1:1 ratio for temporary effects
- Use of the median per-acre costs estimates for specific mitigation (species, vegetation, agriculture, etc.)
- Credit stacking where practicable (e.g., raptor foraging habitat and rare plants stacked with annual grasslands)
- Cultural resources costs that were developed & reviewed by resource specialists using current requirements and anticipated project effects
- Agricultural land cost based on preliminary outreach to Sites real estate team and 2019 land prices
- Exclusion of costs that were not exclusively mitigation (land acquisition costs, easements, right of entry fees, etc.)
- Costs represented by 2019 dollars

Revised Estimate

The results of the 2021 update are an increase in the anticipated mitigation costs of approximately $22.5M in 2019 dollars (Table 1). It is important to note that this estimate is a planning-level estimation and would be modified by changes in land costs, permit terms, the results of future surveys to determine presence/absence of listed and rare surveys and escalation of all related mitigation costs. However, it is a still conservative estimate and very likely an overestimate of the final costs due to the lack of access to the vast majority of the project area necessitating the assumed presence of state and federally listed and rare species and special aquatic sites that are could occur within the project footprint.

Table 1: Results of 2021 mitigation cost estimate update as compared to the 2020 Value Planning update.

Resource	February 2020 Value Planning Estimate	June 2021 Planning Level Cost in 2019 Dollars
Aquatic Resources	$56,000,000	$56,000,000
Sensitive Natural Communities and Wetland & Non-Wetland Waters Resources	$174,800,000	$333,412,500
Terrestrial Wildlife Resources/Wildlife Habitat	$53,000,000	$109,215,500
Surface Water Quality	$200,000	$200,000
Agriculture & Forestry	$31,000,000	$46,059,000
Cultural & Paleontological Resources	$35,000,000	$13,840,300
Air Quality	$200,000	$3,750,000
Riverine-Based Species and Habitats (operations)	$150,000,000	N/A*
Contingencies and Forward Escalation	$40,000,000	N/A
Total	**$540,000,000**	**$562,477,300**

Reservoir Operations Plan

Version 1.0

Draft
Subject to Revision – Not for Public Distribution

November 2021

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Contents

Figures

Attachments

Version History

Version	Description	Date of Revision
1	Initial Draft	11/24/21

Acronyms and Abbreviations

Authority	Sites Project Authority
BiOp	Biological Opinion
CBD	Colusa Basin Drain
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
COA	Coordinated Operation Agreement
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
D-1641	Decision 1641
Delta	Sacramento-San Joaquin River Delta
DWR	California Department of Water Resources
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
GCID	Glenn-Colusa Irrigation District
HCPP	Hamilton City Pumping Plant
I/O	intake/outlet
MAF	million acre-feet
NMFS	National Marine Fisheries Service
NOD	North of Delta
O&M	Operations and Maintenance
PGP	Pumping Generating Plant
RBPP	Red Bluff Pumping Plant
Reclamation	Bureau of Reclamation
ROC on LTO	Reinitiation of Consultation on Long-Term Operations of the Central Valley Project and State Water Project
SCADA	Supervisory Control and Data Acquisition
SOD	South of Delta
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TC Canal	Tehama-Colusa Canal
TCCA	Tehama-Colusa Canal Authority
TRR	Terminal Regulating Reservoir
WIIN	Water Infrastructure Improvements for the Nation
WSIP	Water Storage Investment Program

1.0 Definition of Terms

Key terms used in this Reservoir Operations Plan are defined below:

- **Active Storage** – That portion of Sites Reservoir above dead pool that can be exercised to create water supply-related benefits. The total maximum storage in Sites Reservoir is expected to be 1.5 million acre-feet (MAF). Firm dead pool storage, or the amount of water that cannot be effectively used, is expected to be about 60 thousand acre-feet (TAF). However, operationally another 60 TAF would likely be needed to prevent water quality issues in the storage releases. Therefore, the operational dead pool, or the minimum amount of water needed to maintain operational standards, is considered to be 120 TAF. For this plan, the active storage for Sites Reservoir is considered to be about 1.38 MAF.
- **CalSim II (CalSim) –** A generalized reservoir-river basin simulation model. The model used and presented in this document is the Reclamation/California Department of Water Resources CalSim II planning model that simulates the coordinated operation of the CVP and SWP over a range of hydrologic conditions. The model is run on a monthly timestep.
- **Contract Year** – Period from, and including, January 1 of each calendar year through December 31 of the same year.
- **No Action Alternative (NAA)** – The system modeled without construction of the Project. The modeled results for the NAA include the same regulatory environment/baseline as that included in the with-project modeling.
- **Sites Project Authority (Authority)** – A joint powers authority established to exercise powers common to the Authority Members to, among other things, effectively study, promote, develop, design, finance, acquire, construct, manage, and operate Sites Reservoir and related facilities such as recreation and power generation.
- **Sites Reservoir Project (Project)** – Dams, reservoirs, certain associated diversion and conveyance facilities, and other associated facilities, mitigation lands, and water right owned and operated by the Authority.
- **Storage Allocation** – Amount of storage space (storage volume) in Sites Reservoir allocated to a Storage Partner, as agreed upon in that Storage Partner's Sites Reservoir Benefits and Obligations Contract. Dead storage is not allocated to any Storage Partner.
- **Storage Partner** - The governmental agencies, water organizations and others who have funded and received a Storage Allocation in Sites Reservoir and the resulting water supply or water supply related environmental benefits from the Project. Storage Partners could include local agencies, the State of California, and the Federal Government (see Attachment A for a full list based on 2021 participation).
- **Water Year** – Period from October 1 through September 30.
- **Water Year Type** – Classified water year based on the Sacramento Valley 40-30-30 Water Year Hydrological Classification Index, in accordance with the State Water Resources Control Board (SWRCB) Water Year Hydrologic Classification, presented in D-1641.

2.0 Introduction and Approach

The Sites Reservoir Project (Project) is a proposed 1.5 million acre-feet (MAF) offstream reservoir located west of the community of Maxwell, California. The Project would use existing infrastructure to divert unregulated and unappropriated flow from the Sacramento River at Red Bluff and Hamilton City and would convey water to the reservoir. New and existing facilities would move water into and out of the reservoir. Releases from Sites Reservoir would be made to the Glenn Colusa Irrigation District (GCID) Main Canal and the Tehama-Colusa (TC) Canal. Releases to the TC Canal could be diverted for use or could flow farther downstream to either the Yolo Bypass via the Knights Landing Ridge Cut or back to the Sacramento River via the Knights Landing Outfall Gates and ultimately be exported through the Sacramento-San Joaquin River Delta (Delta) for use in and south of the Delta. Figure 1 and Figure 2 show the location of the Project and its facilities.

The Sites Project Authority (Authority) would own, govern, manage, and operate Sites Reservoir and related facilities. As such, the Authority would, in addition to other responsibilities, be the holder of the water right, enter into contracts for both water supply and Proposition 1-eligible public benefits, coordinate with the Central Valley Project (CVP) and State Water Project (SWP) operators, coordinate with other regional and local water facilities, and be responsible for environmental compliance obligations, operations and maintenance, and dam safety. Organizationally, the Authority has established the Reservoir Committee to develop, through a partnership, both long-term and annual operational plans. The Reservoir Committee consists of Sites' Storage Partners, those entities and organizations that are funding and would receive water supply or water supply-related environmental benefits from the Project.

As defined in the Project's Revised Draft Environmental Impact Report (EIR)/Supplemental Draft Environmental Impact Statement (EIS) (November 2021), the objectives of the Project are as follows:

- Improve water supply reliability and resiliency to meet Storage Partners' agricultural and municipal long-term average annual water demand in a cost-effective manner for all Storage Partners, including those that are the most cost-sensitive.
- Provide public benefits consistent with Proposition 1 of 2014 and use Water Storage Investment Program (WSIP) funds to improve statewide surface water supply reliability and flexibility to enhance opportunities for habitat and fisheries management for the public benefit through a designated long-term average annual water supply.
- Provide public benefits consistent with the Water Infrastructure Improvements for the Nation (WIIN) Act of 2016 by using federal funds, if available, provided by the Bureau of Reclamation (Reclamation) to improve CVP operational flexibility in meeting CVP environmental and contractual water supply needs and improving cold pool management in Shasta Lake to benefit anadromous fish.
- Provide surface water to convey biomass from the floodplain to the Delta to enhance the Delta ecosystem for the benefit of pelagic fishes in the north Delta (e.g., Cache Slough).
- Provide local and regional amenities, such as developing recreational facilities, reducing local flood damage, and maintaining transportation connectivity through roadway modifications.

This document provides a detailed description of the operations of Sites Reservoir (or Sites). Operations of the Project would be flexible and adaptable to meet a wide range of water supply and environmental needs. Version 1 of this Operations Plan includes the operations as they have been identified as of December 2021. All project facilities and modeling results included in this document refer to Alternative

1B, as identified in the Revised Draft EIR/Supplemental Draft EIS. As permitting and water right conditions are finalized, this Plan will be revised and expanded.

It is important to note the following for the reader:

1. This Version 1.0 of the Operations Plan is framed around Alternative 1B, the Authority's Preferred Project in the Revised Draft EIR/Supplemental Draft EIS. As the environmental review process has not yet been completed, the Preferred Project, mitigation measures that may be relevant to water operations, and the selection of the Preferred Project itself may change. This Operations Plan in no way binds the Authority to certain operations, mitigation measures, or the selection of the Preferred Alternative itself. This Plan will be adjusted and revised to reflect the final outcomes of the environmental review process in future versions.
2. The results of the modeling for Alternative 1B conducted for the Revised Draft EIR/Supplemental Draft EIS are used in this Operations Plan and are based on CalSim modeling and are included for illustrative purposes only. While these are valuable building understanding of the operations of the project, it is important for the reader to remember that CalSim modeling is based on monthly timesteps and historic hydrology. Actual daily operations may vary. Daily modeling will be developed in the future, and Version 2 of this Plan will be modified accordingly.

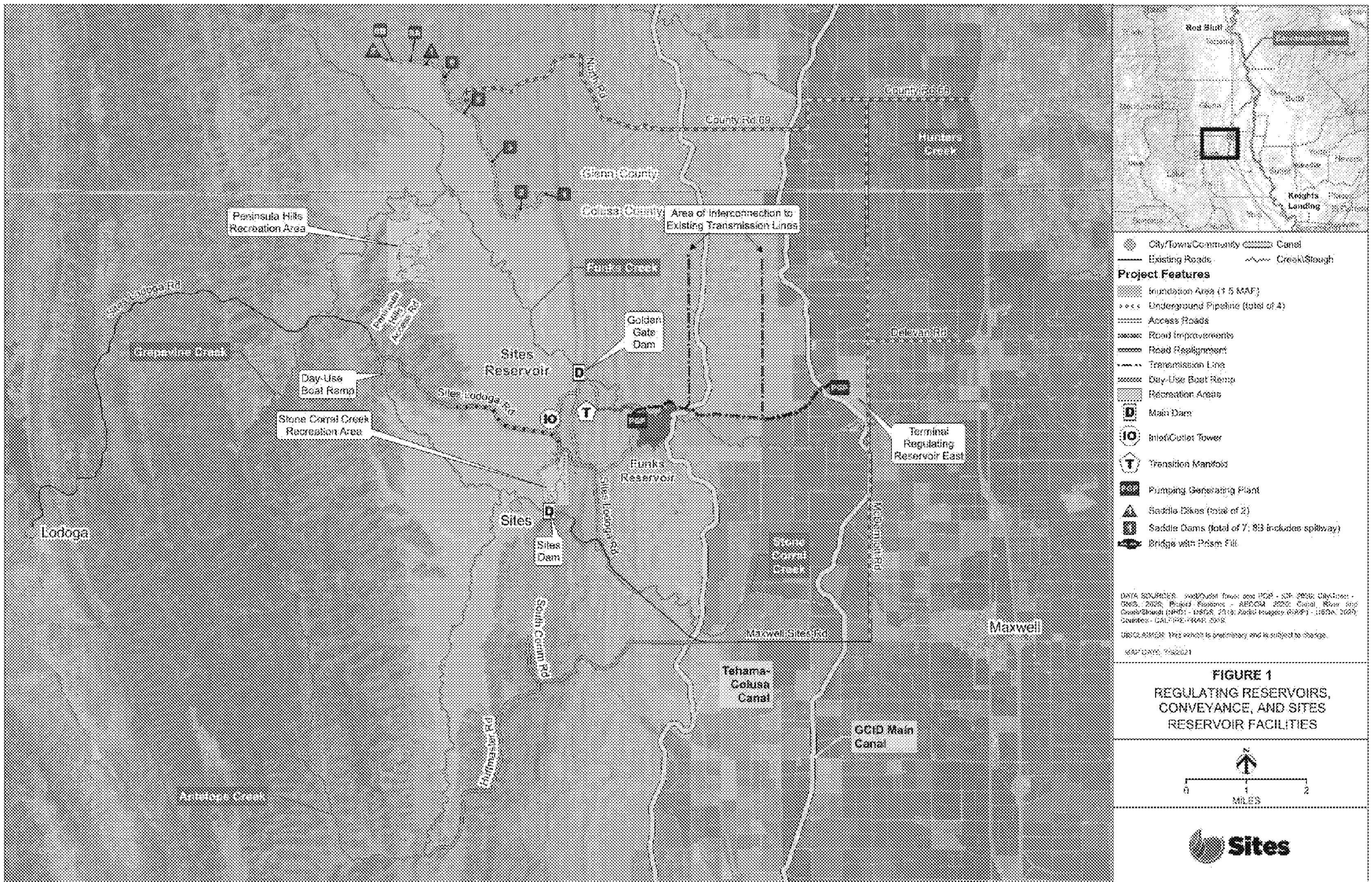


Figure 1. Regulating Reservoirs, Conveyance, and Sites Reservoir Facilities

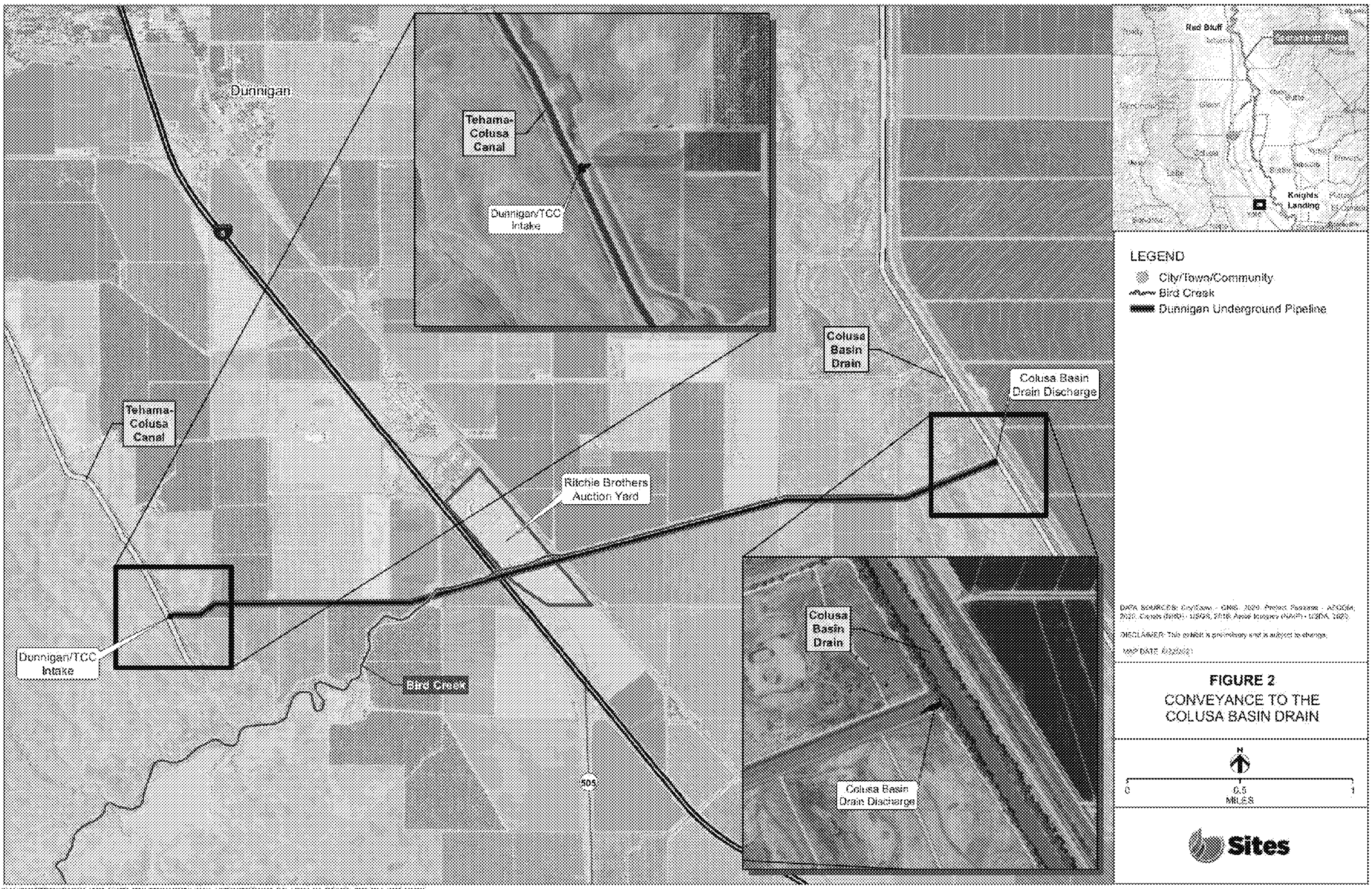


Figure 2. Conveyance to the Colusa Basin Drain

3.0 Operations Planning, Forecasting, and Accounting

3.1 Annual Operating Cycle

Figure 3 summarizes the annual operating cycle. The annual operating cycle depicts the timeline and requirements of components important to operations:

- Initial and final requests for releases from Storage Partners
- Timing of releases for NOD and SOD uses
- Timing of exchanges with DWR and Reclamation
- Coordination with TCCA, GCID, CDFW, and CBD entities

The annual operating cycle can be broadly divided into those times with the Project is diverting water, exchanging water (and releasing for NOD purposes), and releasing water SOD during the transfer window.

January
- Initial requests for Sites water provided by participants for delivery or transfer
- Coordination with GCID and TCCA on diversions

February
- Coordination with GCID and TCCA on diversions
- Final requests for Sites water releases before transfer window (further requests accommodated when possible)

March
- Sites begins releasing water for DWR and Reclamation exchanges
- Coordination with GCID and TCCA on diversions
- Coordination with CDFW on Prop 1 water deliveries
- Some releases for NOD use

April
- Final requests for Sites water releases to SOD (further requests accommodated when possible)
- Releases for NOD purposes
- Coordination with CDFW on Prop 1 water deliveries

May
- SOD participants notify DWR of final Sites requests for season
- Peak release month for exchange water
- Releases for NOD purposes
- Prop 1 water schedule finalized with CDFW

June
- Peak month for water backed into Oroville and Shasta
- Releases for NOD use
- Carriage water costs determined (proposed)

July
- Transfer window opens, SOD deliveries begin
- Water exchanged into Shasta and Oroville begins to release
- Key month: Coordination with TCCA, CBD, DWR on releases to river
- Coordination with Reclamation and DWR on exports
- Releases for NOD use

August
- Exports for SOD use
- Yolo Bypass Prop 1 deliveries
- Key month: Coordination with TCCA, CBD, DWR on releases to river
- Coordination with Reclamation and DWR on exports
- Releases for NOD use

September
- Exports for SOD use
- Key month: Coordination with TCCA, CBD, DWR on releases to river
- Yolo Bypass Prop 1 deliveries
- Coordination with Reclamation and DWR on exports
- Releases for NOD use

October
- Exports for SOD use
- Continued coordination with TCCA, CBD, DWR, Reclamation on releases and deliveries
- Releases for NOD use

November
- Last month for SOD exports
- Coordination with GCID and TCCA on diversions
- Releases for NOD use

December
- Coordination with GCID and TCCA on diversions

Figure 3. Annual Operating Cycle

3.2 Forecasting

Forecasting will be used to estimate the amount of water available to each Storage Partner in a given year. Project-specific forecasts will initiate in February and will be updated weekly. Forecasts will use the best available technology at the time of operations. This could include the California Department of Water Resources' (DWR's) 50 and 90 percent exceedances for Sacramento River flows. Forecasting for diversions is discussed in Section 4.3. Forecasts for Project operations will also include coordination with the CVP and SWP.

3.3 Real-time Tracking and Accounting

A Project dashboard will be developed that will allow the Authority, its operators, and the Storage Partners to track real-time Project operations and accounting. The dashboard will include the following metrics:

- Project diversions at Red Bluff and Hamilton City
- pumping into Sites Reservoir from Funks Reservoir and the Terminal Regulating Reservoir (TRR)
- local inflows and outflows from Stone Corral and Funks Creeks
- storage account levels
- reservoir levels
- requested releases
- actual releases
- power use and generation
- deliveries to turnout or export facilities
- exchanged water and location (including spill or carryover of exchange water)
- estimated losses, including conveyance, evaporation, and carriage water

The real-time dashboard will have the ability to summarize data at various timesteps (e.g., instantaneous data, prior week, prior month, year-to-date).

3.4 Year-end Accounting

Following the final deliveries, year-end accounting and true-up be prepared. Metrics will be provided to Storage Partners and may also be used in the annual water right report. It is anticipated that this report will include a summary of requested releases from storage, actual deliveries, and estimated losses, including spills (or carryover, if allowable) of exchange water in either Shasta or Oroville. The year-ed accounting will be available to Sites Storage Partners as they make their requests for Project water the following year.

3.5 Periodic Synthesis Reporting

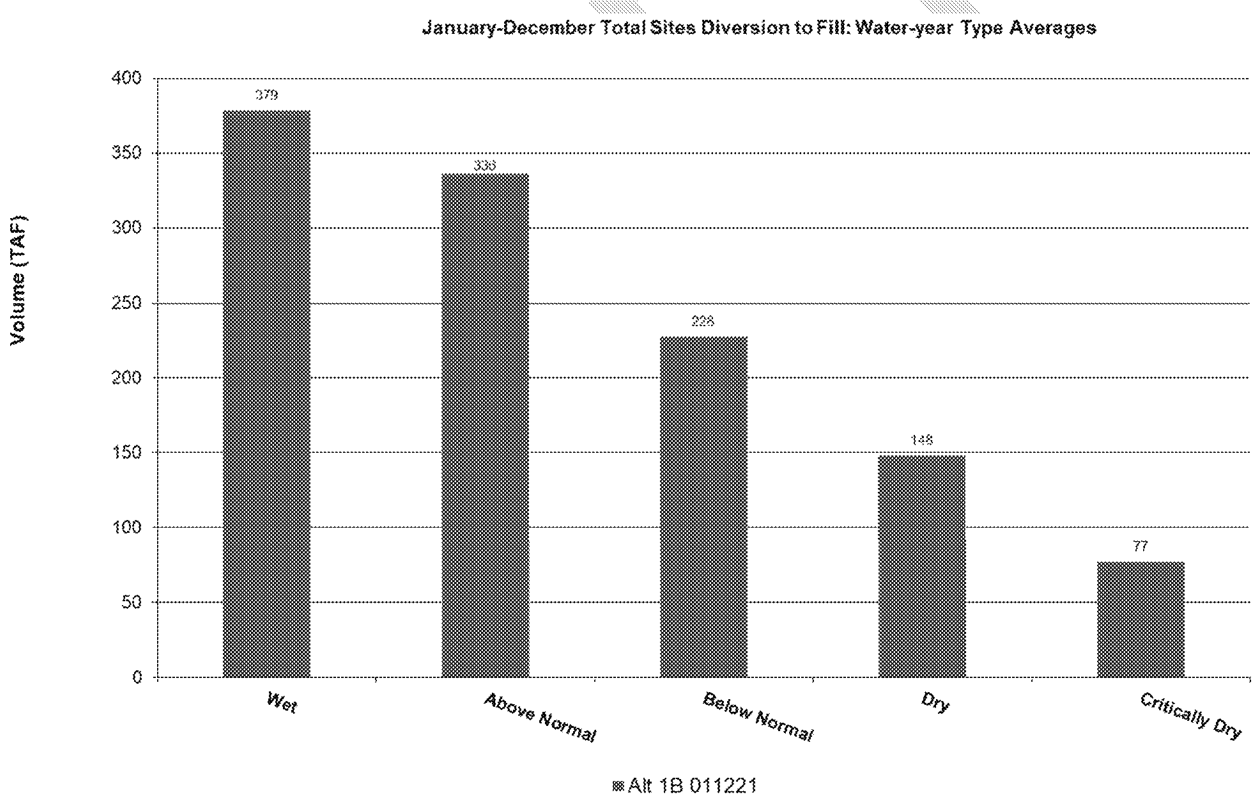
A synthesis report will be prepared by the Authority staff every 5 years, starting 5 years after initial operations of the Project. The synthesis report will evaluate the efficiency and effectiveness of Project operations, describe, at a minimum, challenges and opportunities that occurred over the prior 5 years of operations, and identify improvements to be implemented in the future, including potential changes to this Operations Plan. The Periodic Synthesis Report will incorporate feedback and assess satisfaction of the Storage Partners and operating partners (GCID, TCCA, CBD, DWR and Reclamation) with Project operations.

4.0 Diversions and Conveyance to Sites Reservoir

4.1 Overall Project Diversions

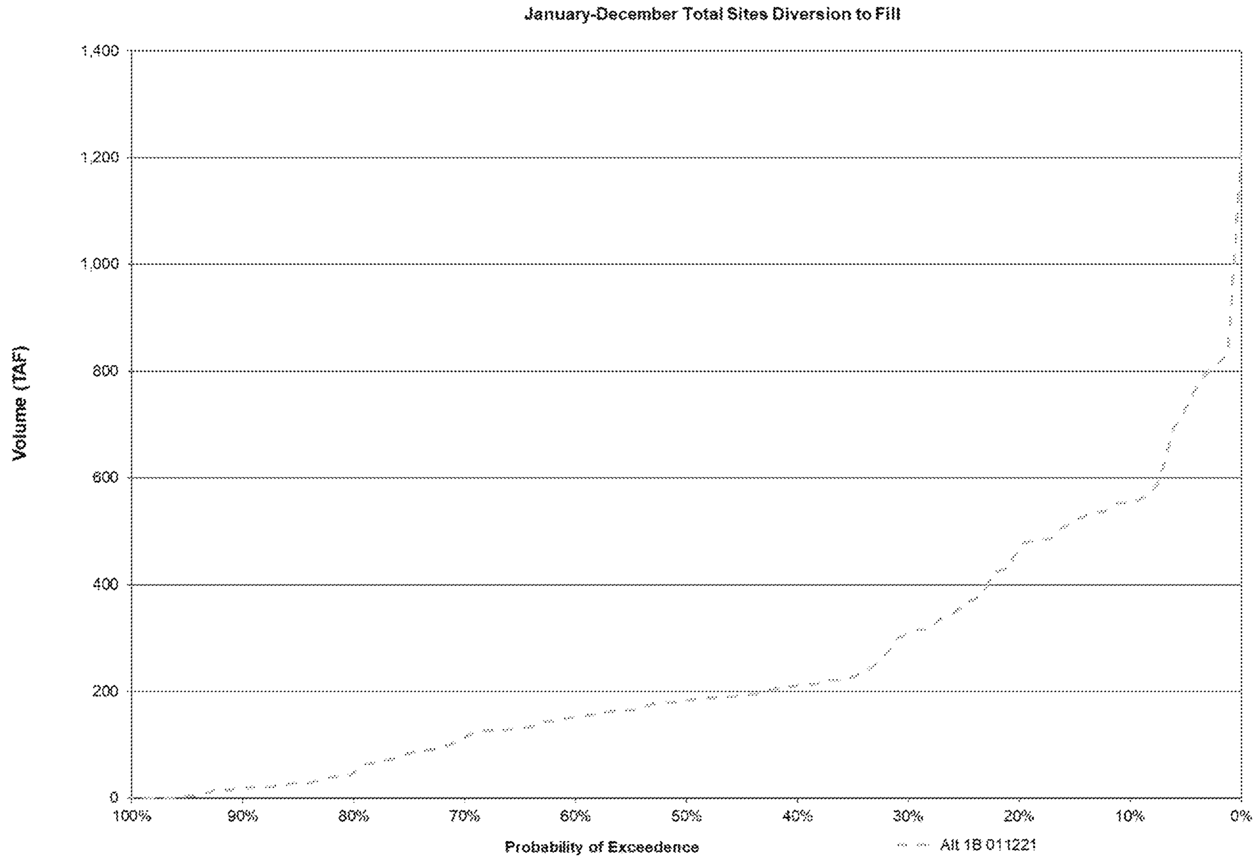
Project diversions would generally occur in the winter and early spring but could occur any time from October 1 through June 14. Project facilities can only be used to divert/fill or release from the Reservoir; simultaneous fill and release is not possible. In addition, and consistent with the expected Project water right, all water diverted under the Project water right must be placed into storage in Sites Reservoir and cannot be directly used (used for a beneficial purpose prior to being stored in Sites Reservoir).

The total diversions and timing for diversions based on the CalSim modeling conducted for the Revised Draft EIR/Supplemental Draft EIS are shown in Figure 4 to Figure 6. Figure 4 shows the total average diversions to Sites from the Sacramento River over the 82-year CalSim hydrology by water year type. Figure 6 depicts monthly averages; actual within-month diversions at the daily or weekly timescale are expected to vary. Daily modeling will be developed in the future, and Version 2 of this Plan will be modified accordingly.



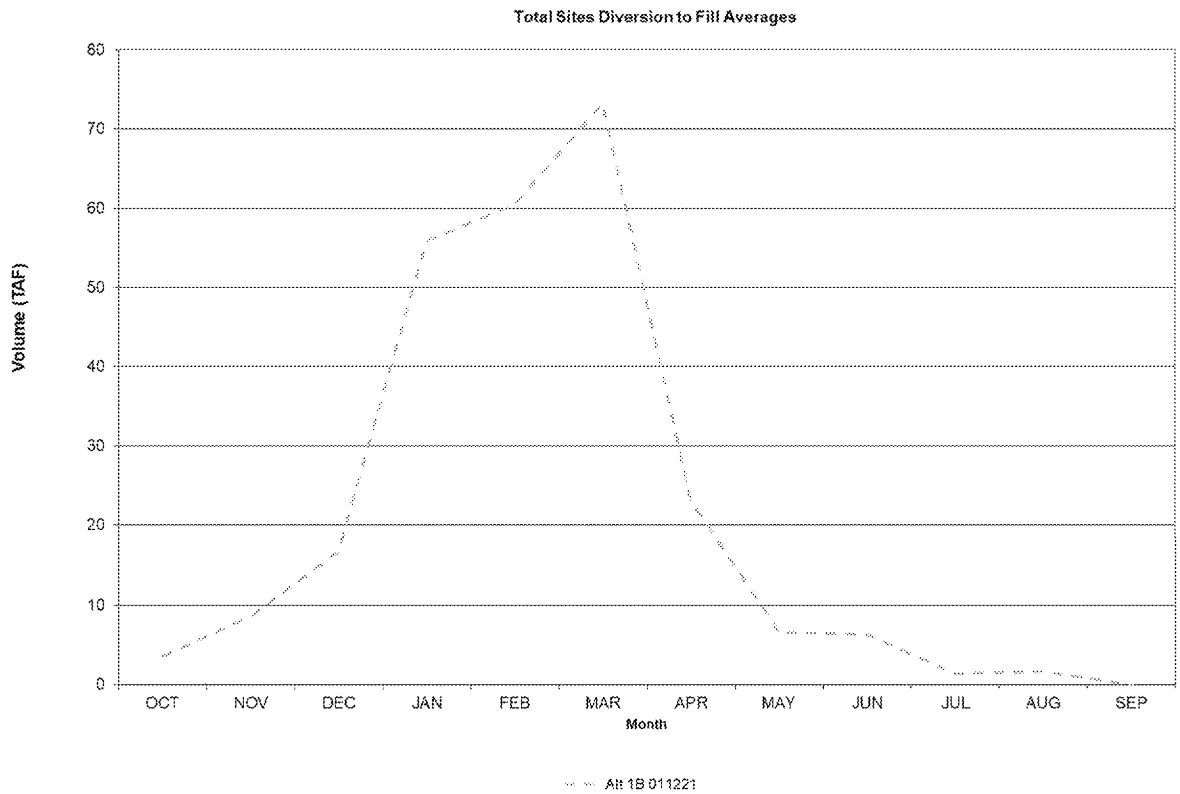
Water year type based on the Sacramento Valley 40-30-30 Water Year Hydrological Classification Index
Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 4. January to December Total Sites Diversion to Fill: Water-year Type Averages



Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 5. Exceedance plot of January to December Total Sites Diversion to Fill



Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 6. Long-term Monthly Average of Total Sites Diversion to Fill

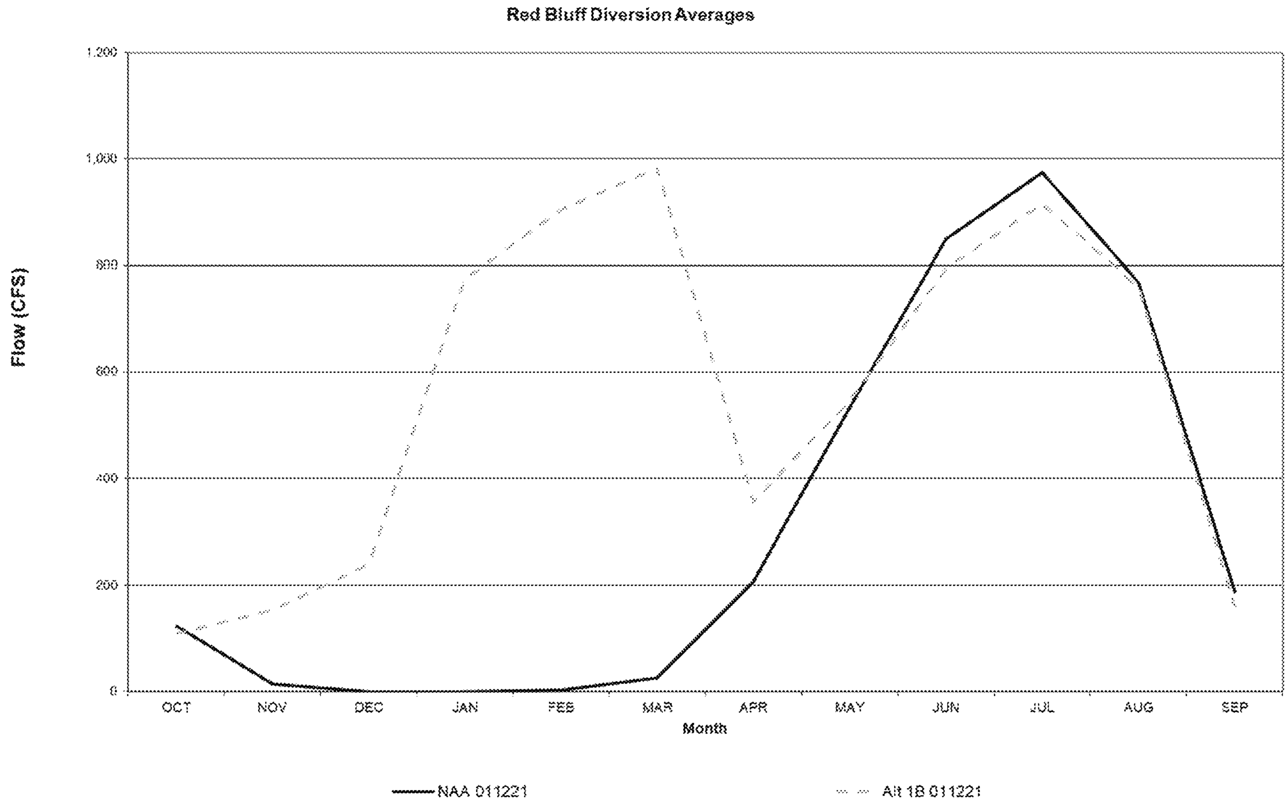
4.2 Diversion and Conveyance Facilities

The following sections describe the diversion and conveyance facilities that may be used in the operation of the Project. The location of these facilities is shown in Figure 1. Facilities are described below in order of operational process (i.e., diversion, storage, release).

4.2.1 Red Bluff Pumping Plant, Tehama-Colusa Canal, and Funks Reservoir

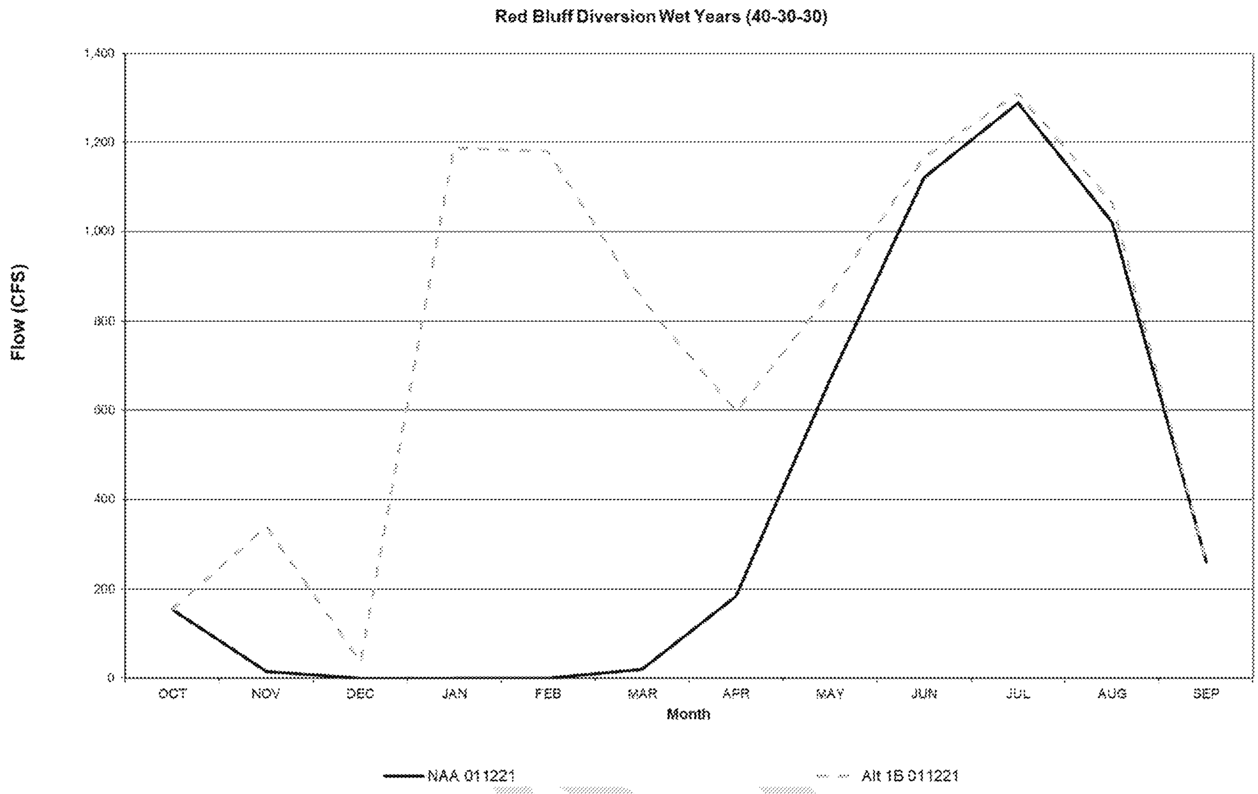
The Project would divert water from the Sacramento River at the existing Red Bluff Pumping Plant (RBPP) and Hamilton City Pump Station (described below). Water diverted at the RBPP enters the TC Canal to be conveyed to Sites Reservoir. The RBPP and TC Canal are owned by Reclamation and operated by the Tehama-Colusa Canal Authority (TCCA). Diversions at the RBPP will be in addition to those occurring for TCCA members as part of their CVP contracts. The RBPP will have a capacity of 2,500 cubic feet per second (cfs) after capacity improvements are made to serve the Project. The facility has a fish screen that meets National Marine Fisheries Service (NMFS) and California Department of Fish and Wildlife (CDFW) criteria.

The total conveyance capacity of the TC Canal at the upstream end of the canal is assumed to be 2,530 cfs and 2,100 cfs at Funks Reservoir (described below). Figure 7 shows average monthly diversions for all water year types at the RBPP with and without the Project. Figure 8 shows average monthly diversions in wet years when diversions are highest. The figures depict the total diversions at the pumping facility for both TCCA and Sites purposes. The total diversions at Red Bluff in the summer months are modeled as decreasing slightly between the No Action Alternative (NAA 011221) and the with-project alternative (Alt 1B 011221) due to exchanges (e.g. TCCA members receiving CVP water from Sites rather than pumping it from the Sacramento River). Note that the figures show monthly averages; actual within-month diversions at the daily or weekly timescale are expected to vary. Daily modeling will be developed in the future, and Version 2 of this Plan will be modified accordingly.



Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 7. Red Bluff Diversion Averages



Water year type based on the Sacramento Valley 40-30-30 Water Year Hydrological Classification Index
Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 8. Red Bluff Diversions in Wet Years

The TC Canal is concrete-lined, resulting in a relatively minor seepage losses during the conveyance of Sites water. Losses occurring between the RBPP and Sites Reservoir are estimated to be 1 percent. However, the actual losses incurred will be estimated by TCCA during Project operations. Losses in the TC Canal will be allocated on a daily basis proportionally to Storage Partners receiving diversions. The TC Canal is currently drained and out of service for maintenance from November to mid-February each year. This maintenance window is expected to be reduced once Sites Reservoir is constructed.

The existing Funks Reservoir will be used as a regulating reservoir to store water from the TC Canal for pumping to, and for release from, Sites Reservoir. Funks Reservoir will have an estimated storage capacity of 2,250 acre-feet following dredging to restore the regulating reservoir's original design capacity. Funks Reservoir is currently drained from November to mid-February during the canal maintenance period. It is not anticipated that Funks would be drained annually while Sites Reservoir is operational, besides potentially during the 2-week canal maintenance window. Funks Reservoir operates at a water surface elevation of 200 to 205 feet, with a preferred operational water surface elevation range of 202 to 204 feet.

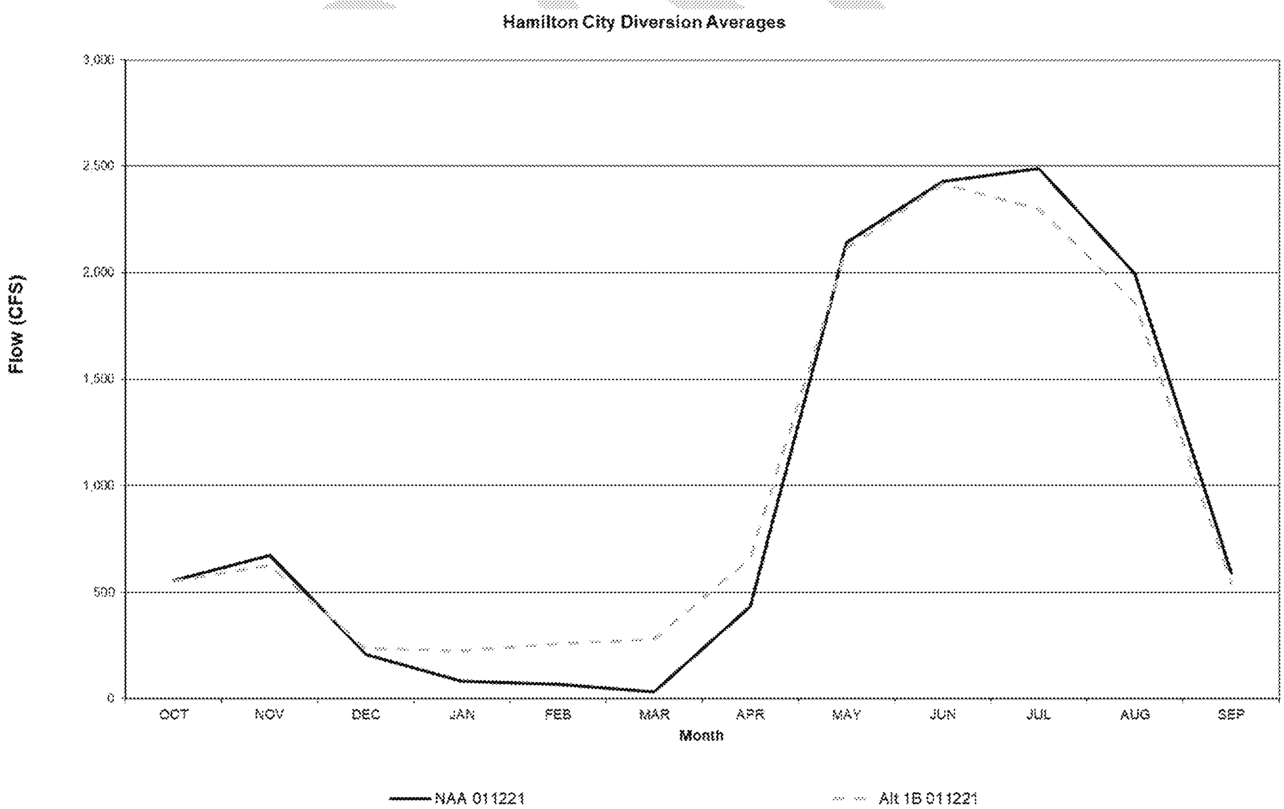
The newly constructed Funks Pumping Generating Plant will be used to pump water from Funks Reservoir to Sites Reservoir with a pumping capacity of 2,100 cfs and a generating capacity of up to 2,000 cfs. The pumping generating plant will require a substation to provide electricity to the associated facilities. Two 12-foot-diameter underground Funks pipelines will convey water approximately 1 mile between the pumping generating plant and Sites Reservoir.

4.2.2 Hamilton City Pumping Plant, Glenn-Colusa Irrigation District Main Canal, and Terminal Regulating Reservoir

Water diverted from the Sacramento River at the existing Hamilton City Pumping Plant (HCPP) enters the GCID Main Canal. The HCPP and the GCID Main Canal are owned and operated by GCID. Diversions at the HCPP will be in addition to those occurring for uses in the GCID system but may be modified to accommodate exchanges with the Project when mutually agreed upon by GCID and the Authority (see Section 7.2 for further discussion on exchanges). The HCPP has a diversion capacity of approximately 3,000 cfs at the Sacramento River intake. The facility has a fish screen that meets NMFS and CDFW criteria.

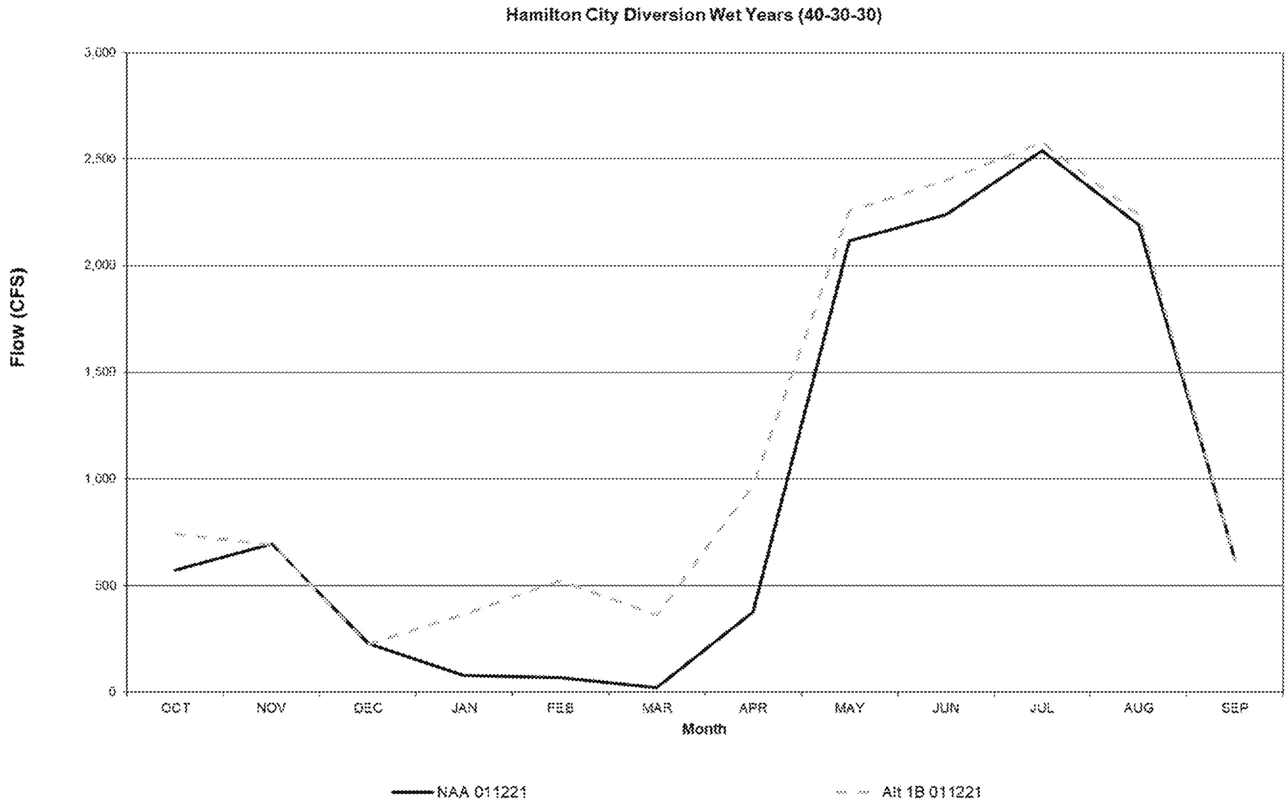
The total conveyance capacity of the GCID Main Canal is assumed to be 1,800 cfs at the TRR (described below). Figure 9 shows average monthly diversions for all water year types at the HCPP with and without the Project. Water year type based on the Sacramento Valley 40-30-30 Water Year Hydrological Classification Index
Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 10 shows average monthly diversions in wet years when diversions are highest. The figures depict the total diversions at the pumping facility for both GCID and Sites purposes. The total diversions at the HCPP in the summer months are modeled as decreasing slightly between the NAA (NAA 011221) and the Alternative 1B (Alt 1B 011221) due to exchanges (e.g. GCID receiving water from Reclamation's storage account in Sites rather than pumping from the Sacramento River). The figures depict monthly averages; actual within-month diversions at the daily or weekly timescale are expected to vary. Daily modeling will be developed in the future, and the Version 2 of this Reservoir Operations Plan will be modified accordingly.



Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 9. Hamilton City Diversion Averages



Water year type based on the Sacramento Valley 40-30-30 Water Year Hydrological Classification Index
Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 10. Hamilton City Diversion Wet Years (40-30-30)

The GCID Main Canal is unlined, resulting in larger seepage losses than the TC Canal during the conveyance of Sites water. Losses from the HCPP to Sites Reservoir are estimated to be 2 percent from November to March and 13 percent from April to October. However, the actual losses incurred from the HCPP to Sites Reservoir will be estimated by GCID during Project operations. Losses in the GCID Main Canal will be allocated on a daily basis proportionally to Storage Partners receiving diversions. Because the GCID Main Canal is unlined, it requires regular annual maintenance—during which time water cannot be conveyed using the canal. The assumed annual maintenance time is 2 weeks in late January or early February.

The newly constructed TRR will be a regulating reservoir up to 600 acre-feet constructed adjacent to the GCID Main Canal, approximately 3 miles northeast of Funks Reservoir. Two options for the TRR are being considered: TRR East and TRR West. Regardless of the alternative selected, the footprint of TRR would be approximately 100 acres. The TRR would have earthen embankments at the perimeter with impermeable lining consisting of a geomembrane overlying geocomposite placed over compacted earth. The TRR would be hydraulically connected to the GCID Main Canal to allow water to be conveyed to and from Sites Reservoir. The TRR would accommodate inflows of up to 1,800 cfs.

The newly constructed TRR Pumping Generating Plant (PGP) will be used to pump water from the TRR to Sites Reservoir with a pumping capacity of 1,800 cfs. The generating plant will have a capacity of 1,000 cfs.

Two 12-foot-diameter underground pipelines would convey water approximately 4 to 4.5 miles between the TRR PGP and Sites Reservoir.

4.3 Diversion Criteria

Sites Reservoir would be filled primarily through the diversion of Sacramento River flows that originate primarily from unregulated tributaries to the Sacramento River downstream from Keswick Dam. A relatively small amount of flow is assumed to be provided by flood releases or spills in wet years from Shasta Lake. Similarly, a small amount of water from Stone Corral and Funks Creeks will be impounded in Sites Reservoir. Sacramento River flows would be diverted at two locations on the Sacramento River, as described above. The following sections describe the existing regulatory environment under which the Project would operate, and the Project-specific diversion criteria that would be finalized through the permitting and water right process. It should be noted that the regulatory environment is not static and Project operations will adjust as needed to meet regulatory requirements that are in place during the time of operations.

4.3.1 System-wide Criteria and Regulations

The primary regulatory requirements that must be met prior to diversions are summarized below, at a high level. The requirements listed are those expected to regularly influence Project operations, but the list is not comprehensive. All diversion criteria, both system-wide and Project-specific, must be met for Project diversions.

- **Sacramento River is not fully appropriated:** The Sacramento River is considered to be fully appropriated from June 15 to August 31. Therefore, the Project will not divert during this window, regardless of river conditions or flows.
- **Excess conditions in the Delta:** The Delta is considered to be "in excess" when the sum of releases from upstream reservoirs plus unregulated flows are greater than Sacramento Valley in-basin uses plus exports. Excess conditions are determined by DWR and Reclamation; the Project can divert only when the Delta is in excess.
- **Senior Water Rights:** Existing CVP and SWP and other water right diversions, including other more senior excess flow priorities would take priority over the diversion of Sites water.
- **SWP Article 21, Reclamation Article 6F and 215:** The SWP contract and CVP contracts include provisions for deliveries above contract amounts in certain conditions. This water is generally available in wetter water year types or in higher flow conditions. The delivery of SWP Article 21 water, CVP Article 6F, and CVP 215 water is senior to Project diversions and deliveries and would take priority over the movement of Project water.
- **SWRCB Decision 1641 (D-1641):** D-1641 and its amendment identify the implementation of water quality and flow objectives for the San Francisco Bay and Sacramento-San Joaquin Delta Estuary. Components of D-1641 expected have the largest influence on Project operations include requirements for the Net Delta Outflow Index, operations of the CVP and SWP related to salinity and X2, and Delta water quality requirements.
- **SWP Incidental Take Permit:** The Project will operate so as to avoid affecting DWR's ability to operate to the SWP Incidental Take Permit. In particular, the Authority will not impinge on DWR's ability to conduct export curtailments for Spring outflow, provide 100 TAF for Delta outflow, or operate to the Delta Smelt Summer-Fall Habitat Action.
- **2019 Biological Opinions (2019 BiOps) for CVP and SWP:** The Project will operate so as to avoid affecting Reclamation's ability to operate to the 2019 BiOps. The Authority will coordinate with Reclamation on exchanges to enhance Reclamation's ability to operate to the 2019 BiOps. In

particular, the Authority will not impinge on Reclamation's ability to provide spring pulse flows, cold water pool preservation in Shasta, and fall flow stability in the Sacramento River downstream of Shasta Lake. The 2019 BiOps are currently under reconsultation. The outcome of this reconsultation will inform the Project's operations and will change the baseline operations of the system.

The Project will also be required to operate under any temporary restrictions on pumping put into place by SWRCB. One example of such a restriction is Term 91, when those holding certain permits and licenses must cease diverting water because water in excess of CVP and SWP storage releases is not available in the system. Term 91 is often implemented under drought conditions, when Project diversions are unlikely to occur due to other requirements such as bypass flows.

As noted above, the regulatory environment is not static. As such, Project operations will adjust as needed to meet regulatory requirements that are in place during the time of operations.

4.3.2 Project-specific Diversion Criteria

Bend Bridge Pulse Protection

Project implementation would include a pulse flow protection measure to be applied to all qualified precipitation-generated peaks in the hydrograph that originate primarily from tributaries to the Sacramento River that flow into the mainstem Sacramento River downstream of Keswick Dam from October through May. Project diversions from the Sacramento River would not occur during a qualified pulse event. Diversions are otherwise unrestricted by the Bend Bridge Pulse Flow protection criteria.

For modeling included in the Revised Draft EIR/Supplement Draft EIS, a qualified pulse flow is defined as follows:

1. Outmigration of anadromous fish is detected based on the Adaptive Management Plan and fish monitoring program; and,
2. The 3-day trailing average of Sacramento River flow at Bend Bridge exceeds 8,000 cfs, the 3-day trailing average tributary flow upstream of Bend Bridge (Cow, Cottonwood, and Battle Creeks) exceeds 2,500 cfs, and a pulse event the previous day was not already in a pulse event.

A pulse event terminates 7 days after initiation. After completion of a pulse event, the following conditions must occur before another pulse event is triggered:

1. The 3-day trailing average of Sacramento River flow at Bend Bridge was less than 7,500 cfs for 7 consecutive days, and,
2. The 3-day trailing average of tributary flow upstream of Bend Bridge (Cow, Cottonwood, and Battle Creeks) was less than 2,500 cfs for 7 consecutive days.

Figure 11 depicts the pulse flow protection criteria.

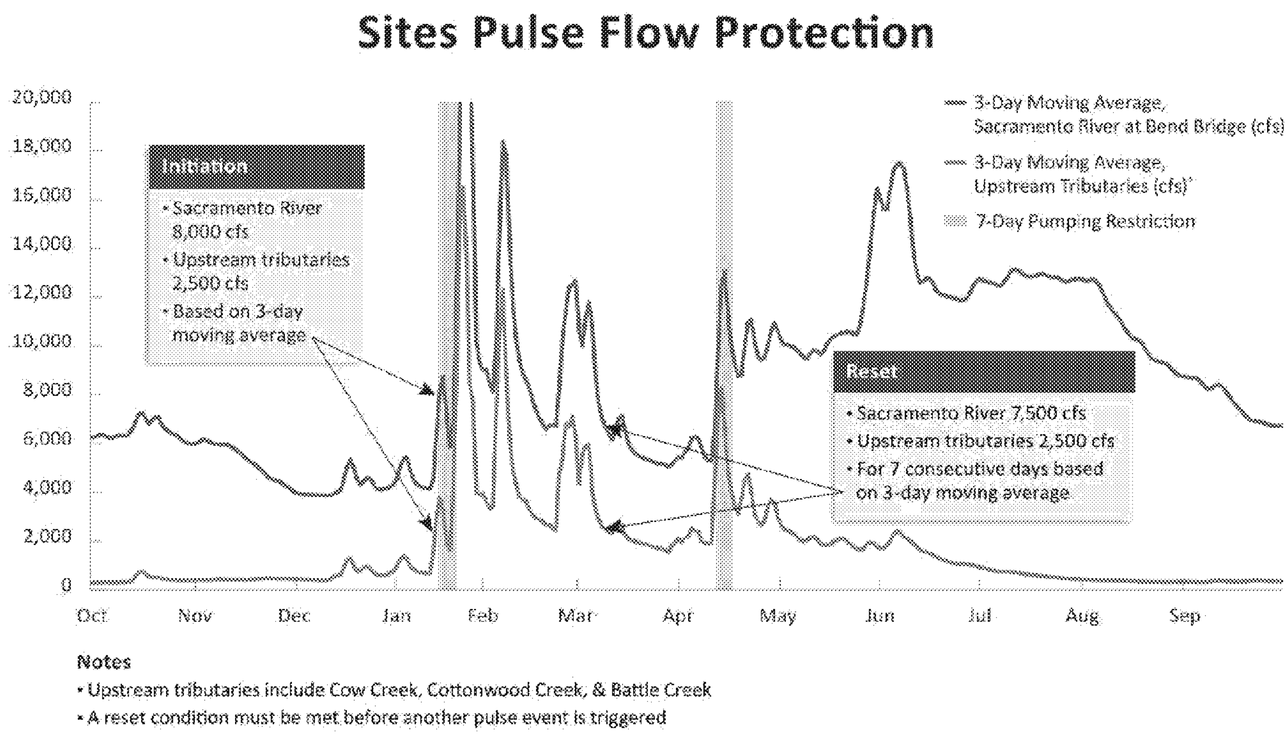


Figure 11. Sites Pulse Flow Protection

The pulse flow criteria described above align with those included in Project modeling for the RDEIR/SDEIS. Final pulse flow criteria are under development and will be revised as necessary in Version 2 of this Reservoir Operations Plan.

Wilkins Slough Bypass Criteria

A minimum bypass flow of 10,700 cfs in the Sacramento River at Wilkins Slough would be in place from March to May and 5,000 cfs during the rest of the Project diversion season (June, and September through February). The current flows at Wilkins Slough will be determined using information available on the California Data Exchange Center for the Sacramento River below Wilkins Slough (WLK) gage. Projected flows/forecasts will be determined either by using correlation between Colusa Bridge forecasts and Wilkins Slough flows or by working with the Sacramento River Forecast Center to develop projections specific to Wilkins Slough. Additional information on flow forecasting will be included in Version 2 of this Operations Plan.

Fremont Weir Notch Protections

The Project's diversion criteria have been formulated to avoid impacts on Reclamation's ability to meet its obligations in the 2019 NMFS BiOp to implement the Yolo Bypass Restoration Salmonid Habitat Restoration and Fish Passage Implementation Plan and inundate over 17,000 acres in the Yolo Bypass from December to April (NMFS 2019). For the purposes of modeling, diversions to Sites Reservoir may occur if no more than a 1 percent reduction in flow through the Fremont Weir Notch would result when flows through the Notch are less than 600 cfs. Project diversions may occur if no more than a 10 percent reduction in flow through the Fremont Weir Notch would occur when flows through the Notch are between 600 cfs and 6,000 cfs. When flows through the Fremont Weir Notch are greater than 6,000 cfs (when flows are over the Fremont Weir), there would be no restriction on Project diversions. These limitations are intended to reduce changes to spill frequency and duration. The actual criteria used in operations related to the Fremont Weir Notch are being developed.

Red Bluff Pumping Plant

Diversions at the RBPP can occur only when flows in the Sacramento River are 3,300 cfs or higher, as measured at Bend Bridge. Diversions are limited because of the fish screen function to prevent entrainment of fish when diverting. Therefore, pumping ramps up as river flows increase, as shown in Figure 12. The minimum pumping rate is 80 cfs, which occurs when river flows are 3,300 cfs. The maximum pumping rate at Red Bluff is 2,100 cfs, which requires a minimum river flow of 7,860 cfs.

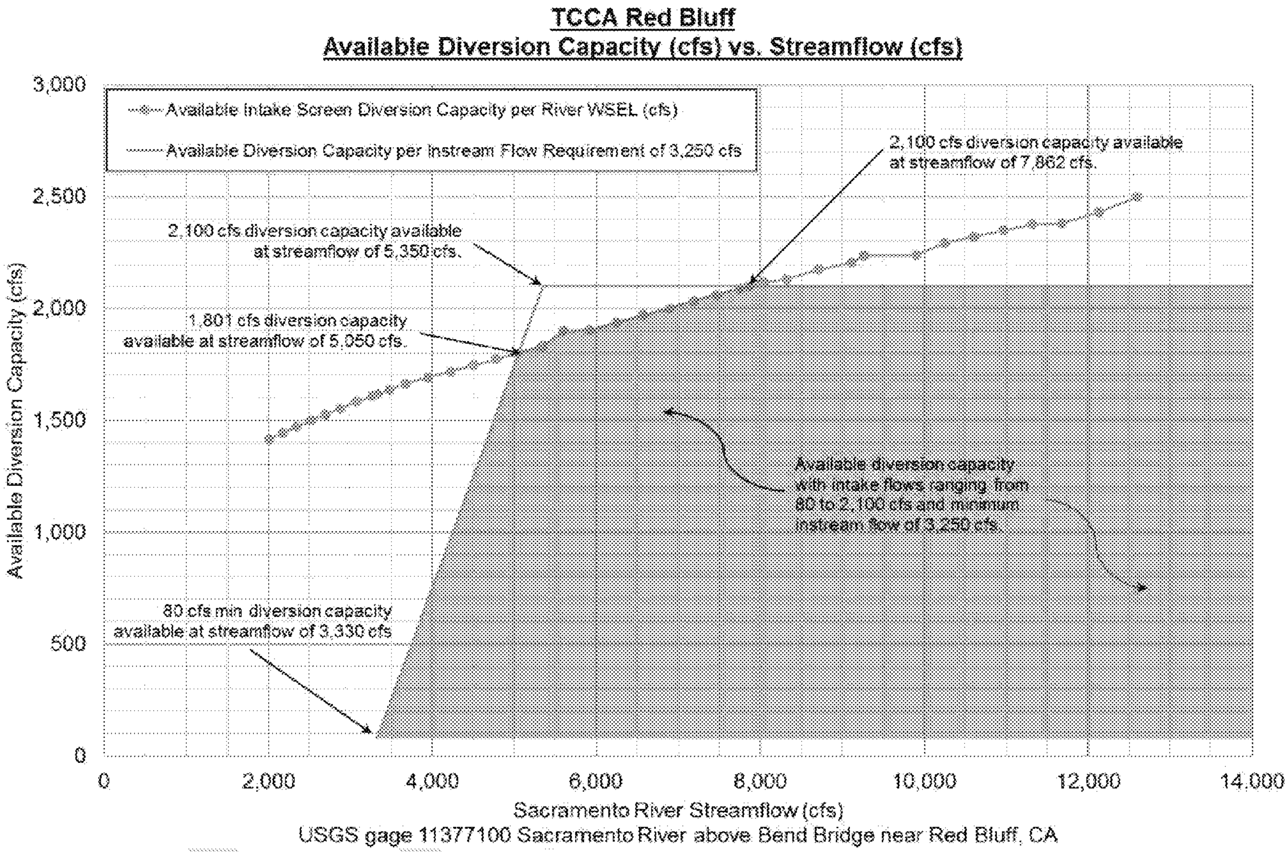


Figure 12. TCCA Red Bluff Available Diversion Capacity (cfs) vs. Streamflow (cfs)

Hamilton City Pumping Plant

Diversions at the HCPP can occur only when flows in the river are 4,150 cfs or higher, as measured at Bend Bridge. Diversions are limited on account of the fish screen function to prevent entrainment of fish when diverting. Therefore, pumping ramps up as river flows increase, as shown in Figure 13. The minimum pumping rate is 150 cfs, which occurs when river flows are 4,150 cfs. The maximum pumping rate at Hamilton City is 3,000 cfs, which requires a minimum river flow of 7,000 cfs. However, the pumping plant at the TRR has a capacity of 1,800 cfs. Therefore, it is unlikely that the full pumping capacity would be used to divert Project water alone.

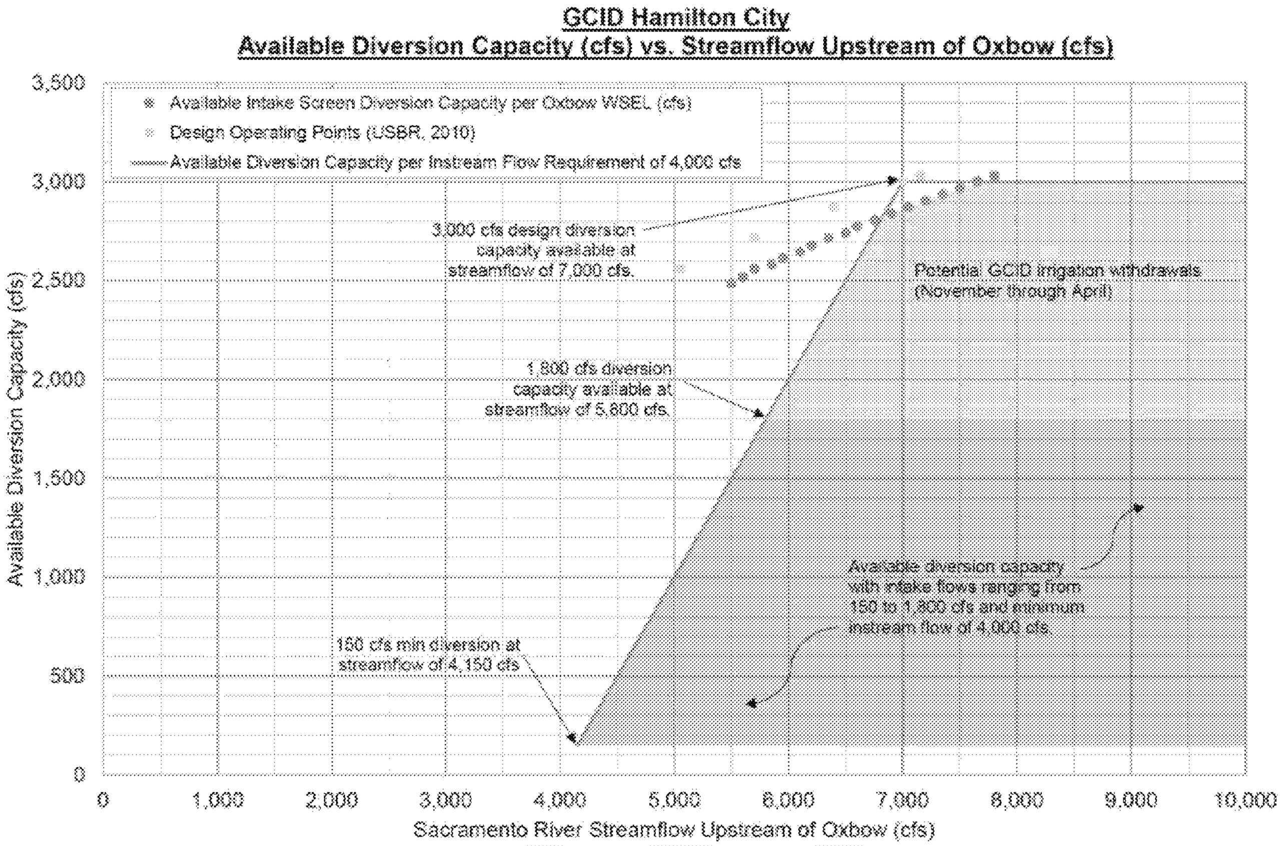


Figure 13. GCID Hamilton City Available Diversion Capacity (cfs) vs. Streamflow Upstream of Oxbow (cfs)

4.4 Diversion Orders

In accordance with the Principles for the Storage, Delivery and Sale of Sites Reservoir Project Water (Storage Principles, Attachment B), the Authority will attempt to maximize the appropriation of water into storage consistent with the regulatory requirements, physical constraints, and hydrologic conditions. The Authority will be responsible for compliance with water right provisions and other conditions that control the appropriation of water into storage in Sites Reservoir. Appropriated water from the Sacramento River will be placed into Sites Reservoir and then allocated into each Storage Partner's Storage Allocation proportional to their Storage Allocation. For example, if 340 TAF of water is appropriated into Sites in any one year, this represents 25 percent of the total allocated storage. In that year, each Storage Partner will receive an amount equal to 25 percent of their Storage Allocation, assuming their Storage Allocation space has at least 25 percent available/empty. Once a Storage Partners Storage Allocation is full, the remainder of the diversions will be allocated to the other Storage Partners.

Storage Partners may opt out of receiving diversions into their Storage Allocation. They can notify the Authority they wish to opt out at any time. Any diversions that occur within 1 week of notification (and the associated variable costs) will be allocated to other Storage Partners, if possible, but may be allocated to the Storage Partner who is opting out if the reservoir is otherwise full. If a Storage Partner opts out of receiving diversions—assuming they have not leased their storage to another entity—all diversions will be allocated to other Storage Partners and the amount of unused storage space will remain empty until the Storage Partner notifies the Authority that they wish to receive diversions again.

4.4.1 Priority of Diversions

At this time, it is not anticipated that diversions will be prioritized to a specific Storage Partner or Storage Partner type. All diversions will be allocated proportionate to Storage Partners based on their Storage Allocation until that allocation is full. If a Storage Partner has no available Storage Allocation, the diversions will be proportionally allocated to those Storage Partners who do have storage capacity remaining in their Storage Allocation.

4.4.2 Diversions of Non-Sites Water

There are opportunities for Storage Partners to request non-Sites water (water not appropriated under the Project's water rights) be diverted and placed into their Storage Allocation. These other sources could include the following: the re-diversion of previously stored water, water transfers, exchange water, etc. The Authority will take all reasonable steps to facilitate these requests. The Storage Partner requesting such diversions will be responsible for the costs of obtaining/storing these other sources of water, including any costs associated with water right changes, environmental compliance, and Reservoir Committee costs associated with reviews. In accordance with the Storage Principles, the Storage Partner requesting such diversions is responsible for all operations and maintenance (O&M) costs of placing this water into their Storage Allocation. Placing water into storage under the Project's water right will take priority over storing water from other sources.

5.0 Storage in Sites Reservoir

5.1 Losses from Storage

Losses from storage are expected to result from evaporation and seepage. The approach to assessing losses is yet to be determined; however, a mass balance or pan evaporation rate may be used. A mass balance estimate would include daily records of reservoir storage, diversions, rainfall, and spills (if applicable) to estimate daily losses. Pan evaporation uses temperature, humidity, rainfall, and wind to estimate the level of evaporation based on surface area. A combination of both methods could also be used.

Using the decided-upon methodology, losses of water held in Sites Reservoir storage—including evaporation and seepage—will be estimated on a daily basis. These losses will be allocated to each Storage Partner based proportionally based on the amount of water in storage that day.

Sites CalSim modeling includes an estimate of net evaporation (precipitation minus evaporation) based on evaporation experienced in nearby reservoirs. Modeling shows an annual net evaporation rate of approximately 37 TAF.

5.2 Dead Pool

Sites Reservoir will have a dead pool of approximately 17,700 acre-feet, below which water cannot physically be removed from the reservoir using the intake/outlet (I/O) works. However, the Authority is currently planning to operate to a dead pool of up to 120 TAF under normal conditions to accommodate water quality considerations. Current operations modeling assumes that the dead pool could be drawn down a further 60 TAF if the water does not return to the Sacramento River. The operational dead pool amount may be revised and reduced in final design and in real-time operations with water quality measurements over time.

5.3 Storage Allocation, Leasing, and Transfers

5.3.1 Storage Allocation

Sites Reservoir is allocated to each Storage Partner proportionate to their annualized acre-feet per year subscription. Because the State of California (State), through Proposition 1, and Reclamation, through the WIIN Act, participate based on available funding versus annualized acre-feet per year, the Storage Allocation for the State and Reclamation are calculated using a different methodology. The State is allocated the storage required to meet Proposition 1 benefits. At this time, the methodology for allocating storage to Reclamation is being developed, but the modeling to date assumes that Reclamation receives a Storage Allocation commensurate with its proportionate cost-share in the Project. Based on the Authority's Preferred Project in the Revised Draft EIR/Supplemental Draft EIS, this results in assumed federal funding of 6.6 percent of Project costs along with 6.6 percent of the active storage in the reservoir. Figure 14 depicts the current Storage Allocation based on the Storage Partners participating in the Project as of December 2021 and aligned with the CalSim modeling developed for Alternative 1B in the Revised Draft EIR/Supplemental Draft EIS.

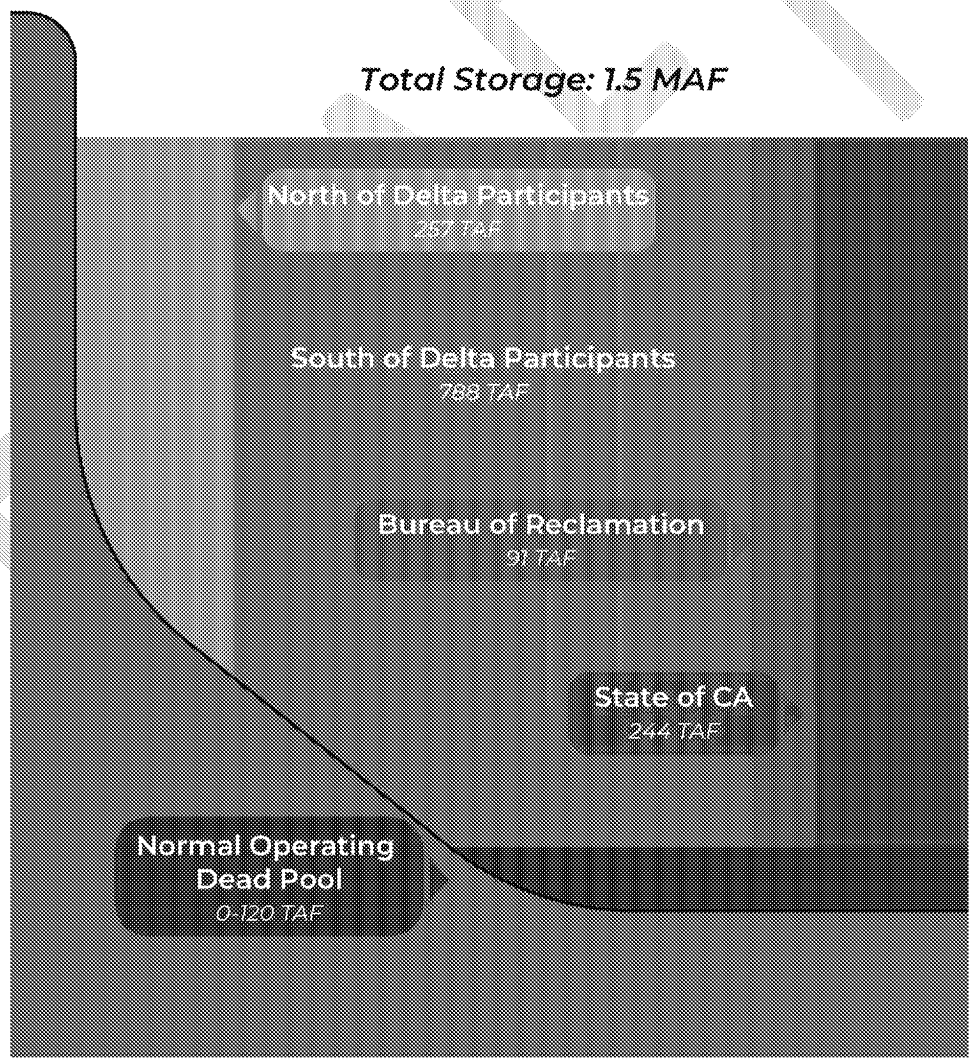


Figure 14. Sites Reservoir Storage Allocation

The methodology for allocating reservoir storage is described in Attachment C. The Storage Allocation is likely to change depending on annualized acre-feet per year requested by Storage Partners and final levels of local, state, and federal funding. The reservoir allocation will be updated in future versions of this Operations Plan.

5.3.2 Storage Leasing and Transfers

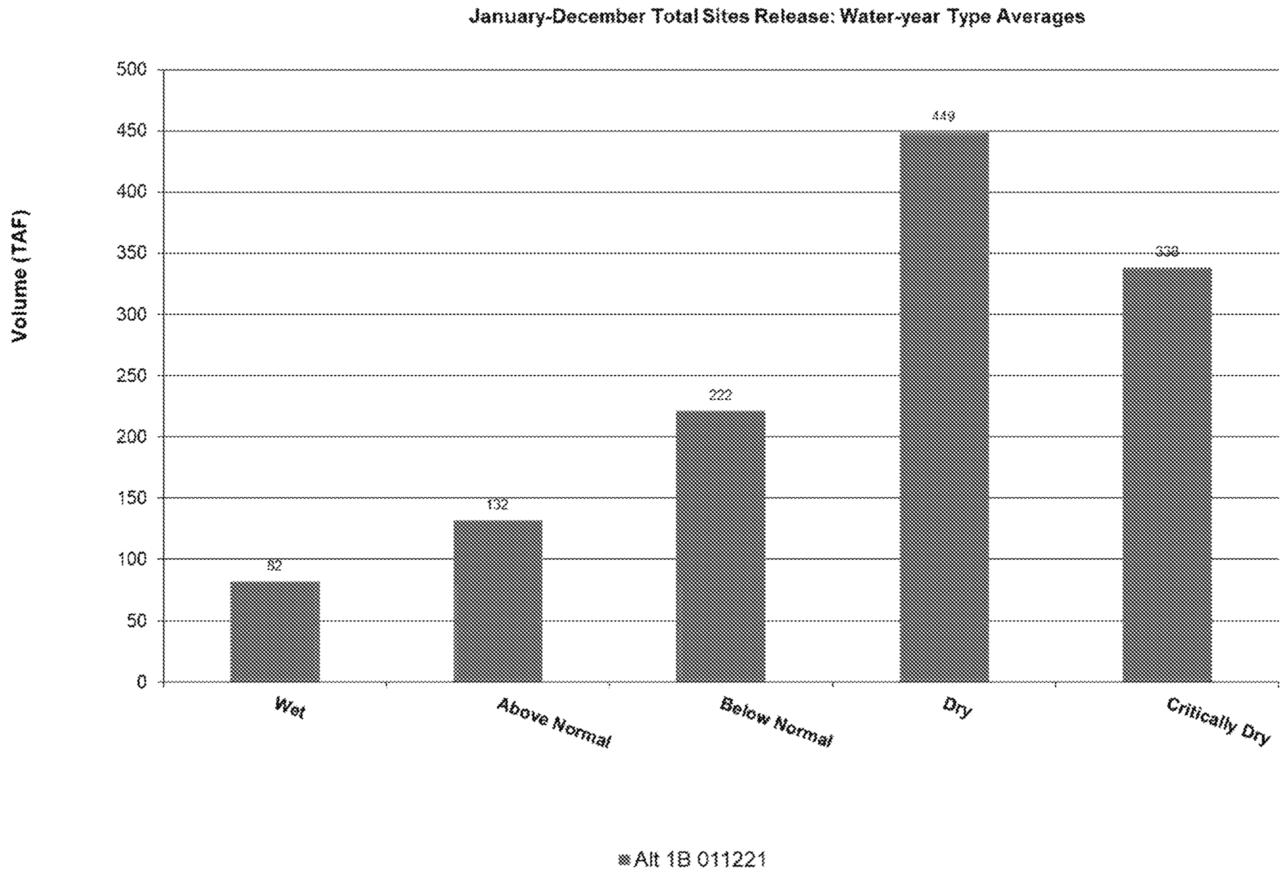
The Storage Principles allow Storage Partners to exchange and transfer stored water to other Storage Partners and water users who are not Storage Partners. Such leasing and transfer agreements can span multiple years or occur within a given contract year. The Authority will account for and track storage leased and transferred in its real-time accounting system. In accordance with the Storage Principles, the Storage Partner whose Storage Allocation is being leased or transferred is responsible for the payment of all allocated capital, fixed O&M, and variable O&M costs, as well as obtaining all environmental permits and water right agreements required.

The methods for notifying the Authority of leases or transfers of Storage Allocations will be developed further in a future version of this Operations Plan.

6.0 Releases from Sites Reservoir

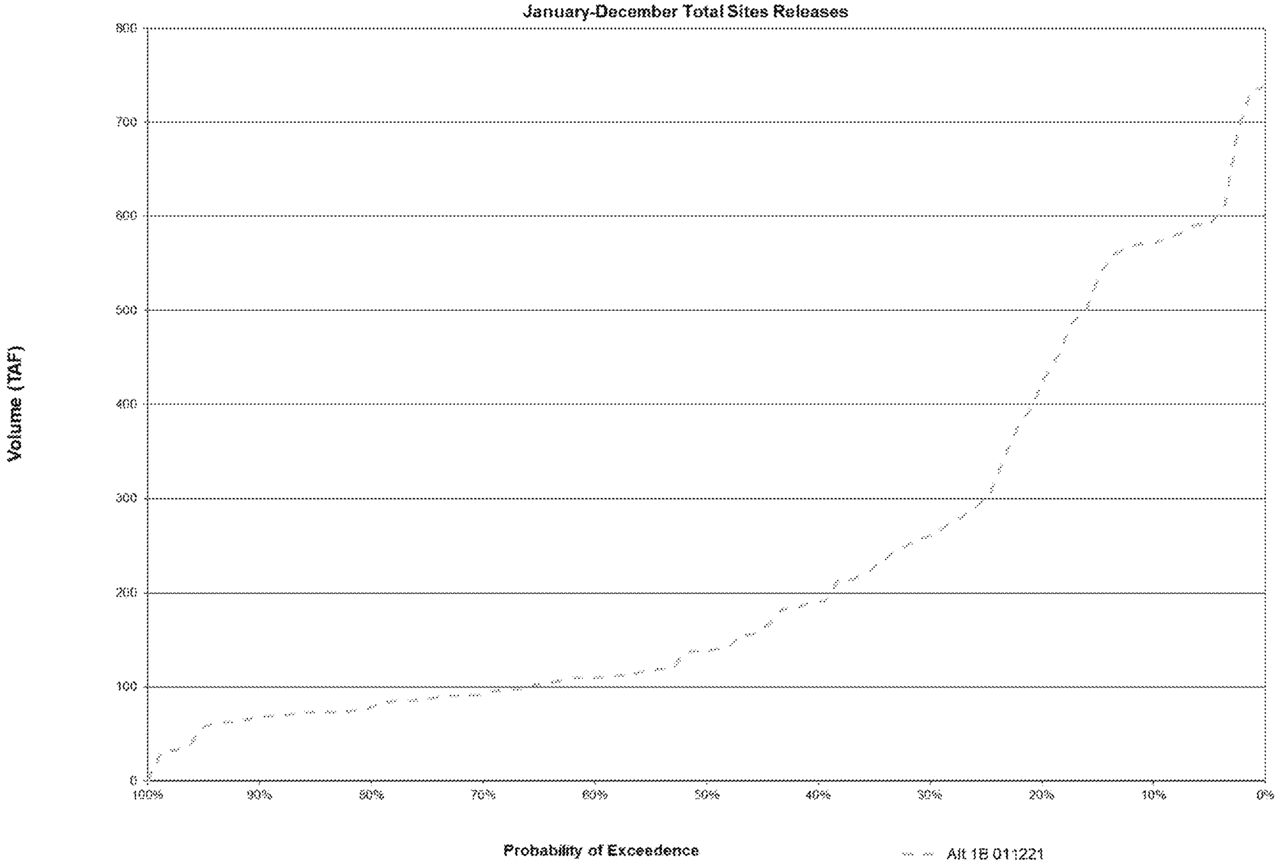
6.1 Overall Project Releases

Project releases would generally occur in the late spring, summer, and fall months but could happen throughout the year. Project exports to Storage Partners south-of-Delta must occur during the transfer window (July through November) of each year. Project deliveries to Storage Partners in the Delta and north of the Delta, including Reclamation (as an exchange partner or investor) and DWR (as an exchange partner), can occur outside the transfer window. The total Project releases by water year type, an exceedance plot of project release, and the timing for releases are shown in Figure 15 to Figure 17. Figure 17 includes all releases from the reservoir, including those used for exchanges with DWR and Reclamation. Further discussions of exchanges are included in Section 8. Note that the figures show monthly averages; actual within-month releases at the daily or weekly timescale are expected to vary. Daily modeling will be developed in the future, and Version 2 of this Plan will be modified accordingly.



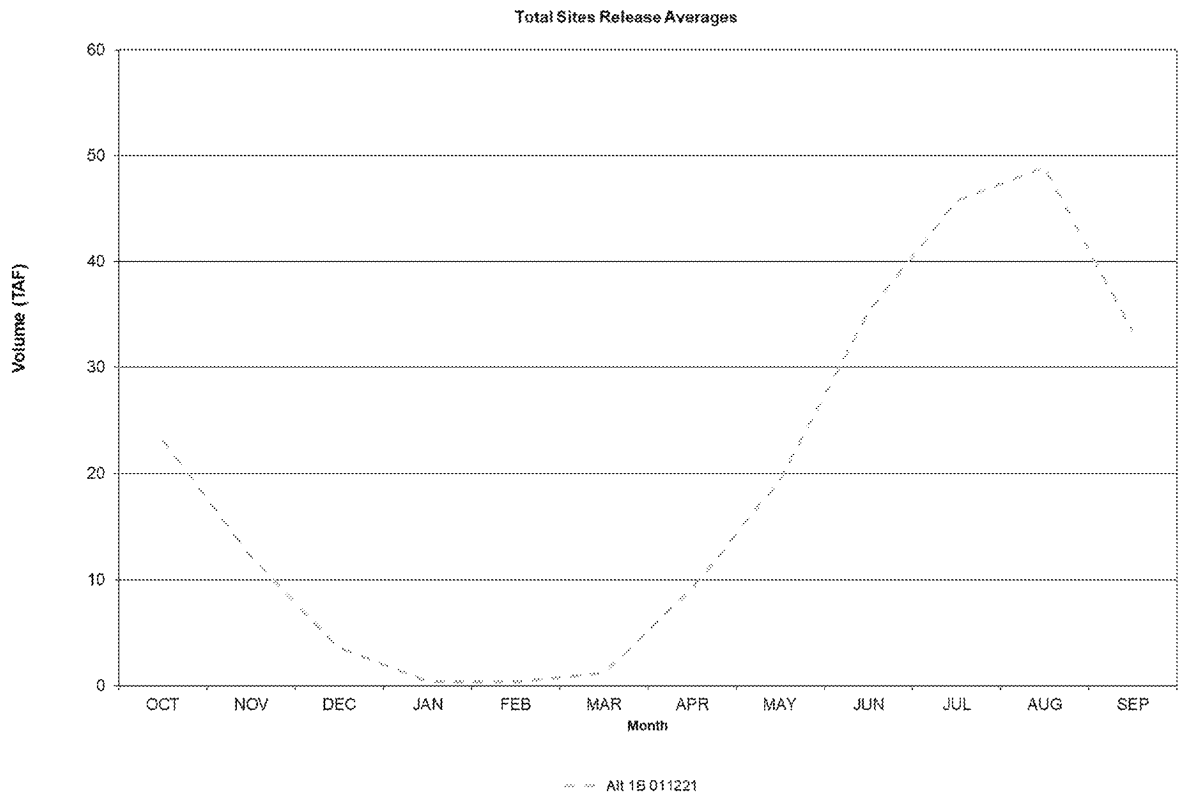
Water year type based on the Sacramento Valley 40-30-30 Water Year Hydrological Classification Index
Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 15. January to December Total Sites Release: Water-year Type Averages



Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 16. January to December Total Sites Releases



Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 17. Total Sites Release Averages

The assumptions used in the CalSim modeling for the Revised Draft EIR/Supplemental Draft EIS for releases, or demands, for specific Storage Partners and deliveries by year type are included as Attachment D.

6.2 Release and Conveyance Facilities

The following sections provide a general description of the release and conveyance facilities that may be used in the operation of Sites Reservoir. The location of these facilities is shown in Figure 1 and Figure 2.

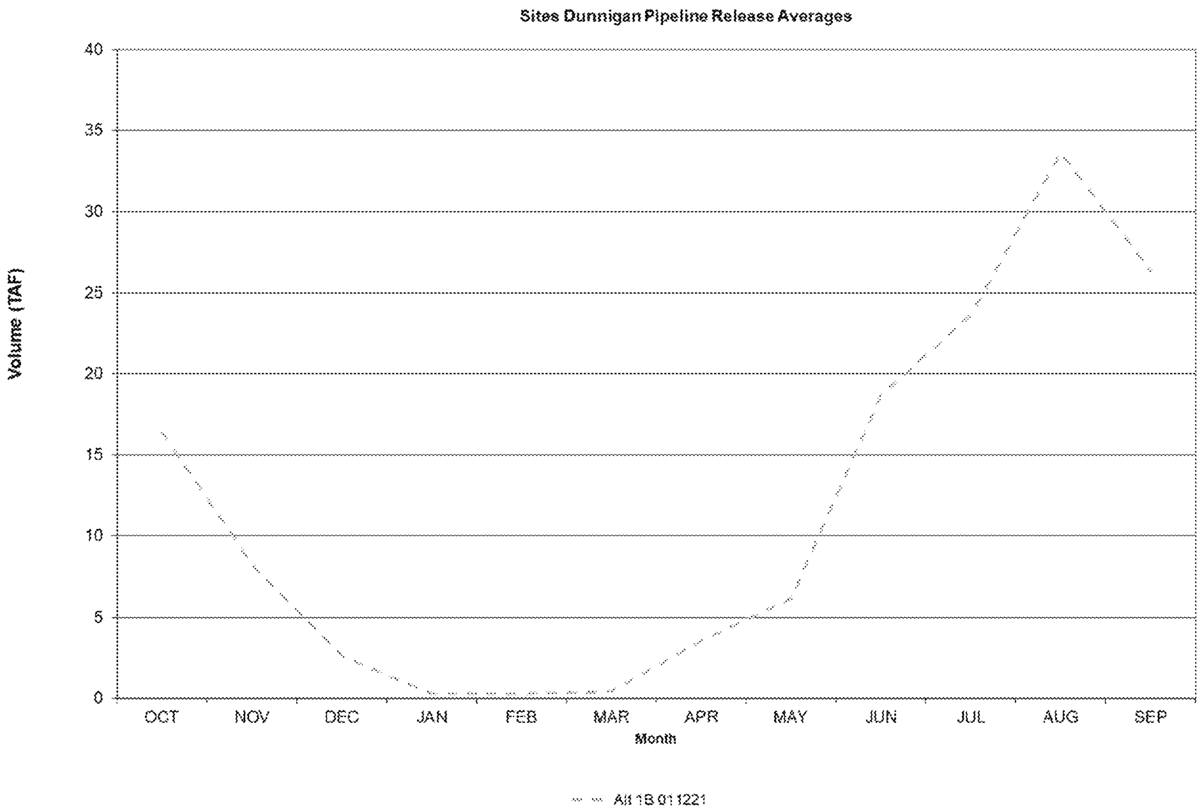
6.2.1 Tehama-Colusa Canal

Most releases from Sites Reservoir would flow into the existing Funks Reservoir (as described in Section 4.2) and into the existing TC Canal. Water would flow within the TC Canal and would either be diverted for delivery of Project water to local Storage Partners or would flow 40 miles south to the new Dunnigan Pipeline. The TC Canal will be used for the release of water to all TC Canal members who are Sites Storage Partners, Delta and south-of-Delta Storage Partners, federal water (with the exception of water delivered to GCID), and environmental water for Proposition 1 for Yolo Bypass and south-of-Delta refuges. Releases to the TC Canal would be limited by available capacity in the TC Canal and the available capacity in the Dunnigan Pipeline. Water would be released from the TC Canal into the Dunnigan Pipeline through a gravity outlet structure.

6.2.2 Dunnigan Pipeline

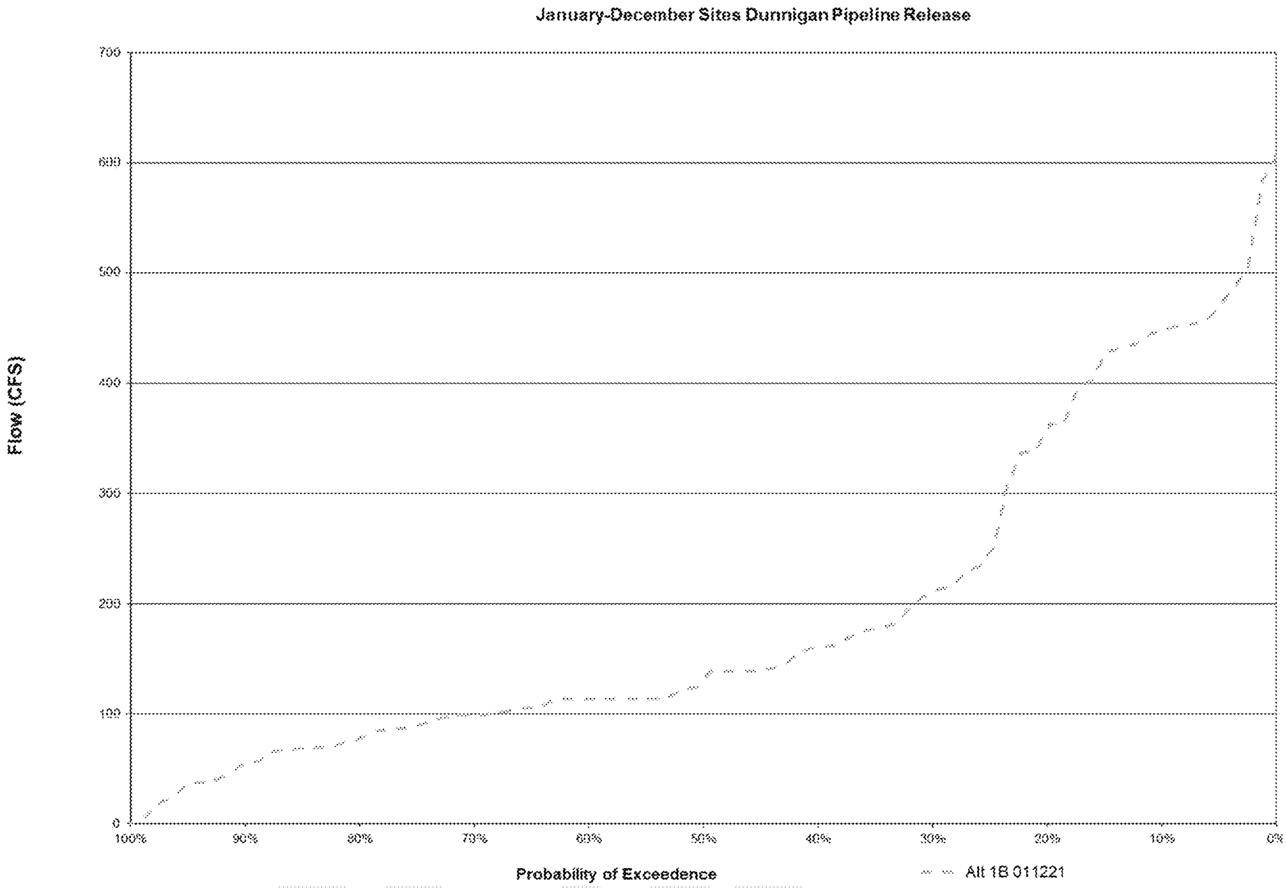
The Dunnigan Pipeline will convey water released from the TC Canal to the Colusa Basin Drain (CBD). The Dunnigan Pipeline will be approximately 4 miles in length and have an inner diameter of approximately 9 feet. A CBD outlet with an energy dissipation structure will be constructed at the downstream end of the pipeline to allow water to discharge into the CBD. Two 60-inch-diameter, fixed-cone valves would be placed at the discharge stilling basin to dissipate energy and adjust the flow being released into the CBD. The conveyance through the Dunnigan Pipeline to the CBD would use gravity and have a flow up to 1,000 cfs. Figure 18 and Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 19 show the modeled flow through the Dunnigan Pipeline. Note that the figures show monthly averages; actual within-month releases through the Dunnigan Pipeline at the daily or weekly timescale are expected to vary. Daily modeling will be developed in the future, and Version 2 of this Plan will be modified accordingly.



Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 18. Sites Dunnigan Pipeline Release Averages



Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 19. January to December Sites Dunnigan Pipeline Release

6.2.3 Colusa Basin Drain

The Dunnigan Pipeline will convey water to the existing CBD at a maximum flow of 1,000 cfs. From the CBD, water may either be discharged into the Yolo Bypass or back into the Sacramento River. Water discharged into the Yolo Bypass/Cache Slough Complex will flow through the Knights Landing Ridgecut. This water will be used for Proposition 1 benefits or for diversion into the North Bay Aqueduct. Water can also flow back to the Sacramento River via the Knights Landing Outfall Gates. Water conveyed back to the Sacramento River may be used by DWR (as an exchange partner) or Reclamation or be conveyed south of the Delta through the Banks or Jones pumping facilities for south-of-Delta Storage Partners or wildlife refuges.

6.2.4 Glenn-Colusa Main Canal

Some Project water is not released through Funks Reservoir and the TC Canal, but instead released back into the TRR and into the GCID Main Canal. Water released into the TRR and the GCID Main Canal would be used by GCID or wildlife refuges as environmental water for Proposition 1. Water is expected to be released to GCID for wildlife refuges north of the Delta in all water year types but is generally not needed in wet year types. The water could be delivered any time of the year, although it is expected that it rarely would be released for this purpose from January through March during the Project's primary diversion season. The long-term average releases to GCID for wildlife refuges is expected to be 5 TAF under historic hydrology.

6.3 Release Criteria

Project water may be released to local users any time the pumping facilities are not diverting water to storage. Water may be exported south of the Delta to refuges or Storage Partners only during the transfer window (July through November) and will, therefore, only be released from the reservoir during that timeframe. The Project can also only release water for exports when the Delta is in balanced conditions, as defined in the Coordinated Operation Agreement (COA) and determined by DWR and Reclamation.

Project releases to the CBD are constrained by capacity in both the Dunnigan Pipeline and the CBD. If it is anticipated that releases are constrained, the Authority will coordinate closely with Storage Partners, DWR, Reclamation, TCCA, GCID, and entities along the CBD in an attempt to meet the requested water release schedules. If there is a release constraint that will affect the ability to meet the requested schedules, the Authority will work with the conflicted Storage Partners to determine whether accommodations can be made. If the conflict cannot be resolved, releases will be made in proportion to the Storage Allocation attributable to the conflicted Storage Partners.

6.3.1 Release Orders

To the extent allowed by the Project's permits, approvals, and agreements and its physical and operational capabilities, Storage Partners have total discretion regarding the amount of water held in their Storage Allocation that they request to be scheduled for release for their use and will have control over the use of their Storage Allocation based on the conditions outlined in the Storage Principles.

In January, Storage Partners will provide initial requests for Project water. Final requests for Project water to be released prior to the transfer window (before July 1) will be provided by the Storage Partners in February. Final requests for Project water to be released in the transfer window (July through November) will be provided by the Storage Partners in April. See Figure 3 for a full description of the annual operational needs and information provided by Storage Partners.

The Authority will work with DWR and Reclamation to schedule deliveries south of the Delta. Beginning in February, operations of the reservoir, along with conditions in the Delta, will be reevaluated at least weekly. From such analysis, the Authority will update release and delivery schedules and will coordinate with Storage Partners should any conflicts arise.

6.3.2 Release Order Adjustments

The Authority will provide regular updates on the scheduling of releases and deliveries. Storage Partners may request additional releases beyond those initially requested, as defined in the annual operations cycle. The Authority will prioritize releases requested by February for water released before the transfer window (for north of Delta deliveries) and by April for water released during the transfer window (for north or south of Delta deliveries). However, the Authority will accommodate later requests for releases to the extent possible.

6.3.3 Weekly Release Order Adjustments

Weekly releases, particularly for those deliveries that must be exported through the Delta, are highly dependent on coordination with DWR and Reclamation. The Authority may shift weekly deliveries as needed to maximize exports. The Authority will notify Storage Partners of any shifts, should they occur.

7.0 GCID and TCCA Coordination

7.1 Facilities Use Agreements and Annual Coordination

The Authority intends to enter into Facility Use Agreements with GCID and TCCA. Because the RBPP and TC Canal are owned by Reclamation, the agreement with TCCA will be in addition to a Warren Act Contract required for the use of federal facilities. Close coordination will be required between the Authority and operators at TCCA and GCID.

7.1.1 TCCA Coordination

Daily operations will be coordinated closely with the Red Bluff and Willows Offices of TCCA. In particular, operations will be closely coordinated in the shoulder and transition seasons, when diversions for the Project are occurring at the same time as deliveries for TCCA contractors. Close operations will also be necessary for frost water, which could occur when the Project is diverting and may require releases from Funks for users on the downstream portion of the TC Canal. TCCA will remain the lead operator for the RBPP and the TC Canal. The Authority will have an operator responsible for the diversions into Sites Reservoir at Funks via the Funks PGP. TCCA operations will take priority over Project operations, although the two entities will coordinate closely to adjust operations to achieve operating objectives.

It is anticipated that the Project's Supervisory Control and Data Acquisition (SCADA) system will also duplicate some of the TCCA system. This will allow logic and alarms to respond appropriately to changing conditions along the canal and in Funks Reservoir. The Authority will work with TCCA in responding to any emergency operations required, and coordination with TCCA will be included in Project's Emergency Action Plan.

7.1.2 GCID Coordination

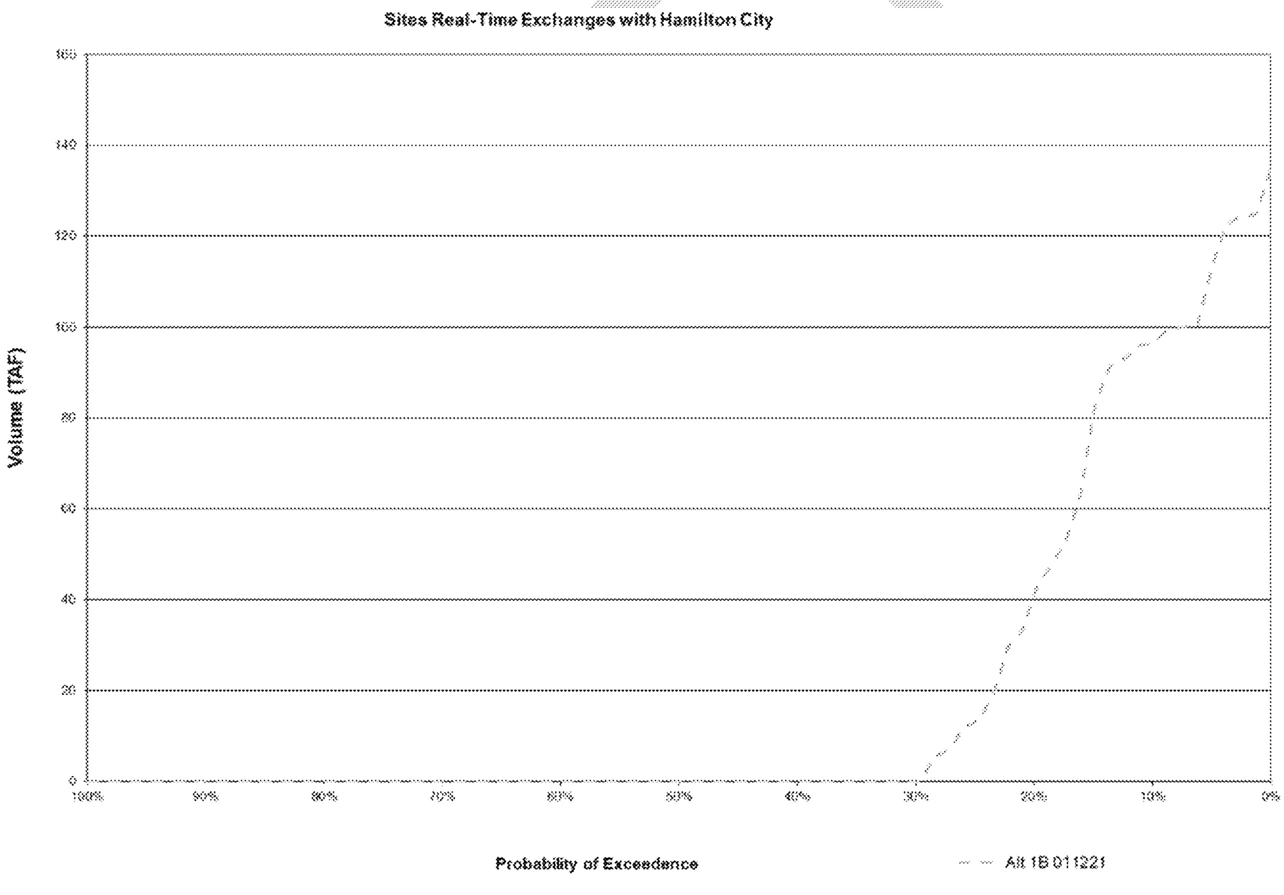
Daily operations will be coordinated closely with the GCID's operations in Hamilton City. In particular, operations will be coordinated during the shoulder and transition seasons, when diversions for the Project are occurring at the same time as deliveries for GCID. Close operations will also be necessary for real-time exchanges, when GCID will receive water from the Project in lieu of diversions from the Sacramento River. GCID will remain the lead operator of the HCPP and the GCID Main Canal. The Authority will have an operator responsible for the diversions into the Sites Reservoir at TRR via the TRR PGP. GCID operations will take priority over Project operations, although the two entities will coordinate closely to adjust operations to achieve operating objectives.

It is anticipated that the Project's SCADA system will also duplicate some of the GCID system. This will allow logic and alarms to respond appropriately to changing conditions along the canal and in the TRR. The Authority will work with GCID in responding to any emergency operations required, and coordination with GCID will be included in Project's Emergency Action Plan.

7.2 Real-time Exchanges

To support timing of releases and deliveries to Storage Partners north and south of the Delta, in-lieu exchanges with local Storage Partners may occur. This type of exchange is most likely to occur with GCID but could also occur with TCCA or other Sacramento River Settlement Contractors and likely would require close coordination with Reclamation. Instead of diverting all of its supply from the Sacramento River, the local Storage Partner would receive a portion of its water from Sites Reservoir. A portion of the water released from Shasta Lake to meet the local Storage Partner's supply would be left in the Sacramento River (i.e., not diverted by that contractor or agency) and used for other Storage Partners. This exchange is expected to occur to facilitate capacity constraints along the Dunnigan Pipeline as well as the delivery of water to Storage Partners upstream of the release facilities (e.g., Carter Mutual and Reclamation District 108). Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 20 depicts the exceedance curve associated with the real-time exchanges at Hamilton City. On average, 21 TAF are exchanged through this process.



Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 20. Sites Real-time Exchanges with Hamilton City

8.0 Central Valley Project and State Water Project Cooperative Operations and Exchanges

8.1 Operational Agreement and Annual Coordination

Success of the Project requires close coordination with Reclamation and DWR. The Authority is currently developing an operational agreement with these agencies to address issues related to operations of the Project. Through the implementation of this agreement, it is expected that the Project will cooperatively interface with the existing and ongoing real-time decision-making processes while working to avoid and minimize adverse effects and, potentially, provide benefit to CVP and SWP facilities, operational plans, listed species, public health, safety, and water supply reliability.

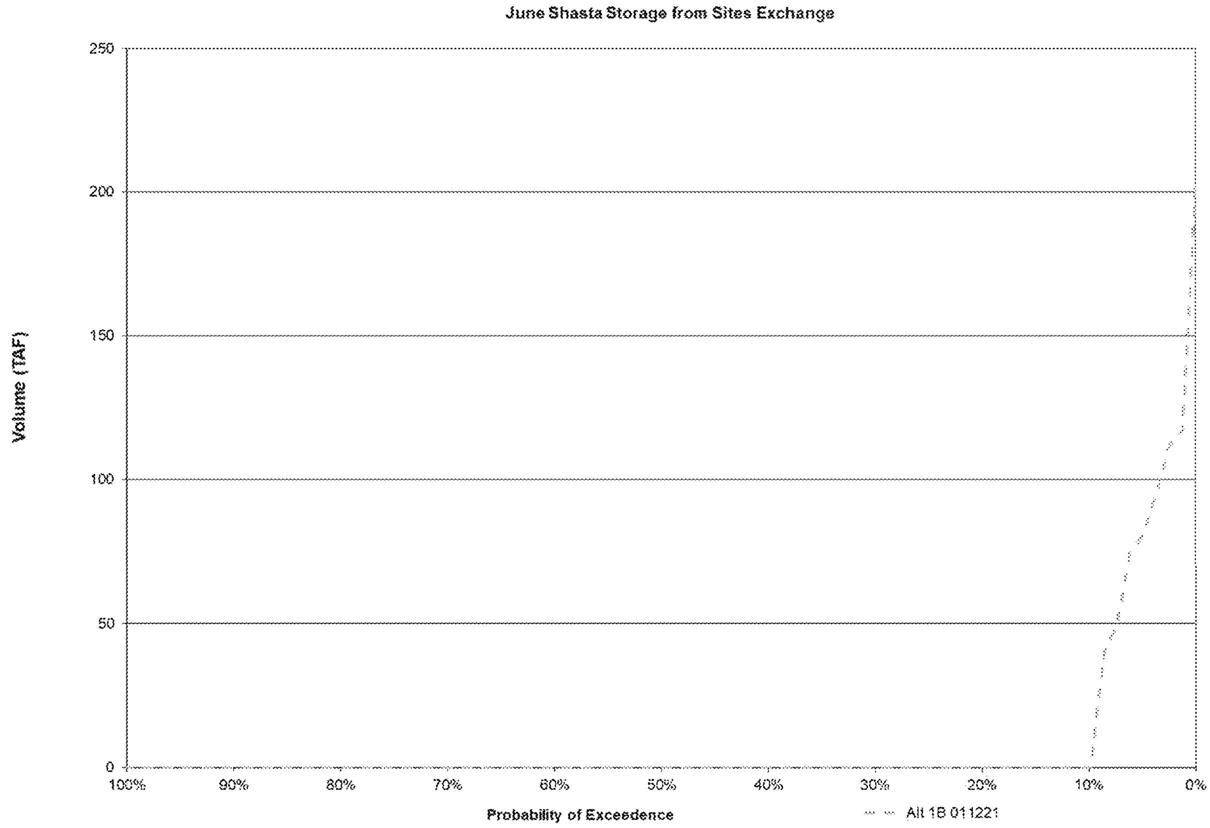
The operational agreement is expected to describe the use of State and federal facilities, seasonal operating goals, use of power and energy, and exchanges of water between Sites Reservoir, the CVP, and the SWP.

It is anticipated that the accounting for exchanges between the Authority, DWR, and Reclamation can occur within the framework of the COA because of mutual places of use, particularly south of the Delta. The parties have discussed COA accounting, and DWR and Reclamation will coordinate on COA issues that will need to be addressed as the Project develops to facilitate the ability of the Project to function as described here and in the Revised Draft EIR/Supplemental Draft EIS. COA administrative actions between Reclamation and DWR will be coordinated with the Authority and are not expected to affect the construction schedule or ongoing Project operations.

8.2 Exchanges with Reclamation

Exchanges with Shasta Lake would be formulated to target cold water pool preservation and anadromous fish benefits. Shasta Lake exchanges would occur in years when forecast temperature-based mortality of early life stage winter-run Chinook salmon would be reduced if the exchange is in place. Under a Shasta Lake exchange, water would be released from the Sites Reservoir in the spring to meet CVP purposes, including CVP water service and/or repayment contractors or Central Valley Project Improvement Act (CVPIA) refuge needs in the Sacramento Valley that could physically receive water from Sites Reservoir. By reducing releases from Shasta Lake in the spring, the storage and cold water pool in Shasta Lake would be preserved for use later in the year, typically during critical months of the cold water pool management season (August and September). In late summer and fall (i.e., August through November), Reclamation would release an equivalent amount of water from Shasta Lake for Storage Partners. A memorandum identifying the modeled criteria for Shasta Exchanges is included as Attachment E. Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 21 depicts the exceedance plot from models demonstrating volume exchanged with Shasta. As shown, exchanges do not occur frequently but can be sizeable when they do occur. As with other modeling presented in this Reservoir Operations Plan, actual exchange volumes could vary beyond modeled amounts.



Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 21. January to December Shasta Storage from Sites Exchange

Exchanges could also occur with Folsom Lake, but these exchanges are not modeled. If they occur, Folsom Lake exchanges would be operated similarly to exchanges with Shasta Lake. Sites Reservoir would release water in the spring and early summer to meet CVP purposes in lieu of Reclamation releases at Folsom Lake. An equivalent amount of water would then be released from Folsom Lake in the late summer and fall for Storage Partners. All exchange water would be released from Folsom Lake in late summer and fall and no exchanged water would be carried over from year to year.

Discussions with Reclamation on expanded exchanges are currently underway and are anticipated to be included in the Project's Biological Assessment and Final EIR/EIS. Exchanges may be expanded such that greater volumes would be held in Shasta Lake. Other options include changes in Project operations to allow for greater spring pulse flow actions or improved fall flow stability downstream of Keswick on the Sacramento River.

8.3 Reclamation as an Investor

Reclamation is anticipated to be a Storage Partner. This Operations Plan and all modeling results shown assume a federal cost-share of up to 7 percent, resulting in approximately 91 TAF of active storage allocated to Reclamation in accordance with Alternative 1B in the Revised Draft EIR/Supplemental Draft EIS. The federal cost share could be as high as 25 percent. In accordance with Reclamation's Federal Feasibility Study for the Project, Reclamation's storage in Sites Reservoir could be used for the purpose of CVP Operational Flexibility. Operational Flexibility is defined in the Federal Feasibility Study as follows:

> The operational flexibility purpose is defined as the benefit accruing to the Federal government from an increased ability to allocate additional water supplies through an investment by the United States in a water supply project. The water supply project would be functionally integrated with the CVP from a water rights and/or contractual basis. The investment would enable the Federal Government to deliver water for beneficial use and better meet authorized project purposes by increasing the efficiency, reuse, or multiple use of existing supplies or by reducing impacts of regulatory or capacity constraints on an existing Reclamation project.

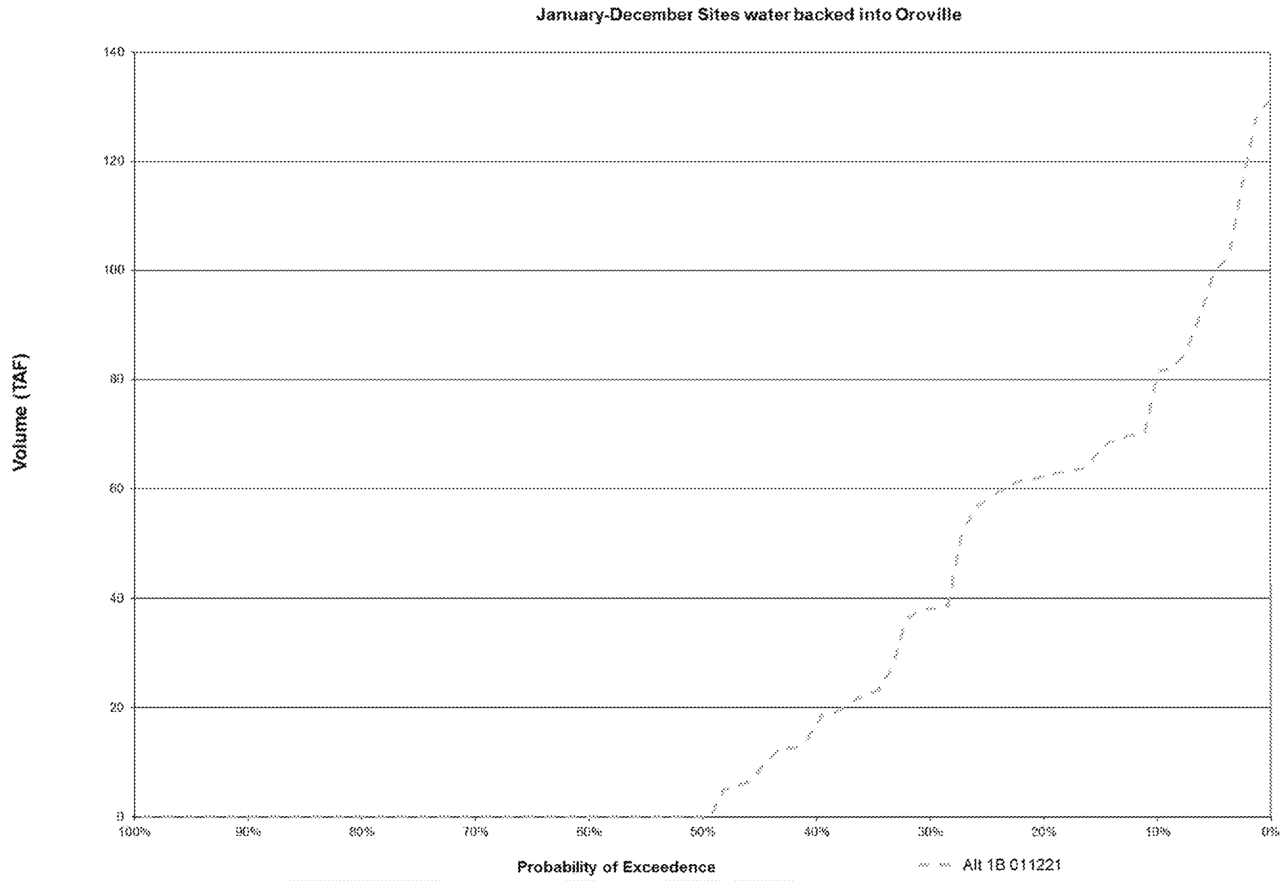
The Project would provide Reclamation an additional water source that could allow for higher allocations in accordance with CVP contracts or releases for environmental restoration, CVPIA refuges, or anadromous fish water quality.

The Authority expects to enter into an agreement with Reclamation relative to the Federal investment in the project. The use of Reclamation's storage in Sites Reservoir may vary, and this Reservoir Operations Plan will be updated accordingly.

8.4 Exchanges with DWR

Exchanges with Lake Oroville would be formulated primarily to facilitate Project deliveries to Storage Partners. The exchanges may also improve cold water pool conditions at Lake Oroville. Exchanges with Lake Oroville are expected to happen more frequently and would be driven by a variety of factors. Under a Lake Oroville exchange, water would be released from the Sites Reservoir primarily in June and July to meet SWP purposes. By reducing releases from Lake Oroville in these months, the storage in Lake Oroville would be preserved for use later in the year. In late summer and fall (i.e., August through November), DWR would release an equivalent amount of water from Lake Oroville for Storage Partners. All exchange water would be released from Lake Oroville in late summer and fall and no exchanged water would be carried over from year to year. A memorandum identifying the modeled criteria for Oroville exchanges is included as Attachment F. Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 22 depicts the exceedance plot from models demonstrating volume exchanged with Oroville. As shown, exchanges occur more frequently than those with Shasta, although the peak exchange volumes are not as great. Actual volumes in real-time operations are expected to vary.



Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 22. January to December Sites Water Backed into Oroville

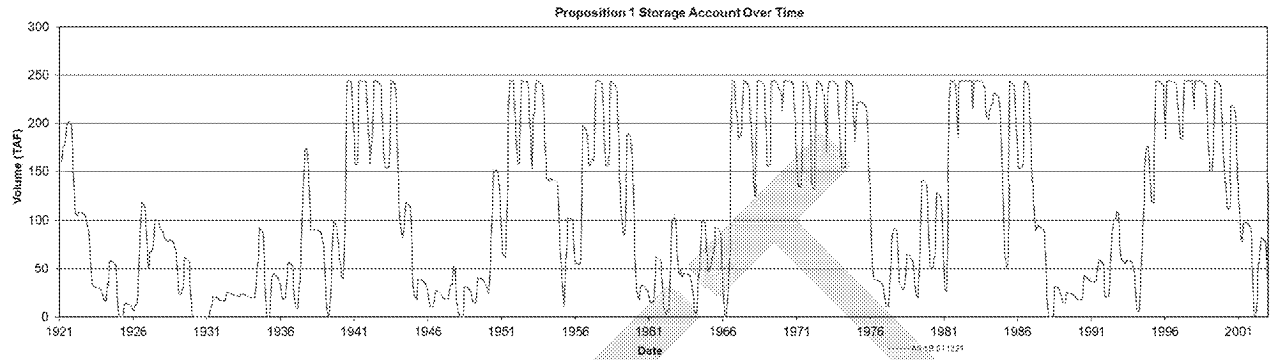
8.5 Operations for Proposition 1 Benefits

A defined Proposition 1 public benefits storage account will be established in Sites Reservoir to be managed by the State to provide water for ecosystem purposes. The Storage Allocation assumed for Proposition 1 purposes is 244 TAF. This amount is comparable to the cost-share paid by the State for environmental benefits (does not include funding for recreation or flood). There are two benefits funded by the State through Proposition 1: flows through the Yolo Bypass/Cache Slough Complex and delivery of Incremental Level 4 water north and south of the Delta.

Flows to the Yolo Bypass will be conveyed through the Knights Landing Ridge Cut via Funks Reservoir, the TC Canal, the Dunnigan Pipeline, and the CBD (described in Section 6.2). Project water will be released in the summer and fall (i.e., August through October) to help increase productivity in the lower Cache Slough and lower Sacramento River areas. This flow is intended to increase desirable food sources for Delta smelt in the late summer and early fall. Sites Reservoir average annual releases to the Yolo Bypass under historic hydrology range from 14 to 63 TAF, depending on water year type. Long-term average releases for the Yolo Bypass are estimated to be 41 TAF.

Project water will also be provided to supplement supply for Incremental Level 4 water north and south of the Delta to provide improvements to managed wetlands. Most water released for this purpose will be exported to managed wetlands south of the Delta. Sites Reservoir average annual releases for Incremental Level 4 water supply under historic hydrology range from 2 to 40 TAF, depending on year type, with long-term average releases for this purpose of 19 TAF. Approximately 5 TAF over the long-term average is expected to go north of the Delta. Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 23 shows the level of the Proposition 1 storage account in Sites Reservoir based on historic hydrology, assuming Sites Reservoir is built and today's regulatory environment is in place.



Source: CalSim II modeling for Alternative 1B (Alt 1B 011221) in the Revised Draft EIR/Supplemental Draft EIS

Figure 23. Proposition 1 Storage Account Over Time

The values provided in this section assume all environmental water for Proposition 1 goes to the funded benefits in accordance with the Authority's Feasibility Study developed for the California Water Commission. However, it is the Authority's intent that this account be flexibly managed so that water could potentially go to other sources to maximize the environmental benefits. The Authority is working with CDFW and other stakeholders on how this account will be managed and the way the benefits are realized. The management of storage and deliveries for benefits will be finalized through an agreement with CDFW that will be developed in 2022/2023.

9.0 Funks and Stone Corral Creeks

In the construction of Sites Reservoir, Funks and Stone Corral Creeks would be impounded in the inundation area by the construction of the Golden Gate Dam and the Sites Dam, respectively. During Project operations, releases would be made from Sites Reservoir into Funks and Stone Corral Creeks. These releases would be made to comply with California Fish and Game Code Section 5937 and to ensure no harm to downstream water right holders on these creeks.

Detailed release schedules for releases into Funks and Stone Corral Creeks have not been developed due to lack of information on the conditions in these creeks. Field studies would be conducted once access is obtained and before final designs for Sites Dam and Golden Gate Dam are completed to determine the following:

- Existing fish assemblage in these creeks, including fish species presence and habitat use;
- Characterization of habitats available (e.g., spawning, rearing, foraging, and sheltering habitats) at varying flow levels;
- Characterization of flows, including assessing the base flow during the summer months;
- Conducting a fluvial geomorphologic study to characterize bed load and flow levels necessary for mobilization;

- Surface Water Ambient Monitoring Program technical study (i.e., bioassessment) that focuses on relationships between physical habitat, water quality, and benthic macroinvertebrates; and
- Hydrological studies to define flow temperature relationships.

Using information from these field studies, along with currently available information on water right holders downstream of the reservoir in both creeks, the Authority will prepare a Funks and Stone Corral Creeks flow schedule that will be incorporated into this Operations Plan that would identify the approach for releases, including release schedules and volumes, a monitoring plan, and an adaptive management plan. Releases into these creeks would be made in consideration of the flood control benefits of the Project and would not overtop the stream banks and flood downstream areas.

Releases into Funks Creek would be made through a new pipeline that terminates at Funks Creek below the dam. These facilities would carry up to 200 cfs with a release range of 0 to 100 cfs into Funks Creek. Releases into Stone Corral Creek would be made through the permanent outlet at Sites Dam. This outlet would have a release range of 0 to 200 cfs, with an emergency release capacity of up to 2,500 cfs.

The Authority has also entered into a Memorandum of Understanding with Colusa County that would allocate net flows from Stone Corral and Funks creeks to the County's Storage Allocation in the reservoir, where net flow equals inflow from the creek minus any required releases into the creeks downstream. The evaporation and seepage losses would also be allocated to the County's Storage Allocation consistent with all other water stored in the reservoir. Future versions of this Operations Plan will include more detail on how inflows from Funks and Stone Corral Creeks will be determined.

10.0 Flood Control and Health and Safety Considerations

10.1 Emergencies

The Project includes the design and operation of facilities to meet California Division of Safety of Dams criteria and requirements for emergency reservoir drawdown. During an emergency release event, Saddle Dam 8B, the I/O works, and Sites Dam may operate simultaneously to release water. Once the water surface elevation falls below the levels of the saddle dam spillway elevation, the I/O works and Sites Dam would operate solely to release the remaining water. The emergency releases would be in accordance with Division of Safety of Dams requirements and would occur as follows:

- Under Alternatives 1, 2, and 3, the spillway on Saddle Dam 8B would release to Hunters Creek. The size of the spillway would accommodate the peak outflow of a probable maximum flood event or the steady-state flow if an over-pumping event occurred. The design and size of the spillway were developed with the assumption that a probable maximum flood overflow event and an over-pumping event have a very low probability of occurring simultaneously.
- The permanent outlet on Sites Dam would release to Stone Corral Creek at a maximum rate of approximately 4,700 cfs.
- The I/O tunnels would release to Funks Reservoir and the TRR at a rate of approximately 16,000 cfs, with 9,000 cfs being discharged to Funks Reservoir and 7,000 cfs to the TRR with a maximum velocity of 40 cfs in the pipelines.

An Emergency Action Plan will be developed and implemented for Project construction and operation. The Emergency Action Plan will include (1) a summary of responsibilities, (2) notification procedures and flowchart, (3) emergency response process, (4) preparedness for different emergencies, and (5) potential inundation mapping. The Emergency Action Plan will also identify the frequency for desktop and full exercises to prepare for emergencies.

10.2 Flood Damage Reduction

In addition to the emergency drawdown requirements described above, the Project will provide flood damage reduction benefits to portions of Colusa County, including Maxwell and the surrounding agricultural areas. Incidental storage in Sites Reservoir would capture and store flood flows from the Funks Creek and Stone Corral Creek watersheds. These flood damage reduction benefits are inherent to the Project design and would occur regardless of the Project's operations for water supply and water-related environmental benefits. While the reservoir would not be operated with flood reduction as a primary objective, the Authority may consider adjusting operations to reduce flood damage as requested by local, state, or federal entities.

10.3 Recreation Considerations

In accordance with the Storage Principles, Sites Reservoir will provide water supply and water supply related environmental benefits, including water quality benefits ("Primary Benefits") and flood control, recreation, and power generation benefits ("Secondary Benefits"). Sites Reservoir will be operated so as to maximize the Primary Benefits for the Storage Partners. Secondary Benefits are considered incidental to the Project and will be subordinate to the provision of Primary Benefits.

The Authority will develop a Recreation Management Plan. The Recreation Management Plan will discuss the operation of the Recreation facilities, including how those operations may change depending on storage volume in the reservoir.

11.0 Changes to this Operations Plan

This Operations Plan will be updated as details surrounding Project permits, including the water right, are further defined. Version 1 of this Operation Plan may be updated with editorial or minor corrections and additions as requested by Project Storage Partners or Authority's Agents. All changes to this plan will be routed through the Ad Hoc Operations and Engineering Workgroup.

Attachment A

Sites Storage Partners as of December 2021

American Canyon, City of
Antelope Valley - East Kern Water Agency
Carter Mutual Water Company
Coachella Valley Water District
Colusa County
Colusa County Water District
Cortina Water District
Davis Water District
Desert Water Agency
Dunnigan Water District
Glenn-Colusa Irrigation District
Irvine Ranch Water District
LaGrande Water District
Metropolitan Water
Reclamation District 108
Rosedale-Rio Bravo Water Storage District
San Bernardino Valley Municipal Water District
San Gorgonio Pass Water Agency
Santa Clara Valley Water District
Santa Clarita Valley Water District
Westside Water District
Wheeler Ridge-Maricopa Water Storage District
Zone 7 Water Agency
State of California
United States Bureau of Reclamation

Attachment B

Principles for the Storage, Delivery and Sale of Sites Reservoir Project Water

PRINCIPLES FOR THE STORAGE, DELIVERY AND SALE
OF SITES RESERVOIR PROJECT WATER

APPLICABILITY

(1) These Principles For The Storage, Delivery And Sale of Sites Reservoir Project Water ("Principles") adopted by the Sites Project Authority ("Authority") on April 21, 2021, supersede the Storage Policy adopted by the Authority on August 26, 2019.

PURPOSE AND SCOPE

(2) These Principles are intended to guide and assist the Authority as it moves forward with the Sites Reservoir Project ("Project"). To that end, these Principles will serve as the basic framework for development, adoption and/or execution of additional or more formal agreements, policies and procedures related to the storage, delivery and sale of Sites Project water, as needed.

DEFINITIONS

(3) Authority – For the purposes of these Principles, the term Authority collectively refers to the Sites Project Authority and its standing Reservoir Committee. The final roles and responsibilities of the Authority and the Reservoir Committee in the day-to-day operations of Sites Reservoir have not yet been defined and the term Authority is used to refer to both entities collectively.

(4) Available Storage – That portion of Sites Reservoir that can be filled, minus dead storage and any storage space intentionally left unfilled at the direction of the Storage Partner who has contracted for that storage space.

(5) Beneficiary Pays Principle – The principle for allocating all costs associated with delivering certain Project benefits, including public and non-public benefits, to the party receiving such benefits.

(6) OM&R – Those costs associated with the operation, maintenance and repair/replacement of Project facilities. These can be broken down into: (a) Fixed OM&R costs that are more predictable year-to-year and that are not significantly influenced by varying diversions or releases of water; and (b) Variable OM&R costs that vary based on actual operations each year, including costs associated with water transfers or exchanges.

(7) Sites Reservoir Project (Project) – Sites Reservoir and associated diversion and conveyance facilities.

(8) Sites Water – Water that is appropriated under the Authority's water right.

(9) Storage Allocation – The amount of storage space (storage volume) in Sites Reservoir allocated to a Storage Partner, as agreed upon in that Storage Partner's Water Storage and Supply Services Contract and the amount of storage space shared or leased, if any, pursuant to Paragraph 25 of these Principles. Dead storage is not allocated to any Storage Partner.

(10) Storage Partners – The governmental agencies, water organizations and others who have funded and received a Storage Allocation in Sites Reservoir and the resulting water supply or water supply related environmental benefits from the Project. Storage Partners could include local agencies, the State of California, and the Federal Government.

(11) Water Storage and Supply Services Contract – That agreement, by whatever name, between the Authority and a Storage Partner that provides for the Storage Partner to obtain the Primary Benefits of the Project provided the Storage Partner meets the funding and other obligations of that agreement.

PRIORITY OF OPERATION

(12) Sites Reservoir will provide water supply and water supply related environmental benefits, including water quality benefits ("Primary Benefits"), as well as flood control, recreation, and power generation benefits ("Secondary Benefits"). Sites Reservoir will be operated so as to maximize the Primary Benefits for the Storage Partners. Secondary Benefits are considered incidental to the Project and will be subordinate to the provision of Primary Benefits.

ROLES

(13) Authority - The Authority will develop, own, operate, and maintain the Project. The Authority will obtain and comply with all permits, approvals and agreements needed to construct, operate and maintain the Project. The Authority will oversee the planning, permitting, and day-to-day operations and accounting of Sites Reservoir storage, releases and losses and related activities, including coordination with each Storage Partner. This will be done in a way that is open and transparent to all Storage Partners.

(14) Storage Partners – The Storage Partners are responsible for managing their Storage Allocation and for paying their allocated capital, fixed OM&R, and variable OM&R costs.

WATER STORAGE AND SUPPLY SERVICES CONTRACTS

(15) The Authority will enter into Water Storage and Supply Services Contracts with individual Storage Partners for the use of Project facilities. Each Water Storage and Supply Services Contract will be based on a Storage Partner's Storage Allocation.

WATER RIGHT AND POINT OF DELIVERY

(16) The Authority will apply for and hold the water right for the Project. In developing the Project and its operations, the Authority will divert water to maximize beneficial use and perfect the water right. The Authority will be responsible for compliance with the terms and conditions in the water right and any other permits, approvals, and agreements that control diversion of water to storage for the Project. The Storage Partners will be responsible for using Sites Water within the terms and conditions allowed in the Authority's water right and for providing the Authority with any information it may need to comply with reporting or other requirements. To the extent permitted by applicable law and with the cooperation of the Storage Partners, the Authority will undertake all reasonable measures to manage, control and protect Sites Water, including initiating any appropriate enforcement proceedings to prevent unlawful diversion of or interference with Sites Water.

(17) The Authority will manage Sites Water from the points of diversion to the primary point of delivery. The primary point of delivery for each Storage Partner will be Funks Reservoir or the Terminal Regulating Reservoir. For Sites Water delivered to Storage Partners not served by the Tehama-Colusa Canal or the Glenn Colusa Irrigation District's distribution system, the Authority may retain control of Sites Water to a secondary point of delivery, as agreed upon by the Authority and the Storage Partner in the respective Water Storage and Supply Services Contract. Storage Partners will be responsible for all losses after the primary point of delivery.

STORAGE OF WATER BY DIVERSION

(18) The Authority will take all actions practicable to maximize the diversion of water into Available Storage consistent with regulatory requirements, physical and operational constraints, and hydrologic conditions. Water diverted will be allocated to each Storage Partner's contractual storage space proportional to its Storage Allocation.[1] If a Storage Partner's Storage Allocation is not available, the available water will be allocated to the remaining Storage Partners who have available Storage Allocation space proportional to their Storage Allocation.

(19) The Authority will establish a process, including schedule, that allows for a Storage Partner to determine the maximum amount of water allocated to the Storage Partner's Storage Allocation each year along with a process to make changes to this amount. A Storage Partner may opt out of having water allocated to their Storage Allocation if they so inform the Authority through the process established by the Authority.

(20) The diversion of water to storage will take priority over the release of stored water. The diversion of Sites Water to storage will take priority over the diversion of water from other sources to storage.

STORAGE OF WATER FROM OTHER SOURCES

(21) Storage Partners may request that the Authority place water from sources other than Sites Water into storage and allocate that water to their Storage Allocation. The Authority will take all reasonable steps to facilitate these requests, subject to the Beneficiary Pays Principle. Placing water into storage from other sources must not negatively impact other Storage Partners, Project operations or financing.

(22) If there is a conflict between placing water into storage in Sites Reservoir from other sources of water and the release of water from Sites Reservoir at the same time, the Authority will prioritize diversions but take reasonable measures to accommodate both Storage Partners' requests.

ACCOUNTING FOR LOSSES

(23) Losses of water held in Sites Reservoir storage – including but not limited to evaporation, seepage, and any releases for dam safety or emergency conditions – will be allocated proportionally to each Storage Partner based on the amount of its water in storage.

SHARING OR LEASING OF STORAGE ALLOCATION

(24) Storage Partners are allowed to share or lease their Storage Allocation with other Storage Partners or other entities. The terms of sharing or leasing are at the discretion of the Storage Partners who are parties to a storage or lease agreement but must not negatively impact other Storage Partners, Project operations or financing. Any sharing or leasing of Storage Allocation must

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[1] *For example, if 275,000 acre-feet of water is able to be diverted to Sites Reservoir in any one year, this represents 20% of the total allocated storage space in Sites Reservoir (275,000/1.38 million acre-feet = 20%). In that year, each Storage Partner would receive an amount of water equal to 20% of their Storage Allocation, unless the Storage Partner has opted out of having water allocated to their Storage Allocation or their Storage Allocation is full. This example assumes a 1.5 million acre-foot reservoir with about 120,000 acre-feet allocated to dead pool.*

be coordinated with the Authority. A Storage Partner may not transfer or assign any of its rights or obligations as part of any sharing or leasing agreement.

SALE OF SITES WATER

(25) Storage Partners are allowed to sell water held in their Storage Allocation to other Storage Partners or other entities. The terms of sales of water held in a Storage Allocation are at the discretion of the Storage Partners who are parties to the sale but must not negatively impact other Storage Partners, Project operations or financing. Any sale of water held in a Storage Allocation must be coordinated with the Authority. A Storage Partner may not transfer or assign any of its rights or obligations as part of any sale of water. The receiving Storage Partner or other entity must have sufficient available Storage Allocation to store the water or release the water upon purchase.

RELEASES OF WATER FROM STORAGE

(26) To the extent allowed by the Project's permits, approvals and agreements and its physical and operational capabilities, Storage Partners have total discretion on the amount of water held in their Storage Allocation that they request to be scheduled for release for their use, and will have control over the use of their Storage Allocation space based on the conditions set forth in these Principles.

(27) Each year, the Authority will make a water storage forecast for each Storage Partner. Each Storage Partner will provide the schedule and amounts of the water they wish to be released in that year. The Authority will establish a process, including schedule, that allows for the Storage Partner to make changes to its water schedule and amounts for release throughout the year.

(28) The Authority will work with each Storage Partner, the State Water Project, Central Valley Project, Tehama Colusa Canal Authority, the Glenn Colusa Irrigation District, entities along the Colusa Basin Drain, and regulatory agencies and make all reasonable efforts to satisfy the water release schedules requested by each Storage Partner. If there is a release constraint affecting the ability of the Authority to meet the requested water release schedules, the Authority will work with those conflicted Storage Partners to see if accommodations can be made. If the conflict cannot be resolved, releases will be made in proportion to the Storage Allocation attributable to the conflicted Storage Partners.

UNIFORM STANDARDS FOR ALL STORAGE PARTNERS

(29) All Storage Partners are subject to uniform standards in the operation of the Project. Uniform standards include, but are not limited to, priority of diversions, storage, releases, and conveyance of Sites Water through Project facilities and utilization of their respective Storage Allocation.

CONFLICT RESOLUTION

(30) The Authority will develop a conflict resolution mechanism to resolve conflicts that may arise in Project operations. This conflict resolution process will be included in the Water Storage and Supply Services Contract.

FUTURE CHANGES

(31) It is anticipated that these Principles will evolve and change as the Project develops and as permits, approvals, and agreements are obtained and executed. These Principles may be modified in the future by the Authority.

DATE

April 21, 2021

Attachment C

Methodology for Allocating Reservoir Storage

Sites

Topic: **Reservoir Committee Meeting Agenda Item 2.2** **2021 April 16**

Subject: **Approach for Allocating Storage Space in the Reservoir**

Requested Action:

Approve the recommended methodology for allocating storage space in Sites Reservoir to each local Storage Partner using the final proposed formulaic approach of 1 acre-foot Amendment 2 participation to 6.234 acre-feet of storage space.

Detailed Description/Background:

An important component of the Principles for the Storage, Delivery and Sale of Sites Reservoir Project Water (Storage Principles), and a foundational principle of the Sites Project, is that each Storage Partner has allocated storage space in Sites Reservoir (termed "Storage Allocation" in the Storage Principles discussed in Item 2.1 of today's agenda). This Storage Allocation is managed by the Storage Partner to optimize the benefits received from the Sites Project and is used to determine the proportion of diverted water provided to each Storage Partner.

If approved, the recommended method would identify the amount of storage allocation to each Storage Partner. Future documents and contracts would include the amount of storage allocated to the respective Storage Partner.

In February 2021, staff reviewed principles and objectives of allocating reservoir storage with the Reservoir Committee and Authority Board. Principles included equitable treatment between local participants, confirming neither the State nor Reclamation receive disproportionate benefits when compared to local participants, and considerations of the Credit Reimbursement Policy. Staff reviewed the proposed allocation again in March 2021 to provide participants a second opportunity to review and ask questions.

The proposed allocation for local, State and Federal Storage Partners, based on a 1.5 million acre-foot reservoir, is shown in Table 1 below.

Table 1. Summary of Storage Allocation for Local, State and Federal Storage Partners

Storage Type	Storage Allocation (thousand acre-feet)	Percent Active Storage
Dead Pool	120	N/A
State – CDFW	244	17.7%
Federal - Reclamation (low end of range)	91	6.6%
Local Storage Partners	1,045	75.7%
Total	1,500	100%

The State Storage Allocation is estimated based on the amount of storage required to meet ecosystem benefits awarded through Proposition 1 which is to be "trued up" later this year through the State's feasibility evaluation.

The Federal Storage Allocation is based on assumptions consistent with Alternative 1B, the Authority's preferred alternative in the Revised Draft EIR/Supplemental Draft EIS. Up to 25% cost share was found to be feasible by the Secretary of Interior and could be accommodated with voluntary reductions in the local agency participation consistent with Alternative 3 in the Revised Draft EIR/Supplemental Draft EIS if funding is available. Increasing the reservoir size beyond 1.5 million acre-feet is not being contemplated at this time.

A recommended methodology for allocating storage to local Storage Partners was provided in February and March 2021 and remains unchanged. The recommended method is the following mathematical conversion based on a 1.5 million-acre-foot reservoir:

Existing participation x 6.234 = Storage Allocation

Example: 1,000 acre-feet per year Amendment 2 participation = 6,234 acre-feet Storage Allocation

The recommended methodology allocates all available storage based on existing participation and after accounting for estimated storage for the State and Federal government along with the dead pool. The State and Federal estimates are expected to be finalized over the next six to nine months. The final State and Federal numbers can affect the local storage amounts but the proportionate shares of the local storage among the participants would remain unchanged. Similarly, using the Alternative 2 reservoir size of 1.3 million-acre-feet would have an effect on the local storage amount allocated to each participant but the proportionate share of space among participants would remain the same.

The recommended methodology was reviewed and recommended for approval by the Storage Policy Small Group and the Ad Hoc Reservoir Operations and Engineering Workgroup. Staff recommends that the Reservoir Committee approve the recommended methodology for allocating storage space in Sites Reservoir to each local Storage Partner using the final proposed formulaic approach of 1 acre-foot Amendment 2 participation to 6.234 acre-feet of storage space.

Prior Action:

March Meetings & February 19, 2021: Reviewed and commented on the approach for allocating storage space in the reservoir.

Fiscal Impact/Funding Source:

None.

Staff Contact:

Ali Forsythe

Attachments:

Attachment A - Storage Allocation Based on Amendment 2 Participation

Storage Allocation Based on Amendment 2 Participation Levels
April 16, 2021

Participant Name	Storage (AF)	% Active Storage
Antelope Valley-East Kern WA	3,117	0.2%
Carter MWC	1,870	0.1%
City of American Canyon	24,937	1.8%
Coachella Valley WD	62,343	4.5%
Colusa County	62,343	4.5%
Colusa County WD	62,799	4.6%
Cortina WD	2,805	0.2%
Davis WD	12,469	0.9%
Desert WA	40,523	2.9%
Dunnigan WD	18,528	1.3%
Glenn-Colusa ID	31,172	2.3%
Irvine Ranch WD	6,234	0.5%
LaGrande WD	6,234	0.5%
Metropolitan Water District of SC	311,717	22.6%
Reclamation District 108	24,937	1.8%
Rosedale-Rio Bravo WD	3,117	0.2%
San Bernardino Valley Municipal WD	133,415	9.7%
San Gorgonio Pass WA	87,281	6.3%
Santa Clara Valley WD	3,117	0.2%
Santa Clarita Valley WA	31,172	2.3%
Westside WD	33,510	2.4%
Wheeler Ridge - Maricopa WSD	19,015	1.4%
Zone 7 WA	62,343	4.5%
Reclamation	91,000	6.6%
State of California - Ecosystem	244,000	17.7%
Dead Pool	120,000	N/A
Total	1,500,000	100%

Attachment D

Assumptions for Releases or Demands and Deliveries by Year Type

Draft – Subject to Revision
Sites Project: Participant Delivery Reports

This document summarizes Sites Project Participants Delivery Reports that have been prepared for Alternative 1A 011221, Alternative 1B 011221, Alternative 2 011221, and Alternative 3 020121. These reports allow each participant to see their long-term and water year-type average Sites Project deliveries as modeled in CalSim II.

Summary of Reports

This document consists of a summary table and individual reports for each participant. The summary table reports the modeled end-point deliveries of Sites Project water to participants for each alternative. Participants are listed alphabetically, grouped by North of Delta and South of Delta.

The individual participants reports display long-term, dry, and critically dry water year, and water year type average end-point deliveries for each Sites Project participant. Water year types are assigned using the D-1641 Sacramento Valley 40-30-30 water year type calculation and annual averages are calculated on a March-February CVP contract year for North of Delta participants and a January-December SWP contract year for South of Delta participants.

Assumptions

End-point deliveries of Sites Project water to each region was assigned proportionally to each participant based on their participation level in Amendment 2 on November 20, 2020.

The following assumptions apply to deliveries to each participant group:

Tehama-Colusa Canal Authority (TCCA)

Water is released from the TCCA Sites account with the intention of meeting up to 100% of participants' CVP contract amount. When water is not needed to meet TCCA participants contract amounts, water may be transferred to the South of Delta Participants account during May of Above Normal and Below Normal water years when account storage is over two-thirds of capacity. Releases are made directly to the Tehama-Colusa Canal. Deliveries are equal to these releases; no conveyance losses are assumed.

Glenn-Colusa Irrigation District (GCID)

Water is released from the GCID Sites account in April and May when CVP Settlement Contract deliveries are reduced to 75% in Shasta critical years. In all other years, except for wet years, water is transferred to the South of Delta Participants account. Releases are made directly to the Glenn-Colusa Canal. Deliveries are equal to these releases; no conveyance losses are assumed.

Reclamation District 108 (RD-108) and Carter MWC

Water is released from the RD-108 and Carter MWC Sites account in April and May when CVP Settlement Contract deliveries are reduced to 75% in Shasta critical years. In all other years, except for wet years, water is transferred to the South of Delta Participants account. Releases are made through the Tehama-Colusa Canal to the Dunnigan Pipeline to facilitate an exchange with the Sacramento River. Deliveries are equal to these releases; no conveyance losses are assumed.

County of Colusa

Water is released from the County of Colusa Sites account for groundwater replenishment. Releases are limited to 10 TAF per year from June through September. Releases are made directly to the Tehama-Colusa Canal. Deliveries are equal to these releases; no conveyance losses are assumed.

South of Delta Participants

Water may be released from the South of Delta Participants Sites account in all but wet water years. There are four ways that water may be delivered to South of Delta Participants: direct release to the Sacramento River through the Dunnigan Pipeline, exchanges with Sacramento River at Hamilton City by replacing CVP diversions to GCID with releases from Sites, exchanges with Shasta Lake, and exchanges with the SWP at Lake Oroville. Releases are then exported from the Delta through Banks Pumping Plant. Exports of releases of South of Delta Participants water are limited to July through November.

Deliveries to South of Delta participants are based on the export at the Banks Pumping Plant. In these reports, deliveries are allocated based on Sites Project participation levels. The difference between the release from Sites Reservoir and Delta Exports accounts for carriage water and other losses. Exports to South of Delta Participants are subject to export availability. It is assumed that all South of Delta participants proportionally share exported water regardless of the pattern of exports.

Limitations

These reports only include deliveries to Sites Project participants from the Sites PWA accounts. It does not report incidental changes in SWP and CVP deliveries or additional CVP deliveries due to CVP Operational Flexibility from federal investment in the Sites Project.

Sites Project Deliveries

DRAFT-Subject to Revision

Participant	Long Term Average Deliveries (TAF/year)			
	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
North of Delta Participants				
Carter Mutual Water Company	0.03	0.03	0.03	0.02
Colusa County WD	10.4	9.7	9.9	8.2
Cortina WD	0.5	0.4	0.4	0.4
County of Colusa	7.0	6.9	7.0	6.7
Davis Water District	2.1	1.9	2.0	1.6
Dunnigan WD	3.1	2.9	2.9	2.4
Glenn Colusa Irrigation District	0.5	0.5	0.5	0.4
LaGrande Water District	1.0	1.0	1.0	0.8
RD-108	0.4	0.4	0.4	0.3
Westside W.D.	5.6	5.2	5.3	4.4
Total NOD Delivery	30.5	28.9	29.3	25.2
South of Delta Participants				
Antelope Valley East Kern WA	0.4	0.4	0.3	0.3
City of American Canyon	2.1	2.1	2.1	2.1
Coachella Valley Water District	7.8	7.2	7.0	5.6
Desert WA	5.1	4.7	4.5	3.7
Irvine Ranch Water District	0.8	0.7	0.7	0.6
Metropolitan Water District of Southern California	38.9	36.1	34.8	28.2
Rosedale-Rio Bravo Water District	0.4	0.4	0.3	0.3
San Bernardino Valley Municipal Water District	16.6	15.4	14.9	12.1
San Gorgonio Pass Water Agency	10.9	10.1	9.7	7.9
Santa Clara Valley WD	0.4	0.4	0.3	0.3
Santa Clarita Valley Water Agency	3.9	3.6	3.5	2.8
Wheeler Ridge-Maricopa WSD	2.4	2.2	2.1	1.7
Zone 7 Water Agency	7.8	7.2	7.0	5.6
Total SOD Delivery	97.4	90.5	87.3	71.3
Total Sites PWA Delivery	127.9	119.4	116.6	96.5

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Mar-Feb CVP contract year for North of Delta participants
4. Annual average deliveries are calculated on a Jan-Dec SWP contract year for South of Delta participants
5. South of Delta deliveries are based on Authority exports modeled in CalSim II
6. Deliveries do not include any San Luis reoperation or south of Delta storage agreements
7. South of Delta delivery arcs were combined and then deliveries were distributed proportional to participation

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: Carter Mutual Water Company

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**0.0**	**0.0**	**0.0**	**0.0**
Dry and Critically Dry Years	**0.1**	**0.1**	**0.1**	**0.1**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	0.0	0.0	0.0	0.0
Dry Years	0.0	0.0	0.0	0.0
Critically Dry Years	0.2	0.2	0.2	0.1

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Mar-Feb CVP contract year for NOD participants

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: Colusa County WD

	Deliveries (TAF/year)			
	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**10.4**	**9.7**	**9.9**	**8.2**
Dry and Critically Dry Years	**24.3**	**22.6**	**23.3**	**19.4**
Wet Years	0.8	0.8	0.8	0.8
Above Normal Years	0.3	0.3	0.3	0.3
Below Normal Years	6.5	6.3	5.5	4.0
Dry Years	21.7	20.8	21.2	17.7
Critically Dry Years	28.3	25.2	26.4	22.0

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Mar-Feb CVP contract year for NOD participants

Sites Project Deliveries **DRAFT-Subject to Revision**

Sites Participant: Cortina WD

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**0.5**	**0.4**	**0.4**	**0.4**
Dry and Critically Dry Years	**1.1**	**1.0**	**1.0**	**0.9**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	0.3	0.3	0.2	0.2
Dry Years	1.0	0.9	0.9	0.8
Critically Dry Years	1.3	1.1	1.2	1.0

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Mar-Feb CVP contract year for NOD participants

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: County of Colusa

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**7.0**	**6.9**	**7.0**	**6.7**
Dry and Critically Dry Years	**8.7**	**8.5**	**8.7**	**7.8**
Wet Years	5.1	5.1	5.1	5.1
Above Normal Years	5.7	5.7	5.7	5.7
Below Normal Years	8.0	8.0	8.1	8.1
Dry Years	8.4	8.6	8.6	8.7
Critically Dry Years	9.1	8.3	8.7	6.5

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. Annual average deliveries are calculated on a Mar-Feb CVP contract year for NOD participants

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: Davis Water District

Deliveries (TAF/year)				
	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**2.1**	**1.9**	**2.0**	**1.6**
Dry and Critically Dry Years	**4.8**	**4.5**	**4.6**	**3.9**
Wet Years	0.2	0.2	0.2	0.2
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	1.3	1.3	1.1	0.8
Dry Years	4.3	4.1	4.2	3.5
Critically Dry Years	5.6	5.0	5.2	4.4

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Mar-Feb CVP contract year for NOD participants

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: Dunnigan WD

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**3.1**	**2.9**	**2.9**	**2.4**
Dry and Critically Dry Years	**7.2**	**6.7**	**6.9**	**5.7**
Wet Years	0.2	0.2	0.2	0.2
Above Normal Years	0.1	0.1	0.1	0.1
Below Normal Years	1.9	1.9	1.6	1.2
Dry Years	6.4	6.1	6.3	5.2
Critically Dry Years	8.4	7.4	7.8	6.5

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Mar-Feb CVP contract year for NOD participants

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: Glenn Colusa Irrigation District

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**0.5**	**0.5**	**0.5**	**0.4**
Dry and Critically Dry Years	**1.4**	**1.2**	**1.4**	**1.2**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	0.0	0.0	0.0	0.0
Dry Years	0.3	0.2	0.3	0.2
Critically Dry Years	3.0	2.8	3.0	2.6

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Mar-Feb CVP contract year for NOD participants

Sites Project Deliveries **DRAFT-Subject to Revision**

Sites Participant: LaGrande Water District

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**1.0**	**1.0**	**1.0**	**0.8**
Dry and Critically Dry Years	**2.4**	**2.2**	**2.3**	**1.9**
Wet Years	0.1	0.1	0.1	0.1
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	0.6	0.6	0.5	0.4
Dry Years	2.1	2.1	2.1	1.8
Critically Dry Years	2.8	2.5	2.6	2.2

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Mar-Feb CVP contract year for NOD participants

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: RD-108

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**0.4**	**0.4**	**0.4**	**0.3**
Dry and Critically Dry Years	**1.0**	**1.0**	**1.0**	**0.9**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	0.0	0.0	0.0	0.0
Dry Years	0.1	0.1	0.1	0.1
Critically Dry Years	2.3	2.2	2.3	2.0

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Mar-Feb CVP contract year for NOD participants

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: Westside W.D.

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**5.6**	**5.2**	**5.3**	**4.4**
Dry and Critically Dry Years	**13.0**	**12.0**	**12.4**	**10.4**
Wet Years	0.4	0.4	0.4	0.4
Above Normal Years	0.1	0.1	0.1	0.1
Below Normal Years	3.5	3.4	2.9	2.2
Dry Years	11.6	11.1	11.3	9.4
Critically Dry Years	15.1	13.5	14.1	11.7

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Mar-Feb CVP contract year for NOD participants

Sites Project Deliveries DRAFT-Subject to Revision

Sites Participant: Total NOD Delivery

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**30.5**	**28.9**	**29.3**	**25.2**
Dry and Critically Dry Years	**63.9**	**59.8**	**61.7**	**52.0**
Wet Years	6.8	6.8	6.8	6.8
Above Normal Years	6.2	6.2	6.2	6.2
Below Normal Years	22.0	21.7	20.0	16.8
Dry Years	55.8	54.1	55.1	47.4
Critically Dry Years	76.0	68.2	71.5	59.0

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Mar-Feb CVP contract year for NOD participants

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: Antelope Valley East Kern WA

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**0.4**	**0.4**	**0.3**	**0.3**
Dry and Critically Dry Years	**1.0**	**0.9**	**0.9**	**0.7**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	0.2	0.1	0.2	0.1
Dry Years	1.0	0.9	0.9	0.7
Critically Dry Years	0.9	0.9	0.8	0.7

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Jan-Dec SWP contract year for SOD participants
4. South of Delta deliveries are based on Authority exports modeled in CalSim II
5. Deliveries do not include any San Luis reoperation or south of Delta storage agreements
6. South of Delta delivery arcs were combined and then deliveries were distributed proportional to participation

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: City of American Canyon

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**2.1**	**2.1**	**2.1**	**2.1**
Dry and Critically Dry Years	**3.9**	**3.9**	**3.9**	**3.9**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	4.0	4.0	4.0	4.0
Dry Years	4.0	4.0	4.0	4.0
Critically Dry Years	3.7	3.7	3.7	3.7

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Jan-Dec SWP contract year for SOD participants
4. South of Delta deliveries are based on Authority exports modeled in CalSim II
5. Deliveries do not include any San Luis reoperation or south of Delta storage agreements
6. South of Delta delivery arcs were combined and then deliveries were distributed proportional to participation

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: Coachella Valley Water District

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**7.8**	**7.2**	**7.0**	**5.6**
Dry and Critically Dry Years	**19.5**	**18.2**	**17.3**	**14.2**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	3.1	2.8	3.2	2.2
Dry Years	20.8	18.9	18.6	14.6
Critically Dry Years	17.7	17.0	15.3	13.5

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Jan-Dec SWP contract year for SOD participants
4. South of Delta deliveries are based on Authority exports modeled in CalSim II
5. Deliveries do not include any San Luis reoperation or south of Delta storage agreements
6. South of Delta delivery arcs were combined and then deliveries were distributed proportional to participation

Sites Project Deliveries **DRAFT-Subject to Revision**

Sites Participant: Desert WA

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**5.1**	**4.7**	**4.5**	**3.7**
Dry and Critically Dry Years	**12.7**	**11.8**	**11.2**	**9.2**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	2.0	1.9	2.1	1.5
Dry Years	13.5	12.3	12.1	9.5
Critically Dry Years	11.5	11.1	9.9	8.8

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Jan-Dec SWP contract year for SOD participants
4. South of Delta deliveries are based on Authority exports modeled in CalSim II
5. Deliveries do not include any San Luis reoperation or south of Delta storage agreements
6. South of Delta delivery arcs were combined and then deliveries were distributed proportional to participation

Sites Project Deliveries DRAFT-Subject to Revision

Sites Participant: Irvine Ranch Water District

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**0.8**	**0.7**	**0.7**	**0.6**
Dry and Critically Dry Years	**2.0**	**1.8**	**1.7**	**1.4**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	0.3	0.3	0.3	0.2
Dry Years	2.1	1.9	1.9	1.5
Critically Dry Years	1.8	1.7	1.5	1.4

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Jan-Dec SWP contract year for SOD participants
4. South of Delta deliveries are based on Authority exports modeled in CalSim II
5. Deliveries do not include any San Luis reoperation or south of Delta storage agreements
6. South of Delta delivery arcs were combined and then deliveries were distributed proportional to participation

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: Metropolitan Water District of Southern California

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**38.9**	**36.1**	**34.8**	**28.2**
Dry and Critically Dry Years	**97.7**	**90.8**	**86.3**	**71.0**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	15.6	14.2	16.1	11.2
Dry Years	103.9	94.5	92.9	73.2
Critically Dry Years	88.4	85.2	76.4	67.7

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Jan-Dec SWP contract year for SOD participants
4. South of Delta deliveries are based on Authority exports modeled in CalSim II
5. Deliveries do not include any San Luis reoperation or south of Delta storage agreements
6. South of Delta delivery arcs were combined and then deliveries were distributed proportional to participation

Sites Project Deliveries DRAFT-Subject to Revision

Sites Participant: Rosedale-Rio Bravo Water District

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**0.4**	**0.4**	**0.3**	**0.3**
Dry and Critically Dry Years	**1.0**	**0.9**	**0.9**	**0.7**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	0.2	0.1	0.2	0.1
Dry Years	1.0	0.9	0.9	0.7
Critically Dry Years	0.9	0.9	0.8	0.7

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Jan-Dec SWP contract year for SOD participants
4. South of Delta deliveries are based on Authority exports modeled in CalSim II
5. Deliveries do not include any San Luis reoperation or south of Delta storage agreements
6. South of Delta delivery arcs were combined and then deliveries were distributed proportional to participation

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: San Bernardino Valley Municipal Water District

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**16.6**	**15.4**	**14.9**	**12.1**
Dry and Critically Dry Years	**41.8**	**38.9**	**37.0**	**30.4**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	6.7	6.1	6.9	4.8
Dry Years	44.5	40.5	39.8	31.3
Critically Dry Years	37.8	36.5	32.7	29.0

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Jan-Dec SWP contract year for SOD participants
4. South of Delta deliveries are based on Authority exports modeled in CalSim II
5. Deliveries do not include any San Luis reoperation or south of Delta storage agreements
6. South of Delta delivery arcs were combined and then deliveries were distributed proportional to participation

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: San Gorgonio Pass Water Agency

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**10.9**	**10.1**	**9.7**	**7.9**
Dry and Critically Dry Years	**27.4**	**25.4**	**24.2**	**19.9**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	4.4	4.0	4.5	3.1
Dry Years	29.1	26.5	26.0	20.5
Critically Dry Years	24.7	23.9	21.4	19.0

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Jan-Dec SWP contract year for SOD participants
4. South of Delta deliveries are based on Authority exports modeled in CalSim II
5. Deliveries do not include any San Luis reoperation or south of Delta storage agreements
6. South of Delta delivery arcs were combined and then deliveries were distributed proportional to participation

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: Santa Clara Valley WD

Deliveries (TAF/year)				
	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**0.4**	**0.4**	**0.3**	**0.3**
Dry and Critically Dry Years	**1.0**	**0.9**	**0.9**	**0.7**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	0.2	0.1	0.2	0.1
Dry Years	1.0	0.9	0.9	0.7
Critically Dry Years	0.9	0.9	0.8	0.7

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Jan-Dec SWP contract year for SOD participants
4. South of Delta deliveries are based on Authority exports modeled in CalSim II
5. Deliveries do not include any San Luis reoperation or south of Delta storage agreements
6. South of Delta delivery arcs were combined and then deliveries were distributed proportional to participation

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: Santa Clarita Valley Water Agency

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**3.9**	**3.6**	**3.5**	**2.8**
Dry and Critically Dry Years	**9.8**	**9.1**	**8.6**	**7.1**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	1.6	1.4	1.6	1.1
Dry Years	10.4	9.5	9.3	7.3
Critically Dry Years	8.8	8.5	7.6	6.8

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Jan-Dec SWP contract year for SOD participants
4. South of Delta deliveries are based on Authority exports modeled in CalSim II
5. Deliveries do not include any San Luis reoperation or south of Delta storage agreements
6. South of Delta delivery arcs were combined and then deliveries were distributed proportional to participation

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: Wheeler Ridge-Maricopa WSD

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**2.4**	**2.2**	**2.1**	**1.7**
Dry and Critically Dry Years	**6.0**	**5.5**	**5.3**	**4.3**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	1.0	0.9	1.0	0.7
Dry Years	6.3	5.8	5.7	4.5
Critically Dry Years	5.4	5.2	4.7	4.1

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Jan-Dec SWP contract year for SOD participants
4. South of Delta deliveries are based on Authority exports modeled in CalSim II
5. Deliveries do not include any San Luis reoperation or south of Delta storage agreements
6. South of Delta delivery arcs were combined and then deliveries were distributed proportional to participation

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: Zone 7 Water Agency

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**7.8**	**7.2**	**7.0**	**5.6**
Dry and Critically Dry Years	**19.5**	**18.2**	**17.3**	**14.2**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	3.1	2.8	3.2	2.2
Dry Years	20.8	18.9	18.6	14.6
Critically Dry Years	17.7	17.0	15.3	13.5

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Jan-Dec SWP contract year for SOD participants
4. South of Delta deliveries are based on Authority exports modeled in CalSim II
5. Deliveries do not include any San Luis reoperation or south of Delta storage agreements
6. South of Delta delivery arcs were combined and then deliveries were distributed proportional to participation

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: Total SOD Delivery

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**97.4**	**90.5**	**87.3**	**71.3**
Dry and Critically Dry Years	**243.2**	**226.2**	**215.3**	**177.7**
Wet Years	0.0	0.0	0.0	0.0
Above Normal Years	0.0	0.0	0.0	0.0
Below Normal Years	42.2	38.9	43.5	31.5
Dry Years	258.5	235.5	231.6	183.2
Critically Dry Years	220.1	212.3	190.8	169.6

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Jan-Dec SWP contract year for SOD participants
4. South of Delta deliveries are based on Authority exports modeled in CalSim II
5. Deliveries do not include any San Luis reoperation or south of Delta storage agreements
6. South of Delta delivery arcs were combined and then deliveries were distributed proportional to participation

Sites Project Deliveries

DRAFT-Subject to Revision

Sites Participant: Total Sites PWA Delivery

Deliveries (TAF/year)

	ALT 1A 011221	ALT 1B 011221	ALT 2 011221	ALT 3 020121
Long-term Average	**127.9**	**119.4**	**116.6**	**96.5**
Dry and Critically Dry Years	**307.1**	**286.0**	**277.0**	**229.8**
Wet Years	6.8	6.8	6.8	6.8
Above Normal Years	6.2	6.2	6.2	6.2
Below Normal Years	64.2	60.6	63.6	48.3
Dry Years	314.4	289.6	286.7	230.5
Critically Dry Years	296.1	280.5	262.3	228.6

Notes:

1. Water year types are calculated using the D-1641 Sacramento Valley 40-30-30 water year type calculation
2. End-point deliveries assume the NOD to SOD transfer operation as defined in the assumptions
3. Annual average deliveries are calculated on a Mar-Feb CVP contract year for NOD participants and on a Jan-Dec SWP contract year for SOD participants
4. South of Delta deliveries are based on Authority exports modeled in CalSim II
5. Deliveries do not include any San Luis reoperation or south of Delta storage agreements
6. South of Delta delivery arcs were combined and then deliveries were distributed proportional to participation

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Attachment E

Memorandum Identifying Modeled Criteria for Shasta Exchanges

Draft – Subject to Revision
Sites Project: Shasta Lake Exchange Modeling Assumptions

This document summarizes Sites Reservoir exchange operations with Shasta Lake. Then, details Reclamation's Cold Water Pool management at Shasta, as described in ROC on LTO. Finally, modeling assumptions are tabulated and expected benefits of the Shasta Exchange operation are highlighted.

Summary of Shasta Exchange Operation

Shasta Exchange is designed to support the Cold Water Pool Management and Fall and Winter Refill and Redd Maintenance Actions in the 2019 BiOps. In the Spring of Shasta Exchange years, Sacramento River Settlement Contractors (SRSC) and Tehama-Colusa Canal Authority (TCCA) members would receive water from Sites in lieu of Shasta. As Shasta is not delivering water to the SRSC and TCCA members, its releases would be reduced. Therefore, Shasta storage and cold water pool would be preserved through the Spring.

At the end of Spring, Sites has delivered CVP water instead of Shasta. The volume of delivered water is equivalent to the exchange volume preserved in Shasta. The exchange volume sustains Shasta cold water pool for use during the critical months of the cold water pool management season (August and September). In Late-Summer and Fall (August – November), the exchange volume augments releases from Shasta with cooler water and provides deliveries to Sites participants.

All exchange water must be released in the August through November period. Release of exchange water shall support the Cold Water Pool Management Action and Fall stability flows aspect of the Fall and Winter Refill and Redd Maintenance Action in the 2019 BiOps. As such, Shasta Exchanges would occur in years when forecasted temperature-based mortality of early life stage winter-run Chinook salmon would be reduced by a Shasta Exchange.

Summary of ROC on LTO Cold Water Pool Management

In the ROC on LTO Alternative 1 description, Reclamation proposes changes to cold water pool management during the temperature management period: May 15th to October 31st or when 95% of Winter-Run Chinook Salmon eggs have hatched and alevin have emerged, whichever is earlier. During the temperature management period, Reclamation will implement a tiered strategy based on Shasta cold water pool or total Shasta storage:

- Tier 1: May 1st cold water pool > 2.8 MAF (total Shasta storage > 4.1 MAF)
    - Daily average temperature of 53.5 deg F at Sacramento River below Clear Creek (CCR) throughout temperature management period
- Tier 2: May 1st cold water pool > 2.3 MAF (total Shasta storage > 3.5 MAF)
    - Daily average temperature of 53.5 deg F at CCR during hatch period (when highest concentration of hatching occurs; estimated as 2 months centered on August 7th)
    - Daily average temperature of 56 deg F at CCR for the rest of the temperature management period (before and after hatch period)
- Tier 3: May 1st total Shasta storage > 2.5 MAF
    - Allow daily average temperature above 53.5 deg F (up to 56 deg F) at CCR during hatch period
    - Attempt to maintain daily average temperature of 56 deg F at CCR for rest of temperature management period (before and after hatch period)
- Tier 4: May 1st total Shasta storage < 2.5 MAF
    - Discuss following intervention measures with USFWS and NMFS:
        - Reclamation would work with USFWS to increase hatchery production of Winter-Run Chinook Salmon
        - Reclamation would implement a downstream trap and haul strategy for the capture and transport of juvenile Chinook Salmon and Steelhead in the Sacramento River watershed.
        - In the event of two successive years with total egg-to-fry survival less than 15% in each year, Reclamation would convene a meeting of the Regional Directors of DWR, NMFS, USFWS, and CDFW to identify and implement actions to address the potential for a third year of low survival.

A decision tree of the tiered strategy is shown on page 5 (Figure 3.4-3 from the ROC on LTO FEIS).

Shasta Exchange Criteria

	Modeled Criteria	**Notes**
Exchange Period	**Dry:** Apr – Jun **Critical:** Apr - May	
Exchange Constraints		
Water year types	Dry and Critically Dry water years	
Temperature Management Tier	Tier 2, 3 and 4 years	
Minimum flow at Sacramento River at Keswick	Apr – May: 6,000 cfs Jun: 10,000 cfs	Exchanges in Dry and Critically Dry water years will not likely impact ROC on LTO Spring Pulse Flows action
Maximum allowable temperature at Sacramento River below Clear Creek	Apr – Jun: Tiers 2 and 3 years: 53.5 deg F Tier 4 years: 56 deg F	Per ROC on LTO FEIS
Sacramento Valley Conditions	Only during Excess conditions	
Release Period	Aug – Nov	Releases are prioritized in August through October.
Release Constraints		
Preferred flow at Sacramento River at Keswick	Aug: 12,000 cfs Sep: 10,000 cfs Oct: 5,000 cfs Nov: 5,000 cfs	Not explicitly modeled
Maximum volume	Limited to Banks Pumping Plant Capacity	Not an explicit constraint; model accounts for mass balance

[1]Several assumptions are required to assume exchange operation criteria per ROC on LTO operations. Main assumptions are provided in “Notes” column.

Shasta Exchange Benefits to ROC on LTO Cold Water Pool Management

- Tier 1 years:
  - No benefit
- Tier 2 years:
  - Decreasing releases in April through June could preserve Shasta cold water pool for more targeted release in the hatching period (described above).
- Tier 3 years:
  - Decreasing releases in April through June could preserve Shasta cold water pool for more targeted release in the hatching period (described above).
- Tier 4 years:
  - Little benefit – On its own, Sites could not benefit Shasta cold water pool in an appreciable manner. In combination with intervention measures, Sites may prove beneficial.

Attachment from ROC on LTO FEIS

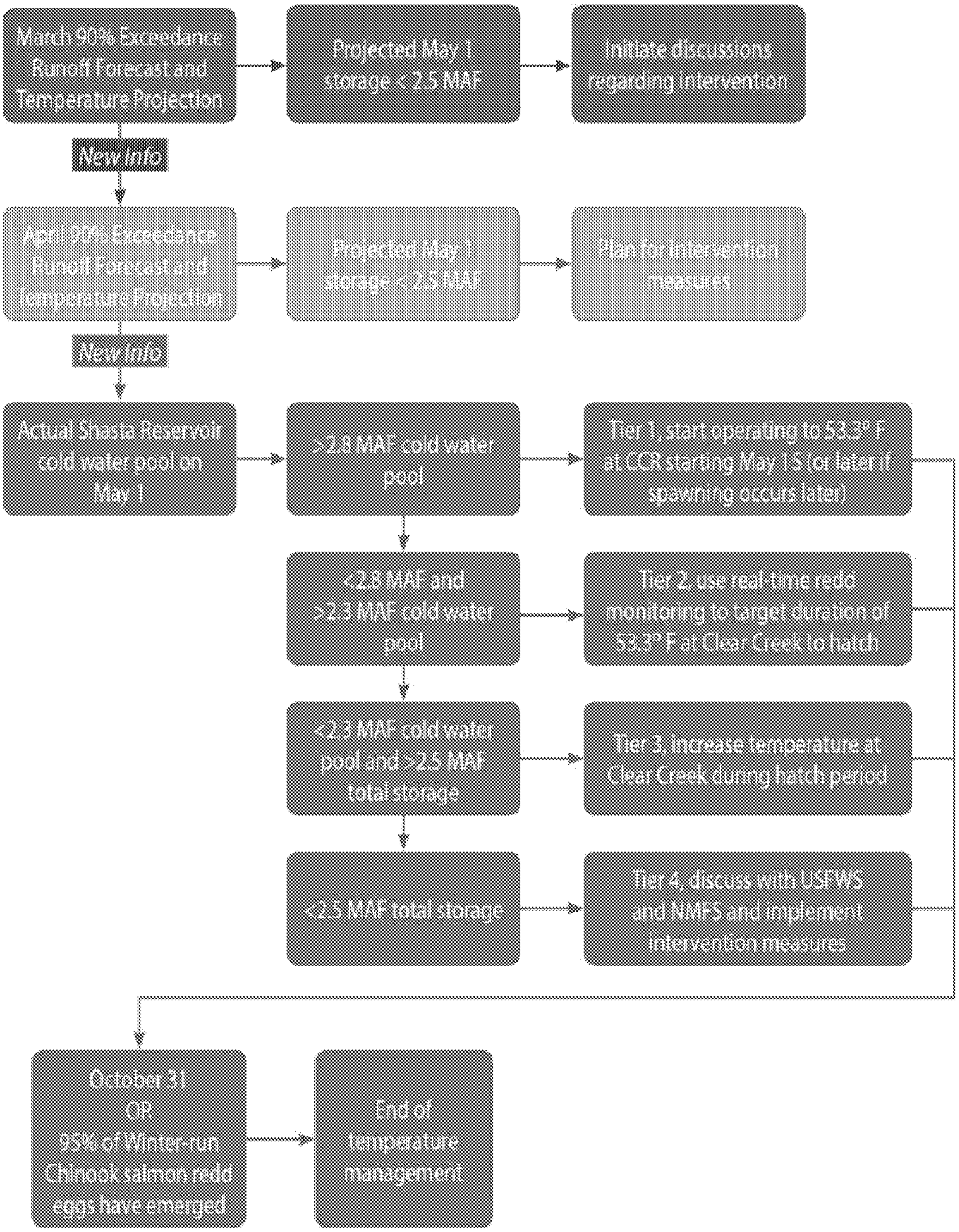

Figure 3.4-3. Decision Tree for Shasta Reservoir Temperature Management

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Attachment F

Memorandum Identifying Modeled Criteria for Oroville Exchanges

Draft – Subject to Revision
Sites Project: Lake Oroville Exchange Modeling Assumptions

This document summarizes Sites Reservoir exchange operations with Lake Oroville. Then, details and tabulates modeling assumptions.

Summary of Oroville Exchange Operation

The Oroville exchange is designed to support cold water pool management of Oroville and augment delivery of Sites water to Delta Participants during the transfer window. In June and July of Oroville exchange years, a portion of SWP obligated releases would come from Sites in lieu of Oroville, reducing releases from Oroville. Therefore, Oroville storage and cold water pool would be preserved through the end of July.

At the end of July, Sites has released SWP water instead of Oroville. The volume of released water is equivalent to the exchange volume preserved in Oroville. In the late-Summer and Fall (August – November), the exchange volume augments Oroville releases, provides deliveries to Sites participants, and supports Oroville cold water pool management.

Oroville Exchange Operational Criteria

Assumptions of Oroville exchange operational criteria are detailed below. These criteria are also summarized in Table 1.

Exchange Period

In terms of physical Oroville storage capacity for an exchange, there is no assumed limit. Instead, the Oroville exchange volume is estimated in June and July based on Sites' forecasted transfer volume to south of Delta Storage Partners in August through November. If the Oroville exchange volume overestimates Sites' ability to transfer water south of the Delta, a portion of Sites exchange water remains in Oroville. This remaining exchange water is subject to spill.

The Oroville exchange period is limited to June and July. The Oroville exchange period starts in June due to the high degree of uncertainty in forecasting south of Delta transfers. Forecasting south of Delta transfers any earlier than June would pose a significant risk to losing Sites water, via spills from Oroville. Additionally, to protect Green Sturgeon habitat, Feather River flows must not decrease in August.

In Wet and Above Normal water years, Sites transfers to south of Delta Storage Partners are limited. As such, Oroville exchanges occur in Below Normal, Dry and Critically Dry water year types.

Release Period

The majority of exchange water is released in August and September, as October and November must consider Feather River fall stability flow targets. Per fall stability flow requirements, total Oroville releases are limited to 2,500 cfs from October 16th through November.

All exchange water must be released in the August through November period. If exchange water is not released by the end of November, it is subject to spill.

Table 1. Oroville Exchange Criteria

	Modeled Criteria	**Notes**
Exchange Period	June – July	Estimating volume of exchange water before June poses risk of losing Sites water to spill; Per Green Sturgeon requirements, Sites may not decrease Feather River flows in August
Exchange Constraints		
Water year types	Below Normal, Dry and Critically Dry water years	Oroville exchange not necessary in Wet and Above Normal water year types
Exchange Volume		Limited to minimize potential for spills of Sites water from Oroville
Release Period	August – November	
Release Constraints		
Delta Export Capacity		Considers conveyance capacity based on Feather River, Sacramento River and Delta regulatory requirements, and Banks Pumping Plant capacity
Max Feather River Flow	Oct: 4,000 cfs Nov: 2,250 cfs	Feather River fall stability flow requirements. October average flow of 4,000 cfs assumes flow requirement of 2,500 cfs for the 16th through 31st. November average of 2,250 cfs to protect fall stability flow requirement.
Spills	Spill Sites water in December	Unused Sites water in Oroville is subject to spill

Sites

Topic: **Updated Mitigation Cost Estimate 2021** **2021 June 18**

Subject: **Update of 2016 AECOM mitigation cost estimate**

Background and Purpose

In October 2016, AECOM, on behalf of the Sites Project Authority (Authority), prepared a technical memorandum (TM) that presented the results of a mitigation measure evaluation and cost estimate that was developed as a planning-level tool for assessing costs *associated with implementing select mitigation measures for the Sites Reservoir (Sites Reservoir Feasibility Study Technical Memorandum – Mitigation Measure Evaluation and Cost Estimate 2016*). The 2016 evaluation and cost estimate of $500 million dollars (M) were based on the mitigation measures and the project description for the North-of-the-Delta-Offstream Storage Preliminary Administrative Draft EIR (DWR 2013). The mitigation measures evaluated were for impacts associated with Sites Reservoir Alternative C.

In October 2019, the Authority pursued a value planning process to determine if further refinements to the Project were warranted. Between October 2019 and April 2020, the Authority considered previous input from state and federal agencies, non-governmental organizations, elected officials, landowners, and local communities, and decided to "right size" the Project to better meet the needs of Sites Storage Partners, the statewide water supply and the environment. Multiple alternatives were considered during the value planning process that took into consideration the public and agency comments received on the 2017 Draft EIR/EIS (Sites Project Authority 2020).

The value planning process culminated in a Sites Project Value Planning Alternatives Appraisal Report (Value Planning Report) that was adopted by the Authority in April 2020 which included an updated mitigation cost estimate of $540M. In September 2020 the Authority approved to designate Alternative 1, which is based on Value Planning Alternative 7 (VP-7) as the Authority's preferred project alternative.

This memorandum (memo) summarizes the results of ICF International (ICF), HDR Engineering (HDR) and the Sites Project Authority's Environmental Planning and Permitting Manager's (EPP) update of AECOM's 2016 mitigation cost estimate using the Authority's revised preferred project alternative (collectively referred to as the mitigation team).

Methods

The mitigation team performed an evaluation of the cost and magnitude of the mitigation measures for resources that will be affected by project construction, operations, and maintenance. The resources evaluated were the same as those identified in AECOM's 2016 TM estimate, which included mitigation measure evaluation and cost estimate tables prepared in May 2016. The resources evaluated in the mitigation team's updated cost estimate included the following:

- Surface Water Quality,
- Aquatic Resources,
- Botanical Resources,
- Wildlife Habitat,
- Wetlands Habitat,
- Cultural Resources,
- Land Use,
- Paleontology, and
- Air Quality.

The mitigation measure evaluation and cost estimating process were built on the October 2016 technical memorandum and incorporate all applicable mitigation measures for these resources based on engineering, design, and planning work on the preferred alternative prior to April 15, of 2021. Assumptions used in the revised cost estimate were based on the following:

- Effects requiring mitigation were taken from the April/May 2021 Administrative Draft Revised Environmental Impact Report/Supplemental Environmental Impact Statement (REIR/SEIS)
- Outreach to experts in mitigation banking for current per-acre market pricing range of mitigation bank habitat and species credits.
- Use of the median per-acre costs estimates for specific mitigation credits (species, vegetation, agriculture, etc.)
- Assumed presence of all listed and rare species with a moderate or greater potential to occur as defined in the 2021 Administrative Draft REIR/SEIS due to lack of access for protocol-level species surveys and on-the-ground vegetation surveys
- Assumed presence of special aquatic habitat based on aerial photograph interpretation, as defined in the 2021 Administrative Draft REIR/SEIS, due to lack of access for on-the-ground vegetation surveys
- Assumed mitigation ratio of 2:1 for permanent effects and 1:1 ratio for temporary effects. Mitigation costs for restoration of temporary habitat effects assumed to be covered under construction-phase pricing
- Credit stacking where practicable (e.g., raptor foraging habitat and rare plants stacked with annual grasslands)
- Cultural resources costs that were developed & reviewed by resource specialists using current requirements and anticipated project effects
- Agricultural land cost based on preliminary outreach to Sites real estate team and 2019 land prices
- Exclusion of costs that were not exclusively mitigation (land acquisition costs, easements, right of entry fees, etc.)
- Costs represented by 2019 dollars

Revised Estimate

The results of the 2021 update are an increase in the anticipated mitigation costs of approximately $22.5M (Table 1). It is important to note that this estimate is a planning-level estimation and would be modified by changes in land costs, mitigation bank credit costs, permit terms, the results of future surveys to determine presence/absence of listed and rare surveys and escalation of all related mitigation costs. However, it is a still conservative estimate and very likely an overestimate of the final costs due to the lack of access to the vast majority of the project area necessitating the assumed presence of state and federally listed and rare species and special aquatic habitats that are likely to occur within the project footprint.

The June 2021 planning level cost estimated resulted in a cost increase for five resource categories, a decrease for one resource, and no-change for two resources. The following sections identify the primary drivers that result in net-changes to resource mitigation costs to each resource category.

- Sensitive Natural Communities and Wetland & Non-Wetland Waters Resources (previously Botanical Resources and Wetland Habitat). As indicated in Table 1, the June 2021 planning level cost for these resources represented an approximate $158.6 million increase from the 2020 VPE. Two primary factors contributed to the increase in cost. First, there was in increase in potentially affected habitat acreage for some sensitive natural communities, as determined based on recent aerial imagery interpretation as defined in the 2021 Administrative Draft REIR/SEIS. Secondly, and the most significant factor contributing factor to the cost increase, was that the median cost of a mitigation bank credit for each affected habitat was used instead of the average land cost. Mitigation bank credit costs factor in restoration components that will be required of the project that would not be covered by land costs alone. These include cost associated with design, establishment, maintenance, and monitoring of habitats as well as long-term endowments for land management of mitigation lands.

- Terrestrial Wildlife Resources/Wildlife Habitat (previously Wildlife Habitat). As indicated in Table 1, the June 2021 terrestrial wildlife resources and wildlife habitat planning level cost represented an approximate $56 million increase from the 2020 VPE. Two primary factors contributed to the increase in cost. First, there was in increase in potentially affected acreage for some species as determined based on modeled habitat acreages. Habitat models were used to determine potential suitable habitat in-lieu of protocol-level surveys and on the ground surveys which could not be performed at this time. Secondly, and the most significant factor contributing to the cost increase, was that the cost of a mitigation bank credit for each affected species was used instead of the average land cost. A decrease in suitable habitat acreage totals, and thus a resulting decrease in overall mitigation cost for wildlife resources, may be recognized when protocol-level field surveys can be performed.

- Agriculture and Forestry (previously Land Use). As indicated in Table 1, the June 2021 agriculture and forestry planning level cost represented an approximate $15 million increase from the 2020 VPE. The increase in mitigation associated with this resource may be attributed to the refinement of the mitigation measures for this resource in the 2021 Administrative Draft REIR/SEIS which consisted of the 1) purchase of agricultural conservation easements to preserve regional important farmland, and 2) to minimize impacts on Williamson Act Contracted lands. Based on preliminary outreach to Sites real estate team an approximate average cost per acre was developed and applied to the affected lands.

- Cultural and Paleontological Resources. The June 2021 cultural and paleontological planning level cost estimate represented an approximate $21.2 million decrease from the 2020 VPE. Cultural resources costs were developed and reviewed by resource specialists using current requirements and anticipated project effects including planning, pre-construction, construction, and operations-related costs. The mitigation cost development team further reviewed the overall cultural and paleontological resources cost estimate to determine which line items were specifically associated with project mitigation. Those costs are presented in Table 1.

- Air Quality. As indicated in Table 1, the June 2021 air quality planning level cost represented a $3.5 million increase from the 2020 VPE, which only included a mitigation cost to develop an emissions reduction plan. Based on current air quality regulations, the 2021 planning level cost included a line-item cost to mitigate for the estimated (modeled) greenhouse emissions associated with Site Reservoir construction.

Table 1: Results of 2021 mitigation cost estimate update as compared to the 2020 Value Planning update.

Resource	February 2020 Value Planning Estimate	June 2021 Planning Level Cost in 2019 Dollars
Aquatic Resources	$56,000,000	$56,000,000
Sensitive Natural Communities and Wetland & Non-Wetland Waters Resources	$174,800,000	$333,412,500
Terrestrial Wildlife Resources/Wildlife Habitat	$53,000,000	$109,215,500
Surface Water Quality	$200,000	$200,000
Agriculture & Forestry	$31,000,000	$46,059,000
Cultural & Paleontological Resources	$35,000,000	$13,840,300
Air Quality	$200,000	$3,750,000
Riverine-Based Species and Habitats (operations)	$150,000,000	N/A*
Contingencies and Forward Escalation	$40,000,000	N/A
Total	**$540,000,000**	**$562,477,300**

Sites

Topic: **Updated Mitigation Cost Estimate 2021** **2021 June 18**

Subject: **Update of 2016 AECOM mitigation cost estimate**

Background and Purpose

In October 2016, AECOM, on behalf of the Sites Project Authority (Authority), prepared a technical memorandum (TM) that presented the results of a mitigation measure evaluation and cost estimate that was developed as a planning-level tool for assessing costs *associated with implementing select mitigation measures for the Sites Reservoir (Sites Reservoir Feasibility Study Technical Memorandum – Mitigation Measure Evaluation and Cost Estimate 2016*). The 2016 evaluation and cost estimate of $500 million dollars (M) were based on the mitigation measures and the project description for the North-of-the-Delta-Offstream Storage Preliminary Administrative Draft EIR (DWR 2013). The mitigation measures evaluated were for impacts associated with Sites Reservoir Alternative C.

In October 2019, the Authority pursued a value planning process to determine if further refinements to the Project were warranted. Between October 2019 and April 2020, the Authority considered previous input from state and federal agencies, non-governmental organizations, elected officials, landowners, and local communities, and decided to "right size" the Project to better meet the needs of Sites Storage Partners, the statewide water supply and the environment. Multiple alternatives were considered during the value planning process that took into consideration the public and agency comments received on the 2017 Draft EIR/EIS (Sites Project Authority 2020).

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This memorandum (memo) summarizes the results of ICF International (ICF), HDR Engineering (HDR) and the Sites Project Authority's Environmental Planning and Permitting Manager's (EPP) update of AECOM's 2016 mitigation cost estimate using the Authority's revised preferred project alternative (collectively referred to as the mitigation team).

Methods

The mitigation team performed an evaluation of the cost and magnitude of the mitigation measures for resources that will be affected by project construction, operations, and maintenance. The resources evaluated were the same as those identified in AECOM's 2016 TM estimate, which included mitigation measure evaluation and cost estimate tables prepared in May 2016. The resources evaluated in the mitigation team's updated cost estimate included the following:

- Surface Water Quality,
- Aquatic Resources,
- Botanical Resources,
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- Wetlands Habitat,
- Cultural Resources,
- Land Use,
- Paleontology, and
- Air Quality.

The mitigation measure evaluation and cost estimating process were built on the October 2016 technical memorandum and incorporate all applicable mitigation measures for these resources based on engineering, design, and planning work on the preferred alternative prior to April 15, of 2021. Assumptions used in the revised cost estimate were based on the following:

- Effects requiring mitigation were taken from the April/May 2021 Administrative Draft Revised Environmental Impact Report/Supplemental Environmental Impact Statement (REIR/SEIS)
- Outreach to experts in mitigation banking for current per-acre market pricing range of mitigation bank habitat and species credits.
- Use of the median per-acre costs estimates for specific mitigation credits (species, vegetation, agriculture, etc.)
- Assumed presence of all listed and rare species with a moderate or greater potential to occur as defined in the 2021 Administrative Draft REIR/SEIS due to lack of access for protocol-level species surveys and on-the-ground vegetation surveys
- Assumed presence of special aquatic habitat based on aerial photograph interpretation, as defined in the 2021 Administrative Draft REIR/SEIS, due to lack of access for on-the-ground vegetation surveys
- Assumed mitigation ratio of 2:1 for permanent effects and 1:1 ratio for temporary effects. Mitigation costs for restoration of temporary habitat effects assumed to be covered under construction-phase pricing
- Credit stacking where practicable (e.g., raptor foraging habitat and rare plants stacked with annual grasslands)
- Cultural resources costs that were developed & reviewed by resource specialists using current requirements and anticipated project effects
- Agricultural land cost based on preliminary outreach to Sites real estate team and 2019 land prices
- Exclusion of costs that were not exclusively mitigation (land acquisition costs, easements, right of entry fees, etc.)
- Costs represented by 2019 dollars

Revised Estimate

The results of the 2021 update are an increase in the anticipated mitigation costs of approximately $22.5M (Table 1). It is important to note that this estimate is a planning-level estimation and would be modified by changes in land costs, mitigation bank credit costs, permit terms, the results of future surveys to determine presence/absence of listed and rare surveys and escalation of all related mitigation costs. However, it is a still conservative estimate and very likely an overestimate of the final costs due to the lack of access to the vast majority of the project area necessitating the assumed presence of state and federally listed and rare species and special aquatic habitats that are likely to occur within the project footprint.

The June 2021 planning level cost estimated resulted in a cost increase for five resource categories, a decrease for one resource, and no-change for two resources. The following sections identify the primary drivers that result in net-changes to resource mitigation costs to each resource category.

- Sensitive Natural Communities and Wetland & Non-Wetland Waters Resources (previously Botanical Resources and Wetland Habitat). As indicated in Table 1, the June 2021 planning level cost for these resources represented an approximate $158.6 million increase from the 2020 VPE. Two primary factors contributed to the increase in cost. First, there was in increase in potentially affected habitat acreage for some sensitive natural communities, as determined based on recent aerial imagery interpretation as defined in the 2021 Administrative Draft REIR/SEIS. Secondly, and the most significant factor contributing factor to the cost increase, was that the median cost of a mitigation bank credit for each affected habitat was used instead of the average land cost. Mitigation bank credit costs factor in restoration components that will be required of the project that would not be covered by land costs alone. These include cost associated with design, establishment, maintenance, and monitoring of habitats as well as long-term endowments for land management of mitigation lands.

- Terrestrial Wildlife Resources/Wildlife Habitat (previously Wildlife Habitat). As indicated in Table 1, the June 2021 terrestrial wildlife resources and wildlife habitat planning level cost represented an approximate $56 million increase from the 2020 VPE. Two primary factors contributed to the increase in cost. First, there was in increase in potentially affected acreage for some species as determined based on modeled habitat acreages. Habitat models were used to determine potential suitable habitat in-lieu of protocol-level surveys and on the ground surveys which could not be performed at this time. Secondly, and the most significant factor contributing to the cost increase, was that the cost of a mitigation bank credit for each affected species was used instead of the average land cost. A decrease in suitable habitat acreage totals, and thus a resulting decrease in overall mitigation cost for wildlife resources, may be recognized when protocol-level field surveys can be performed.

- Agriculture and Forestry (previously Land Use). As indicated in Table 1, the June 2021 agriculture and forestry planning level cost represented an approximate $15 million increase from the 2020 VPE. The increase in mitigation associated with this resource may be attributed to the refinement of the mitigation measures for this resource in the 2021 Administrative Draft REIR/SEIS which consisted of the 1) purchase of agricultural conservation easements to preserve regional important farmland, and 2) to minimize impacts on Williamson Act Contracted lands. Based on preliminary outreach to Sites real estate team an approximate average cost per acre was developed and applied to the affected lands.

- Cultural and Paleontological Resources. The June 2021 cultural and paleontological planning level cost estimate represented an approximate $21.2 million decrease from the 2020 VPE. Cultural resources costs were developed and reviewed by resource specialists using current requirements and anticipated project effects including planning, pre-construction, construction, and operations-related costs. The mitigation cost development team further reviewed the overall cultural and paleontological resources cost estimate to determine which line items were specifically associated with project mitigation. Those costs are presented in Table 1.

- Air Quality. As indicated in Table 1, the June 2021 air quality planning level cost represented a $3.5 million increase from the 2020 VPE, which only included a mitigation cost to develop an emissions reduction plan. Based on current air quality regulations, the 2021 planning level cost included a line-item cost to mitigate for the estimated (modeled) greenhouse emissions associated with Site Reservoir construction.

Table 1: Results of 2021 mitigation cost estimate update as compared to the 2020 Value Planning update.

Resource	February 2020 Value Planning Estimate	June 2021 Planning Level Cost in 2019 Dollars
Aquatic Resources	$56,000,000	$56,000,000
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Air Quality	$200,000	$3,750,000
Riverine-Based Species and Habitats (operations)	$150,000,000	N/A*
Contingencies and Forward Escalation	$40,000,000	N/A
Total	**$540,000,000**	**$562,477,300**

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/18/2021 10:40:04 AM
To: Luu, Henry [Henry.Luu@hdrinc.com]
CC: Alicia Forsythe [aforsythe@sitesproject.org]; Monique Briard (monique.briard@icf.com) [monique.briard@icf.com]; Oakes, Harry [Harry.Oakes@icf.com]; Williams, Daniel [Daniel.Williams@hdrinc.com]; Arsenijevic, Jelica [Jelica.Arsenijevic@hdrinc.com]
Subject: Dunnigan Mitigation Costs
Attachments: LandCover_Alt1_Alt2_Dunnigan.xlsx; SitesReservoir_MitigationCostEstimate_DunniganPipeline_Alt1_06172021.xlsx

Hi Henry,
We have been able to work through the Dunnigan mitigation costs, and as it currently stands we have an estimate of approximately $120M, which is a somewhat conservative estimate based on all the things we have previously talked about (access, assumed presence of listed spp and habitats, mitigation ratios, etc.). There are a few places in the estimate that I could split hairs on, but for the most part this fits with a level 4 estimate.

Attached are spreadsheets that 1) identifies the land cover that occurs within the Dunnigan project area and, 2) a cost estimate spreadsheet that details the specific mitigation cost. The cost estimate's tabs for Botanical and Wildlife are specific to the mitigation costs of the Dunnigan pipeline. However, we didn't modify the other tabs that were used to estimate overall project mitigation estimate (eg., aquatic, cultural) because we weren't certain how those cost might be shared among the Dunnigan/non Dunnigan users. If that is something you need us to do we can take a stab at it, but we will need to get a list of assumptions from you to work from.

Happy to jump on a call to discuss.

John

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

HDR
2379 Gateway Oaks Drive, Suite 200
Sacramento, CA 95833
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File Provided Natively

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/18/2021 12:07:32 PM
To: Luu, Henry [Henry.Luu@hdrinc.com]
CC: Alicia Forsythe [aforsythe@sitesproject.org]; Arsenijevic, Jelica [Jelica.Arsenijevic@hdrinc.com]
Subject: Dunnigan Mitigation Costs
Attachments: LandCover_Alt1_Alt2_Dunnigan.xlsx

Hi Henry,
We have been able to work through the Dunnigan mitigation costs and as it currently stands it is approximately $120M, which is a somewhat conservative estimate based on all the things we have previously talked about (access, assumed presence of listed spp and habitats, mitigation ratios, etc.). There are a few places in the estimate that I could split hairs on, but for the most part this fits with a level 4 estimate.

The attached spreadsheet's tabs for Botanical and Wildlife are specific to the mitigation costs of the pipeline. We didn't modify the other tabs that were used to estimate overall project costs (eg., aquatic, cultural) because we weren't certain how those cost might be shared among the Dunnigan users. If that is something you need us to do we can take a stab at it, but we will need to get a list of assumptions from you to work from.

Happy to jump on a call to discuss.

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File Provided Natively

Sites

Topic: **Updated Mitigation Cost Estimate 2021** **2021 June 18**

Subject: **Update of 2016 AECOM mitigation cost estimate**

Background and Purpose

In October 2016, AECOM, on behalf of the Sites Project Authority (Authority), prepared a technical memorandum (TM) that presented the results of a mitigation measure evaluation and cost estimate that was developed as a planning-level tool for assessing costs *associated with implementing select mitigation measures for the Sites Reservoir (Sites Reservoir Feasibility Study Technical Memorandum – Mitigation Measure Evaluation and Cost Estimate 2016*). The 2016 evaluation and cost estimate of $500 million dollars (M) were based on the mitigation measures and the project description for the North-of-the-Delta-Offstream Storage Preliminary Administrative Draft EIR (DWR 2013). The mitigation measures evaluated were for impacts associated with Sites Reservoir Alternative C.

In October 2019, the Authority pursued a value planning process to determine if further refinements to the Project were warranted. Between October 2019 and April 2020, the Authority considered previous input from state and federal agencies, non-governmental organizations, elected officials, landowners, and local communities, and decided to "right size" the Project to better meet the needs of Sites Storage Partners, the statewide water supply and the environment. Multiple alternatives were considered during the value planning process that took into consideration the public and agency comments received on the 2017 Draft EIR/EIS (Sites Project Authority 2020).

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Contingencies and Forward Escalation	$40,000,000	N/A
Total	**$540,000,000**	**$562,477,300**

From: Jerry Brown [jbrown@sitesproject.org]
Sent: 6/21/2021 7:52:34 AM
To: Luu, Henry [Henry.Luu@hdrinc.com]
Subject: FW: Sites Project - Draft Feasibility Cost Estimate

Can you check on this with John and provide a response to Mike today?

From: Michael Azevedo <mjazevedo@countyofcolusa.com>
Date: Monday, June 21, 2021 at 7:44 AM
To: Jerry Brown <jbrown@sitesproject.org>
Cc: "Luu, Henry" <Henry.Luu@hdrinc.com>, Rob Kunde <rkunde@wrmwsd.com>
Subject: RE: Sites Project - Draft Feasibility Cost Estimate

Thanks for the info Jerry.

Recently (believe it was coordinating committee call) I questioned the mitigation cost not being adjusted for the Delevan pipeline and Mr. Kunde correctly reminded me the Delevan Pipe line was stricken from consideration at the onset of the Value Planning effort. However, after reviewing my notes and consulting Supervisor Evans, it seems to us the cost of mitigation "was to be status qou due to habitat and species uncertainty". Is our recollection correct?

Michael J Azevedo
Colusa County Public Works
530.458.0466

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Monday, June 21, 2021 6:52 AM
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Subject: Re: Sites Project - Draft Feasibility Cost Estimate

Reservoir Committee Participants –

Recently, the following two additional items were added to the participant web portal (https://sitesproject.org/participant-portal-documents/) for your use:

1. Final draft of the 2021 mitigation cost update memo – This document includes the requested rationale for the increases in key resource areas as compared to the mitigation cost estimate used on the 2019 Value Planning study.

2. 2021 Feasibility Cost Estimate Fact Sheet – This document is being used to communicate with community leaders and other members of the public on the 2021 Feasibility Cost Estimate. This is in addition to the communication messages that were previously sent to you in the email below and were posted for your use in communicating to your senior management and boards/councils. The information is similar, but reformatted to a fact sheet.

Please don't hesitate to reach out to me or Henry Luu (henry.luu@hdrinc.com) if there is anything else you need in this regard.

Jerry

From: Jerry Brown <jbrown@sitesproject.org>
Date: Tuesday, June 8, 2021 at 3:53 PM
To: "'fhernandez@cityofamericancanyon.org'" <fhernandez@cityofamericancanyon.org>, "'DChisam@avek.org'" <DChisam@avek.org>, "'BenCarter@succeed.net'" <BenCarter@succeed.net>, "'RCheng@cvwd.org'" <RCheng@cvwd.org>, "'MJAzevedo@countyofcolusa.org'" <MJAzevedo@countyofcolusa.org>, "'CCwd2@frontiernet.net'" <CCwd2@frontiernet.net>, "'MKrause@dwa.org'" <MKrause@dwa.org>, "'TBettner@gcid.net'" <TBettner@gcid.net>, "'weghorst@irwd.com'" <weghorst@irwd.com>, "'RNeudeck@mwdh2o.com'" <RNeudeck@mwdh2o.com>, "'WVanderwaal@rd108.org'" <WVanderwaal@rd108.org>, "'dbartel@rrbwsd.com'" <dbartel@rrbwsd.com>, "'BobT@sbvmwd.com'" <BobT@sbvmwd.com>, "'jdavis@sgpwa.com'" <jdavis@sgpwa.com>, "'CKao@valleywater.org'" <CKao@valleywater.org>, "'DMarks@SCVWA.org'" <DMarks@SCVWA.org>, "'JimP@chiconut.com'" <JimP@chiconut.com>, "'Jamie@tnpfarms.com'" <Jamie@tnpfarms.com>, "'WVanderwaal@rd108.org'" <WVanderwaal@rd108.org>, "'Zachary@CanalFarms.com'" <Zachary@CanalFarms.com>, "'flylegacy@yahoo.com'" <flylegacy@yahoo.com>, "'RKunde@wrmwsd.com'" <RKunde@wrmwsd.com>, Amparo Flores <AFlores@zone7water.com>, "'JHolley@cityofamericancanyon.org'" <JHolley@cityofamericancanyon.org>, "'rhendryx@cityofamericancanyon.org'" <rhendryx@cityofamericancanyon.org>, "'DFlory@ppeng.com'" <DFlory@ppeng.com>, "'AnnCarter4@comcast.net'" <AnnCarter4@comcast.net>, "'kccarter13@gmail.com'" <kccarter13@gmail.com>, "'ccmp503@gmail.com'" <ccmp503@gmail.com>, "'pvasileva@cvwd.org'" <pvasileva@cvwd.org>, "'JBarrett@cvwd.org'" <JBarrett@cvwd.org>, "'sbermudez@cvwd.org'" <sbermudez@cvwd.org>, "'skasumovic@cvwd.org'" <skasumovic@cvwd.org>, "'GEvans@countyofcolusa.org'" <GEvans@countyofcolusa.org>, "'boardclerk@countyofcolusa.com'" <boardclerk@countyofcolusa.com>, "'1cjm@frontiernet.net'" <1cjm@frontiernet.net>, "'SBaca@dwa.org'" <SBaca@dwa.org>, "'SJohnson@dwa.org'" <SJohnson@dwa.org>, "'hdawley@gcid.net'" <hdawley@gcid.net>, "'KHightower@gcid.net'" <KHightower@gcid.net>, "'welch@irwd.com'" <welch@irwd.com>, "'vanderpl@irwd.com'" <vanderpl@irwd.com>, "'NHawk@mwdh2o.com'" <NHawk@mwdh2o.com>, "'LBair@RD108.org'" <LBair@RD108.org>, "'mmisuraca@rrbwsd.com'" <mmisuraca@rrbwsd.com>, "'HeatherD@sbvmwd.com'" <HeatherD@sbvmwd.com>, "'josem@sbvmwd.com'" <josem@sbvmwd.com>, "'leckhart@sgpwa.com'" <leckhart@sgpwa.com>, "'ELeitterman@valleywater.org'" <ELeitterman@valleywater.org>, "'scole@SCVWA.org'" <scole@SCVWA.org>, "'Jamie@tnpfarms.com'" <Jamie@tnpfarms.com>, "'jspoonerfarms@gmail.com'" <jspoonerfarms@gmail.com>, "'DRuiz@westsidewd.com'" <DRuiz@westsidewd.com>, "'SNicholas@wrmwsd.com'" <SNicholas@wrmwsd.com>, "'vpryor@zone7water.com'" <vpryor@zone7water.com>, "'cmahoney@zone7water.com'" <cmahoney@zone7water.com>, "'lxie@zone7water.com'" <lxie@zone7water.com>
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Subject: Sites Project - Draft Feasibility Cost Estimate

Reservoir Committee Participants,

As you know, the project team has been working with Reservoir Committee workgroups over the past 3 months to develop a feasibility design cost estimate that incorporates the latest design information and value engineering options for the project alternatives. The final feasibility cost estimate is scheduled to be considered for acceptance at this month's Joint Reservoir Committee/Authority Board meeting on June 23, 2021.

This work has resulted in a feasibility design cost estimate increase of ~30% (in 2021 dollars) over the appraisal level cost estimate that came out of value planning. To assist you in communicating the cost changes to your agency's management, boards and councils the project team has put together the attached communications messages. We're getting these to you in advance of the June 23 meeting so that your internal communications can occur prior to the public release of the estimate. Also, for those of you seeking additional details about the cost estimate, we have placed the following reference documents on the participant web portal (https://sitesproject.org/participant-portal-documents/):

1. Feasibility Design Considerations TM – a brief summary of the Sites Project Authority feasibility design and considerations.
2. HR Feasibility Cost Estimate TM – basis of feasibility cost estimate for the reservoir and roadway project features.
3. HC Feasibility Design Basis of Estimate – basis of feasibility cost estimate for the conveyance project features.

As a reminder, the project cost estimate is one of several factors that affect the project's affordability. The project team will present all the updated information around affordability at our July 23 affordability workshop.

Please don't hesitate to reach out to me or Henry Luu (henry.luu@hdrinc.com) if there is anything else you need in this regard.

Jerry

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From: Davis-Fadtke, Kristal@Wildlife [Kristal.Davis-Fadtke@wildlife.ca.gov]
Sent: 6/21/2021 3:50:41 PM
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CC: Spranza, John [john.spranza@hdrinc.com]; Uttley, Paige@Wildlife [Paige.Uttley@wildlife.ca.gov]; Williams, Jonathan@Wildlife [Jonathan.Williams@wildlife.ca.gov]; Kearns, Zachary@Wildlife [Zachary.Kearns@Wildlife.ca.gov]
Subject: CDFW Comments on Admin Draft Chapters
Attachments: AdminDraft_Group3_Ch11_AquaticBiologicalResources_Sites_REIR-SEIS_06012021_CDFW comments.docx; AdminDraft_Group2_App_11A_Aquatic_Species_Life_Histories_05242021_CDFW comments.docx; AdminDraft_Group2_App_11F_Smelt_Analysis_05242021_CDFW comments.docx; AdminDraft_Group3_App_11B_Fisheries_Impact_Assess_Methods_05282021_CDFW comments.docx; AdminDraft_Group3_31_Cumulative_Impacts_06012021_CDFW comments.docx; AdminDraft_Group3_28_Climate_Change_06012021_CDFW comments.docx; AdminDraft_Group3_Ch05_Surface_Water_Resources_06012021_CDFW comments.docx; AdminDraft_Group3_App2D_Best_Management_Practices_06012021_CDFW comments.docx

Hello Ali,

Please find attached our comments on the remaining chapters. We recognize these are administrative drafts that are still under development and, consequently, not all the chapters are complete and analyses are missing. Additionally, we did not receive the following appendices: 4A, 5A, 5C, 6D, 11G, 11I, and 11M. Appendix 11I was received last week, but not in time for us to review it and provide comments by today. Without supporting data and with incomplete sections, our review was limited in scope and depth. I hope the comments we have provided will be useful to you in finalizing a draft for public review. We anticipate having additional comments upon review of completed analyses and supporting data. Please do not hesitate to contact me if you have any questions about the comments we have provided.

Best,

Kristal

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Chapter 11 Aquatic Biological Resources

11.1 Introduction

This chapter describes the environmental setting and environmental impact area for fish and aquatic resources in the Project area, methods of analysis, analysis of impacts that could result from construction, operation, and maintenance of the project, and provides mitigation measures to reduce the effects of any potentially significant impacts. The environmental impact area for aquatic biological resources is based on the area that could be affected by the project. This includes the following areas:

- Sacramento River from Keswick Dam to the Legal Sacramento–San Joaquin River Delta (Delta)
- Lower American River from Nimbus Dam to its confluence with the Sacramento River
- Lower Feather River from Oroville Dam to its confluence with the Sacramento River
- Funks and Stone Corral Creeks
- CBD
- Flood Bypasses (i.e., Butte Basin, Sutter Bypass, and Yolo Bypass)
- Delta
- Suisun Marsh and Bay
- San Pablo Bay
- San Francisco Bay

For the purpose of analysis, the environmental impacts were divided into a construction impacts and operations impacts:

- Construction Impacts: includes areas where construction activities would be conducted plus buffer zones of varying sizes around those areas, and the areas that would be inundated by under the alternative reservoir sizes.
- Operations Impacts: include areas potentially impacted by operations of the Project to divert and deliver water and maintenance of the Project facilities.

The analysis used multiple factors to account for the potential effects of the Project on State and federally-listed species and their critical habitats, special-status species and their aquatic habitat, and other species of management concern and their aquatic habitats (see below for additional discussion). Where data were available, several analytical tools, including water operations/hydrologic models (e.g., California Water Resources Simulation Model II [CALSIM II], Delta Simulation Model II [DSM2]), were used to screen for potential direct and indirect effects and where the results indicated essentially no difference between the Project and No Action, no effect was assumed. Areas of no effect included the Trinity River, Trinity Lake, and the San Joaquin River watershed upstream of the Delta. The presence of species and their required habitat in the Project area affected by construction further defined the geographic extent of the study area.

Tables 11-1a and 11-1b summarize the CEQA determinations and NEPA conclusions for construction, operation, and maintenance impacts, respectively, between alternatives.

Table 11-1a: Summary of Construction Impacts and Mitigation Measures for Aquatic Biological Resources

Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
Impact FISH-1: Construction Effects on Special-Status Fish			
No Project	NI		NI
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE

Notes:
NI = CEQA determination of no impact
LTS = CEQA determination of less-than-significant impact
LTSM = CEQA determination of less than significant with mitigation
SU = CEQA determination of significant and unavoidable
B = NEPA conclusion of beneficial effects
NE = NEPA conclusion of no effect or no adverse effect
AE = NEPA conclusion of adverse effect
SA = NEPA conclusion of substantial adverse effect

Table 11-1b: Summary of Operations and Maintenance Impacts and Mitigation Measures for Aquatic Biological Resources

Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
Impact FISH-2: Operations Effects on Winter-Run Chinook Salmon			
No Project	NI	-	NI
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FISH-3: Operations Effects on Spring-Run Chinook Salmon			

Commented [CC1]: Highly questionable that a project of this magnitude results in less than significant impacts to all fish species with no mitigation. It will require significant effort to evaluate this material line by line, review references cited for accuracy, review appendices, and examine modeling inputs and verify results. This level of effort is beyond the scope of the timelines and due dates for this review.

Commented [CC2R1]: In regard to modeling results, we will note again that biological responses and impacts to proposed project occur on a daily time step. The use of layered modeling inputs resulting in monthly averaged results is not capable of detecting impacts that occur on a daily or short term time steps. While we acknowledge the need to evaluate impacts through this modeling approach due to the complexity of this proposed project, we consider these results as a lines of evidence but not definitive stand alone confirmation that significant impacts do or do not occur. Additionally, we consider magnitudes of impacts as determined by these modeling approaches to be evidence of general trends but also to be highly uncertain.

Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
No Project	NI	-	NI
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FISH-4: Operations Effects on Fall-Run/Late Fall–Run Chinook Salmon			
No Project	NI	-	NI
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FISH-5: Operations Effects on Central Valley Steelhead			
No Project	NI	-	NI
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FISH-6: Operations Effects on Green Sturgeon			
No Project	NI	-	NI
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FISH-7: Operations Effects on White Sturgeon			
No Project	NI	-	NI
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FISH-8: Operations Effects on Delta Smelt			
No Project	NI	-	NI
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FISH-9: Operations Effects on Longfin Smelt			
No Project	NI	-	NI
Alternative 1	LTSM/NE	MM Fish 9-1 Tidal Habitat Restoration for Longfin Smelt	LTS/NE
Alternative 2	LTSM/NE	MM Fish 9-1 Tidal Habitat Restoration for Longfin Smelt	LTS/NE
Alternative 3	LTSM/NE	MM Fish 9-1 Tidal Habitat Restoration for Longfin Smelt	LTS/NE
Impact FISH-10: Operations Effects on Lampreys			
No Project	NI	-	NI
Alternative 1	LTS/NE	-	LTS/NE

Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FISH-11: Operations Effects on Native Minnows (Sacramento Splittail, Sacramento Hitch, Hardhead, and Central California Roach)			
No Project	NI	-	NI
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FISH-12: Operations Effects on Starry Flounder and Northern Anchovy			
No Project	NI	-	NI
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FISH-13: Operations Effects on Striped Bass			
No Project	NI	-	NI
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FISH-14: Operations Effects on American Shad			
No Project	NI	-	NI
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FISH-15: Operations Effects on Threadfin Shad			
No Project	NI	-	NI
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FISH-16: Operations Effects on Black Bass (Largemouth Bass, Smallmouth Bass, and Spotted Bass)			
No Project	NI	-	NI
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FISH-17: Operations Effects on California Bay Shrimp			
No Project	NI	-	NI
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FISH-18: Operations Effects on Reservoir Species			
No Project	NI	-	NI

Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FISH-19: Operations Effects on Southern Resident Killer Whale			
No Project	NI	-	NI
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact FISH-20: Maintenance Effects on Fish and Aquatic Biological Resources			
No Project	NI	-	
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE

Notes:
NI = CEQA determination of no impact
LTS = CEQA determination of less-than-significant impact
LTSM = CEQA determination of less than significant with mitigation
SU = CEQA determination of significant and unavoidable
B = NEPA conclusion of beneficial effects
NE = NEPA conclusion of no effect or no adverse effect
AE = NEPA conclusion of adverse effect
SA = NEPA conclusion of substantial adverse effect

11.2 Environmental Setting

11.2.1. Fish and Aquatic Species of Management Concern

Aquatic habitats include riverine and estuarine habitats. As noted above, these include San Francisco Bay, San Pablo Bay, Suisun Marsh, Suisun Bay, and the legal Sacramento–San Joaquin River Delta (Delta), and extends upstream within the channels of the Sacramento River to Keswick Dam, the American River to Nimbus Dams, Feather River to Oroville Dam, Funks and Stone Corral Creeks, the CBD, and flood bypasses (i.e., Butte Basin, Sutter Bypass, and Yolo Bypass). Fish species that occur in each of the aquatic habitats are listed in Table 11-2.

In this EIR, fish and aquatic species were selected for analysis based on their importance and/or vulnerability and their potential to be affected by construction activities, operations (diversions) associated with the Project, and changes in Central Valley Project (CVP) and State Water Project (SWP) system-wide operations that would be expected to be implemented in response to, or in conjunction with, the Project alternatives (Table 11-2). These fish species, referred to herein as the species of management concern, include species listed by state or federal agencies as endangered or threatened or listed by Moyle et al. (2015) as Species of Special Concern (critical, high or moderate). Species of management concern also include those of tribal, commercial, or recreational importance. In addition to the species listed in Table 11-2, southern resident killer whale (*Orcinus orca*, federally listed as endangered) is also considered because of potential effects to their prey, Chinook salmon. The species of management concern for this EIR are listed in Table 11-2 with the general geographic areas where they occur. Species descriptions are provided in Appendix 11A.

Table 11-2. Aquatic Species of Management Concern by Area of Occurrence

Species and *ESU/DPS*	Federal Status	State Status	Tribal, Commercial, or Recreational Importance	Geographic Areas of Occurrence within Region
Winter-run Chinook Salmon *Sacramento River ESU*	Endangered	Endangered	Yes	Sacramento River, Bay-Delta
Spring-run Chinook Salmon *Central Valley ESU*	Threatened	Threatened	Yes	Sacramento, Feather, and American Rivers, Bay-Delta
Fall-Run/Late Fall–Run Chinook Salmon *Central Valley ESU*	Species of Concern	Species of Special Concern	Yes	Sacramento, Feather, and American Rivers, Bay-Delta
Steelhead *California Central Valley DPS*	Threatened	None	Yes	Sacramento, Feather, and American Rivers, Bay-Delta
Delta Smelt	Threatened	Endangered	No	Delta and Suisun Marsh
Longfin Smelt *Bay Delta DPS*	Candidate	Threatened, Species of Special Concern	No	Bay-Delta
Green Sturgeon *Southern DPS*	Threatened	Species of Special Concern	Yes	Sacramento and Feather Rivers, Bay-Delta
White Sturgeon	None	Species of Special Concern	Yes	Sacramento, Feather, and American Rivers, and Bay-Delta
Pacific Lamprey	Species of Concern	Species of Special Concern	Yes	Sacramento, Feather, and American Rivers, and Bay-Delta
River Lamprey	None	Species of Special Concern	Yes	Sacramento, Feather, and American Rivers, and Bay-Delta
Sacramento Hitch	None	Species of Special Concern	No	Sacramento, Feather, and American Rivers, Funks Creek, Stone Corral Creek, CBD, and Delta
Sacramento Splittail	None	Species of Special Concern	No	Sacramento, Feather, and American Rivers, Delta, and Suisun Marsh

Commented [KNK3]: Phillis et al 2017 Endangered winter-run Chinook salmon rely on diverse rearing habitats in a highly altered landscape.

Winter-run Chinook salmon are at risk of extinction primarily due to lost habitat.
•We find that 44–65% of surviving adults reared in non-natal habitats as juveniles.
•Most habitats were not previously known to be demographically important.
•Non-natal habitats likely provide growth and survival benefits.
•Protection of these critical habitats could help prevent species extinction

Species and *ESU/DPS*	Federal Status	State Status	Tribal, Commercial, or Recreational Importance	Geographic Areas of Occurrence within Region
Hardhead	None	Species of Special Concern	No	Sacramento, Feather, and American Rivers, and Delta
Sacramento Perch	None	Species of Special Concern	No	In pond at Gray Lodge Wildlife Area
Central California Roach	None	Species of Special Concern	No	Sacramento, Feather, and American Rivers, CBD, Stone Corral Creek, and Delta
Starry Flounder	None	None	Yes	Bay-Delta
Northern Anchovy	None	None	Yes	Bay-Delta
Striped Bass	None	None	Yes	Sacramento, Feather, and American Rivers, and Bay-Delta
American Shad	None	None	Yes	Sacramento, Feather, and American Rivers, and Bay-Delta
Threadfin Shad	None	None	Yes	Delta and Suisun Marsh
Black Bass (Largemouth, Smallmouth, Spotted)	None	None	Yes	Sacramento, Feather, and American Rivers, Delta and Suisun Marsh, reservoirs
California Bay Shrimp	None	None	Yes	Bay-Delta

ESU = evolutionarily significant unit; DPS = distinct population segment.

11.2.2. Habitat Conditions and Environmental Stressors

The sections below describe and characterize habitats with properties needed to support the different life stages of the fish species of management concern that rely on the geographic area being evaluated. Environmental stressors are factors that limit a habitat's capacity to support the life stages present. The descriptions focus on stressors that potentially would be affected by the Project. For example, habitat availability for salmonid egg and alevin life stages refers to, among other properties, river bottom substrates with clean suitably sized gravels, suitable and stable water levels, cool water temperatures, and adequate flow to supply dissolved oxygen (DO) to the developing eggs and alevins. Environmental stressors potentially limiting spawning habitat availability could include inadequate flow, warm water temperatures, or insufficient spawning gravels, for example.

11.1.1. Delta and Suisun Bay/Marsh

11.2.2.1. Description of Delta and Suisun Bay/Marsh

Ecologically, the Delta consists of three geographic regions: (1) the north Delta freshwater flood basins composed primarily of freshwater inflow from the Sacramento River system; (2) the south Delta distributary channels composed of predominantly San Joaquin River system inflow; and

(3) the central Delta tidal islands landscape wherein the Sacramento, San Joaquin, and eastside tributary flows converge and tidal influences from San Francisco Bay are greater.

Suisun Bay and Marsh are ecologically linked with the western portions of the central Delta, although with different tidal and salinity conditions than are found upstream. Suisun Bay and Marsh are the largest expanse of remaining tidal marsh habitat within the greater San Francisco Estuary ecosystem and include Honker, Suisun, and Grizzly bays; Montezuma and Suisun sloughs; and numerous other smaller channels and sloughs.

The Butte Basin, Sutter Bypass, and Yolo Bypass convey flood flows from the Sacramento Valley, including the Sacramento River, Feather River, American River, and westside tributaries.

11.2.2.2. Habitat Conditions and Environmental Stressors in Delta and Suisun Bay/Marsh

A summary of habitat conditions and environmental stressors in the Delta and Suisun Bay/Marsh was recently provided by the California Department of Water Resources (DWR) (2020). The following is largely taken from that description and includes consideration of the Delta and Suisun Bay/Marsh as well as the Yolo Bypass.

Delta

Aquatic Habitat

Flow management in the Delta has altered the aquatic habitat by (1) changing aspects of the historical flow regime (e.g., timing, magnitude, duration) that supported life history traits of native species; (2) limiting access to or quality of habitat; (3) contributing to conditions better suited to invasive, nonnative species (e.g., reduced spring flows, increased summer inflows and exports, and low and less-variable interior Delta salinity [Moyle and Bennett 2008]); and (4) causing net reverse flows in channels leading to CVP and SWP south Delta export facilities that can entrain fish (Mount et al. 2012). Native species of the Delta are adapted to and depend on variable flow conditions at multiple scales, which is influenced by the region's dramatic seasonal and interannual climatic variation. In particular, most native fishes evolved reproductive, or outmigration timing associated with historical peak flows during spring (Moyle 2002).

Researchers have studied the impacts of water export on Delta flow and velocity using hydrodynamic models. The Salmonid Scoping Team (SST) recently provided a summary of these effects (Salmonid Scoping Team 2017). The SST concluded that the effect of the SWP water exports on Delta flow and velocity varied as a function of distance from the facility as well as a function of export volume, total Delta inflow, and tidal action. While export rates had little effect on distributaries such as Georgiana Slough, a much greater effect exists in the south Delta, particularly in Old River near the CVP and SWP south Delta export facilities.

Commented [CC4]: This conclusion is based on one journal article in which the authors assert that water velocity affects fish therefore only velocity should be examined. Cavallo and Zeug 2015. The paper is more a hypothesis that is poorly supported at it's foundation. Interesting but hardly definitive.

Water temperatures in the Delta follow a seasonal pattern of winter coldwater conditions and summer warmwater conditions, largely because of the region's Mediterranean climate and its alternating cool/wet and hot/dry seasons. Currently in the Delta, the most significant changes in water temperatures have been in the form of increased summer water temperatures over large areas of the Delta because of high summer ambient air temperatures and, to a lesser extent, the increased temperature of river inflows, reduced quantities of freshwater inflow, and modified tidal and groundwater hydraulics (Kimmerer 2004; Mount et al. 2012; National Research Council 2012; Wagner et al. 2011). Water temperatures in summer now approach or exceed the upper thermal tolerances (e.g., 20 degrees Celsius [°C] to 25°C for coldwater fish species such as salmonids and Delta-dependent species such as delta smelt [*Hypomesus transpacificus*]). This is especially true in parts of the south Delta and San Joaquin River, potentially restricting the distribution of these species and precluding previously important rearing areas (National Research Council 2012).

Commented [CC5]: This is also true for Longfin Smelt which experience thermal stress at 20C. I suggest adding a reference to Jeffries et al. 2016. Effects of high temperatures on threatened estuarine fishes during periods of extreme drought. J Exp Biol 1 June 2016; 219 (11): 1705–1716.

Landscape-scale changes resulting from tidal land reclamation for agriculture and flood management infrastructure, along with flow modifications, have eliminated most of the historical tidal wetlands and floodplain habitat in the Delta and its tributaries, thereby degrading and diminishing Delta habitat for native plant and animal communities (Mount et al. 2012). The reduction of hydrologic variability and landscape complexity, coupled with degradation of water quality, has supported invasive aquatic species, which have further degraded conditions for native species. Consequently, the Delta hasundergone an ecological regime shift unfavorable to many native species (Baxter et al. 2010), including delta smelt, longfin smelt (*Spirinchus thaleichthys*), Sacramento splittail (*Pogonichthys macrolepidotus*), green sturgeon and white sturgeon, and Chinook salmon (Jassby et al. 1995; Kimmerer 2002a; Rosenfield and Baxter 2007; Kimmerer et al. 2009; Fish 2010; Perry et al. 2012; Thomson et al. 2010; Feyrer et al. 2010; Loboschefsky et al. 2012; Mount et al. 2012; Heublein et al. 2017).

In response to these landscape conditions, DWR is working with California EcoRestore (see the below discussion related to regulatory setting) to advance the restoration of at least 30,000 acres of tidal wetland, floodplain habitat, and riparian habitat throughout the Delta. DWR is the lead agency on 28 of the 30 EcoRestore projects, including but not limited to Decker Island, Bradmoore Island, Lookout Slough Tidal Habitat Restoration and Flood Improvement Project, Winter Island, and the Tule Red Project (California Department of Water Resources 2019a). As these projects are implemented, they would be adaptively managed to improve habitat for delta smelt and other species. DWR is also working with other resource agencies, including the California Department of Fish and Wildlife (CDFW), which is leading the effort, to explore the feasibility of restoring a portion of Franks Tract to reduce invasive weeds and predation while increasing turbidity and fish food production (California Department of Fish and Wildlife 2018a).

Salinity

Salinity is a critical factor influencing the distribution of aquatic communities in the Delta. Although estuarine fish species are generally tolerant of a range of salinities, this tolerance varies by species and life stage. Some species can be highly sensitive to excessively low or high salinity during physiologically vulnerable periods, such as reproductive and early life stages. While most of the Delta contains fresh water year-round due to inflows from rivers, the south Delta can have low salinity because of agricultural return water and the west Delta contains a fresh water/salt water prism typical of estuaries. This tidal prism moves east and west in the delta with the tides and the distance it moves may be influenced by the volume of fresh water inflow from tributary rivers, primarily the Sacramento River.

X2, which represents the location of the 2 parts per thousand (ppt) isohaline and is measured in kilometers as the distance to the Golden Gate Bridge, has been used to determine the location of the low salinity zone and the extent of habitat for oligohaline fish species and their habitat.

Several researchers (e.g., Feyrer 2007, 2010; Kimmerer 2002a, 2002b; KImmer et al. 2009, Jassby et al. 1995) have explored the relationship between X2 and population status of delta smelt (*Hypomesus transpacificus*), longfin smelt (*Spirinchus thaleichthys*), and other pelagic fishes in the Delta. The U.S. Fish and Wildlife Service (2008 and 2019) and the California State Water Resources (Decision D 1641) have relied on this work to establish the location of X2 as a factor in regulating the effect of the State and Federal water projects on habitat quantity and quality for these species.

More recent research (e.g., Hutton et al. 2015, Mac Nally et al. 2010, Murphy and Weiland 2019) has demonstrated the limitations of using a single location for evaluating salinity trends in the estuary, questioned the appropriateness of a single measure (X2) as a surrogate for regulating the complexity between flow, salinity, habitat quality, and population response of delta pelagic fishes in the estuary. Nevertheless, X2 remains a regulatory standard for maintenance of fall habitat for delta smelt (CWQCB D-1641).

Commented [CC6]: X2 is used as a regulatory standard for water quality throughout the year and is also correlated with the abundance of other aquatic species including prey items for listed fish. Provide a more thorough discussion of regulations and ecological processes related to X2.

Nutrients and Foodweb Support

Nutrients are essential components of terrestrial and aquatic environments because they provide a resource base for primary producers. Typically, in freshwater aquatic environments, phosphorus is the primary limiting macronutrient, whereas in marine aquatic environments, nitrogen tends to be limiting. A balanced range of abundant nutrients provides optimal conditions for maximum primary production (phytoplankton), a robust foodweb (zooplankton and macroinvertebrates), and productive fish populations. However, changes in nutrient loadings and forms, excessive amounts of nutrients, and altered nutrient ratios can lead to a suite of problems in aquatic ecosystems, such as low DO concentrations, un-ionized ammonia, excessive growth of toxic forms of cyanobacteria, and changes in components of the foodweb. Nutrient concentrations in the Delta have been well studied (Jassby et al. 2002; Kimmerer 2004; Van Nieuwenhuyse 2007; Glibert et al. 2011, 2014).

Estuaries are commonly characterized as highly productive nursery areas for numerous aquatic organisms. Nixon (1988) noted that there is a broad continuum of primary productivity levels in different estuaries, which affects fish production and abundance. Compared to other estuaries, pelagic primary productivity in the upper San Francisco Estuary is relatively poor, and a relatively low fish yield is expected (Wilkerson et al. 2006). In the Delta and Suisun Marsh, this appears to result from turbidity, clam grazing (Jassby et al. 2002), and nitrogen and phosphorus dynamics (Wilkerson et al. 2006; Van Nieuwenhuyse 2007; Glibert et al. 2011, 2014).

A significant long-term decline in phytoplankton biomass (chlorophyll a) and primary productivity to low levels has occurred in the Suisun Bay region and the Delta (Jassby et al. 2002). Shifts in nutrient concentrations, such as high levels of ammonium and nitrogen relative to phosphorus (i.e., the ratios of nitrogen to phosphorus and ammonium to nitrate), may contribute to the phytoplankton reduction and to changes in algal species composition in the San Francisco Estuary (Wilkerson et al. 2006; Dugdale et al. 2007; Lehman et al. 2005, 2008a, 2010; Glibert et al. 2011, 2014). Low and declining primary productivity in the Estuary may be contributing to the long-term pattern of relatively low and declining biomass of pelagic fishes (Jassby et al. 2002).

The introductions of two clams from Asia have led to major alterations in the foodweb in the Delta. Overbite clams (*Potamocorbula amurensis*) are most abundant in the brackish and saline water of Suisun Bay and the west Delta, and Asian clams (*Corbicula fluminea*) are most abundant in the fresh water of the central Delta. These filter feeders significantly reduce the phytoplankton and zooplankton concentrations in the water column, reducing food availability for native fishes such as delta smelt and young Chinook salmon (Feyrer et al. 2007; Kimmerer 2002a; Kimmerer and Thompson 2014).

In addition, introduction of the clams led to the decline of native copepods of higher food quality and the establishment of poorer quality nonnative copepods. The clams have been cited for the decline in *Neomysis mercedis* (Orsi and Mecum 1986; Feyrer et al. 2003), the shift in distribution of anchovies (Kimmerer 2006) and young-of-the-year striped bass (Kimmerer et al. 2000; Feyrer et al. 2003; Sommer et al. 2007), as well as the decline in diatoms (Kimmerer 2005) and several zooplankton species (Kimmerer et al. 1994). The impact of the clams on chlorophyll a and the Delta ecosystem is also reflected by a shift in many of the original correlations between species abundance and X2, that occurred after the establishment of the clams (Kimmerer 2002b; Sommer et al. 2007).

More recently, the cyclopoid copepod, *Limnoithona*, has rapidly become the most abundant copepod in the Delta since its introduction in 1993 (Hennessy and Enderlein 2013). This species is hypothesized to be a low-quality food source and intraguild competitor of native and nonnative calanoid copepods (Gould et al. 2010). The overbite clam also has been implicated in the reduction of the native opossum shrimp, a preferred food of Delta native fishes such as Sacramento splittail and longfin smelt (Feyrer et al. 2003).

Studies on food quantity and quality have been relatively limited in the San Francisco Estuary, with limited information available regarding long-term trends. Nonetheless, several studies have documented or suggested the food limitations for aquatic species in the estuary, including zooplankton (Mueller-Solger et al. 2002; Kimmerer et al. 2005), delta smelt (Bennett 2005; Bennett et al. 2008), Chinook salmon (Sommer et al. 2001), Sacramento splittail (Greenfield et al. 2008), striped bass (Loboschefsky et al. 2012), and largemouth bass (Nobriga 2009).

Turbidity

Commented [CC7]: Turbidity has been identified as an important habitat component for Delta Smelt. Provide some discussion on turbidity as a component of Delta Smelt habitat.

Turbidity is an important water quality component in the Delta that affects physical habitat through sedimentation and foodweb dynamics by means of attenuation of light in the water column. Light attenuation, in turn, affects the extent of the photic zone where primary production can occur and the ability of predators to locate prey and for prey to escape predation.

Turbidity has been declining in the Delta, as indicated by sediment data collected by the U.S. Geological Survey since the 1950s (Wright and Schoellhamer 2004), and the decline has important implications for foodweb dynamics, nonnative submerged aquatic vegetation growth, and predation. Higher water clarity is at least partially caused by increased water filtration and plankton grazing by highly abundant overbite clams and other benthic organisms (Kimmerer 2004; Greene et al. 2011) and potentially by filtration by high densities of aquatic vegetation (Hestir et al. 2016). High nutrient loads coupled with reduced sediment loads and higher water clarity could contribute to plankton and algal blooms and overall increased eutrophic conditions in some areas (Kimmerer 2004).

The first high-flow events of winter create turbid conditions in the Delta, which can be drawn into the south Delta during reverse flow conditions in Old and Middle River, driven by south Delta CVP and SWP exports. Delta smelt may follow turbid waters into the southern Delta, increasing their proximity to project export facilities. This may increase their entrainment risk (U.S. Fish and Wildlife Service 2008). In response to the delta smelt resiliency strategy, DWR assessed the feasibility of adding sediment to increase turbidity in the low-salinity zone of the Delta to improve delta smelt habitat conditions. Computer modeling was performed to assess (1) whether sediment supplementation is feasible, (2) the magnitude of supplement that would be required to affect turbidity, and (3) the spatial and temporal extent of supplementation to affect overall turbidity in the low-salinity zone of the Delta (California Natural Resources Agency 2017). The results of the modeling predicted that 3,350 cubic yards per day of sediment release was needed to increase turbidity by 10 nephelometric turbidity units (NTU) from Emmaton and Mallard Island (Bever and MacWilliams 2018).

Contaminants

Contaminants can change ecosystem functions and productivity through numerous pathways. Trends in contaminant loadings and their ecosystem effects are not well understood in the San Francisco Estuary (Johnson et al. 2010; Brooks et al. 2012; Fong et al. 2016). A large body of research has been conducted on contaminant occurrence and effects on aquatic organisms in the Delta. A wide array of contaminants, including pesticides, metals, pharmaceuticals, and personal care products, have been detected in Delta water and sediment. Recent monitoring programs are routinely detecting multiple pesticides in each water sample from the Delta. Fong et al. (2016) report that “For example, 27 pesticides or degradation products were detected in Sacramento River samples, and the average number of pesticides per sample was six. In San Joaquin River samples, 26 pesticides or degradation products were detected, and the average number detected per sample was 9.” The effects of chemical mixtures on aquatic organisms is generally unknown but many chemicals may have additive or synergistic effects. Anthropogenic toxins cause significant disruption to development, reduce growth and recruitment, and increase mortality (Johnson et al. 2010).

In addition to anthropogenic contaminants, natural toxins are associated with blooms of *Microcystis aeruginosa*, a cyanobacterium (blue-green algae) that releases a potent toxin known as microcystin. Toxic microcystins cause food web impacts at multiple trophic levels, and histopathological studies of fish liver tissue suggest that fish exposed to elevated concentrations of microcystins have developed liver damage and tumors (Lehman et al. 2005, 2008b, 2010; Acuña et al. 2012a, 2012b).

There are longstanding concerns related to mercury and selenium in the Sacramento and San Joaquin watersheds, the Delta, and San Francisco Bay. DWR is conducting an additional study to determine imports and exports of mercury and methylmercury from freshwater tidal wetlands in the Delta and Suisun Marsh per the Sacramento San Joaquin Delta Methylmercury TMDL (total maximum daily load) and Basin Plan Amendment (Lee et al. 2015; Wood et al. 2010). Current research shows that tidal wetlands do not export mercury or methylmercury in large amounts, although seasonal differences occur and imports and exports are heavily influenced by flow and whether the wetland is associated with a floodplain (Mitchell et al. 2012; Lee et al. 2015). Methylmercury increases in concentration at each level in the food chain and can cause concern for people and birds that eat piscivorous fish (e.g., striped bass) and benthic fishes such as sturgeon. Studies summarized by Alpers et al. (2008) indicate that mercury in fish has been linked to hormonal and reproductive effects, liver necrosis, and altered behavior in fish. A study by Lee et al. (2011) on dietary methylmercury noted significant abnormalities in the liver and kidneys, lower growth rates, and higher mortality in both green sturgeon and white sturgeon, but particularly in green sturgeon. With regard to selenium, benthic foragers like diving ducks, sturgeon, and Sacramento splittail have the greatest risk of selenium toxicity. Beckon and Maurer (2008) suggest that salmonids are probably among the species that are most sensitive to selenium, while delta smelt are likely to be at low risk of selenium toxicity. The invasion of the nonnative bivalves (e.g., overbite clams) has resulted in increased bioavailability of selenium to benthivores in San Francisco Bay (Linville et al. 2002).

Baxter et al. (2008) prepared a 2007 synthesis of results as part of a POD Progress Report, including a summary of prior studies of contaminants in the Delta. The summary included studies, which suggested that phytoplankton growth rates may be inhibited by localized high concentrations of herbicides (Edmunds et al. 1999). Toxicity to invertebrates has been noted in water and sediments from the Delta and associated watersheds (Kuivila and Foe 1995; Weston et al. 2004, 2014, 2019). The 2004 Weston study of sediment toxicity recommended additional study of the effects of the pyrethroid insecticides on benthic organisms. Undiluted drainwater from agricultural drains in the San Joaquin River watershed can be acutely toxic (i.e., quickly lethal) to fish (e.g., Chinook salmon and striped bass) and have chronic effects on growth, likely because of high concentrations of major ions (e.g., sodium, sulfates) and trace elements (e.g., chromium, mercury, selenium) (Saiki et al. 1992).

A more recent synthesis of contaminant studies described multiple lines of evidence that contaminants affect species of concern in the Delta (Fong et al. 2016). Fong et al. (2016) reported that many contaminants detected in Delta waters exceed regulatory standards and most water samples contain multiple contaminants. They also summarize the multiple studies that have found sublethal, lethal, chronic, and acute toxicity of Delta water to test species and Delta species of concern, including delta smelt and salmon.

Fish Passage and Entrainment

With its complex network of channels, low eastern and southern tributary inflows, and reverse flows created by pumping for water exports in the south Delta, the Delta presents a challenge for anadromous and resident fish during upstream and downstream migration. These complex conditions can lead to straying, migration delays, extended exposure to predators, and entrainment during outmigration. Tidal elevations, salinity, turbidity, Delta inflow, meteorological conditions, season, habitat conditions, and south Delta CVP and SWP exports all have the potential to influence fish movement, currents, and ultimately the level of entrainment and fish passage success and survival.

North Delta Fish Passage and Entrainment

In the north Delta, migrating fish have multiple potential pathways as they move upstream into the Sacramento or San Joaquin River systems. Marston et al. (2012) studied stray rates for immigrating San Joaquin River Basin adult salmon that stray into the Sacramento River Basin. Results indicated that it was unclear whether reduced San Joaquin River pulse flows or elevated south Delta exports caused increased stray rates. The Delta Cross Channel (DCC), when open, can entrain fish into the interior Delta from the Sacramento River as they emigrate. The opening of the DCC when salmon are returning to spawn to the Mokelumne and Cosumnes Rivers is believed to lead to increased straying of these fish into the American and Sacramento Rivers because of confusion over olfactory cues associated with Sacramento River water flow (through the DCC) into the lower forks of the Mokelumne River. Experimental DCC closures during the fall-run Chinook salmon migration season for selected days, coupled with pulsed flow releases from reservoirs on the Mokelumne River, have been implemented to reduce straying rates of returning adults. These closures have corresponded with reduced recoveries of Mokelumne River Hatchery fish in the American River system and increased returns to the Mokelumne River Hatchery (East Bay Municipal Utility District 2012).

Water quality can also affect fish passage in the north Delta. Water quality in the mainstem Sacramento River and its distributary sloughs can be poor at times during summer, creating conditions that may stress migrating fish or even impede migration. These conditions include low DO and high water temperatures. For adult Chinook salmon, DO concentration less than 3 to 5 milligrams per liter (mg/L) can impede migration (Hallock et al. 1970), as can mean daily water temperatures of 70 degrees Fahrenheit (°F) to 73°F (approximately 21°C to 23°C), depending on whether water temperatures are rising or falling (Strange 2010). DO levels are generally greater than 5 mg/L throughout the Delta, but water temperatures can exceed these thresholds during summer and fall. Contaminants at concentrations that have been detected in the

Commented [CC8]: Adult salmonids also stray into the Colusa Basin Drain via the Cache Slough Complex. One of the terminus points of the Colusa Basin Drain connects to the Knights Landing Ridge Cut Slough which then connects to the eastern toe drain of the Yolo Bypass which eventually drains out to the Cache Slough Complex in the northern delta, near Liberty Island. Tidal influence from the delta enhances flows from the Yolo Bypass in the Cache Slough Complex, creating attraction flows that draw salmonids into the bypass and subsequently the Colusa Basin Drain. This occurs both during flooding and non-flooding of the Yolo Bypass. Gahan, G. , M. Healey, C. McKibbbin, H. Kubo and C. Purdy. Colusa Basin Drain and Wallace Weir Fish Trapping and Relocation Efforts. California Department of Fish and Wildlife; 1/23/2017.

Commented [CC9]: Lack of flow and poor water quality conditions also contribute to mixed attraction signals, decreased adult homing to natal spawning grounds, and increased stray rate.

Commented [CC10R9]: Please expand this section to incorporate these issues

Delta have also been found to impair olfactory responses in many fish, which can lead to straying (Fong et al. 2016; Sandahl et al. 2007; Tierney et al. 2010).

Michel (2010) and Michel et al. (2015) used acoustic telemetry to examine survival of late fall–run Chinook salmon smolts outmigrating from the Sacramento River through the Delta and San Francisco Estuary. Survival was lowest in the tidally-influenced freshwater portion (Delta) and the brackish portion of the Estuary relative to survival in the non-tidal riverine portion of the migration route.

Analyses by Perry et al. (2015, 2018) suggests that the mechanisms governing route selection are complex. Their analyses revealed the strong influence of tidal forcing on the probability of fish entrainment into the interior Delta. The probability of entrainment into Georgiana Slough was highest during low Sacramento River flow and associated reverse-flow flood tides, and the probability of fish remaining in the Sacramento River was near zero during flow reversals (Perry et al. 2015). The magnitude and duration of reverse flows at this river junction decrease as flow in the Sacramento River increases. Consequently, reduced Sacramento River inflow increases the frequency of reverse flows at this junction, thereby increasing the proportion of fish that are entrained into the interior Delta, where mortality is higher relative to the mainstem Sacramento River and west Delta (Perry 2010).

Central and South Delta Fish Passage and Entrainment

The south Delta intake facilities include the SWP and CVP south Delta export facilities; local agency intakes, including Contra Costa Water District intakes; and agricultural intakes. Contra Costa Water District intakes include fish screens. However, many agricultural intakes throughout the Delta do not include fish screens. Water flow patterns in the south Delta are influenced by water diversion actions and operations, seasonal temporary barriers, and tides and river inflows to the Delta (Kimmerer and Nobriga 2008). Water from the San Joaquin River mainly moves downstream through the head of Old River and through the channels of the Old and Middle rivers and Grant Line and Fabian-Bell Canals toward the CVP and SWP south Delta intake facilities. Conversely, when water to the north of the diversion points for the two facilities moves southward (upstream), the net flow is negative (toward) the export facilities. When the temporary rock barriers are installed from April through November to protect water quality and stage elevation for local diverters, internal reverse circulation is created within the channels isolated by the barriers from other portions of the south Delta. These conditions are most pronounced during late spring through fall when San Joaquin River inflows are low and water diversion rates are typically high. Drier hydrologic years also reduce the frequency of net downstream flows in the south Delta and mainstem San Joaquin River. While Delta flows are tidal and naturally reverse twice daily, Delta diversions can create net reverse flows, which may draw (entrain) fish toward CVP and SWP south Delta export facilities (Arthur et al. 1996; Kimmerer et al. 2008; Grimaldo et al. 2009).

Commented [CC11]: Delta exports result in net negative flow in Old and Middle River under most conditions. It would be more accurate to say that Delta diversions create net reverse flows under most circumstances. I suggest providing a visualization or summary of Old and Middle River flow.

A portion of fish that enter the Jones Pumping Plant approach channel and the Clifton Court Forebay are salvaged at screening and fish salvage facilities, transported downstream by trucks, and released. The National Marine Fisheries Service (NMFS 2009) estimated that the direct loss of fish from the screening and salvage process is in the range of 65% to 83.5% for fish from the point they enter the Clifton Court Forebay or encounter the trash racks at the CVP facilities. In addition, mark-recapture experiments indicate that most fish are probably subject to predation prior to reaching the fish salvage facilities (e.g., in the Clifton Court Forebay) (Gingras 1997; Clark et al. 2009; Castillo et al. 2012). Fish entrainment and salvage are of particular concern during dry years when the distributions of young striped bass, delta smelt, longfin smelt, and other migratory fish species may shift closer to the CVP facilities (Stevens et al. 1985; Sommer et al. 1997).

Salvage estimates reflect the number of fish entrained by project exports, but these numbers alone do not account for other sources of mortality related to the export facilities. These numbers do not include pre-screen losses that occur in the waterways leading to the diversion facilities, which may in some cases reduce the number of salvageable fish (Gingras 1997; Clark et al. 2009; Castillo et al. 2012). Pre-screen losses are reported to account for most delta smelt mortality (Castillo et al. 2012). In addition, larval fish are not salvaged because they cannot be diverted from the export facilities by existing fish screens. The number of fish salvaged also does not include losses of fish that pass through the louvers intended to guide fish into the fish collection facilities or the losses during collection, handling, transport, and release back into the Delta.

The life stage of the fish at which entrainment occurs may be important for population dynamics (Independent Review Panel 2011). For example, winter entrainment of delta smelt, longfin smelt, and threadfin shad (*Dorosoma petenense*) ~~may~~ corresponds to migration and spawning of adult fish, and spring and summer exports ~~may~~ overlaps with development of larvae and juveniles. The loss of prespawning adults and all their potential progeny may have greater consequences than entrainment of the same number of larvae or juvenile fish. Conversely, the entrainment of larvae or juvenile fish which is not quantified, is likely to have greater consequences than the overall entrainment of prespawning adults.

Commented [CC12]: This section would benefit from discussion of indirect mortality of larval and juvenile osmerids in the south and central Delta.

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While swimming through south Delta channels, fish can be subjected to stress from poor water quality (seasonally high temperatures, low DO, high water transparency, and Microcystis blooms) and low water velocities, which create lacustrine-like conditions. Any of these factors can cause elevated mortality rates by weakening or disorienting the fish and increasing their vulnerability to predators (Vogel 2011).

Considerable debate remains regarding the relationship between the export to inflow ratio on the survival of fall-run Chinook salmon and steelhead. The SST evaluated data from multiple studies and found a positive relationship between April and May ratios of San Joaquin River inflow to exports (I:E) and through-Delta survival of San Joaquin River fall-run Chinook salmon when the Head of Old River Barrier is in place. The SST also found that fall-run Chinook salmon survival in the San Joaquin River from Mossdale to the Turner Cut junction tends to increase for higher I:E values but data for the tidal portion of the Delta are mixed, with Chinook salmon survival being highest for an I:E ratio of approximately 2, and lowest for I:E ratios of approximately 1 or greater than 4. They found no evidence linking survival through the facilities to I:E ratios (Salmonid Scoping Team 2017).

For steelhead, the SST (2017) found survival in the south Delta tended to increase for higher levels of I:E, but observations are limited to 2 years of acoustic telemetry data available (2011 and 2012). Survival increased from the Turner Cut junction to Chipps Island, and overall from Mossdale to Chipps Island, as the April to May I:E increased. However, the pattern was weaker than the survival pattern observed for inflow based on SST scatterplots. Survival estimates from Mossdale to the Turner Cut junction were similar regardless of I:E based on SST scatterplots. Survival from the CVP trash rack through the facility to Chipps Island, and from the Clifton Court Forebay radial gates to Chipps Island, increased with I:E for fish released during April and May (Salmonid Scoping Team 2017). They further conclude that the high correlation between inflow and exports limits the ability to evaluate survival over a range of I:E ratios. Although not directly comparable, this contrasts with the results of Zeug and Cavallo (2012), who also found little evidence that large-scale water exports or inflows influenced coded-wire tag recovery rates in the ocean from 1993 to 2003. However, Zeug and Cavallo only evaluated direct mortality and not indirect mortality associated with export operations.

In contrast, Cunningham et al. (2015) found a negative influence of the export/inflow ratio on the survival of fall-run Chinook salmon populations and a negative influence of increased total Delta exports on the survival of spring-run Chinook salmon populations. An increase in total exports of 1 standard deviation from the 1967 to 2010 average was predicted to result in a 68.1% reduction in the survival of Deer, Mill, and Butte Creek spring-run Chinook salmon. Similarly, an increase in the ratio of Delta water exports to Delta inflow of 1 standard deviation was expected to reduce survival of the four fall-run Chinook salmon populations by 57.8% (Cunningham et al. 2015). Although a mechanistic explanation for the reduction in survival remains elusive, "direct entrainment mortality seems an unlikely mechanism given the success of reclamation and transport procedures, even given increased predation potential at the release site. Changes to water routing may provide a more reasonable explanation for the estimated survival influence of Delta water exports" (Cunningham et al. 2015).

Delaney et al. (2014) reported results of a mark-recapture experiment examining the survival and movement patterns of acoustically tagged juvenile steelhead emigrating through the central Delta and south Delta. Their results indicated that most tagged steelhead remained in the mainstem San Joaquin River (77.6%). However, approximately one quarter (22.4%) of tagged steelhead entered Turner Cut. Route-specific survival probability for tagged steelhead using the Turner Cut route was 27.0%. The survival probability for tagged steelhead using the mainstem route was 56.7% (Delaney et al. 2014). Travel times for tagged steelhead also differed between these two routes, with steelhead using the mainstem route reaching Chipps Island significantly sooner than those that used the Turner Cut route. Travel time was not significantly affected by the limited Old and Middle River flow treatments examined in their study. While not significant, there was some evidence that fish movement toward each export facility could be influenced by the relative volume of water entering the export facility (Delaney et al. 2014).

Research conducted during 2010 and 2011 showed that upriver movements of adult delta smelt are achieved through a form of selective tidal stream transport by using lateral movement to shallow edges of channels on ebb tides to maintain their position, with movement into the river channel on the flood tide (Bennett and Burau 2015). Turbidity gradients could be involved in the lateral positioning of delta smelt within the channels, but large-scale turbidity pulses through the system may not be necessary to trigger upriver migrations of delta smelt if they are already occupying sufficiently turbid water (Independent Review Panel 2011).

Low DO levels have been measured in the San Joaquin River, in particular in the Deep Water Ship Channel from the Port of Stockton 7 miles downstream to Turner Cut (Lee and Jones-Lee 2003). These conditions are the result of increased residence time of water combined with high oxygen demand in the anthropogenically modified channel, which leads to DO depletion, particularly near the sediment-water interface (San Joaquin Tributaries Authority 2012). Despite these conditions, adult salmon and steelhead migration does not appear to be adversely affected (Pyper et al. 2006). However, during the 1960s, Hallock et al. (1970) found that adult radio-tagged Chinook salmon delayed their upstream migration whenever DO concentrations were less than 5 mg/L at Stockton. It has been shown that low DO conditions in the San Joaquin River can be ameliorated somewhat through installation of the Head of the Old River Barrier, which increases San Joaquin River flows (San Joaquin Tributaries Authority 2012).

There are more than 2,200 diversions in the Delta (Herren and Kawasaki 2001). These irrigation diversion pipes are shore-based, typically small (30 to 60 centimeters pipe diameter), and operated via pumps or gravity flow, and most lack fish screens. These diversions increase total fish entrainment and losses and alter local fish movement patterns (Kimmerer and Nobriga 2008). Delta smelt have been found in samples of Delta irrigation diversions, as well as larger wetland management diversions downstream. However, Nobriga et al. (2004) found that the low and inconsistent entrainment of delta smelt measured in their study of typical irrigation diversions reflected offshore habitat use by delta smelt and relatively small hydrodynamic influence of the diversions. The overlap of juvenile salmonid occurrence in the Delta with irrigation diversions is limited and not thought to be of population-level consequence (Vogel 2011:94).

Nonnative Invasive Species

Introduced species may influence the Delta ecosystem by increasing competition and predation on native species, reducing habitat quality (as result of invasive aquatic macrophyte growth), and reducing food supplies by altering the aquatic food web. Many of these introductions become invasive, however CDFW does not consider all introduced species invasive.. CDFW defines invasive species as "species that establish and reproduce rapidly outside of their native range and may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat (California Department of Fish and Game 2008)," for example the overbite clam discussed above. Some introduced species have minimal ability to spread or increase in abundance. Others have commercial or recreational value (e.g., striped bass, American shad, largemouth bass).

Many nonnative fishes have been introduced into the Delta for sport fishing (game fish such as striped bass, largemouth bass, smallmouth bass, bluegill [*Lepomis macrochirus*], and other sunfish), as forage for game fish (threadfin shad, golden shiner [*Notemigonus crysoleucas*], and fathead minnow [*Pimephales promelas*]), for vector control (inland silverside [*Menidia beryllina*], western mosquitofish [*Gambusia affinis*]), for human food use (common carp [*Cyprinus carpio*], brown bullhead, and white catfish [*Ameiurus catus*]), and from accidental releases (yellowfin goby [*Acanthogobius flavimanus*], Shimofuri goby [*Tridentiger bifasciatus*], and Shokihaze goby [*Tridentiger barbatus*]) (Moyle 2002). Although, CDFW does not consider many of these invasive species, they can affect native populations through competion for resources and predation.

Because of invasive species and other environmental stressors, native fishes have declined in abundance throughout the region (Matern et al. 2002; Brown and Michniuk 2007; Sommer et al. 2007; Mount et al. 2012). Habitat degradation, changes in hydrology and water quality, and stabilization of natural environmental variability are all factors that generally favor nonnative, invasive species (Mount et al. 2012; Moyle et al. 2012).

As described in the discussion of nutrients and foodweb support above, the introductions of two clams from Asia have led to major alterations in the food web in the Delta. Potamocorbula and Corbicula clams significantly reduce the phytoplankton and zooplankton concentrations in the water column, reducing food availability for native fishes, such as delta smelt and young Chinook salmon (Feyrer et al. 2007; Kimmerer 2002b).

Predation

Predation is an important factor that influences the behavior, distribution, and abundance of prey species in aquatic communities to varying degrees. Predation can have differing effects on a population of fish, depending on the size or age selectivity, mode of capture, mortality rates, and other factors. Predation is a part of every foodweb, and native Delta fishes were part of the historical Delta foodweb. The introduction of nonnative predators has likely increased mortality fates for juvenile salmonids in the Delta (Vogel 2011). NMFS (2014a) rated predation of juvenile winter-run Chinook salmon and spring-run Chinook salmon during rearing and outmigration as a stressor of "Very High" importance. Predation occurs by fish, birds, and mammals.

A panel of experts was convened to review data on predation in the Delta and draw preliminary conclusions on the effects of predation on salmonids. The panel acknowledged that the system supports large populations of fish predators that consume juvenile salmonids (Grossman et al. 2013). However, the panel concluded that because of extensive flow modification, altered habitat conditions, native and nonnative fish and avian predators, temperature and DO limitations, and the overall reduction in salmon population size, it was unclear what proportion of juvenile salmonid mortality could be attributed to predation. The panel further indicated that predation, while the proximate cause of mortality, may be influenced by a combination of other stressors that make fish more vulnerable to predation.

Striped bass, white catfish, largemouth bass and other centrarchids, and silversides are among the introduced, nonnative species that are notable predators of smaller-bodied fish species and juveniles of larger species in the Delta. Along with largemouth bass, striped bass are believed to be major predators on larger-bodied fish in the Delta. In open-water habitats, striped bass are most likely the primary predator of juvenile and adult delta smelt (California Department of Water Resources et al. 2013) and can be an important open-water predator on juvenile salmonids (Johnston and Kumagai 2012). Native Sacramento pikeminnow (*Ptychocheilus grandis*) may also prey on juvenile salmonids and other fishes. Limited sampling of smaller pikeminnows did not find evidence of salmonids in the foregut of Sacramento pikeminnow (Nobriga and Feyrer 2007), but this does not mean that Sacramento pikeminnow do not prey on salmonids in the Delta.

Largemouth bass abundance has increased in the Delta over the past few decades (Brown and Michniuk 2007). Although largemouth bass are not pelagic, their presence at the boundary between the littoral and pelagic zones makes it probable that they opportunistically consume pelagic fishes. The increase in salvage of largemouth bass occurred during the time period when Brazilian waterweed (*Egeria densa*) was expanding its range in the Delta (Brown and Michniuk 2007). The beds of Brazilian waterweed provide good habitat for largemouth bass and other species of centrarchids. Largemouth bass have a much more limited distribution in the estuary than striped bass, but a higher per capita impact on small fishes (Nobriga and Feyrer 2007). Increases in largemouth bass may have had a particularly important effect on threadfin shad and striped bass, whose earlier life stages occur in littoral habitat (Grimaldo et al. 2004; Nobriga and Feyrer 2007).

Invasive Mississippi silverside is another potentially important predator of larval and pelagic fishes in the Delta. This introduced species was not believed to be an important predator on delta smelt, but studies using DNA techniques detected the presence of delta smelt in the guts of 12.5% of Mississippi silversides sampled in midchannel trawls across a variety of habitats in the north Delta and identified turbidity as a significant predictor of predation (Baerwald et al. 2012; Schreier et al. 2016). This finding may suggest that predation impacts could be significant, given the increasing numbers of Mississippi silversides in the Delta (Mahardja et al. 2016) and decreasing trends in turbidity (Feyrer et al. 2007).

Predation of fish in the Delta is known to occur in specific areas, for example at channel junctions and areas that constrict flow or confuse migrating fish and provide cover for predatory fish (Vogel 2011). Sabal (2014) found similar results at Woodbridge Dam on the Mokelumne River where the dam was associated with increased striped bass per capita salmon consumption, which decreased outmigrant juvenile salmon survival by 10% to 29%. CDFW identified subadult striped bass as the major predatory fish in the Clifton Court Forebay (California Department of Fish and Game 1992). In 1993, for example, striped bass made up 96% of the predators removed (Vogel 2011). Cavallo et al. (2012) studied tagged salmon smolts to test the effects of predator removal on outmigrating juvenile Chinook salmon in the south Delta. Their results suggested that predator abundance and migration rates strongly influenced survival of salmon smolts.

Exposure time to predators has been found to be important for influencing survival of outmigrating salmon in other studies in the Delta (Perry et al. 2012).

DWR examined the species distribution and abundance of salvaged fish at the SWP pumping facilities to determine whether alternative release scenarios between salvaged delta smelt and predatory species would increase smelt survival. An initial evaluation of historical records on species distribution of salvaged fish lead to the conclusion that adjusting salvage operations to stop returning predatory fish to the Delta would have little impact on delta smelt survival (California Natural Resources Agency 2017:3).

Aquatic Macrophytes

Aquatic macrophytes are an important component of the biotic community of Delta wetlands and can provide habitat for aquatic species, serve as food, produce detritus, and influence water quality through nutrient cycling and DO fluctuations. Whipple et al. (2012) described likely historical conditions in the Delta, which have been modified extensively, with major impacts on the aquatic macrophyte community composition and distribution. The primary change has been a shift from a high percentage of emergent aquatic macrophyte wetlands to open water and hardened channels.

The introduction of two nonnative invasive aquatic plants, water hyacinth (*Eichhornia crassipes*) and Brazilian waterweed (*Egeria densa*), has reduced habitat quantity and value for many native fishes. Water hyacinth forms floating mats that greatly reduce light penetration into the water column, which can significantly reduce primary productivity and available food for fish in the underlying water column. Brazilian waterweed grows along the margins of channels in dense stands that prohibit access by native juvenile fish to shallow water habitat. In addition, the thick cover of these two invasive plants provides excellent habitat for nonnative ambush predators such as bass, which prey on native fish species. Studies indicate low abundance of native fish, such as delta smelt, Chinook salmon, and Sacramento splittail, in areas of the Delta where submerged aquatic vegetation infestations are thick (Grimaldo et al. 2004, 2012; Nobriga et al. 2005).

Invasive aquatic macrophytes are still equilibrating within the Delta and resulting habitat changes are ongoing, with negative impacts on habitats and foodwebs of native fish species (Toft et al. 2003; Grimaldo et al. 2009). Concerns about invasive aquatic macrophytes are centered on their ability to form large, dense growth that can clog waterways, block fish passage, increase water clarity, provide cover for predatory fish, and cause high biological oxygen demand. DWR is actively engaged in a program of aquatic weed control. Building on the state's existing herbicide treatment program, DWR targeted 200 acres of delta smelt habitat at Decker Island in the western Delta and the Cache Slough complex in the north Delta. Ongoing field studies are investigating the effect of herbicide treatment on delta smelt habitat (California Natural Resources Agency 2017).

Suisun Bay/Marsh

Aquatic Habitat

Suisun Marsh is a brackish-water marsh bordering the northern edge of Suisun Bay. Most of its marsh area consists of diked wetlands managed for waterfowl, and the rest of the acreage consists of tidally influenced sloughs and emergent tidal wetlands (Suisun Ecological Workgroup 2001). The central latitudinal location of Suisun Marsh within the San Francisco Estuary makes it an important rearing area for euryhaline freshwater, estuarine, and marine fishes. Many fish species that migrate or use Delta habitats are also found in the waters of Suisun Bay. Tides reach Suisun Bay and Suisun Marsh through the Carquinez Strait, and most freshwater flows enter at the southeast border of Suisun Marsh at the confluence of the Sacramento and San Joaquin Rivers. The mixing of freshwater outflows from the Central Valley with saline tidal water in Suisun Bay and Suisun Marsh results in brackish water with strong salinity gradients, complex patterns of flow interactions, and generally the highest biomass productivity in the entire estuary (Siegel et al. 2010).

Flow, turbidity, and salinity are important factors influencing the location and abundance of zooplankton and small prey organisms used by Delta species (Kimmerer et al. 1998). The location where net current flowing inland along the bottom reverses direction and sinking particles are trapped in suspension is associated with the higher turbidity known as the estuarine turbidity maximum. Burau et al. (2000) reports that the estuarine turbidity maximum occurs near the Benicia Bridge and in Suisun Bay near Garnet Point on Ryer Island. Zooplanktonic organisms maintain position in this region of historically high productivity in the estuary through vertical movements (Kimmerer et al. 1998).

Salinity in the Suisun Marsh and Bay system is a major water quality characteristic that strongly influences physical and ecological processes. Many fish species native to Suisun Marsh require low salinities during the spawning and rearing periods (Suisun Ecological Workgroup 2001; Kimmerer 2004; Feyrer et al. 2007, 2010; Nobriga et al. 2008). The Suisun Marsh and Bay usually contain both the maximum estuarine salinity gradient and the low- salinity zone. The overall estuarine salinity gradient trends from west (higher) to east (lower) in Suisun Bay and Suisun Marsh. The location of the low- salinity zone gradient is influenced by outflow. Suisun Marsh also exhibits a persistent north-south salinity gradient. Despite low and seasonal flows, the surrounding watersheds have a significant water freshening effect because of the long residence times of freshwater inflows to the marsh, including discharges from the upper sloughs and wastewater effluent.

The Suisun Bay and Suisun Marsh system contains a wide variety of habitats such as marsh plains, tidal creeks, sloughs, channels, cuts, mudflats, and bays. These features and the complex hydrodynamics and water quality of the system have historically fostered significant biodiversity within Suisun tidal aquatic habitats, but these habitats, like the Delta, have also been significantly altered and degraded by human activities over the decades.

Categories of tidal aquatic waters include bays, major sloughs, minor sloughs, and the intertidal mudflats in those areas (Engle et al. 2010). These tidal waters total approximately 26,000 acres, with the various embayments totaling about 22,350 acres. Tidal slough habitat is composed of major and minor sloughs. Major sloughs of Suisun Marsh have a combined acreage of about 2,200 acres consisting of both shallow and deep channels. Minor sloughs are made up of shallow channel habitat and have a combined acreage of about 1,100 acres. Habitats in Suisun Marsh bays and sloughs support a diverse assemblage of aquatic species that typically use open water tidal areas for breeding, foraging, rearing, or migrating.

Fish Entrainment

DWR and Reclamation have constructed several facilities to provide lower-salinity water to managed wetlands in Suisun Marsh, including the Roaring River Distribution System (RRDS), Morrow Island Distribution System, and Goodyear Slough Outfall. Other facilities constructed under the Suisun Marsh Preservation Agreement that could entrain fish include the Lower Joice Island and Cygnus Drain diversions.

The intake to the RRDS is screened to prevent entrainment of fish larger than approximately 1 inch (approximately 25 millimeters). DWR monitored fish entrainment from September 2004 through June 2006 at the Morrow Island Distribution System to evaluate entrainment losses at the facility. Monitoring took place over several months under various operational configurations and focused on delta smelt and salmonids. More than 20 species were identified during the sampling, but only two fish the size of fall-run Chinook salmon were observed at the South Intake in 2006, and no delta smelt from entrained water were observed (Enos et al. 2007). The Goodyear Slough Outfall system is open for free fish movement except near the outfall when flap gates are closed during flood tides (Bureau of Reclamation 2008). Conical fish screens have been installed on the Lower Joice Island diversion on Montezuma Slough.

11.2.3. Sacramento River Flood Bypasses (Butte Basin, Sutter Bypass, and Yolo Bypass)

There are three major floodplain bypasses in the Sacramento River system – Butte Basin, Sutter Bypass, and Yolo Bypass – with a total of 10 overflow structures along the lower Sacramento River (six weirs, three flood relief structures, and an emergency overflow roadway) that provide access to broad, inundated floodplain habitat during wet years.

All six weirs (Moulton, Colusa, Tisdale, Fremont, Sacramento, and Cache Creek) consist of the following: (1) a fixed-level, concrete overflow section; followed by (2) a concrete, energy dissipating stilling basin; with (3) a rock and/or concrete erosion blanket across the channel beyond the stilling basin; and (4) a pair of training levees that define the weir-flow escape channel.

All overflow structures except the Sacramento Weir pass floodwaters by gravity once the river reaches the overflow water surface elevation. The Sacramento Weir has gates on top of the overflow section that hold back floodwaters until opened manually by the DWR' Division of Flood Management (California Department of Water Resources 2010).

Four other relief structures are concentrated along 18 river miles between Big Chico Creek (River Mile 194) and the upstream end of the left (east) bank levee of the Sacramento River Flood Control Project (near River Mile 176). These structures function like weirs but are not called weirs because they do not have all four structural characteristics previously described. All of these relief structures convey water into the Butte Basin (a natural trough east of the river) upstream of the levee system designed to guide the flood waters. Three of the structures are designated as flood relief structures (M&T, 3B's, and Goose Lake). If these three fail as designed a raised 6,000-foot roadway near the south end of Parrott Ranch allows excess floodwaters to escape the Sacramento River to the Butte Basin before being confined by the downstream project levees (California Department of Water Resources 2010).

Unlike other Sacramento River and Delta habitats, floodplains and floodplain bypasses are seasonally dewatered (as high flows recede) during late spring through autumn. This prevents introduced fish species from establishing year-round dominance except in perennial water sources (Sommer et al. 2003). Moreover, many of the native fish are adapted to spawn and rear in winter and early spring (Moyle 2002) during the winter flood pulse. Introduced fish typically spawn during late spring through summer when the majority of the floodplain is not available to them.

11.2.3.1. Butte Basin

The Butte Basin lies east of the Sacramento River and extends from Big Chico Creek near Chico Landing, to the north, to the Butte Slough outfall gates near Meridian. Flood flows are diverted out of the Sacramento River into the Butte Basin and Sutter Bypass via two weirs, Moulton and Colusa, and several designated overflow areas (i.e., low points along the east side of the river) that allow high flood flows to exit the Sacramento River channel; M&T, 3B's, and Goose Lake).

Moulton Weir was completed in 1932. It is located along the easterly side (left bank looking downstream) of the Sacramento River approximately eight miles north of the town of Colusa and about 100 miles north of Sacramento. Its primary function is to release overflow waters of the Sacramento River into the Butte Basin at such times when floods exceed the safe carrying capacity of the main channel of the Sacramento River downstream from the weir. The fixed crest reinforced concrete weir is 500 feet long with concrete abutments at each end. The outlet channel is flanked by training levees and is approximately 3,000 feet long. The crest elevation is 76.75 feet and the project design capacity of the weir is 25,000 cfs. The Moulton Weir is typically the last of the non-gated weirs to overtop, and spills for the shortest duration (California Department of Water Resources 2010).

Colusa Weir was completed in 1933. It is located along the left bank of the Sacramento River one mile north of the town of Colusa. Its primary function is to release overflow waters of the Sacramento River into the Butte Basin. The fixed crest reinforced concrete weir is 1,650 feet long and is flanked by training levees that connect the river to the basin. The crest elevation is 61.80 feet and the project design capacity of the weir is 70,000 cfs. Normally, the Colusa Weir does not overtop until the Tisdale Weir is also spilling, except for flood events that are characterized by rapid rise in Sacramento River stage (California Department of Water Resources 2010).

11.2.3.2. Sutter Bypass

The Sutter Bypass is a floodwater bypass conveying Sacramento River flood flows from the Butte Basin and the Tisdale Weir. The bypass area is an expansive land area in Sutter County used mainly for agriculture.

Tisdale Weir was completed in 1932. It is located along the left bank of the Sacramento River about ten miles southeast of the town of Meridian and about 56 miles north of Sacramento. Its primary purpose is to release overflow waters of the Sacramento River into the Sutter Bypass via the Tisdale Bypass. The fixed crest reinforced concrete weir is 1,150 long. The four-mile leveed bypass channel (Tisdale Bypass) connects the river to the Sutter Bypass. The crest elevation is 45.45 feet and the project design capacity of the weir is 38,000 cfs. Typically, the Tisdale Weir is the first of the five weirs in the Sacramento River Flood Control System to overtop, and continues to spill for the longest duration (California Department of Water Resources 2010).

The Sutter Bypass, in turn, conveys flows to the lower Sacramento River region at the Fremont Weir near the confluence with the Feather River and into the Sacramento River and the Yolo Bypass.

11.2.3.3. Yolo Bypass

Fremont Weir was completed in 1924. It is the first overflow structure on the river's right bank and its two-mile overall length marks the beginning of the Yolo Bypass. It is located about 15 miles northwest of Sacramento and eight miles northeast of Woodland. South of this latitude the Yolo Bypass conveys 80 percent of the system's floodwaters through Yolo and Solano Counties until it connects to the Sacramento River a few miles upstream of Rio Vista. The weir's primary purpose is to release overflow waters of the Sacramento River, Sutter Bypass, and the Feather River into the Yolo Bypass. The crest elevation is 33.50 feet and the project design capacity of the weir is 343,000 cfs.

The Sacramento Weir was completed in 1916. It is the only weir that is manually operated – all others overflow by gravity on their own. It is located along the right bank of the Sacramento River approximately 4 miles upstream of the Tower Bridge, and about 2 miles upstream from the mouth of the American River. Its primary purpose is to protect the City of Sacramento from excessive flood stages in the Sacramento River channel downstream of the American River. The weir limits flood stages (water surface elevations) in the Sacramento River to project design levels through the Sacramento/West Sacramento area. The project design capacity of the weir is 112,000 cfs.

Aquatic Habitat

Aquatic habitats in the Yolo Bypass include stream and slough channels for fish migration and when flooded, seasonal spawning habitat and productive rearing habitat (Sommer et al. 2001; CALFED Bay-Delta Program 2000a, 2000b). During years when the Yolo Bypass is flooded, it serves as an important migratory route for juvenile Chinook salmon and other native migratory and anadromous fishes moving downstream. During these times, it provides juvenile anadromous salmonids an alternative migration corridor to the lower Sacramento River (Sommer et al. 2003) and, sometimes, better rearing conditions than the adjacent Sacramento River channel (Sommer et al. 2001, 2005). When the floodplain is activated, juvenile salmon can rear for weeks to months in the Yolo Bypass floodplain before migrating to the estuary (Sommer et al. 2001). Research on the Yolo Bypass has found that juvenile salmon grow substantially faster in the Yolo Bypass floodplain than in the adjacent Sacramento River, primarily because of the greater availability of invertebrate prey in the floodplain (Sommer et al. 2001, 2005). Increased frequency and duration of connectivity between the Sacramento River and the Yolo Bypass may increase off channel rearing opportunities that expand the life history diversity portfolio for Central Valley Chinook salmon (Takata et al. 2017). When not flooded, the lower Yolo Bypass provides tidal habitat for young fish that enter from the lower Sacramento River via Cache Slough Complex—a network of tidal channels and flooded islands that includes Cache Slough, Lindsey Slough, Liberty Island, the Sacramento Deepwater Ship Channel, and the Yolo Bypass (McLain and Castillo, unpublished data).

Sommer et al. (1997) demonstrated that the Yolo Bypass is one of the single most important habitats for Sacramento splittail. Because the Yolo Bypass is dry during summer and fall, non-native species (e.g., predatory fishes) generally are not present year-round except in perennial water sources (Sommer et al. 2003). In addition to providing important fish habitat, winter and spring inundation of the Yolo Bypass supplies phytoplankton and detritus that may benefit aquatic organisms downstream in the brackish portion of the San Francisco Estuary (Sommer et al. 2004; Lehman et al. 2008a).

The benefit of seasonal inundation of the Yolo Bypass has been studied by DWR as part of the Delta Smelt Resiliency Strategy, which was developed by DWR and other state and federal resource agencies to boost both immediate- and near-term reproduction, growth rates, and survival of delta smelt (California Natural Resources Agency 2016; Mahardja et al. 2019). The Yolo Bypass has been identified as a significant source of phytoplankton and zooplankton biomass to the Delta in the winter and spring during floodplain inundation. However, little has been known about its contribution to the food web during the drier summer and fall months.

One action taken by DWR under the strategy is the implementation of food web enhancement projects in the Yolo Bypass. Under this action, DWR worked with farmers as well as irrigation and reclamation districts to direct water through the Yolo Bypass in the form of flow pulses during summer and fall (Frantzich et al. 2018). The first examination of off-season flow pulses occurred in 2016 when a flow pulse of 12,700 acre-feet (AF) was released over 2 weeks in the summer. The second examination occurred during 2018 when a 19,821 cubic feet per second (cfs) flow occurred over 4 weeks in the fall. These flow pulses were followed in turn by a significant increase in phytoplankton biomass in the Cache Creek Complex and further downstream in the lower Sacramento River (California Natural Resources Agency 2017; California Department of Water Resources 2019ab, 2019ca). The increase in phytoplankton biomass was also found to enhance zooplankton growth and production, thereby increasing food supplies for delta smelt and other Delta fish species. During the second year of implementing flow pulses, a managed flow pulse was generated in the fall of 2018. The 2018 Fall North Delta Flow Action generated a flow pulse of 19,821 AF over 4 weeks, which while not coinciding with a increased pulse of phytoplankton moving through the Yolo Bypass, did result in an export of higher densities of zooplankton into downstream habitats of lower Cache Slough and the Sacramento River at Rio Vista (California Department of Water Resources 2019cb).

Studies continued in 2019 on the issue of food web enhancement in the Yolo Bypass. Working with the GCID and other partners, DWR tested the benefit of passing water through the Yolo Bypass to enhance delta smelt habitat in the north Delta region (Davis et al. 2019). The action was expected to generate a seasonal positive flow pulse through the Yolo Bypass Toe Drain, which was expected to benefit the food web in downstream areas for fishery resources. DWR altered the operation of the Knights Landing Outfall Gates and Wallace Weir to direct agricultural return flows from the CBD through Ridge Cut Slough and Wallace Weir into the Yolo Bypass between late August and late September. Analysis of the results is ongoing (Davis et al. 2019).

Commented [CC14]: It should be noted that water for these studies may be limited in years of drought, or limited to better than average water type years.

Commented [CC15R14]: CDFW recommends that more discussion on this is provided.

Commented [CC16]: It should be noted that there are impacts to migrating adult fall-run Chinook as a result of this study and the increased flows through the Yolo Bypass during the late summer/early fall, and as a result, CDFW was tasked with capturing and relocating adults below Wallace Weir. Immediately after the pulse flow in 2018, 76 adult Chinook salmon were recovered downstream of Wallace Weir and in 2019, 340 salmon during and immediately after the pulse flow (CDFW unpublished data, 2018-2019). Similar actions due to increased flows from the CBD into the Yolo Bypass may have similar impacts to adult salmonids. Although there is a collection facility to capture these fish at Wallace Weir, this is still a migratory delay for salmonids as they perish in these waters due to poor water quality (high water temperatures, low D.O., etc.) without contributing to the spawning population unless relocated back to the Sacramento River.

Commented [CC17R16]: CDFW recommends adding this information.

Fish Passage

The Fremont Weir is a major impediment to adult Chinook salmon, steelhead, and sturgeon passage and a source of migratory delay and mortality (National Marine Fisheries Service 2009; Sommer et al. 2014). Although fish with strong jumping capabilities (such as salmonids) may be able to pass the weir at higher flows. In 2018, DWR implemented the Fremont Weir Adult Fish Passage Modification Project. The project replaced an old, undersized, inefficient fish ladder in the center of the weir with a wider and deeper gate structure. Monitoring and evaluation of the structure's effectiveness is ongoing.

Adult winter-run, spring-run, and fall-run Chinook salmon and white sturgeon have been documented to migrate into the Yolo Bypass via the Toe Drain and Tule Canal when there is no flow into the floodplain over the Fremont Weir (National Marine Fisheries Service 2009). Fyke trap monitoring by DWR has shown that adult salmon and steelhead migrate up the Toe Drain in autumn and winter regardless of whether the Fremont Weir spills (Harrell and Sommer 2003; Sommer et al. 2014). The Toe Drain does not extend to the Fremont Weir because the channel is fully or partially blocked by roads or other higher ground at several locations and fish are often unable to reach upstream spawning habitat in the Sacramento River and its tributaries (Harrell and Sommer 2003; Sommer et al. 2014). Other structures in the Yolo Bypass, such as the Lisbon Weir, and irrigation dams in the northern end of the Tule Canal may also impede upstream passage of adult anadromous fish (National Marine Fisheries Service 2009). Modifications to some of these structures were made as part of the Fremont Weir Adult Fish Passage Modification Project, and two agricultural road crossings were altered to improve fish passage.

In addition, sturgeon and salmonids attracted by high flows into the Bypass become concentrated behind the Fremont Weir, where they are subject to heavy illegal fishing pressure. Passage blockage of green sturgeon at Fremont Weir could have population-level consequences (Thomas et al. 2013).

Stranding of juvenile salmonids and sturgeon has been reported in the Yolo Bypass in scoured areas behind the weir and in other areas as floodwaters recede (National Marine Fisheries Service 2009; Sommer et al. 2005). However, Sommer et al. (2005) found most juvenile salmon migrated off the floodplain as it drained.

DWR and Reclamation have been working on the Yolo Bypass Habitat Restoration (YBHR) program, which is developing and implementing six restoration actions in the Yolo Bypass, including removal of several fish passage barriers. Some of these actions are complete, or nearly complete, including the Wallace Weir Fish Rescue Facility Project and the Fremont Weir Adult Fish Passage Modification Project.

The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project has been developed to significantly improve fish passage and increase floodplain fisheries rearing habitat in the Yolo Bypass and the lower Sacramento River basin by constructing a notch with operable gates on Fremont Weir (Bureau of Reclamation and California Department of Water Resources 2019). The goal of the project is to increase the number of out-migrating juvenile winter-run Chinook salmon that enter the Yolo Bypass. Downstream out-migration is triggered by the ~~first winter~~flow events flows. Once constructed, the gates would open each wet season as early as November 1, based on hydrologic conditions. All gates would be opened when the river stage reaches 15 feet, which is one foot above the lowest gate invert. At this stage, about 130 cfs would enter the gated notch. If the river continues to rise, the gates would stay open until the flow through the gates reaches 6,000 cfs (river stage about 28 feet). At this point, the two smaller gates would be programmed to start closing to maintain flows of 6,000 cfs. Once Fremont Weir begins to overtop, the smaller gates would remain in their last position prior to the weir overtopping (generally both would be closed at this point). After the overtopping event is over, the smaller gates would open and close as needed to keep the flow through the gate as close as possible to 6,000 cfs. All gates would close when the river stage falls below 14 feet. Gate operations to increase inundation could continue through March 15 of each year, based on hydrologic conditions. The gates may remain partially open after March 15 to provide adult fish passage.

Commented [CC18]: "triggered by the first winter flows". Immigration is triggered by increases in flows, not necessarily increased flows occurring in winter; for instance a peak flow/emigration event may occur in spring.

Commented [CC19R18]: CDFW recommends making this modification

Construction of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project is scheduled to be completed in 2022. Nevertheless, it is considered part of the environmental setting for purposes of modeling potential project impacts (see modeling analysis below).

Commented [CC20]: Please note that construction of the Big Notch Project also includes a supplemental fish passage structure along the western side of the Fremont Weir. It is uncertain whether the supplemental fish passage facility will be completed in 2022.

11.2.4. Upstream of Bay-Delta

11.2.4.1. General Description of Rivers and Reservoirs Upstream of Bay-Delta

The areas upstream of the Bay-Delta in the Central Valley that could potentially be affected by the alternatives include those areas in the SWP and CVP system that may be affected by alterations in SWP and CVP operations, including the reservoirs, rivers, and other components of the SWP and CVP. These components include the following instream, reservoir, and riparian areas:

- Shasta Reservoir and the upper and lower Sacramento River
- Oroville Reservoir, Thermalito Afterbay, and the lower Feather River
- Folsom Reservoir, Lake Natoma and the lower American River

The timing, duration, and magnitude of water exports can affect operations of SWP and CVP reservoirs upstream of the Delta, which can affect hydrodynamic conditions for species present in the rivers and tributaries reaches. Flows are important to the movement and migration behaviors, straying potential, habitat availability and suitability, and stranding potential of numerous aquatic species. Operational changes to various flow attributes (timing, duration, magnitude, frequency, and rate of change) can directly affect anadromous species immigration and emigration, spawning and egg incubation, and rearing, as well as resident non-migratory species habitat availability for all life stages.

11.2.5. Sacramento River

11.2.5.1. Description of Shasta Lake, Keswick Reservoir, and Sacramento River

Shasta Lake

Shasta Lake is formed by Shasta Dam, which is located on the Sacramento River just downstream of the confluence of the Sacramento, McCloud, and Pit rivers. Shasta Dam has no fish passage facilities, but it has a fish trapping facility that operates in conjunction with Livingston Stone National Fish Hatchery downstream of Shasta Dam to propagate winter-run Chinook salmon.

Shasta Lake fish species include native and introduced warm-water and cold-water species. The reservoir is typically thermally stratified from April through November, during which time the upper layer (epilimnion) can reach a peak water temperature of 80 degrees Fahrenheit (°F) (Bureau of Reclamation 2003). The epilimnion supports warm-water game fish, while the lower layers (metalimnion and hypolimnion) support cold-water fishes. Nonnative, warm-water fish species in Shasta Lake include smallmouth bass, largemouth bass, spotted bass (*Micropterus punctulatus*), black crappie (*Pomoxis nigromaculatus*), bluegill, green sunfish, channel catfish (*Ictalurus punctatus*), white catfish, and brown bullhead (California Department of Water Resources et al. 2013). Cold-water species include rainbow trout, brown trout, landlocked white sturgeon, landlocked coho salmon (Bureau of Reclamation et al. 2003), and landlocked Chinook salmon (Bureau of Reclamation 2013). Other fish species in Shasta Lake include golden shiner, threadfin shad, and common carp. Native fish species include hardhead (*Mylopharadon conocephalus*), Sacramento sucker (*Catostomus occidentalis*), and Sacramento pikeminnow (California Department of Water Resources et al. 2013; Bureau of Reclamation 2013).

Water quality in Shasta Lake is generally considered good, largely because of the continual inflow of cool, high-quality water from the major tributaries to the reservoir. The primary water quality concern in the reservoir is turbidity, typically associated with heavy rainfall events that move soils and runoff from abandoned mines in the area into the reservoir.

Warm-water fish habitat in Shasta Lake is influenced primarily by fluctuations in the lake level and the availability of shoreline cover (Bureau of Reclamation 2003). Water surface elevations in Shasta Lake can fluctuate approximately 55 feet annually as a result of operation of Shasta and upper Sacramento River diversions (Bureau of Reclamation 2003). Fluctuations in the surface elevation of the reservoir can disturb shallow, nearshore habitats, including spawning and rearing habitat for warm-water fish species. The shoreline of Shasta Lake is generally steep. This, with the large fluctuations in surface elevation, limits shallow, warm-water fish habitat, and the establishment of vegetation or other shoreline cover (Bureau of Reclamation 2003).

Keswick Reservoir

Keswick Reservoir is a re-regulating reservoir for Shasta Lake. The water surface elevation is relatively constant. Residence time for water in Keswick Reservoir is about a day, compared with a residence time of about a year for water in Shasta Lake. Consequently, water temperatures tend to be controlled by releases from Shasta Dam and average less than 55°F. Despite the cool temperatures, the reservoir supports warm-water and cold-water fishes, including largemouth bass, crappie, catfish, and rainbow trout (Bureau of Reclamation 2003).

Sacramento River

Aquatic resources in the Sacramento River rely on the habitat in and along the river and along the tributaries that connect to the river. Habitat along the river ranges from artificial structures used for water supply and flood management to open spaces that provide more natural types of habitat. The flow regime of the Sacramento River is managed for water supply and flood management.

The upper Sacramento River extends from Keswick Dam for approximately 240 miles to the Delta. The Sacramento River is the largest river in California. The river and its tributaries provide spawning, rearing, and migratory habitat for four races of Chinook salmon, steelhead, and two species of sturgeon. Winter-run and spring-run Chinook salmon are federally and state-listed species and Central Valley steelhead and green sturgeon are federally-listed.

These species are described further in Appendix 121A.

The level of flow in the upper Sacramento River below Keswick Dam result from controlled releases from Shasta and Keswick reservoirs, as well as transfers from the Trinity River and natural accretions. The releases and transfers are determined by a suite of laws, regulations, contracts, and agreements to address demands of water users, requirements for water quality, and needs of fish populations throughout the river and the Delta. In particular, operations are regulated by the State Water Resources Control Board's (SWRCB) D-1641 decision, which requires flow releases to meet Delta standards, the WRO 90-5 decision, which requires cold water releases to meet temperature targets at compliance points in the upper Sacramento River, as modified by the 2019 NMFS BiOp, which prescribes a tiered operational approach that allows

Commented [CC21]: Not true. 90-5 stands as is. and is not and cannot be modified by the NMFS BO or the USBR PA.

for variable water temperature objectives for egg incubation based on water-year and cold water pool conditions (see additional discussion below).

The upper Sacramento River's water temperatures are controlled by selective withdrawal through the temperature control device (TCD) in Shasta Reservoir and by balancing releases between Lewiston (Trinity River) and Shasta Reservoirs. The water temperature operations have three principal objectives: (1) provide enough cold water to optimize survival of the current year's winter-run Chinook salmon eggs and alevins and those of other salmonids (Chinook Salmon and steelhead), (2) stabilize water levels through the fall to avoid dewatering redds and stranding juveniles of winter-run and other salmonids, and (3) conserve and rebuild Shasta storage in the fall and winter to provide the coldwater pool resources needed to optimize survival of the next year's winter-run eggs and alevins and those of other salmonids. Protection of other salmonids, especially spring-run Chinook salmon and steelhead, is an important objective, but winter-run Chinook salmon is the principal target of operations because it alone has no spawning habitat other than that in the upper Sacramento River (with some recent spawning in Battle Creek and Clear Creek).

11.2.5.2. Habitat Conditions and Environmental Stressors in Sacramento River Area

Aquatic Habitat

The mainstem Sacramento River provides habitat for native and introduced (nonnative) fish and other aquatic species. The diversity of aquatic habitats ranges from fast-water riffles and glides in the upper reaches to tidally influenced slow-water pools and glides in the lower reaches (Vogel 2011).

A few miles downstream of Keswick Dam, the river enters the valley and the floodplain broadens. Historically, this area had wide expanses of riparian forests, but the riparian zone now has a great deal of urban encroachment. In the middle Sacramento River between Red Bluff and Chico Landing, the mainstem channel is flanked by broad floodplains (The Nature Conservancy 2007a). In the lower reaches downstream of Verona, much of the Sacramento River is constrained by levees.

Dredging, dams, levee construction, urban encroachment, and other human activities in the Sacramento River have modified aquatic habitat, altered sediment dynamics, simplified stream bank and riparian habitat, reduced floodplain connectivity, and modified hydrology (National Marine Fisheries Service 2009). However, some complex floodplain habitats remain in the system such as reaches with setback levees and the Yolo and Sutter Bypasses.

Commented [CC22]: Describe the Sacramento River National Wildlife Area and associated restoration efforts.

Beginning in 1995, planning was initiated to restore naturally spawning anadromous fish populations in Battle Creek, and construction began in 2010 on the Battle Creek Salmon and Steelhead Restoration Project (Bureau of Reclamation 2014). When complete, the restoration project will restore ecological processes along 42 miles of Battle Creek and 6 miles of tributaries, including about 5 miles of habitat suitable for spawning by winter-run Chinook in North Fork Battle Creek. Higher minimum flow requirements will increase instream flows, subsequently cooling water temperatures, increasing stream area, and providing reliable passage conditions for adult salmonids in downstream reaches. The project also will result in improved water quality for the Coleman National Fish Hatchery. In 2018, 220,000 juvenile winter-run Chinook salmon from Livingston Stone National Fish Hatchery were released into Battle Creek; in 2019, 185,000 juveniles were released (Sisco 2019).

Holding Habitat

An abundance of deep, cold-water pools in the mainstem Sacramento River provide habitat for holding adult anadromous salmonids during all months of the year (Vogel 2011). Green sturgeon also use deep pools for holding and spawning, but can tolerate warmer water temperatures than salmon, so can hold farther downstream.

Commented [CC23]: Due to decreased flows in the late summer months, temperatures in the lower Sacramento River commonly exceed thermal tolerances of chinook, and green sturgeon in June, July, August and September (CDEC data).

Spawning Habitat

Spawning habitat on the Sacramento River is affected by the amount and quality of coarse sediment and the levels of flow and water temperature, including levels determined by the operations of the CVP and local water diverters.

Water Temperatures

Water temperatures in the upper Sacramento River are influenced by the timing, volume, and temperature of water releases from Shasta and Keswick Dams, and are currently managed according to SWRCB State Water Board Water Rights Orders 90-05 and 91-01. These orders require Reclamation to operate Keswick and Shasta Dams and the Spring Creek Power Plant to meet a daily average water temperature of 56°F as far downstream in the Sacramento River as practicable during periods when higher temperatures would be harmful to winter-run Chinook salmon. Under the orders, the water temperature compliance point may be modified to an upstream location when the objective cannot be met at RBPP. A temperature control device (TCD) on Shasta Dam allows Reclamation to control the temperature of the water released from the dam. Water temperature directly affects many metabolic functions of fish and affects the availability of dissolved oxygen (DO), which is required for respiration. In recent years, elevated water temperatures have resulted in high mortalities of winter-run eggs and alevin (Martin et al. 2016) and may have adversely affected other salmon runs and other fish species present in the Sacramento River during summer. Drought conditions make efforts to maintain suitable water temperatures in the upper Sacramento River more difficult because reduced storage in Lake Shasta results in a smaller coldwater pool.

The summary of the USFWS and NMFS BiOps for long-term SWP/-CVP operations noted (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2019:17; see also discussion of regulatory setting below):

> *"[The p]roposed action includes actions to build Shasta Reservoir storage in the fall and winter months and manage to a sustainable plan throughout the summer months. Efforts to explicitly build storage primarily include fall and winter refill and redd maintenance actions. Other actions which are likely to result in higher storage from historical include a modification to sharing responsibility under the Central Valley Project/State Water Project Coordinated Operation Agreement, reduced fall outflow and salinity targets in wet years and increased flexibility on summer releases for exports resulting from increased spring exports. The Shasta Cold Water Pool*

Management Plan addresses temperature goals with commitments to operate to the lowest tier possible, to stay within a tier once selected on May 1st and to coordinate temperature plans through the Sacramento River Temperature Task Group. Tier 3 and Tier 4 actions include intervention measures to reduce risks in drier/lower storage years and will be developed through collaboration with NMFS and others. The proposed project also includes a commitment to biological performance metrics and independent review process to evaluate performance and highlight areas for improvement (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2019 :17; see also discussion of regulatory setting below)."

Sediment Conditions

Shasta and Keswick Dams substantially influence sediment transport in the upper Sacramento River because they block sediment that would normally be transported downstream (The Nature Conservancy 2007a; California Department of Water Resources 1985). The result has been a net loss of coarse sediment, including gravel particle sizes suitable for salmon spawning, in the Sacramento River downstream of Keswick Dam (Bureau of Reclamation 2013). To address the issue of spawning gravel loss downstream of Keswick Dam, Reclamation has placed approximately 5,000 tons of washed spawning gravel into the Sacramento River downstream of Keswick about every other year since 1997 (Bureau of Reclamation 2010a).

Spawning Habitat Availability

The suitability of physical habitat for salmonid spawning (i.e., not including water quality parameters such as temperature and DO) is largely a function of the availability of clean, coarse gravel for constructing redds, favorable depths, and suitable flow velocities. Instream flow potentially affects all three of these habitat characteristics and often affects the availability of suitable habitat.

Most winter-run Chinook salmon spawn in the uppermost reach of the Sacramento River, from Keswick Dam to the confluence with Clear Creek. Operations of Shasta and Keswick Dams generally determine flow and temperature in this area and largely determine spawning habitat availability.

Like winter-run Chinook salmon, the spawning distributions of spring-run, fall-run, and late fall–-run Chinook salmon populations that spawn in the Sacramento River are primarily upstream of RBDD, the Red Bluff Diversion Dam, with fall-run spawning the farthest downstream. About 15% of fall-run redds are constructed downstream of the RBDD. Spring-run spawning locations are generally between those of winter-run and fall-run Chinook salmon, and late fall–-run spawning distribution is most similar to that of winter-run Chinook salmon (National Marine Fisheries Service 2017). The spawning substrate, depth, and flow velocity requirements of the four Chinook salmon runs are generally similar, so differences in spawning habitat availability among the runs are most strongly related to differences in their spawning distributions and in the prevailing flow and temperature levels during the time of year that they spawn.

Variations in flow can also have major effects on spawning habitat. Reductions in flow following spawning may result in dewatering of the redds and mortality of incubating eggs and alevins (U.S. Fish and Wildlife Service 2006). Large increases in flow may result in scouring of riverbed sediments, including any redds present, or entombment in deposited sediments.

The spawning distribution of steelhead in the upper Sacramento River is poorly known, but the suitability of spawning habitat is largely determined by the same physical habitat and water quality parameters that affect the Chinook salmon runs, although preferred depths, flow velocities, and spawning substrates are somewhat different than those for Chinook salmon. As for the salmon runs, the availability of suitable spawning habitat for steelhead is strongly affected by instream flow (U.S. Fish and Wildlife Service 2011bc).

Rearing Habitat

Rearing habitat suitability for juvenile salmonids is generally related to flow much as described above for spawning habitat suitability, although important habitat features for rearing include cover, and the suitability of specific depths and flow velocities differ from those for spawning (U.S. Fish and Wildlife Service 2005a, 2005b).

Inundated floodplains typically provide large areas of suitable rearing habitat for juvenile salmonids (Sommer et al. 2001). In the Sacramento River between Red Bluff and Chico Landing, the mainstem channel is flanked by broad floodplains. Ongoing sediment deposition in these areas provides evidence of continued inundation of floodplains in this reach (California Department of Water Resources 1994). Between Chico Landing and Colusa, the Sacramento River is bounded by levees that provide flood protection for cities and agricultural areas. However, the levees in this portion of the Sacramento River are, for the most part, set back from the mainstem channel such that flooding can be significant within the river corridor (The Nature Conservancy 2007b). Downstream of Colusa, the Sacramento River channel is tightly constrained by federal levees, dominated by riprap, with no floodplain and only remnant riparian vegetation.

Vogel (2011) suggested that the mainstem Sacramento River may not provide adequate rearing areas for fry-stage anadromous salmonids, as evidenced by rapid displacement of fry from upstream to downstream areas and into nonnatal tributaries during increased flow events. Underwater observations of salmon fry in the mainstem Sacramento River suggest that optimal habitats for rearing may be limited at higher flows (Vogel 2011).

Commented [CC24]: The theme of less rearing habitat during higher flows needs more support.

Commented [CC25R24]: CDFW suggests providing more than one study to support this statement

Fish Passage and Entrainment

Historically, anadromous salmonids had access to a minimum of about 493 miles of habitat in the Sacramento River (Yoshiyama et al. 1996). After completion of Shasta Dam in 1945, access to approximately 207 miles was blocked. Keswick Dam, just downstream of Shasta Dam, is now the upstream extent of available habitat for anadromous fish in the Sacramento River.

Until relatively recently, three large-scale, upper Sacramento River diversions, the Anderson Cottonwood Irrigation District (ACID) and GCID intakes and RBDD, were of particular concern as potential passage or entrainment problems for Chinook salmon, steelhead, sturgeon, and other migratory fish species (National Research Council 2012; National Marine Fisheries Service

2009a; McEwan and Jackson 1996). The RBDD Red Bluff Diversion Dam gates were permanently opened from 2012 onwards, the GCID fish screens were installed, and fish passage at the ACID intake was improved (National Research Council 2012). At the ACID Dam, new fish ladders and fish screens were installed around the diversion and began operating in the summer 2001 diversion period. However, adult green sturgeon that migrate upstream in April, May, and June continue to be completely blocked by the ACID Dam (National Marine Fisheries Service 2009), rendering approximately 3 miles of spawning habitat upstream of the diversion dam inaccessible. Adult green sturgeon that pass upstream of the intake before April are delayed for 6 months until the flashboards are pulled and they can return downstream to the ocean. Newly emerged green sturgeon larvae that hatch upstream of the ACID Dam must hold for 6 months upstream of the dam, or pass over it and be subjected to higher velocities and turbulent flow below the Dam (National Marine Fisheries Service 2009).

Numerous other diversions are located on the Sacramento River. Herren and Kawasaki (2001) documented up to 431 diversions from the Sacramento River between Shasta Dam and the city of Sacramento. Studies at some unscreened diversions in the Sacramento River found low rates of entrainment of juvenile Chinook salmon (Vogel 2013; Hanson 2001). Mussen et al. (2014) examined the risk to green sturgeon from unscreened water diversions and found that juvenile green sturgeon entrainment susceptibility (in a laboratory setting) was high relative to that estimated for Chinook salmon, suggesting that unscreened diversions could be a contributing mortality source for threatened southern distinct population segment (DPS) of green sturgeon. Reclamation is currently coordinating with USFWS via the Anadromous Fish Screen Program to support improvements at other fish screens.

The Coleman Fish Hatchery weir is a barrier to anadromous fish upstream passage in Battle Creek, as are various Pacific Gas and Electric Company (PG&E) dams (e.g., Wildcat) located on the creek (Yoshiyama et al. 1996). Yoshiyama et al. (1996) reported that the Coleman South Fork Diversion Dam is the first impassible barrier on Battle Creek.

Hatcheries

The Livingston Stone National Fish Hatchery (NFH), located at the foot of Shasta Dam, is a conservation hatchery that has been producing and releasing juvenile winter-run Chinook salmon since 1998. There is growing concern about the potential genetic effects that may result from the use of a conventional hatchery program to supplement winter-run Chinook salmon populations for extended periods of time. To maintain a low risk of compromised genetic fitness, Lindley et al. (2007) recommend that no more than 5% of the naturally spawning population should be composed of hatchery fish. Since 2001, more than 5% of the winter-run Chinook salmon run has been composed of hatchery-origin fish, and in 2005, the contribution of hatchery fish was more than 18% (Lindley et al. 2007).

The Livingston Stone NFH minimizes hatchery effects in the population by preferentially collecting wild adult winter-run Chinook salmon for brood stock (U.S. Fish and Wildlife Service 2011cb). Up to 15% of the estimated run size for winter-run Chinook salmon run may be collected for brood stock use (up to a maximum of 120 natural-origin winter-run Chinook salmon per brood year). Although there is no adult production goal, Livingston Stone NFH releases up to 250,000 winter run Chinook salmon a year in late January or early February. Winter-run Chinook salmon are released at the pre-smolt stage and are intended to rear in the freshwater environment prior to smoltification. The pre-smolts are released into the Sacramento River at Caldwell Park in Redding, about 10 miles downstream of the hatchery. All juvenile winter-run Chinook salmon produced at Livingston Stone NFH are adipose fin-clipped and coded wire-tagged (California Hatchery Scientific Review Group 2012). As previously noted, 220,000 juvenile winter-run Chinook salmon from Livingston Stone NFH were released into Battle Creek in 2018, and 185,000 in 2019 (Sisco 2019).

Coleman NFH, located on Battle Creek, was established in 1942 by Reclamation to partially mitigate habitat and fish losses from historical spawning areas caused by construction of two CVP facilities, Shasta and Keswick Dams. The hatchery is funded by Reclamation and operated by USFWS. The steelhead program at the hatchery was initiated in 1947 to mitigate losses resulting from the CVP (U.S. Fish and Wildlife Service 2012).

Disease

Several endemic salmonid-specific pathogens occur in the Sacramento River: *Ceratonova shasta* (salmonid ceratomyxosis), *Parvicapsula minibicornis*, *Flavobacterium columnare* (columnaris), Infectious Hematopoietic Necrosis (IHN) virus, *Renibacterium salmoninarum* (bacterial kidney disease), *Flavobacterium psychrophilum* (cold-water disease), *Ichthyophthirius multifiliis* (white spot disease or Ich), and *Aeromonas salmonicida* (Furunculosis) (California Department of Water Resources 2004; Foott 2014). Of these, salmonid *Ceratonova shasta* and *Parvicapsula minibicornis* are of most concern for fisheries management in the region (Foott 2014; Foott et al. 2017). The Coleman National Fish Hatchery (NFH) on Battle Creek employs best management practices and protocols to minimize the spread of diseases to Battle Creek and the Sacramento River (Cramer Fish Sciences 2016).

Salmonid ceratomyxosis is endemic to the Sacramento River Basin. While native fish have developed some resistance to the disease, mortality in all ages of anadromous and resident salmonids still occurs. Steelhead appear to be particularly susceptible to the disease, compared to Chinook (California Department of Water Resources 2004). Fish can become infected at temperatures as low as 39°F; however, mortality predominantly occurs at water temperatures exceeding 50°F (Bartholomew 2012).

The risk of infection in the Sacramento River Basin with salmonid ceratomyxosis is highest when the fish remain for an extended period in an infectious zone. This is an area with a high concentration of infectious pathogen(s) (Foott et al. 2017; Pacific Fishery Management Council 2018). An infectious zone may develop when the following factors coincide: low flow velocity and volume (especially in proximity to spawning areas) and water temperatures above 54–-59°F (Ray and Bartholomew 2013; Foott et al. 2017; Pacific Fishery Management Council 2018).

Predation

On the mainstem Sacramento River, high rates of predation have been known to occur at the diversion facilities and areas where rock revetment has replaced natural river bank vegetation (National Marine Fisheries Service 2009). Chinook salmon fry, juveniles, and smolts may be more susceptible to predation at these locations because Sacramento pikeminnow and striped bass congregate in areas that provide predator refuge (Williams 2006; Tucker et al. 2003). A recent study by Stompe et al. (2020) comparing angling catch per unit effort (CPUE) at engineered (water diversions or beam bridges), rip-rap, and natural locations found no statistically significant difference for striped bass and a marginally significant difference for Sacramento pikeminnow (greater CPUE catch per unit effort at engineered sites compared to natural sites), with no significant difference in diet composition between sites.

11.2.6. Feather River

11.2.6.1. Description of Oroville Reservoir, Thermalito Afterbay and Feather River

The Feather River contributes approximately 25% of the total flow in the Sacramento River (Federal Energy Regulatory Commission 2007). The lower Feather River extends about 67 miles from the Fish Barrier Dam below Oroville Dam to its confluence with the Sacramento River. There are two reaches where Chinook salmon, steelhead and green sturgeon spawn: the low-flow channel, which extends about 8 miles from the Fish Barrier Dam to the Thermalito Afterbay outlet, and the high-flow channel, which extends about 15 miles from the Thermalito Afterbay outlet to Honcut Creek (Vogel 2011). Most of the in-river spawning and rearing by salmon and steelhead occurs in the low-flow channel (Federal Energy Regulatory Commission 2007; California Department of Water Resources 2007).

The Oroville Facilities include Oroville Dam, the Thermalito Diversion Dam, the Thermalito Complex, and the Feather River Fish Hatchery. The hatchery, which is managed by CDFW, raises spring and fall-run Chinook salmon and steelhead. A special fish barrier dam leads adults returning to spawn in the Feather River into the Feather River Fish Hatchery (California Department of Water Resources 2007). Central Valley spring-run and Central Valley fall-run Chinook salmon and California Central Valley steelhead are reared at the Feather River Hatchery, using cold water diverted from Oroville Reservoir. The capacity of this facility is 2.5 million fingerlings a year. Approximately 20 percent% of the salmon and steelhead returning to spawn use the hatchery and 80 percent spawn in the Feather River (ICF International 2015). Hatchery operations are discussed in more detail below.

Oroville Dam impounds Oroville Reservoir, which is the principal water storage facility of the SWP. The reservoir has a storage capacity of 3.5-million- acre-feet (AF) and a surface area of 15,810 acres. The surface elevation of Oroville Reservoir is reduced through the summer season as releases from storage are required to meet downstream requirements, including instream flow, environmental requirements, in- basin uses, and urban and agricultural demand. In wetter years, the maximum total release from Oroville Reservoir typically occurs in February and March, due primarily to the requirement for large releases to meet flood control criteria and maintain adequate flood storage in the reservoir. In drier years, the highest releases from Oroville Reservoir typically occur in July (California Department of Water Resources 2007).

Releases from Oroville Reservoir are made into the Diversion Pool below Oroville Dam, where water can be released through the Thermalito Diversion Dam Power Plant to the low- flow channel (LFC) of the Feather River, or diverted through the Thermalito Power Canal Forebay and into Thermalito Afterbay. Flows can be diverted from Thermalito Afterbay into agricultural canals to meet local Feather River Service Area requirements (including WCWD and RID) or released through the Thermalito Afterbay outlet back into the Feather River, where they combine with flows passing through the LFC to produce the high-flow channel. Flows in the LFC are currently required to be at least 800 cfs from September 9 to March 31 of each water year, to accommodate spawning by anadromous salmonids, and at least 700 cfs the remainder of the year. Water temperatures in the LFC are required to meet stringent standards for protection of all life stages of the anadromous salmonids.

Oroville Reservoir

Oroville Reservoir typically thermally stratifies beginning in the spring, begins to de-stratify in the fall, and remains relatively uniform throughout the winter. Because of this stratification regime, Oroville Reservoir supports both coldwater and warmwater fisheries that are thermally segregated for much of the year. The coldwater fish use the deeper, cooler, well-oxygenated hypolimnion and thermocline, whereas the warmwater fish are found in the warmer, shallower, epilimnetic and littoral zones (California Department of Water Resources 2007).

Oroville Reservoir's coldwater fishery is primarily composed of coho salmon, although rainbow trout, brown trout, and lake trout (*Salvelinus namaycush*) are periodically caught. The coldwater fishery for coho salmon is sustained by hatchery stocking. The Oroville Reservoir warmwater fishery is a self-sustaining fishery. Spotted bass are the most abundant bass species in Oroville Reservoir, followed by largemouth, redeye (*Micropterus coosae*), and smallmouth bass. Catfish species and, white crappie (*Pomoxis annularis*), and black crappie are also present. Resident native species include white sturgeon, Sacramento sucker, Sacramento pikeminnow, and hardhead (California Department of Water Resources 2007).

Project operations influence fish habitat in Oroville Reservoir through manipulation of the amount of cold water released into the Feather River and changes in Oroville Reservoir's water surface elevation that result from flood control, power generation, and water releases downstream. Cold water is taken from Oroville Reservoir's hypolimnion for releases to the downstream fishery in the main channel of the Feather River, thereby potentially limiting the amount of cold water available for salmonids in Oroville Reservoir. Water surface elevation fluctuations in Oroville Reservoir occur on a seasonal basis, resulting from seasonal variations in upstream tributary inflows into the reservoir, as well as seasonal variations in Oroville Facilities reservoir releases. Reservoir stage reductions can reduce the amount of littoral fish habitat, bass nest survival, invertebrate food supply, and coldwater pool volume (California Department of Water Resources 2007).

Thermalito Afterbay

Thermalito Afterbay provides habitat for both coldwater and warmwater fishes. This 4,300 surface-acre reservoir has gently sloping banks with large areas of rooted aquatic vegetation along its upper margins. Depths rarely exceed 20 feet. Changes in flow rates, pumpback operations, and water surface elevations resulting from project operations affect water temperatures and the quality, quantity, and distribution of fish habitat in the afterbay. Water temperatures can vary widely around the afterbay in the summer, from the low 60s (°F) near the tailrace channel that feeds the afterbay to the mid-80s (°F) in the backwater areas that do not readily circulate (California Department of Water Resources 2007). The operational range of surface elevation fluctuations is 12 feet, although the normal fluctuation range is between 4 and 8 feet. The water surface elevation can fluctuate rapidly and frequently, resulting in a high degree of variability in water levels from day -to -day and week -to week, depending on project operation (California Department of Water Resources 2007).

Fish species observed in Thermalito Afterbay include largemouth bass, smallmouth bass, rainbow trout, brown trout, sunfish species, black crappie, channel catfish, carp, and large schools of wakasagi (*Hypomesus nipponensis*). The rainbow and brown trout that occur in the afterbay likely are washed in from the smaller and colder Thermalito Forebay. The Thermalito Afterbay likely provides good habitat for largemouth and smallmouth bass, except that nest dewatering from reservoir fluctuations likely limits juvenile recruitment. Large schools of wakasagi provide a plentiful source of prey (California Department of Water Resources 2007).

Lower Feather River

At least 22 fish species have been found in the lower Feather River, although some of these may be non-residents washed down from Oroville Reservoir (Table 3.4-3). Fish Species of Management Concern present in the lower Feather River include Central Valley spring-run Chinook salmon, Central Valley fall-run Chinook salmon, California Central Valley steelhead, southern DPS green sturgeon, Pacific lamprey, river lamprey (*Lampetra ayresii*), hardhead, and Sacramento splittail. Chinook salmon are abundant in the Feather River, with an estimated 30,000 to 170,000 Chinook salmon spawning in the Feather River annually (Federal Energy Regulatory Commission 2007). There is substantial introgression between Feather River spring-run and fall-run Chinook salmon, likely a result of past hatchery practices and loss of geographic separation when Oroville Dam was built (Williams 2006; National Marine Fisheries Service 2009; Vogel 2011).

Oroville Dam releases are managed to benefit coldwater fisheries. Most Feather River spring-run Chinook salmon, fall-run Chinook salmon, and steelhead natural spawning occurs in the low-flow channel (LFC), which has flow and water temperature restrictions (Federal Energy Regulatory Commission 2007:122). Flows in the LFC are currently required to be at least 800 cfs from September 9 to March 31 of each water year, to accommodate spawning by anadromous salmonids, and at least 700 cfs the remainder of the year. Water temperatures in the channel LFC range from 47°F in the winter to 65°F in the summer (Vogel 2011). The summer water temperatures can limit salmon production. Gravel recruitment is also an issue for the LFC of the river (Vogel 2011).

The flow regime in the reach of the Feather River extending from the Thermalito Afterbay outlet (RM 59) to the confluence of the Feather and Sacramento Rivers varies depending on runoff and month. Flows in this reach of the Feather River typically vary from the minimum flow requirement up to a flow of 7,500 cfs (Federal Energy Regulatory Commission 2007). Spawning by southern DPS green sturgeon was documented in 2011, a wet year, at the Thermalito Afterbay outlet (Seesholtz et al. 2015).

11.2.6.2. Habitat Conditions and Environmental Stressors in Feather River Area

Aquatic Habitat

The lower Feather River contained at least 71 miles of suitable spawning habitat for winter-run and spring-run Chinook salmon, steelhead, and green sturgeon prior to the installation of the Oroville Complex on the Feather River (Yoshiyama et al. 2001; Schick et al. 2005). Extensive mining, irrigation, and other dams significantly reduced the amount of suitable habitat for these species (Yoshiyama et al. 2001). Currently, most spawning for these fishes is concentrated in the uppermost 3 miles of accessible habitat downstream of the Feather River Fish Hatchery (Federal Energy Regulatory Commission 2007). As a result, spawning is concentrated at unnaturally high levels directly downstream of Oroville Dam and the Fish Barrier Dam in the LFC.

The lower Feather River is almost entirely contained within a series of levees. Streamflow is regulated by the Oroville Complex (composed of the Oroville Dam, Thermalito Diversion Dam, and Thermalito Afterbay outlet), and releases from the Oroville Complex are planned weekly to accommodate water deliveries, Sacramento Valley in-basin demands such as Delta requirements, instream flow requirements in the Feather River, and minimum flood management space requirements. The lower Feather River's modified flow regime has reduced the frequency of channel- forming flows, which, along with levees, has reduced the lateral movement of the Feather River and resulted in a more channelized river with reduced sinuosity.

Natural channel processes have also been affected by flow fluctuations, including the interruption of the downstream movement of gravel and wood, lateral river movement forming side channels, and a reduction in the frequency of inundated flood plains. An estimated 97% of the sediment from the upstream watershed has been trapped behind Oroville Dam, only allowing the discharge of fine sediment into the lower Feather River (Federal Energy Regulatory Commission 2007). As a result, optimum habitat features such as gravel and large woody materials from upstream reaches are now limited in the lower Feather River, and the median gravel diameter (D50) in the LFC may generally be too large for successful redd construction by native salmonids (Federal Energy Regulatory Commission 2007). However, the lower Feather River watershed encompasses approximately 803 square miles, with approximately 190 miles of major streams and 695 miles of minor streams, which contribute to the sediment load of the lower Feather River. The Federal Energy Regulatory Commission (FERC) (2007) noted that the suitability of gravel sizes for spawning Chinook salmon increased with distance downstream of Oroville Dam.

DWR currently operates the Oroville Complex consistent with the applicable NMFS and USFWS BiOps. When Lake Oroville surface elevation is greater than 773 feet, minimum instream flow releases downstream of the Thermalito Afterbay outlet range from 1,000 to 1,700 cfs, depending on water year type and season.

Mean daily flow in the Feather River ranged from approximately 2,000 cfs in Critically Dry Water Years to 18,000 cfs in Wet Water Years prior to the completion of Oroville Dam (Oroville gage 1906–1965), and from approximately 1,000 cfs during Critically Dry Water Years to 12,000 cfs during Wet Water Years after the completion of the Oroville Dam (Gridley gage 1969–2012) (National Marine Fisheries Service 2016).

Modeling and surveys have been conducted to inform management decisions by identifying optimum water flow for native salmonids. According to DWR (2002), optimum Chinook salmon flow suitability for spawning is about 800–825 cfs in the LFC and 1,200 cfs in the high-flow channel. Steelhead appeared to have no optimum flow for spawning in the LFC; however, optimum flow was just under 1,000 cfs in the high-flow channel (California Department of Water Resources 2004).

Fish Passage

The Oroville Complex facilities (i.e., the Oroville Dam, Thermalito Diversion Dam, and Fish Barrier Dam) currently block the upstream migration of anadromous fish from historically available spawning areas in the Feather River and have altered flow regimes as part of ongoing operations, which affects upstream and downstream migration passage in downstream reaches. The loss of spawning habitat and altered passage conditions downstream of the dams have resulted in hybridization of spring-run and fall-run Chinook salmon populations and have decreased population sizes.

In addition to the Oroville Complex, two other potential/partial upstream migration barriers exist in the lower Feather River during low-flow or high-flow conditions (approximately 2,074 cfs or 9,998 cfs, respectively). These are the Sunset Pumps Diversion Dam and Steep Riffle (Federal Energy Regulatory Commission 2007). The Sunset Pumps Diversion Dam is a rock weir structure approximately 27 miles downstream of the Fish Barrier Dam that may impede or delay passage under certain flow conditions. Planning efforts are underway to resolve/correct this feature. Steep Riffle is located approximately 2 miles upstream of the Thermalito Afterbay outlet but is generally considered passable under both low and high flows (Beamesderfer et al. 2004).

Hatcheries

The Feather River Fish Hatchery is part of the SWP Oroville Complex. The hatchery is operated as part of a mitigation measure established to address anadromous fish decline as a result of loss of habitat upstream of Oroville Dam (National Marine Fisheries Service 2009). This facility produces fall-run Chinook salmon, spring-run Chinook salmon, and steelhead and is the sole contributor of hatchery-raised spring-run Chinook salmon found within the Central Valley (California Hatchery Scientific Review Group 2012). The hatchery-raised spring-run Chinook salmon are included in the federal designation of Central Valley spring-run Chinook salmon evolutionarily significant unit (ESU) (70 Federal Register [FR] 37160).

The initial Chinook salmon production protocols separated returning spring-run and fall-run Chinook salmon based solely on the run timing periods, which resulted in considerable mixing of spring-run and fall-run Chinook salmon stocks due to the overlap in spawning periods (California Department of Water Resources 2009; National Marine Fisheries Service 2012). In 2005, the Feather River Fish Hatchery changed their methodology to prevent any further mixing; only fish entering the hatchery prior to July 1 receive an external tag. These are the only fish used as spring-run Chinook salmon broodstock (California Hatchery Scientific Review Group 2012; California Department of Water Resources 2009). Additionally, all hatchery-raised spring-run Chinook salmon are now adipose fin-clipped, coded wire-tagged (California Hatchery Scientific Review Group 2012), and thermally otolith-marked with race and brood year specific details (California Department of Water Resources 2009). The juvenile hatchery production goal is two million smolts, which are released during April or May. Returning hatchery-produced spring-run Chinook salmon are intended to spawn and integrate with the natural population in the lower Feather River, although there are no specific goals for the number of adult spring-run Chinook salmon.

The steelhead program at the Feather River Fish Hatchery traps marked hatchery-origin and unmarked natural-origin steelhead to artificially produce steelhead for later release. However, few unmarked fish are trapped annually, and only fish returning to the Feather River Basin are used for broodstock. There are no specific goals for the quantity of adults produced by this program; however, there is an annual production goal of 450,000 yearlings released in January or February. All Feather River Hatchery steelhead have their adipose fin clipped prior to release to distinguish them from the naturally spawned population (California Hatchery Scientific Review Group 2012).

The Feather River Fish Hatchery disease management protocols employ an ultraviolet treatment system, periodic testing, prescribed therapeutic treatments, and has modified the stocking practices of Lake Oroville to successfully manage disease (California Department of Water Resources 2004).

Disease

Several endemic salmonid-specific pathogens and diseases occur in the Feather River Basin: *Ceratomyxa shasta* (salmonid ceratomyxosis), *Flavobacterium columnare* (columnaris), Infectious Hematopoietic Necrosis (IHN) virus, *Renibacterium salmoninarum* (bacterial kidney disease), and *Flavobacterium psychrophilum* (cold-water disease) (California Department of Water Resources 2004). Each of these diseases has been shown to infect stocked and native salmonids in the Feather River (Federal Energy Regulatory Commission 2007). Of these, salmonid ceratomyxosis and IHN are of most concern for fisheries management in the region because of the associated fish mortality rates at the hatchery (California Department of Water Resources 2004).

Salmonid ceratomyxosis is endemic to the Feather River Basin. While native fish have developed some resistance to the disease, mortality in all ages of anadromous and resident salmonids still occurs. Steelhead appear to be particularly susceptible to the disease, compared to Chinook salmon (California Department of Water Resources 2004). Fish can become infected at temperatures as low as 39°F; however, mortality predominantly occurs at water temperatures exceeding 50°F (Bartholomew 2012). While whirling disease has been found in upstream tributaries of the Feather River, it has not been detected downstream of Oroville Dam (California Department of Water Resources 2004).

The Feather River Fish Hatchery experienced severe IHN outbreaks in 2000 and 2001. The University of California at Davis and USFWS have indicated that although there were no clinical signs of disease, 28% and 18% of adult salmonids returning to the Yuba and Feather Rivers, respectively, carried IHN (Brown et al. 2004). Survivors of IHN can become carriers, and the disease can be spread via contaminated water or contact with carriers, making IHN particularly difficult to control.

The Feather River Fish Hatchery employs best management practices and protocols to avoid the spread of diseases. By installing an ultraviolet treatment system, modifying the stocking of Lake Oroville, conducting periodic testing, and using prescribed therapeutic treatments, the hatchery has been successful in adaptively managing disease concerns as they arise (California Department of Water Resources 2004).

Predation

Sufficient information is not available to estimate the current rate of predation on juvenile salmonids in the lower Feather River. As reported by FERC (2007), the Fish Barrier Dam concentrates most anadromous salmonid spawning within the low-flow channel LFC. Reported counts of known predators on juvenile anadromous salmonids in the low-flow channel LFC were low. However, significant numbers of predators reportedly do exist throughout the lower Feather River and have been known to congregate at passage impediments, such as the Sunset Pumps Diversion Dam (Seesholtz et al. 2004; Windell et al. 2017). Passage impediments increase the risk of predation by providing habitat for predator fishes that feed on out-migrating juvenile salmonids that become disoriented in the turbulent water below the dam, and by increasing the exposure to predation by delaying passage.

11.2.7. American River

11.2.7.1. Description of Folsom Reservoir, Lake Natoma and American River

The American River watershed includes nearly 2,100 square miles (Bureau of Reclamation et al. 2006). Three forks of the American River (north, middle, and south forks) meet upstream of Folsom Dam, and the collective flow is transported through Lake Natoma and the 23-mile lower American River before converging with the Sacramento River just north of the city of Sacramento. Access to the upper reaches of the American River by anadromous fish is blocked at Nimbus Dam.

Folsom Reservoir has a capacity of approximately 977 thousand acre-feet (TAF) (U.S. Army Corps of Engineers 2002). Thermal stratification occurs in Folsom Reservoir from April until November which results in a thermocline with warmer, less dense water at the surface and colder, denser water underneath (U.S. Army Corps of Engineers et al. 2012). This thermal stratification allows both cold-water and warm water fish species to coexist in the reservoir. Warm water fish species include native hardhead, California roach, Sacramento pikeminnow, and Sacramento sucker, as well as nonnative largemouth bass, smallmouth bass, spotted bass, sunfish, black crappie, and white crappie (Bureau of Reclamation 2007). Cold-water fish species include native rainbow trout and planted Chinook ~~and kokanee~~ salmon, as well as nonnative brown trout (Bureau of Reclamation 2007).

Commented [CC26]: Can not compete with Wakasagi. Wakasagi are a big driver of fish species composition due to their ability to out-compete juvenile fishes for food resources.

Lake Natoma is a regulating afterbay to the Folsom Power plant and provides more uniform releases into the lower American River. Lake Natoma is formed by Nimbus Dam and is relatively shallow (average depth near 16 feet) (Bureau of Reclamation 2005). Lake Natoma also serves as a forebay for diversions to the Folsom South Canal. Surface water elevations in Lake Natoma may fluctuate daily between 4 and 7 feet (U.S. Army Corps of Engineers et al. 2012). Owing to the high fluctuation in surface water elevations and water temperatures, the lake has relatively low productivity as a fishery. The fish species present in Lake Natoma are generally similar to those found in Folsom Lake (Bureau of Reclamation 2007). ~~Lake Natoma is regularly stocked with hatchery rainbow trout, although conditions are better suited for warm-water fish species (Bureau of Reclamation 2007).~~

Commented [CC27]: Not anymore due to the potential for moving below Nimbus into the AR and genetic introgression with steelhead. Also this practice has been stopped so as not to allow a vector for pathogens such as IHN to move across lake natoma into the fish hatcheries and into the lower river.

Reclamation operates the CVP American River Division for flood control, municipal, industrial, and agricultural water supplies, hydroelectric power generation, fish and wildlife protection, recreation, and Delta water quality. Many other small reservoirs above Folsom Reservoir with a combined reservoir storage of approximately 820 TAF provide hydroelectric generation and water supply without specific flood control responsibilities. Because Folsom Reservoir is the closest reservoir among SWP/CVP reservoirs to the Delta, operators can use releases from Folsom to address any Delta regulatory requirements, such as water quality or flow requirements more quickly than upstream reservoirs.

Reclamation currently operates the reservoir to meet downstream regulatory requirements. ~~the minimum flow requirements (MFR) established in the 2006 Water Forum Lower American River Flow Management Standard (2006 FMS). The MFR establishes minimum flows, as measured by the total release at Nimbus Dam, which vary throughout the year in response to the hydrology of the Sacramento and American River Basins. The October 1 through December 31 MFR range between 800 and 2,000 cfs. The January 1 through Labor Day MFR range between 800 and 1,750 cfs. The post- Labor Day through September MFR range between 800 and 1,500 cfs. As a general rule, the MFR must equal or exceed 800 cfs year-round. Narrowly defined exceptions to this rule allow Nimbus releases to drop below 800 cfs to avoid depletion of water storage in Folsom Reservoir when dry or critical hydrologic conditions are forecasted to occur. These narrowly defined exceptions to the MFR are an important component of the 2006 Flow Management Standard.~~

Commented [CC28]: This is incorrect. Suggest updating the entire paragraph to reflect current operations (2017 FMS).

Minimum release requirements are the following:
October: 500-1,500 cfs
November-December: 500 - 2,000 cfs
January: 500 - 1,750 cfs
February-March: 500 - 1,750 cfs
April-June: 500 - 1,500 cfs
July-September: 500 - 1,750 cfs

Commented [CC29R28]: Also confirm if the overall Calsim II modeling was conducted using out of date American River operations or current American River operations.

Commented [CC30]: This is all outdated. In reality Reclamation operates Folsom to meet system wide needs primarily compliance with D-1641 but also to meet exports and other purposes like USACE flood control requirements. Reclamation rarely operates Folsom at the minimum flow requirements though will use the FMS as a backstop for minimum flows.

Water temperatures in the lower American River are ~~influenced~~managed primarily by the timing, magnitude, and temperature of water releases from Folsom and Nimbus Dams.

~~The 2019 NMFS biological opinion requires temperatures at Watt Avenue not to exceed 68°F from May 15 to October 31 for more than seven consecutive days unless it is a critical year based on the Sacramento Valley index or a year following one or more critical years. In critical years, and years immediately after a critical year, the temperature exceedance requirement is 68°F at Hazel Avenue. These requirements will be met through operational modifications of temperature control shutters on Folsom Dam, and structural improvements on several intakes in Folsom Lake and Lake Natoma. The 2019 NMFS biological opinion also requires that flows are not to be higher than 50,000 cfs in the American River during January to May with the exception of flood control or emergency conditions. Seasonal operational decisions that affect water temperature and river flows shall be coordinated through the American River Group.~~

As a result of the recent reinitiation of consultation on coordinated SWP/CVP/SWP operations, the following refinements for American River operations have been made relative to the 2009 NMFS BiOp RPA, as summarized by USFWS and NMFS (2019:20):

> *"The proposed action is consistent with the approach under the 2009 RPA with a modified flow management standard that targets preserving coldwater pool in the drier years to improve temperature management and reduce the magnitude and frequency of the high temperatures seen under the 2013-2016 drought. A commitment to modify the shutters in drought conditions is also included to improve temperature management (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2019:20)."*

Commented [CC31]: This is not correct. Exhibit C of the 2017 FMS the water temperature objectives are 65 degrees or less and Reclamation uses an iterative temperature matrix to achieve the lowest possible temperature. To be met with current measures including power bypass now and not when pending structural improvements are finished. It may be a decade or more before those are done. There is also an October 15 target of 60F and a 56F target Nov 1, along with bypass of power generation

11.2.7.2. Habitat Conditions and Environmental Stressors in American River Area

Aquatic Habitat

The completion of Nimbus Dam in 1955 blocked upstream passage by anadromous fish and restricted available habitat in the lower American River to the approximately 23- river- mile reach below the dam to the confluence with the Sacramento River. Additionally, completion of Folsom Dam has blocked downstream transport of sediment that contributes to the formation and maintenance of habitat for aquatic species in the American River and further downstream.

Beginning in 2008, in coordination with USFWS and the Sacramento Water Forum, Reclamation implemented a salmonid habitat improvement program in the lower American River. In 2008, approximately 5,000 cubic yards of gravel and cobble were put in the river just upstream of Nimbus Fish Hatchery. The following year, an additional approximately 7,000 cubic yards were placed adjacent to the Nimbus Fish Hatchery. In 2010, approximately 11,688 cubic yards of gravel and cobble were placed at Sailor Bar to enhance spawning habitat for Chinook salmon and steelhead in the lower American River (Merz et al. 2012). Additionally, the 2010 augmentation site contained a constructed cobble island and "scallops" in the substrate designed to add habitat heterogeneity to the main channel and rearing habitat for juvenile Chinook salmon and steelhead. An estimated 5,500 tons of cleaned cobble were also placed downstream of the

2010 augmentation site to divert flow into an adjacent, perched side channel, thereby ~~preventing~~minimizing the dewatering of salmonid redds in a historically important spawning and rearing area if flows dropped.

Commented [CC32]: This gravel has been rearranged since 2010 during high flow events and it no longer functions in this capacity.

At higher flows, channel geomorphology in the lower American River consists of bar complexes and side channel areas, which may disappear at lower flows (National Marine Fisheries Service 2009). Spawning bed materials in the lower American River may begin to mobilize at flows of 30,000 cfs, with more substantial mobilization at flows of 50,000 cfs or greater (Bureau of Reclamation 2008a). At 115,000 cfs (the highest flow modeled), particles up to 70 mm median diameter would be moved in the high-density spawning areas around Sailor Bar and Sunrise Avenue. Flood frequency analysis for the American River at the Fair Oaks gage shows that, on average, flood control releases exceed 30,000 cfs about once every 4 years and exceed 50,000 cfs about once every 5 years (Bureau of Reclamation 2008a).

In 2008, Reclamation began implementing floodplain and spawning habitat restoration projects in the American River to assist in meeting the requirements of the 1992 CVPIA, Section 3406 (b)(13). Spawning and rearing habitat enhancement projects have occurred each year since 2008 and they are planned to continue.

Fish Passage

Historically, more than 125 miles of riverine habitat was available for anadromous salmonids in the American River watershed (Yoshiyama et al. 1996). Access to the upper reaches of the river has been blocked by a series of impassable dams, which preceeded the construction of Folsom Dam, including Old Folsom Dam, first constructed in the American River between 1895 and 1939.

Reclamation operates a fish diversion weir approximately 0.25 mile downstream of Nimbus Dam, which functions to divert adult steelhead and Chinook salmon into Nimbus Fish Hatchery. The weir is installed annually during September prior to the arrival of fall-run Chinook salmon and steelhead and is removed at the conclusion of fall-run Chinook salmon immigration in early January (Bureau of Reclamation and California Department of Fish and Game 2011). Some steelhead may be trapped prior to weir removal, but they are returned to the river. A new fish passageway is being implemented in the Nimbus Dam stilling basin, commonly referred to as Nimbus Shoals. The passageway will replace the existing fish diversion weir with a new flume and fish ladder that will connect to the existing fish ladder near Nimbus Fish Hatchery.

Hatcheries

Commented [CC33]: The Mokelumne River Hatchery is not listed; it should be noted that any project actions that affect flows in the lower Sacramento River, or the Prospect Slough via the Colusa Basin Drain can influence stray rates of adult Chinook salmon. Proportionally high numbers of Mokelumne River Hatchery origin fall-run Chinook have been observed in the Ridge Cut and Colusa Basin Drain and are worth consideration.

The Nimbus Salmon and Steelhead Hatchery and American River Trout Hatchery (collectively, Nimbus Fish Hatchery) is located immediately downstream from Nimbus Dam. Facilities for the hatchery include a fish weir, fish ladder, gathering and handling tanks, hatchery-specific buildings, and rearing ponds. Nimbus Fish Hatchery was constructed primarily to mitigate the loss of spawning habitat for Chinook salmon and Central Valley steelhead (regardless of unintended genetic differences) that were blocked by the construction of Nimbus Dam (Bureau of Reclamation and California Department of Fish and Game 2011). It does not address lost habitat upstream from Folsom Dam (California Hatchery Scientific Review Group 2012). Under contract with Reclamation, CDFW operates the hatchery (Lee and Chilton 2007). Operations include trapping, artificially spawning, rearing, and releasing steelhead and fall- /late fall–-run Chinook salmon. The Nimbus Fish Hatchery Winter-Run Steelhead Program is an isolated-harvest program, meaning it does not include natural-origin steelhead in the broodstock, and is designed and implemented to artificially spawn the adipose fin-clipped adult steelhead that seasonally enter the trapping facilities (California Hatchery Scientific Review Group 2012). These fin-clipped fish are not considered part of the Central Valley steelhead DPS by NMFS. The Nimbus Fish Hatchery Winter-Run Steelhead Program propagates fish for recreational fishing opportunities and harvest (California Hatchery Scientific Review Group 2012).

Historically, steelhead were trapped at Nimbus Fish Hatchery as early as the first week of October. Beginning in 2000, the ladder has been opened in early November. Trapping of steelhead has continued to occur as late as the second week of March. Presently, winter-run Steelhead are trapped at Nimbus Fish Hatchery, and artificially spawned adults are marked with an adipose fin clip (California Hatchery Scientific Review Group 2012). Unmarked steelhead adults are not retained at Nimbus Fish Hatchery for use in the annual broodstock and are released back to the river (California Hatchery Scientific Review Group 2012). In addition, marked or unmarked *O. mykiss* that are less than 16 inches long may be resident hatchery-origin trout and are returned to the river (California Hatchery Scientific Review Group 2012).

The hatchery has raised and released an average of approximately 422,000 yearling steelhead per year since brood year 1999 (California Hatchery Scientific Review Group 2012). Since 1998, all steelhead/rainbow trout produced in Nimbus Fish Hatchery have been marked with an adipose fin-clip to aid in subsequent identification of hatchery-origin fish.

Juvenile steelhead yearlings are not held past March 30 due to higher hatchery water temperatures and to encourage outmigration during spring. If releases occur during periods of low flows in the Sacramento River and possibly the American River, some released fish migrate back to Nimbus Fish Hatchery and may take up residency rather than migrating downstream (Lee and Chilton 2007). Additionally, juvenile fish are released in February and early March to coincide with SWRCB State Water Board D-1641 closures of the DCC gates from February 1 through May 20, which reduces straying into the Delta. Reclamation determines the exact timing and duration of the gate closures each year after discussion with USFWS, CDFW, and NMFS.

Reclamation is implementing a genetic screening study of Nimbus Fish Hatchery steelhead. Reclamation, in contract with NMFS, is conducting a parental-based tagging study of American River steelhead and continuing a study to determine a more genetically appropriate stock.

CDFW releases all hatchery-produced steelhead juveniles into the American River at boat ramps or at the confluence of the Sacramento and American Rivers and releases all unclipped steelhead adults returning to Nimbus Fish Hatchery into the lower American River via the river return tube that is just downstream of the fish ladder. In accordance with California law, the current protocol of Nimbus Fish Hatchery is to destroy all surplus eggs to prevent inter-basin transfer of eggs or juveniles to other hatcheries or waters.

The goal of the Nimbus Fish Hatchery Integrated Fall-/Late Fall--Run Chinook Salmon Program is to release 4 million smolts. Each fall, Nimbus Hatchery staff collect approximately 10,000 adult fall-run Chinook salmon, with an annual goal of harvesting 8,000,000 eggs and releasing the 4,000,000 smolts. All adult fall run Chinook salmon collected at the hatchery are euthanized, and no trapped salmon are returned to the American River (Bureau of Reclamation 2008a).

Disease

CDFW has observed the occurrence of a bacterial-caused inflammation of the anal vent (commonly referred to as "rosy anus") of steelhead in the lower American River. The inflammation has been linked to relatively warm water temperatures (Water Forum 2005). Disease transmission may be exacerbated by crowding under conditions when water flows are reduced (Water Forum 2005).

Predation

Several predatory fish are present in the lower American River, including black basses (largemouth bass, smallmouth bass, and spotted bass) and striped bass, that exert predatory pressure on salmonids and other native fish species. Two factors—, reduced cold-water storage in Folsom Reservoir and using Folsom Reservoir to meet Delta water quality objectives and demands—, influence habitat conditions in the lower American River for warm-water predator species that feed on juvenile salmonids and potentially alter predation pressure (Water Forum 2005). Additionally, isolation of redds in side channels resulting from fluctuations in Folsom Reservoir releases may increase predation of emergent fry (Water Forum 2005).

Commented [CC34]: Black bass are minimally present and in the lower warmer reaches of the river and striped bass density is variable from minimally present to seasonally present.

Commented [CC35]: There are not really striped bass and black bass in these side channels

11.2.8. San Pablo and Francisco Bays

11.2.8.1. Description of San Pablo and San Francisco Bays

Hydrologically, the Bay may be divided into two broad subdivisions with differing ecological characteristics: a southern reach consisting of South San Francisco Bay; and a northern reach composed of Central San Francisco, San Pablo, and Suisun Bays (The Bay Institute 1998; CALFED Bay-Delta Program 2000a). The southern reach receives little freshwater discharge, leading to high salinity and poor circulation (high residence time). It also has more extreme tides. The northern reach, which directly receives Delta outflow, is characterized by less extreme tides and a pronounced horizontal salinity gradient, ranging from near full marine conditions in Central Bay to near freshwater conditions in Suisun Bay. Central Bay and Suisun Bay contain large islands, features not present in San Pablo Bay and South Bay (The Bay Institute 1998; CALFED Bay-Delta Program 2000a). All of the bays except Central Bay include extensive marshlands. Suisun Bay is not treated in this section because it was covered with the Delta in a previous section.

Northern Reach—Central San Francisco and San Pablo Bays

Ecological factors having the greatest influence on fish of Central San Francisco Bay and San Pablo Bay include freshwater inflow from rivers, wetlands, riparian vegetation, and aquatic habitat diversity. Habitats in these bays are tidal perennial aquatic habitat, tidal saline emergent wetland, seasonal wetland, perennial grassland, agricultural land, and riparian habitat. These habitats support a variety of native marine, estuarine, freshwater, and anadromous fish (CALFED Bay-Delta Program 2000a). San Francisco Bay is designated as a coastal estuary Habitat Area of Particular Concern (HAPC) and eelgrass (Zostera marina) is designated as seagrass HAPC for Pacific groundfish species. Fish species that currently depend on tidal marshes and adjoining sloughs, mudflats, and embayments include delta smelt, longfin smelt, Chinook salmon, green sturgeon, white sturgeon, Pacific herring (*Clupea pallasii*), starry flounder (*Platichthys stellatus*), Sacramento splittail, American shad, and striped bass (The Bay Institute 1998; CALFED Bay-Delta Program 2000a; Baxter et al. 2008). Other fish commonly found in Central Bay include northern anchovy (*Engraulis mordax*), halibut, American shad, bay goby (*Lepidogobius lepidus*), white croaker (*Genyonemus lineatus*), Pacific staghorn sculpin (*Leptocottus armatus*), and marine surfperches. English sole (*Parophrys vetulus*), shiner surfperch (*Cymatogaster aggregata*), jacksmelt (*Atherinopsis californiensis*), topsmelt (*Atherinops affinis*), diamond turbot (*Hypsopsetta guttulata*), and speckled sand dab (*Citharichthys stigmaeus*) are common in shallow waters around Central Bay. The leopard shark (*Triakis semifasciata*), sevengill shark (*Notorynchus cepedianus*), and the brown smoothhound (*Mustelus henlei*) are abundant in the intertidal mudflats of the Central Bay. The sand substrate and rock outcrops in the Central Bay support recreational fish such as the halibut, striped bass, rockfish, and lingcod (*Ophiodon elongatus*).

Southern Reach—South San Francisco Bay

The southern reach receives far less freshwater runoff and does not generally exhibit the type of estuarine circulation that occurs in the northern reach (The Bay Institute 1998). Salinity is characteristically high, often similar to nearshore ocean levels, but is generally homogeneous. The reach is characterized by a much higher residence time of water, and on average is flushed at about one-fourth the rate of the northern reach (The Bay Institute 1998).

The South Bay supports a primarily marine fish assemblage owing to its saline water environment. Fish species include planktivorous topsmelt, jacksmelt, bay pipefish (*Syngnathus leptorhynchus*), brown rockfish (*Sebastes auriculatus*), surfperches, surf smelt (*Hypomesus pretiosus*), longfin smelt, diamond turbot, arrow goby (*Clevelandia ios*), and staghorn sculpin (The Bay Institute 1998). Anadromous salmonids produced in tributaries to the South Bay include steelhead and Chinook salmon.

11.2.8.2. Habitat Conditions and Environmental Stressors in San Pablo and San Francisco Bay Area

Environmental stressors for fish populations in San Francisco and San Pablo Bays include water and sediment quality, exposure to toxic substances, reduction in Delta outflows, legal and illegal harvest, food availability, reduction in seasonally-inundated wetlands, wave and wake erosion, introduced nonnative plant and animal species, competition for food resources with non-native fish and macroinvertebrates (e.g., filter feeding by the non-native mollusks) (CALFED Bay-Delta Program 2000a; Armor et al. 2005;, Baxter et al. 2008).

11.2.9. Local Drainages

Both Stone Corral and Funks Creeks have small watersheds originating in the eastside foothills of the Coast Range at elevations of 700 to 850 feet and flow intermittently, mostly in winter and early spring months. From their origins, both creeks flow through low foothills, across Antelope Valley (the location of the Sites Reservoir footprint), through a series of ridges, and onto the Sacramento Valley floor (Figure 1). For much of their course on the valley floor, they are confined to narrow channels between berms along agricultural fields and road prisms[1]. While the stream channels of these creeks are not actively managed, their straight channels and angular turns around agricultural fields and along roads indicate that they were modified from their natural channels at some point in the past. In the upper parts of the watersheds just below the dam locations, these streams are largely devoid of riparian cover due to cattle grazing activity (USBR and DWR 2008). In the lower reaches where the streams run through and around agricultural fields, riparian habitat is sparse and consists mostly of low shrubs, grasses, and occasional oak and cottonwood trees.

11.2.9.1. Stone Corral Creek

Stone Corral Creek has a drainage area of 32.8 square miles. From the location of the Sites Dam, Stone Corral Creek meanders through a shallow canyon onto the valley floor, where it flows through an incised channel across grazing lands. At 4.6 miles from the Sites Dam location, Stone Corral Creek crosses over a siphon in the TC Canal and begins to travel through agricultural lands. About 3 miles below the TC Canal siphon, Stone Corral Creek crosses the GCID Main Canal siphon. Although most of the water in the GCID Main Canal passes under Stone Corral Creek in the siphon, GCID releases water from the canal to Stone Corral Creek for delivery to agricultural fields downstream. About 5.5 miles below the GCID Main Canal, Stone Corral Creek merges with Funks Creek and then flows an additional 5.7 miles to the CBD.

11.2.9.2. Funks Creek

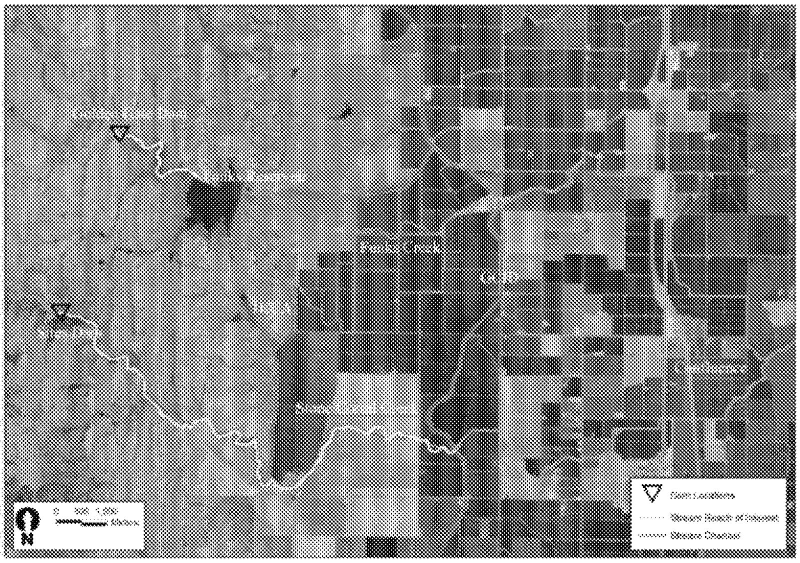
Funks Creek, a tributary to Stone Corral Creek, has a drainage area of 43 square miles. From the location of Golden Gate Dam, Funks Creek meanders through a series of low ridges and grazing lands for about 1.8 miles to Funks Reservoir. Funks Reservoir is a re-regulating reservoir on the TC Canal and is created by a low dam on Funks Creek. Funks Dam is operated by TCCA mostly for flood control purposes. The Funks Dam gates are opened during large storm events to pass flood waters through the reservoir and downstream to avoid compromising the TC Canal and its operations. There are no requirements to maintain flows in Funks Creek below Funks Reservoir, but seepage through the dam gates allow a few cfs, which maintains flow in Funks Creek.

Commented [CC36]: Seepage is fine if it maintains the fishery, however the fishery is actually protected; Fish and Game code (article 5937) states: The owner of any dam shall allow sufficient water at all times to pass though a fish way, or in the absence of a fishway, allow sufficient water to pass over around or through the dam, to keep in good condition any fish that may exist below the dam......"

Below Funks Dam, Funks Creek travels 3.9 miles through agricultural fields in a combination of natural and straightened channels to where it crosses the GCID Main Canal. While the GCID

[1] Characterization of stream channels is based on desktop review of streams using Google Earth.

Main Canal passes under Funks Creek in a siphon, GCID releases water from the canal to Funks Creek and uses the downstream portions of the creek as part of its conveyance system to deliver water to agricultural fields. Approximately 2 miles northeast of Maxwell and 1 mile east of Interstate 5, Funks Creek flows into Stone Corral Creek.



11.2.9.3. Water Quality

Stone Corral Creek is listed under section 303(d) as an impaired water body for low dissolved oxygen levels (SWRCB 2017). The creek was originally listed in 2010 and is scheduled to have a Total Maximum Daily Load plan by 2027. This designation is based on samples collected at a sampling site located where Stone Corral Creek crosses 4-mile Road. This location is downstream of the confluence between Funks and Stone Corral Creeks, at the western edge of the Delevan National Wildlife Refuge. The source of the oxygen depletion is listed as unknown (SWRCB 2017) but, given the amount of algae visible in Google Earth photos, nutrient loading from the cattle grazing lands and agricultural fields is a likely source in both watersheds. During fish surveys in 1998 and 1999, CDFW noted that water quality was poor and high in dissolved minerals. They reported that the total dissolved solids in the water were so high that it precluded electrofishing as a means of sampling (CDFG 2003).

SWRCB (2017) did not report on water quality in Funks Creek but given similar size, geology, and land use between the two watersheds, the water quality in Funks Creek is likely comparable to Stone Corral Creek.

11.2.9.4. Hydrology

Both streams originate at low elevations below the snow line of the Coast Range and consequently do not receive cold snowmelt water. Rather, they respond rapidly to significant rainfall events and flash flooding and substantial overland flow has been observed (USBR and DWR 2013).

The U.S. Geological Survey (USGS) collected 25 years of discharge measurements in Stone Corral Creek near the town of Sites from 1958 through 1985. During that time, there were 3 years of zero flow: 1972, 1976, and 1977. Yates (1989) estimated the recurrence interval of a winter without flow at 12 to 14 years. The maximum mean daily flow of 2,230 cfs occurred on December 24, 1983. The instantaneous peak flow was 5,700 cfs on January 26, 1983. The 100-year discharge was established in a 1987 Colusa Basin flood flow frequency analysis as 7,870 cfs (DWR 1987, cited in USBR and DWR 2008).

Commented [CC37]: *No measurable flow, which does not necessarily mean there is no flow at all

There is no comparable data set for Funks Creek. However, given the comparable size, geology, and topography of the two watersheds and their proximity to each other upstream of their confluence, Stone Corral Creek hydrology is likely representative of Funks Creek hydrology in terms of amount and seasonality of flow. The daily mean hydrology for Stone Corral Creek was presented in the Draft EIR/EIS and is included in Table 1. It shows the variability of flow over the period of record differs considerably from a static flow of 10 cfs.

Table 1. Stone Corral Creek Daily and Monthly Flows Near Sites, USGS 11390672

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Daily Flows (cfs) for Period of Record												
Min	0	0	0	0	0	0	0	0	0	0	0	0
Max	0	74	2,230	1,910	2,150	1,980	619	45	9	1	0	0
Avg	0	1	11	32	39	21	8	1	0	0	0	0
Monthly Flows (AF) for Period of Record												
Min	0	0	0	0	0	0	0	0	0	0	0	0
Max	0	427	11,432	8,825	11,137	15,227	4,451	740	146	19	0	0
Avg	0	37	660	1,946	2,190	1,300	484	83	13	1	0	0

Commented [CC38]: Would be good to present both the mean and median to better characterize flows.

Source: Sites Project Authority and Reclamation 2017.
Period of Record 4/1/1958 – 9/30/1964 and 10/1/1965 – 9/30/1985
Drainage Area = 38.2 Square Miles

11.3 Modeling Results

11.4 Methods of Analysis

The impact assessment relies primarily on modeled hydrologic changes in SWP and CVP operations that would occur as a result of Project operations. The monthly flow output of the

CALSIM II model was used to assess changes in reservoir water surface elevation, storage, and instream flows associated with implementation of the alternatives. The CALSIM II monthly flow output also served as input to many of the other models used to analyze potential impacts to aquatic resources. Given that the CALSIM II model uses a monthly time step, incremental flow and storage changes of 5 percent or less are generally considered within the standard range of uncertainty associated with model processing. Flow changes of 5 percent or less were considered to be similar to the Existing Conditions/No Project/No Action Condition flow levels in the comparative analyses using CALSIM II conducted in this EIR/EIS. Changes in flow exceeding 10 percent were considered to represent a potentially meaningful difference.

Commented [CC39]: Consider looking at changes in flow on a daily timestep- 10% change on a monthly timestep should be justified with more context to explain its application.

For this RDEIR/SDEIS, the term *No Project Alternative* describes both the No Project Alternative and No Action Alternative for CEQA and NEPA purposes, respectively. They are also synonymous with the existing conditions. Additional information on the No Project Alternative is in Chapter 2, *Project Description and Alternatives*, and Chapter 3, *Environmental Analysis*. Additionally, under the No Project Alternative, none of the Project facilities would be constructed, operated, or maintained, thus there would be no temporary or permanent impacts on special-status aquatic species or their habitats. The No Project Alternative assumes existing regulatory criteria, including implementation of the 2019 Biological Opinions from the U.S. Fish and Wildlife Service and National Marine Fisheries Service for the Reinitiation of Consultation on the Coordinated Operations of the CVP and SWP (ROC on LTO; USFWS 2019 and NMFS 2019) and the Incidental Take Permit for Long-term Operations of the State Water Project in the Sacramento-San Joaquin Delta (SWP ITP) (CDFW 2020). Regulatory criteria also include the SWRCB water rights and water quality criteria related to the CVP and SWP operations. For the reasons outlined above, all operations activities (Impact FISH-2 through Impact FISH-19) under the *No Project Alternative* would have no impact on aquatic biological resources.

Hydrologic simulation results of end-of-month reservoir storage and elevations provided a quantitative basis to assess the potential impacts of operations on fish species, relative to the bases of comparison, for the period of simulation extending from Water Year 1922 through 2003 (82-year simulation period).

A detailed discussion of the specific methodologies and indicators used to evaluate potential impacts due to changes in SWP and CVP operations as a result of Project implementation is provided in Appendix 11B Fisheries Impact Assessment Methodology; potential effects on habitat conditions for each species and life stage are presented in Appendix 11C Fisheries Impact Summary.

[Table 11.X, "draft aquatic tools table TO COME.]

Table 11-X. Methods for Analysis of Potential Effects on Fish and Aquatic Resources

11.4.1. Construction

The best management practices/environmental commitments described in Table 2-25 are incorporated into the analysis of potential construction impact on aquatic biological resources.

The assessment of potential impacts to fish resources consisted of a qualitative evaluation of construction effects of the Project facilities. The impact assessment addressed two primary impact types: (1) temporary and localized impacts associated with construction of the Project facilities; and (2) permanent impacts associated with construction of Project facilities and filling of Sites Reservoir.

The assessment of impacts to fish resources was based on the CEQA significance thresholds described below, and professional judgment that considers current state, federal, and local regulations and policies, currently available peer-reviewed scientific literature, field survey observations, and knowledge of species' distribution, life history, and habitat requirements. Key considerations in the evaluation of impacts included the magnitude of environmental effects (e.g., spatial extent and duration of habitat modification), sensitivity of the species to these effects, and potential exposure or extent to which the population would be affected.

The impact analysis includes the following key assumptions:

- Installation of the two additional TC Canal diversion pumps at the RBPP would not affect special-status fish or their habitat because construction would occur in the existing facility footprint which does not support habitat for special-status fish. No impacts are anticipated and this area is not considered further in this analysis.
- Construction performed at various locations along the GCID Main Canal associated with upgrades to support the operation of Sites Reservoir would not affect special-status fish or their habitat because construction would occur in the existing facility footprint which does not support habitat for special-status fish. No impacts are anticipated and this area is not considered further in this analysis.
- Construction impacts on special-status fish in the Sacramento River, including listed species and associated designated critical habitat, would occur only under Alternative 2.
- Piles for work platforms to construct the Sacramento River discharge (Alternative 2) are assumed to be within 200 feet of the Sacramento River channel and could produce underwater noise levels during impact pile driving that exceed the interim criteria for injury to fish.
- The reservoir would replace existing intermittent and ephemeral streams with open water and Alternative 1 or 3 would permanently flood slightly more stream habitat than Alternative 2.

The following BMPs, which are described in Appendix 2D, *Best Management Practices*, are incorporated into the analysis of potential construction impacts on fish resources.

- Develop and Implement Stormwater Pollution Prevention Plan(s) (SWPPP) and Gain Coverage under Stormwater Construction General Permit (Storm Water and Non-Storm Water) – requires development and use of erosion control measures, sediment control measures, construction materials management measures, waste management measures, non-stormwater control measures, and post-construction stormwater management measures.
- Develop and Implement Spill Prevention and Hazardous Materials Management/Accidental Spill Prevention, Containment, and Countermeasure Plans (SPCCPs) and Response Measures – requires site-specific plans with measures to minimize effects from spills of hazardous or petroleum substances during construction and operation/maintenance.
- Worker Environmental Awareness Program (WEAP) – requires training of all construction crews and contractors on protection and avoidance of biological, cultural, archaeological, paleontological, and other sensitive resources.
- Develop and Implement an Underwater Sound Control, Abatement, and Monitoring Plan – requires a plan with measures to avoid and minimize the effects of underwater construction noise on fish, particularly underwater noise effects associated with impact pile driving activities, by restricting the seasonal and daily timing of pile driving, conducting hydroacoustic monitoring during impact pile driving, and monitoring the in-water work area for signs of distressed or injured fish.
- Develop and Implement Hazardous Materials Management Plans (HMMPs) – requires HMMPs before beginning construction that considers hazardous materials present on site and known historic site contamination, governs the storage, use, or transfer of hazardous materials, outlines emergency spill containment and cleanup procedures, and outlines procedures for handling, hauling, and disposing of hazardous waste generated at work sites.
- Develop and Implement Fish Rescue and Salvage Plans for Funks Reservoir, Stone Corral Creek, and Funks Creek, and CBD for Alternatives 1, 2 and 3; for Sacramento River for Alternative 2 – requires plan to outline fish herding and/or fish rescue operations where dewatering and resulting isolation of fish may occur. The plans will include detailed fish collection, holding, handling, and release procedures.
- Construction Best Management Practices and Monitoring for Fish, Wildlife, and Plant Species Habitats, and Natural Communities – requires a construction monitoring plan for sensitive biological resources and in-water construction activities, use of exclusion fencing around sensitive biological resources, and restricting in-water construction activities on the Sacramento River to September 1 through October 15 and in non-anadromous waters to June 1 through October 15.

11.4.2. Operation

The best management practices/environmental commitments described in Table 2-25 are incorporated into the analysis of potential operation impacts on cold-water and warm-water species of fish in reservoirs.

Implementation of the alternatives could potentially result in alterations to storage volumes and water surface elevations in Shasta, Oroville, Folsom, San Luis, Trinity, New Melones, and Millerton reservoirs, which could potentially affect reservoir fish species. Model output parameters derived from CALSIM II used to determine potential impacts included:

- End-of-month (average annual monthly) reservoir storage volume
- End-of-month (average annual monthly) water surface elevations

During the period when these reservoirs are thermally stratified (generally April through November), cold-water fish within the reservoir reside primarily within the deeper layers of the reservoir where water temperatures remain suitable. Implementation of the cooperative operations agreements with Reclamation and DWR could increase reservoir storage during this period; implementation could also increase the reservoir's cold-water pool volume, thereby increasing the quantity of habitat available to cold-water fish species during these months. Reservoir cold-water pool size generally increases as reservoir storage increases, although not always in direct proportion because of the influence of reservoir basin shape. To assess potential storage-related impacts on cold-water fish habitat availability in Trinity, Shasta, Oroville, and Folsom reservoirs, end-of-month storage was simulated for the alternatives were compared to end-of-month storage simulated for the Existing Conditions/No Project/No Action Condition for each month of the April through November period (Appendix 11E Reservoir Storage and Water Surface Elevation Summary Tables).

Commented [CC40]: Is this really an increase, or a change in how water is stored and released?

Commented [CC41]: Expand to describe what changes in operations/agreements could result in the meaningful increases analyzed, references supporting suggested fish use would also be helpful.

Because reservoir warm-water fish species[2] use the warm upper layer of the reservoir and nearshore littoral habitats, seasonal changes in reservoir storage, as it affects reservoir water surface elevation, and the rates at which water surface elevation change during specific periods of the year, can directly affect warm-water fish nesting and spawning success. To assess the impacts of potential reservoir water surface elevation changes on warm-water fish, the following approach was used. The magnitude of change, as measured in feet with reference to mean sea level (feet mean sea level), in reservoir water surface elevation occurring each month of the primary spawning period for nest-building fish (March through June) simulated for the alternatives was determined and compared to the Existing Conditions/No Project/No Action Condition. Specifically, the number of times that reservoir reductions of 6 feet or more per month could occur with implementation of the alternatives was compared to the number of occurrences of the same modeled for the Existing Conditions/No Project/No Action Condition (Appendix 11E Reservoir Storage and Water Surface Elevation Summary Tables).

[2] Largemouth bass are evaluated as an indicator species in this EIR/EIS analysis to reflect potential impacts on warm-water game fishes.

A detailed description of the specific methods utilized to evaluate potential impacts on cold-water and warm-water fish species in each of the existing reservoirs potentially affected by implementation of the alternatives is provided in Appendix 11B Fisheries Impact Assessment Methodology.

11.4.3. Maintenance

Operation activities may have some limited potential to "harm" juvenile and adult fishes by direct physical contact, including physical injury or mortality. The assessment of impacts from maintenance activities was based on a qualitative evaluation for the facilities included under Alternatives 1, 2, and 3 and focuses on maintenance activities that are near waterways and can affect fish. Examples include debris removal, vegetation control, rodent control, routine inspections, etc. Electrical transmission connections and lines, substations, distribution lines, dam monitoring equipment, and administration and other buildings are not included in the assessment since these facilities are located away from waterways and will not affect fish and aquatic resources. The analysis also considers BMPs that are described in Section 2.5.4, *Project Commitments and Best Management Practices Common to All Alternatives*.

11.4.4. Thresholds of Significance

An impact on aquatic biological resources would be considered significant if the Project would:

- Have a substantial adverse effect, either directly or through habitat modifications, on any fish species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service.
- Interfere substantially with the movement of any native resident or migratory fish species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites.
- Conflict with any local policies or ordinances protecting aquatic biological resources.
- Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan.

11.5 Impact Analysis and Mitigation Measures

Impact FISH-1: Construction Effects on Special-Status Fish

No Project

Under the No Project Alternative, no Project facilities would be constructed and there would be no associated ground-disturbance that would result in temporary or permanent impacts on special-status fish or aquatic biological resources from construction activities (including ground disturbance) or placement of Project facilities, respectively.

Significance Determination

The No Project Alternative would not result in construction effects on special-status fish or aquatic biological resources because no new Project facilities would be built. There would be no impact.

Alternatives 1, 2, and 3

Effects of Alternatives 1, 2, and 3

Acoustic Effects

Under Alternatives 1, 2, and 3, underwater noise would be generated by a variety of construction activities including pile driving (impact and vibratory)[3], dredging in Funks Reservoir, geotechnical investigations, bridge and culvert construction and replacement, and riprap placement for the CBD outlet. Pile driving is proposed for cofferdam construction associated with GCID system upgrades at the head gates, Walker Creek siphon, and Willow Creek siphon; cofferdam and wall construction at the Funks and TRR PGPs; installation of sheet pile vertical shafts for the tunnel crossings for the TRR pipelines at the GCID Main Canal and TC Canal; and cofferdam construction for the Dunnigan Pipeline at the CBD discharge. Underwater noise from construction activities associated with Alternatives 1, 2, and 3 has the potential to disturb or result in the injury and/or mortality of special-status fish in Funks and Stone Corral Creeks and the CBD (Table 11-2).

Under Alternative 2, additional construction activities with potential to generate underwater noise would include placement of riprap and cofferdam construction in the Sacramento River and the installation of up to two temporary work platforms, each with 12 to 15 vibrated or hammer-driven pipe piles on the river bank, for the discharge and energy dissipation structure for the Sacramento River discharge. Underwater noise from construction activities for Alternative 2 also has the potential to disturb special-status fish, including listed species, in the Sacramento River (Table 11-2). Under Alternative 2, the work platforms would be constructed in about 2 weeks, while cofferdam installation is predicted to take 4 to 6 weeks.

Impact pile driving in or near aquatic habitat (i.e., within 200 feet) would be of most concern as it generates sound levels that can injure or kill fish and other aquatic organisms. Alternatives 1, 2, and 3 include physical or structural components that would require vibratory and/or impact driving of temporary and permanent piles during construction. Several of these components

[3] Impact pile driving uses a hydraulic hammer mounted on a piling rig with a ram mass to dynamically drive piles into the ground, while vibratory pile driving uses a low impact method of creating vertical vibrations that puts soil particles into motion thereby loosening the soil and allowing the pile to penetrate the soil. Impact pile driving results in high intensity impulsive sounds that can potentially cause injury in fish. Vibratory hammers generally produce less sound than impact hammers and are often employed as a mitigation measure to reduce the potential for adverse effects on fish that can result from impact pile driving (Caltrans 2015:2-17). In addition, there are no established injury criteria for vibratory pile driving (Caltrans 2015:2-17); therefore, effects on fish from vibratory pile driving are typically behavioral.

involve pile driving activities in or adjacent to water bodies supporting fish, resulting in their potential exposure to pile driving noise.

Research indicates that impact pile driving can result in adverse effects on fish because of the level of underwater sound produced (Popper and Hastings 2009:464–480). The effects of pile driving noise on fish may include behavioral responses, physiological stress, temporary and permanent hearing loss, tissue damage (auditory and non-auditory), and direct mortality. Factors that may influence the magnitude of effects include: (1) species, life stage, and size of fish; (2) type and size of pile and hammer; (3) frequency and duration of pile driving; (4) site characteristics (e.g., water depth, channel bends); and (5) distance of fish from the source.

Dual interim criteria have been established to provide guidance for assessing the potential for injury of fish resulting from pile driving noise (Fisheries Hydroacoustic Working Group 2008:1) and were used in this evaluation. The dual criteria for impact pile driving are shown in Table 11-Const1.

Table 11-Const1. Interim Criteria for Injury to Fish from Impact Pile-Driving Activities

Interim Criteria	Agreement in Principle
Peak sound pressure level (SPL)	206 dB re: 1 μPa (for all sizes of fish)
Cumulative sound exposure level (SEL)	187 dB re: 1 μPa^2-sec—for fish size ≥ 2 grams 183 dB re: 1 μPa^2-sec—for fish size < 2 grams

Source: Fisheries Hydroacoustic Working Group 2008
dB = decibel; μPa = microPascal; sec = second

The following criteria relate to impact pile driving only. The peak sound pressure level (SPL) is considered the maximum sound pressure level a fish can receive from a single strike without injury. The cumulative sound exposure level (SEL) is considered the total amount of acoustic energy that a fish can receive from single or multiple strikes without injury. The cumulative SEL threshold is based on the cumulative daily exposure of a fish to noise from sources that are discontinuous (e.g., noise that occurs for only 8 to 12 hours in a day, with 12 to 16 hours between exposure). This quiet period assumes that the fish is able to recover from any pile driving effects during this 8- to 12-hour period.

Vibratory pile driving methods produce more continuous, lower energy sounds below the thresholds associated with injury. There are currently no established noise thresholds associated with continuous sound waves, and vibratory methods are generally accepted as an effective measure for minimizing or eliminating the potential for injury of fish during in-water pile driving operations, though they are likely to still cause physiological and behavioral changes (McCauley et al. 2003; Popper and Hastings 2009).

The following analysis also considers the potential for pile driving sound to adversely affect fish behavior. Potential mechanisms include startle or avoidance responses that can disrupt or alter normal activities (e.g., migration, holding, feeding) or expose individuals to increased predation risk. Insufficient data are currently available to support the establishment of a noise threshold for behavioral effects (Hastings and Popper 2005:46; Popper and Hastings 2009:464). NMFS generally assumes that a noise level of 150 decibels (dB) root mean square (RMS) is an appropriate threshold for behavioral effects, although neither research data nor related citations have been provided to support this threshold (Caltrans 2015:4-23).

Because pile driving specifics are not known at this time, it was necessary to evaluate the potential for physical injury to fish from exposure to pile driving sounds using data from other projects, where similar pile driving methods are proposed, to estimate the distances from the pile that sound attenuates to the peak or cumulative criteria. As such, the potential for injury to fish from exposure to pile driving sounds from Project construction was determined based on the predicted pile driving sound levels for construction-related activities associated with cofferdam installation on the Sacramento River (NMFS 2017:110–116). That analysis evaluated the potential for injury to fish using a spreadsheet model developed by NMFS to calculate the distance from the pile that sound attenuates to the peak or cumulative criteria. The NMFS spreadsheet calculates these distances based on estimates of the single-strike sound levels for each pile type (measured at a known reference distance from the pile, typically 10 meters) and the rate at which sound attenuates with distance. Assumed pile-driving source levels are typically taken from measured source levels for similar piles driven in similar conditions and reported in Caltrans (2015). In addition, a standard sound attenuation rate of 4.5 dB per doubling of distance is typically assumed in the absence of other data. To account for the exposure of fish to multiple pile driving strikes, the model computes a cumulative SEL for multiple strikes based on the single-strike SEL and the number of strikes per day or pile driving event. The NMFS spreadsheet also employs the concept of *effective quiet*, which assumes that cumulative exposure of fish to pile driving sounds of less than 150 dB SEL does not result in injury. These distances define the area in which the criteria are expected to be exceeded because of impact pile driving. The following assessment presents the maximum effect that is reasonably foreseeable based on the noise levels predicted to exceed the interim injury and behavioral thresholds from construction-related activities associated with cofferdam installation on the Sacramento River (NMFS 2017:110–116). Because driving of piles with an impact hammer in water results in greater underwater sound levels than land-based pile driving, the predicted noise levels associated with impact driving of sheet piles for the cofferdam encompass predicted levels that would result from impact driving of piles on land for the temporary work platforms.

For cofferdam sheet piles, the pile driving analysis suggests that the distance from the source pile to sound level thresholds (i.e., upstream and downstream) would extend 30 feet for the 206 dB injury threshold and 2,814 feet for the 187 dB SEL injury threshold, assuming an unimpeded propagation path (NMFS 2017:110–116). However, the potential for behavioral effects would extend much farther. Based on the threshold of 150 dB RMS, potential behavioral effects are calculated to extend up to 13,058 feet (2.5 miles) from the source pile. While the extent of the 187-dB and 150-dB RMS thresholds overlap and would cover the entire width of the CBD (Alternatives 1, 2, or 3) and Sacramento River (Alternative 2), major bends in the CBD (approximately 5,500 feet upstream and downstream from the outlet) and in the Sacramento River (approximately 6,000 feet upstream and 2,500 feet downstream from the discharge site) would limit the propagation of the sound path. These estimates likely reflect maximum distances from the source pile for potential direct injury and behavioral impacts on special-status fish in the CBD and Sacramento River (Table 11-2). Furthermore, this analysis assumes use of impact pile driving exclusively (i.e., no vibratory pile driving during initial pile installation). Thus, these effect estimates are conservative.

Geotechnical investigations could result in temporary acoustic effects on fish. Acoustic effects from standard geotechnical penetration tests (i.e., dropping a 140-pound automatic hammer to drive a sampler about 1.5 feet) are limited to minimal, short-duration vibrations (NMFS 2017:177). Placement of riprap has the potential to result in temporary loud noises, although the available data from analogous situations suggest such effects would be limited. For example, sound data taken during the 2012 installation of rock barriers as part of DWR's Temporary Barriers Project in the South Delta showed that noise levels at 100 meters from construction were below the NMFS criteria for adverse behavioral effects (150 dB). Effects on fish in the CBD or Sacramento River (Alternative 2 only) would be limited to behavioral effects only while the riprap is being placed.

Pile driving would be performed in compliance with a BMP for an Underwater Sound Control, Abatement, and Monitoring Plan. Where impact pile driving is performed, hydroacoustic monitoring would be conducted to ascertain compliance with established objectives (e.g., distances to cumulative noise thresholds) and identify corrective actions to be taken should the predicted threshold distances be exceeded. In addition, all pile driving (impact or vibratory) would be conducted in compliance with seasonal (September 1 to October 15) and daily (7:00 a.m. to 7:00 p.m.) timing limitations.

Given the proposed seasonal and daily timing restrictions and localized effect of pile driving and other in-water construction activities, it is expected that underwater noise generated by these activities would adversely affect a small proportion of special-status fish species in Funks Creek, Stone Corral Creek, and the CBD (Table 11-2) under Alternatives 1, 2, or 3. Under Alternative 2, adult and juvenile fish in the Sacramento River (Table 11-2) would be exposed to high sound levels as they pass the affected area in the Sacramento River. However, pile driving and other in-water construction activities would be timed (September 1–October 15) for periods of reduced abundance for listed and other special-status fish species, and any fish present would be expected to pass through the affected area relatively quickly. In combination with seasonal restrictions, limiting pile driving to daylight hours only would give fish a 12-hour period to recover between exposures or migrate through the area unexposed. Thus, noise generated by pile driving and other in-water construction activities would be expected to affect only a small proportion of these fish populations in the Sacramento River.

<u>**Sediment Disturbance**</u>

The construction of Alternatives 1, 2, and 3 would involve activities that would potentially cause erosion and the disturbance of sediment and soil, subsequently resulting in sediment transport and delivery to streams. Sediment input to streams could temporarily increase water column turbidity and sedimentation rates above ambient levels and potentially alter fish physiology, behavior, and habitat conditions in waterways. Construction activities that have the potential to result in erosion and sediment transport and delivery to streams include: (1) site clearing and vegetation removal in the inundation area and at the CBD outlet; (2) excavation, grading, and soil placement to construct the main, saddle, and saddle dike dams; (3) topsoil storage and road construction and relocation; (4) culvert and bridge modification and construction; (5) dredging/excavation in Funks Reservoir; (6) bed and bank disturbance at creek crossings; and (7) the placement and removal of cofferdams and stream diversions to construct the main dams. Under Alternative 2, sediment- and turbidity-producing activities would include: (1) constructing the Dunnigan Pipeline to the Sacramento River; (2) site clearing and vegetation removal to construct the Sacramento River discharge; and (3) installing a cofferdam and placing riprap for the Sacramento River discharge. Construction activities that would occur in or immediately adjacent to stream channels (e.g., excavation, grading, vegetation removal, bridge and culvert construction, and the placement and removal of cofferdams and stream diversions) and Funks Reservoir (dredging/excavation) or during the wet season have the greatest potential to disturb stream sediments or cause erosion and contribute sediment to streams.

Elevated levels of suspended sediments have the potential to result in physiological, behavioral, and habitat effects on fish. The severity of these effects depends on the sediment concentration, duration of exposure, proximity of the action to the waterbody, and timing of the disturbance relative to the occurrence of the species and sensitive life stages. Short-term increases in turbidity and suspended sediment may disrupt normal behavior patterns of fish, potentially affecting foraging, rearing, and migration. The level of disturbance may also cause juvenile fish to abandon protective habitat or reduce their ability to detect predators, potentially increasing their vulnerability to predators (e.g., piscivorous birds and fish). Chronic exposure to high turbidity and suspended sediment may affect fish growth and survival by impairing respiratory function, reducing tolerance to disease and contaminants, and causing physiological stress (Waters 1995). Deposition of excessive fine sediment on the stream bottom could eliminate habitat for aquatic insects; reduce density, biomass, number, and diversity of aquatic insects and vegetation; reduce the quality and quantity of spawning habitat; and block the interchange of surface and subsurface waters. Substantial sediment input and deposition could: (1) cause channel braiding; (2) increase width: depth ratios; (3) increase incidence and severity of bank erosion; (4) reduce pool volume and frequency; and (5) increase subsurface flow. See Chapter 7, *Fluvial Geomorphology,* for additional information on potential effects related to elevated levels of suspended sediments.

Based on general observations of similar in-water construction activities, increases in turbidity and suspended sediment generated during construction would be temporary and localized, and unlikely to reach levels causing direct injury or mortality to fish. In some cases, increases in turbidity could produce minor positive effects. For example, turbidity has been known to reduce vulnerability to predation in some species interactions (Gregory and Levings 1998:275). NMFS (2008:95) reviewed observations of turbidity plumes during installation of riprap for bank protection projects on the Sacramento River and concluded that visible plumes are expected to be limited to only a portion of the channel width, extend no more than 1,000 feet downstream, and dissipate within hours of cessation of in-water activities. Based on these observations, NMFS (2008:95) concluded that such activities could result in turbidity levels exceeding 25–75 NTU.

This level of effect is considered representative of potential turbidity effects from the alternatives.

Eroded soils have been known to transport pollutants such as nutrients; metals; oils, fuels, and grease; and pesticides, herbicides, and other agricultural chemicals. Eroded soils could result in the potential release and dispersal of these contaminants if contaminated sediments are disturbed during construction and transported and delivered to streams. Fish could be directly exposed to elevated levels of contaminants if they are in immediate proximity to construction activities that disturb contaminated sediments. Channel bed disturbance could also result in indirect effects on fish. Toxins in river channel sediments can enter the food web through uptake by benthic organisms. If contaminated sediments are disturbed and become suspended in the water column, they also become available directly to pelagic organisms, including fish species and planktonic food sources of fish species. Thus, construction-related disturbance of contaminated bottom sediments creates another potential pathway to the food chain, and the potential bioaccumulation of these toxins in various fish species. The bioaccumulation of toxins can lead to lethal effects, as well as sublethal effects (e.g., effects on behavior, digestion, and immune system response; Connon et al. 2011:290). Because toxins in contaminated sediments are adhered to the sediment, increases in suspended sediment generated during construction could release these contaminants to the water column and substrate. However, as described above for turbidity, increases in suspended sediment and associated contaminants would be spatially limited to a portion of channel width and not extend far downstream, dissipating within hours of construction activities ceasing.

The Project would be subject to a construction-related stormwater permit and dewatering requirements of the federal Clean Water Act and National Pollutant Discharge Elimination System program. The Project operators would obtain required permits through the Central Valley Regional Water Quality Control Board before any ground-disturbing construction activity occurs. As required by the Construction General Permit, a SWPPP would be prepared and implemented before and throughout the construction period. The SWPPP would identify BMPs to prevent and minimize the introduction of contaminants into surface waters (see Section 2.5.4, Project Commitments and Best Management Practices Common to All Alternatives). BMPs would also be implemented as part of Project design to address erosion control, sediment control, construction materials control, waste management, non-stormwater management, post-construction storm water management, and good housekeeping practices based on the best available technology. These measures would ensure that storm water runoff would be controlled to reduce or avoid degradation of water quality in watercourses downstream of the construction sites that would affect fish populations and habitat. The Project would also limit all in-water construction activities to allowable in-water work windows and include the preparation and implementation of a topsoil storage and handling plan and a construction monitoring plan for the protection of fish, wildlife, and plant species. As a result, there would be no changes to surface water quality from construction that would result in increased or contaminated stormwater runoff or violations of water quality standards that would adversely affect fish populations and habitat.

<u>**Water Quality Effects**</u>

Construction of Alternatives 1, 2, and 3 could result in accidental spills of contaminants, including cement, oil, fuel, hydraulic fluids, paint, and other construction-related materials, resulting in localized water quality degradation. This could in turn result in adverse effects on fish through direct injury and mortality (e.g., damage to gill tissue that causes asphyxiation) or delayed effects on growth and survival (e.g., increased stress or reduced feeding), depending on the nature and extent of the spill and the contaminants involved. In addition, under Alternative 2, accidental spills of contaminants could occur while constructing the Dunnigan Pipeline to the Sacramento River, constructing the discharge and energy dissipation structure at the Sacramento River, and installing the cofferdam and placing riprap for the Sacramento River discharge.

The greatest potential for an adverse water quality impact is associated with an accidental spill from construction activities occurring in or near surface waters. Construction of Golden Gate Dam and Sites Dam, installation of cofferdams and stream diversions, road construction and improvements at creek crossings, and pipeline construction at creek crossings in particular involve extensive in-water work. Other construction elements that occur in upland areas or are isolated from fish-bearing waters have little potential for accidental spills that could affect fish because of the distance separating construction activities from receiving waters. Discharge of water from construction sites could also affect water quality for fish. See Chapter 6, Surface Water Quality, for additional information on potential surface water quality effects associated with Project construction.

Direct Physical Injury

In-water construction for Alternatives 1, 2, and 3 may result in direct physical injury or mortality to fish from activities including pile driving, cofferdam installation, and stream and cofferdam dewatering (i.e., fish stranding or entrainment into pumps used during dewatering). In addition, under Alternative 2, direct physical injury or mortality to fish could occur from cofferdam placement in the Sacramento River at the discharge site, and cofferdam dewatering. Installation of piles or placement of riprap could involve fish being crushed, although that risk would be expected to be very low based on the limited spatial extent of the work and the high probability of fish avoiding such activities. Displacement of fish away from habitat near construction activities seems the most likely adverse effect. Fish entrapped in construction areas enclosed by cofferdams or diverted stream segments that are subsequently dewatered would die without fish rescue activities, although the number of fish being trapped in such areas would be a low proportion of individuals relative to the overall extent of species' ranges. Fish that are rescued from stream segments proposed for dewatering and from cofferdams prior to or during dewatering could be injured and killed during rescue activities or as a result of handling. Dredging/excavation of Funks Reservoir would not result in any direct physical injury to fish because this activity would occur in the dry after the irrigation reservoir is lowered during the non-operational period (i.e., December through February), thus exposing the reservoir bottom.

Reduced Prey Availability

Construction of Alternatives 1, 2, and 3 has the potential to reduce prey availability for fish through disturbance of aquatic habitat. Prey species may be affected by: (1) pile driving (e.g., from noise effects or direct physical contact); (2) dredging (e.g., sediment disturbance); (3) removal of riparian aquatic habitat (i.e., reducing habitat structures for prey in or above water during clearing and grubbing); and (4) riprap placement (e.g., direct physical contact and sediment disturbance). In addition, under Alternative 2, disturbance of aquatic habitat with potential to adversely affect prey availability would occur in the Sacramento River associated with removal of riparian aquatic habitat and placement of riprap for the Sacramento River discharge. Isolation of construction areas with cofferdams would prevent fish access to prey in these areas for the duration that these features are installed at each location. The potential effects would be limited in extent relative to the overall area of habitat available to fish in the affected waterways.

Increased Predation

Construction of Alternatives 1, 2, and 3 has the potential for increased predation risk for juvenile fish associated with the removal of riparian vegetation and the placement of riprap associated with the CBD outlet. In addition, under Alternative 2, increased predation risk for juvenile fish would occur in the Sacramento River associated with the removal of riparian vegetation, installation of a cofferdam, and placement of riprap during construction of the Sacramento River discharge. The removal of riparian vegetation, installation of a cofferdam, and placement of riprap would reduce habitat complexity and shading. This reduction in habitat complexity and shading could potentially lead to the creation of nonnative predatory habitat for alien fish species, making juvenile fish more susceptible to predation. Overall, however, the potential effects from presence of in-water structure and removal of riparian vegetation would be limited as the overall extent of the removal of riparian vegetation and addition of riprap would be low and cofferdams would be temporary. The loss of riparian vegetation and the addition of riprap from construction of the alternatives would be expected to be limited in terms of additional negative effects.

In addition to riparian vegetation removal and in-water structure effects during construction, the various forms of in-water construction work (pile driving, cofferdam installation, and riprap placement) have the potential to increase predation risk for smaller fish species by increasing disturbance and susceptibility to predation (e.g., by masking the sounds of approaching predators, or causing fish to flee disturbed areas), which in turn could increase predation success of larger predatory fish such as black bass and striped bass (Sacramento River only). Such effects would be temporally and spatially limited in extent. Loss of riparian vegetation, including SRA cover habitat, and other shallow-water habitat because of construction could also increase susceptibility to predation.

Loss of Riparian Vegetation (Including SRA Cover) and Increased Water Temperature

The removal of trees where necessary at construction sites (e.g., during clearing and grubbing) under Alternatives 1, 2, and 3 would reduce the extent of riparian vegetation, including vegetation supporting shaded riverine aquatic (SRA) cover habitat (see Tables 9-3a, 9-3b, 9-4a, and 9-4b in Chapter 9, *Vegetation and Wetland Resources*). Under Alternative 2, tree removal would also occur along the Sacramento River during construction of the Sacramento River discharge (Tables 9-4a and 9-4b in Chapter 9, *Vegetation and Wetland Resources*).

Riparian vegetation is important in controlling stream bank erosion, contributing to instream structural diversity, and maintaining undercut banks in the absence of rock revetment. In addition, canopy cover (overhanging vegetation [a form of SRA cover]) maintains shade that is necessary to reduce thermal input and provides an energy input to the aquatic habitats in the form of fallen leaves and insects (a food source for fish). SRA cover also provides fish with protection from predators in the form of undercut banks and instream woody material in the form of submerged branches, roots, and logs.

Riparian and SRA cover habitats are essential components of salmonid rearing habitat that may limit the production and abundance of salmonids in the Sacramento River. Salmonid populations in particular are highly influenced by the amount of available cover (Raleigh et al. 1984). The amount of existing riparian and SRA cover habitat in the study area and in the region is of variable quality because of past and ongoing impacts, including levee construction and bank protection activities (i.e., placement of rock revetment).

USFWS mitigation policy identifies California's riparian habitats, including SRA cover habitat, as a Resource Category 2 habitat. The designation criteria for habitat in Resource Category 2 is "habitat to be impacted is of high quality for evaluation species and is relatively scarce or becoming scarce on a national basis or in the ecoregion section" (U.S. Fish and Wildlife Service 1993) for which "no net loss of in-kind habitat value" is recommended (46 FR 7644, January 23, 1981). In addition, NMFS typically recommends revegetating onsite at a 3:1 ratio (three units replaced per each unit of affected habitat) with native riparian species to facilitate the development of SRA cover habitat. Implementation of Mitigation Measure VEG-2.2 described in Chapter 9, *Vegetation Wetland Resources*, would compensate for the removal of riparian vegetation and SRA cover habitat.

The removal of SRA cover habitat that contributes to stream shading could potentially increase water temperature and have adverse effects on fish, depending on species-specific temperature preferences. However, such increases would be extremely localized as the linear extent of SRA cover habitat that would be removed at individual construction sites would be relatively small, ranging from a footprint impact as small as several trees at construction sites on tributary streams to a footprint impact as large as approximately 200 to 250 linear feet of continuous riparian habitat along the Sacramento River under Alternative 2. NMFS (2017:220) noted the Sacramento River is a wide, faster-moving waterbody and is less likely to experience warming of water temperatures caused by limited decreases in riparian vegetation, such as would occur with construction of the alternatives. This is because as river channels become wider, a smaller fraction of the channel is affected by shading from the riparian vegetation found along those riverbanks. As further described by NMFS (2017:220), the volume of water present in the river channel acts as a thermal sink, resisting temperature changes caused by shading along a narrow riparian zone. Temperature changes are more influenced by the greater surface area of exposed open water in the river channel, ambient air temperatures over those exposed areas, solar irradiation, and the influence of water layers mixing within the main river channel. Because any water temperature increases as a result of decreased riparian vegetation under the alternatives are anticipated to be small and localized, the effects on fish from changes in water temperature would be expected to be minimal.

Reduced Habitat Extent and Access

Filling of the reservoir would result in permanent modification of aquatic habitat by replacing intermittent and ephemeral stream habitat above the dams with a permanent body of water subject to fluctuations in volume, depth, and surface area. Under Alternatives 1 and 3, filling of the reservoir would result in the permanent loss of a cumulative total of approximately 24.3 miles (61%) of stream habitat in Funks Creek, Stone Corral Creek, Antelope Creek, and Grapevine Creek upstream of the dam sites at maximum reservoir inundation levels. Under Alternative 2, a cumulative total of approximately 24.1 miles (60%) of stream habitat would be permanently lost in these same drainages at maximum reservoir inundation levels. These impacts include the loss of stream habitat in Funks Creek, Stone Corral Creek, Antelope Creek, and Grapevine Creek that supports native Sacramento hitch and Central California roach based on sampling conducted in the inundation area by CDFW (Brown 2000:23–27). Brown (2000:24, 43) characterized these streams as being deeply incised channels with little vegetation on the banks and little cover in the streams, having poor water quality, in part, due to high dissolved minerals, and possessing a highly variable flow regime with periods of high flow during winter, declining flows in spring, and intermittent flow, and perhaps no flow, in late summer. In addition, the high concentration of sediments and aquatic vegetation present in these streams may make them uninhabitable to most fish in summer due to high oxygen demand (Brown 2000:43). See Chapter 7, *Fluvial Geomorphology*, for a description of the geologic and topographic setting, and geomorphic characteristics associated with these drainages.

The response of native minnow populations to reservoir construction cannot be conclusively determined but general predictions can be made based on observations from other California reservoirs and general species requirements. Reservoirs can provide suitable habitat for native and introduced fish species but are generally less productive than natural lakes because of their depth, steep slopes, and fluctuating water levels that typically limit spawning and rearing success (Moyle 2002:36). Some minnows (e.g., hitch) are reported to use reservoirs and, in some cases, have developed large populations where introduced predators or competitors are absent (Moyle 2002:37), while other native minnow species (e.g., roach) typically are absent from reservoirs and exist only in the small tributaries above them (Moyle et al. 2015:8). It is expected that Sites Reservoir would contain predatory species that are the result of either planned fish stocking (Chapter 2, Section 2.3.3, *Potential Future Uses*) or future potential introductions of nonnative predators or competitors through the transfer of water or accidental or deliberate introductions. Considering the physical and operational characteristics of the reservoir and the expected presence of predatory fish species, the reservoir may not provide suitable habitat for native fish species. Although existing stream habitat in the inundation area would be lost, native fish populations would be expected to continue to persist in Funks Creek and Stone Corral Creek above the inundation area and in stream reaches downstream of Sites Dam and Golden Gate

Dam provided that tailwater releases below the dams provide suitable temperature and habitat conditions for native species, such as hitch (Moyle et al. 2015:3). See Impact FISH-11, for further discussion on operations effects on native minnows downstream of the dams.

Construction of Sites Dam and Golden Gate Dam on Stone Corral Creek and Funks Creek, respectively, would preclude fish in those drainages from moving upstream or downstream past the dams, as the dams would not include fish passage facilities. These barriers would prevent juvenile and adult fish in Funks Creek and Stone Corral Creek from making seasonal movements within their respective creeks for spawning or dispersal purposes, or to search for refugia during late spring and summer dry periods. Although specific information on fish movements and habitat needs in these streams is lacking, Brown (2000:27) concluded that the general absence of fish larger than 5.9 inches at sampling locations in the inundation area indicated that primarily juvenile fish rear in these areas and that adult fish ascend these seasonal creeks in winter and spawn in these stream reaches in early spring before migrating downstream after spawning, although it is unknown which species of fish to which CDFW was referring. However, it should be noted that some of the roach and hitch collected by CDFW (Brown 2000) in Funks Creek and Stone Corral Creek were likely adults as roach typically become mature after they reach 45–60 mm (1.8–2.4 inches) and hitch can reach sexual maturity when only 49–54 mm (1.9–2.1 inches) (Moyle 2002:138, 142). This suggests that adults are likely present year-round in these streams and that stream reaches unaffected by reservoir inundation would be expected to continue to support roach and hitch. Nevertheless, dams have been implicated as a major factor limiting, or potentially limiting, population viability of Sacramento hitch and Central California roach due to habitat fragmentation, altered flows and reduced habitat suitability (Moyle et al. 2015:3–4, 7–11).

Although construction of Sites Reservoir would result in habitat fragmentation in Funks Creek and Stone Corral Creek, it is expected that populations of these species would continue to persist upstream and downstream of the reservoir. The permanent loss of stream habitat and related negative effects on population size associated with reservoir inundation would represent a very small proportion of overall habitat and individuals when put in a broader population-wide context for these species.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

Project construction would result in ground-disturbance activities, the construction of Project facilities, the use of heavy equipment and hazardous materials, in-water construction, and the filling of Sites Reservoir. These activities would result in temporary impacts on special-status fish during construction activities, and permanent impacts from placement of Project facilities and the conversion of stream habitat to open water habitat. Construction BMPs, including timing restrictions for in-water work, would minimize or avoid impacts on special-status fish, thereby avoiding population-wide consequences for aquatic biological resources. Therefore, impacts of Project construction would be less than significant.

NEPA Conclusion for Alternatives 1, 2, and 3

Construction effects on special-status fish species and aquatic biological resources under Alternative 1, 2, or 3 would be the same as described above for CEQA. Project construction would not result in adverse effects on special-status fish and aquatic biological resources.

Impact FISH-2: Operations Effects on Winter-Run Chinook Salmon

Alternatives 1, 2, and 3

Effects of Alternatives 1, 2, and 3

Potential exposure of winter-run Chinook salmon to the effects of Alternatives 1, 2, and 3 depends on the species' spatiotemporal distribution. Several sources of information are available to inform potential exposure. General information on spatiotemporal distribution is presented in the species account in Appendix 11A. Appendix 11A also provides graphs from the SacPAS website (http://www.cbr.washington.edu/sacramento/) that give a summary of historical patterns of juvenile winter-run capture at various sampling locations in the Sacramento River and Delta. An 11-year study (1981–1991) of monthly sampling at 13 beach seine sites in the Sacramento River between river mile 164 (just upstream of Princeton) and river mile 298 (Redding, CA) by Johnson et al. (1992) provides perhaps the best spatial information related to juvenile Chinook salmon occurrence upstream and downstream of the Red Bluff and Hamilton City diversions. A long-term (1981–2019) beach seine database provides temporal occurrence information for juvenile Chinook salmon between river mile 71 (Elkhorn) and river mile 144 (Colusa State Park). Estimates of adult Chinook salmon escapement by tributary from the GrandTab database (Azat 2019) give perspective on the relative proportion of the ESU that could experience near-field and far-field effects of the alternatives' diversions.

The main patterns of juvenile winter-run Chinook salmon occurrence at the locations documented in the SacPAS summary in Appendix 11A include:

- Red Bluff Diversion Dam rotary screw traps (Figure WR_RBRST, Appendix 11A): Passage begins in early July and ends from early April to late May, and rarely into June. The first half (50%) of the run passes within a one-month period, late September to late October, whereas the main portion of the run (90%) begins passage through the diversion dam within a few days of September 1st and finishes anywhere from mid-October to as late as the end of December.
- Tisdale Weir rotary screw traps (Figure WR_TWRST, Appendix 11A): Passage begins in early September and lasts until the first of May. The passage of winter-run chinook at this weir is very dynamic: the first half (50%) of the run passes anywhere from the first of November to the first of March, whereas the main portion (90%) begins to pass the weir from early October to late November and ends anywhere from the end of December to early March.

Commented [CC42]: Please confirm with CDFW on accurate characterization of passage timing at Tisdale RSTs. Although data on SacPAS may indicate the narrative, sampling dates have changed since 2016. It is also not possible for passage at Tisdale to occur later than Knights Landing downstream. It is important to understand the limitations of an RST monitoring program when using such to characterize passage.

Another solution would be to change the narrative to reflect the majority of the passage period. This currently reads as though it is encompassing the entirety of the passage period.

Commented [CC43R42]: CDFW recommends that the authors include sampling dates for each location. Sampling protocols state that when water temperatures exceed thresholds for safe handling of juveniles, sampling will cease. Sampling is not ended because fish are not present. CDFW recommends restructuring this section to accurately reflect the data and the protocols associated with collecting these data.

Commented [CC44]: It should be noted that data from Tisdale is brief in scale when compared to the other data sets.

Trap capture efficiency or confidence intervals should be included for the individual sampling sites for better perspective.

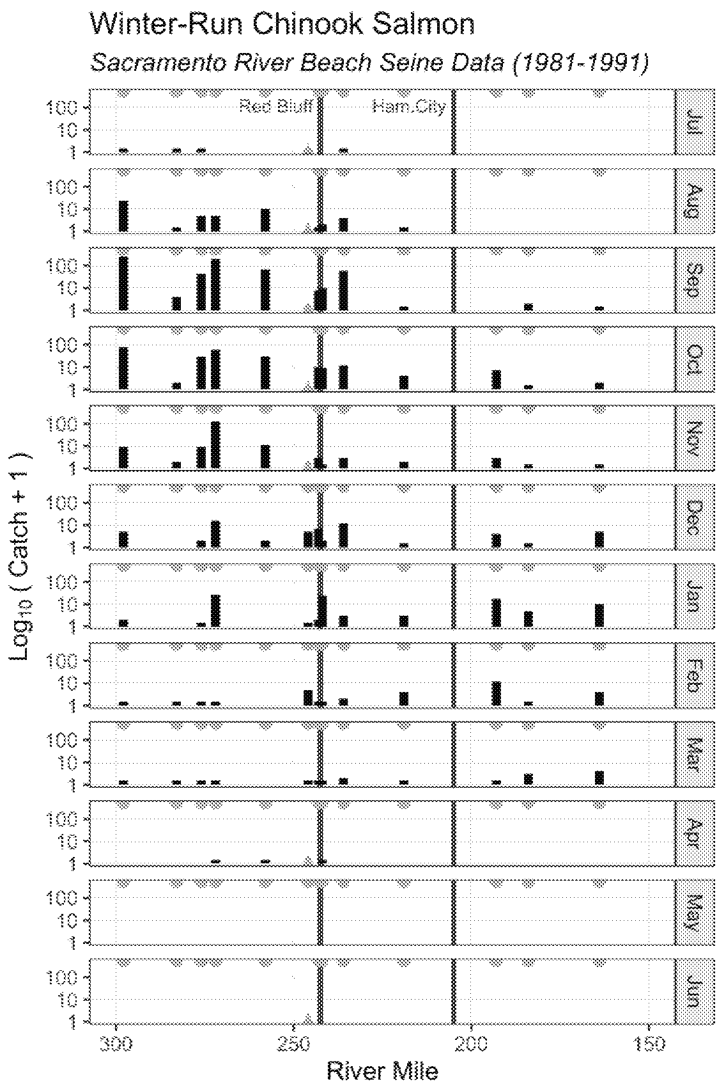
- Knights Landing rotary screw traps (Figure WR_KLRST, Appendix 11A): Passage begins in early to mid-September, though rarely as early as late August. The first half (50%) is variable, happening as early as the first of November or as late as early March. The bulk (90%) of the run begins to pass from early October to mid-early March, and can take only a few weeks to pass, with the bulk of the run finishing in mid-December to mid-March.

Commented [CC45]: Analysis for this report was earlier stated as using KL trap data from 2008-2018, many of those years are drought years. It should be noted that the KL study has been in operation since 1996 and other seasons data may suggest emigration at Knight Landing can occur in August.

- Sacramento beach seines 1st (Figure WE_Seines, Appendix 11A): Occurrence can begin anywhere from mid-September to mid-December and can end anywhere from mid-January to the first of April. The first half (50%) occurs from early December, rarely mid-November, to the first of March, whereas the main portion (90%) of the run begins to occur in the seines in mid-October to mid-January and ends early January to early March. The exception to these trends was 2009 when the entire run occurred in approximately one week surrounding March.
- Sacramento trawls (Sherwood Harbor) (Figure WR_Sherwood, Appendix 11A): Occurrence begins from early September to early March and ends from the first of March to the end of April. The bulk (50%) occurs anywhere from the end of November to the first of April, whereas the main portion (90%) is highly variable, beginning from late October to mid-March and finishing from Mid- February to early April. The exception to these trends was 2012, when the entire cohort occurred in roughly 10 days surrounding December 1st.
- Chipps Island trawls (Figure WR_Chipps, Appendix 11A): Occurrence begins anywhere from the first of December to early March and finishes consistently from mid-April to the end of May. The first half (50%) occurs from early March to mid-April, whereas the main portion (90%) occurs in late December to late March and finish by late March to late April.
- Salvage (unclipped, length-at-date) (Figure WR_salvage_unclipped_date, Appendix 11A): Salvage begins in early December to early March and finishes from late March to late May. The first half (50%) occurs in early January, though in the bulk of years 50% occurs in March. The main portion of salvage (90%) begins in mid-December to mid-March and finishes mid-January to early April.
- Salvage (clipped, length-at-date) (Figure WR_salvage_clipped_date, Appendix 11A): Salvage begins in early December to mid-January and finishes from late February to early May. The first half (50%) occurs from late December to early April, whereas the main portion (90%) begins in mid-December to mid-January and finishes from late February to early May. The 2013 cohort was the exception to these trends, having occurred entirely in approximately two weeks in mid-March.
- Salvage (clipped, CWT-Race) (Figure WR_salvage_clipped_CWT_race, Appendix 11A): Salvage begins in mid-December to late January and finishes from mid-January to early May. The first half (50%) occurs from early January to mid-February, whereas the main portion (90%) begins in late January to early February and finishes from mid-January to

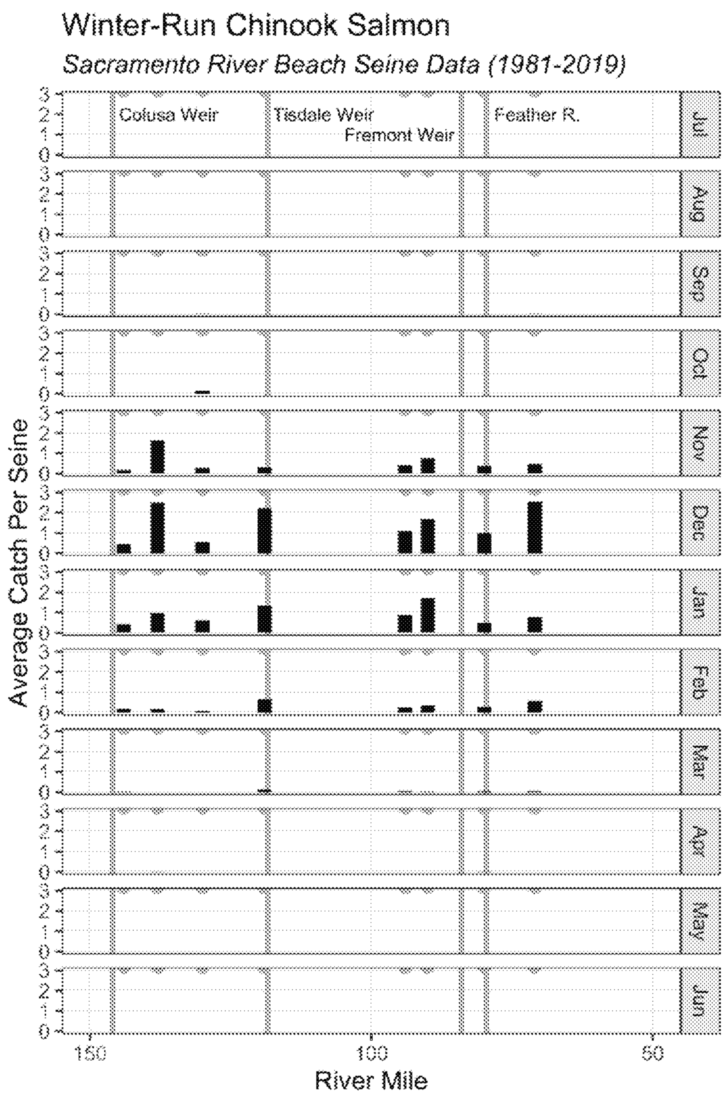
mid-May. The 2013 cohort is an exception to these trends, having occurred entirely in March.

Juvenile winter-run Chinook salmon catches in extensive beach seining during 1981–1991 were more concentrated in the upper reaches of that study area during roughly August–October, spreading downstream in the winter months (Figure WR_johnson). The catch dropped to essentially zero from April to July in that data set. The pattern of catches spreading downstream in the fall and winter is consistent with the 1981–2019 beach seine data collected further downstream, where the catch rate was very low until November, then peaked in December–January, before tapering off in February (Figure WR_DJFMP).



Source: Johnson et al. (1992; their Table 4). Note: Sampled sites are denoted by grey semicircles at the top of each plot. Sites that were not sampled in a given month are denoted by grey triangles at the bottom of a panel. Values denoted as "<1" by Johnson et al. are shown as 0.5. Red lines indicate locations of Red Bluff and Hamilton City diversions.

Figure WR_johnson. Mean Monthly Catch Per Beach Seine of Juvenile Winter-Run Chinook Salmon in the Sacramento River Between River Mile 164 and River Mile 298, 1981–1991.



Source: https://www.fws.gov/lodi/juvenile_fish_monitoring_program/jfmp_index.htm . Note: Sampled sites are denoted by grey semicircles at the top of each plot. Grey lines indicate locations of Colusa, Tisdale, and Fremont Weirs, and the confluence with the Feather River.

Figure WR_DJFMP. Mean Monthly Catch Per Beach Seine of Juvenile Winter-Run Chinook Salmon in the Sacramento River Between River Mile 71 and River Mile 144, 1981–2019.

All winter-run Chinook salmon spawning occurs upstream of Red Bluff (Azat 2019), so all juvenile winter-run migrating downstream would need to pass the two intake locations at Red Bluff and Hamilton City. Recent analyses based on otolith microchemistry of adults surviving to escape to spawning grounds in the Sacramento River suggest that many juvenile winter-run Chinook salmon rear within non-natal habitat: from 2007 to 2009, between 34% and 51% reared in the natal habitat of the Sacramento River, whereas between 17% and 26% reared in the American River, 7%–34% in tributaries of Mount Lassen (Battle, Mill, or Deer Creeks), and 7%–23% in the Feather River or Delta. There is some uncertainty as to when the redistribution of juvenile winter-run Chinook salmon occurs to non-natal rearing habitats, and also to the relative survival within the different non-natal habitats, which could result in the proportion of juveniles surviving to adulthood from each habitat varying considerably from the proportion of juveniles entering each habitat.

Sacramento River

Near-Field Effects

Distribution in River Channel—Screen Exposure

The spatial distribution of migrating fish within the river channel is important for evaluating near-field effects of the Red Bluff and Hamilton City intakes. Juvenile salmonids, including winter-run Chinook salmon, must pass close to the intakes to have the potential for near-field effects from the intakes. Locating the intakes on the outside of river or oxbow channel bends to achieve sweeping velocity requirements may lead to a greater proportion of fish passing close to the intakes than if the fish were occurring evenly distributed across the channel cross section. Several studies on the Sacramento River provide evidence for the distribution of fish toward the outer sides of bends, including at Clarksburg Bend (Burau et al. 2007: Figure C.17), the Delta Cross Channel (Burau et al. 2007: Figure 2.5), and near Fremont Weir (Blake et al. 2017: Figures 2 and 20). The distribution of fish towards the outside of bends is the result of centrifugal and pressure forces in bends which induce a secondary flow that lies in a plane perpendicular to the primary flow direction (Dinehart and Burau 2005) and is reflected in the bathymetry of such areas: the deeper areas, including the thalweg, coincide with the areas subject to the secondary flow (Burau et al. 2007: Figure C.1). These observations agree with the general pattern of downstream-migrating juvenile salmonids in the Pacific northwest often being distributed near the thalweg, or near the shoreline (Smith et al. 2009). It is possible that a relatively large proportion of downstream-migrating juvenile salmonids could pass relatively close to the Red Bluff and Hamilton City intakes, particularly during nighttime periods when most migration occurs (Chapman et al. 2013; Zajanc et al. 2013; Plumb et al. 2016). However, when holding (e.g., during the day), juvenile salmonids could also occur on the inside of river bends, as illustrated at Clarksburg Bend (Burau et al. 2007: Figure C.15).

The Hamilton City intake is on an oxbow of the Sacramento River, with available studies suggesting that the percentage of river flow entering the oxbow varies based on river flow and percentage of river diverted at the intake (Figure ham%). Note that the data shown in Figure ham% reflect a partially obstructed (15%) oxbow channel, which would tend to reduce the percentage of river flow entering the oxbow, as suggested by comparison of the trendlines based on 2018 daily data to two field measurements collected in 2011/2012 (triangles on graph). On the basis of the diversion rates for the alternatives, and assuming that fish are generally moving into the oxbow at a similar or slightly lower percentage as the flow split (Cavallo et al. 2015), it would be expected that approximately 10–30% of downstream-migrating juvenile salmonids approaching the river-oxbow split would enter the oxbow and have the potential to be exposed to the Hamilton City intake screen. There is some uncertainty in this estimate given that diversion rate data at higher flow (i.e., >10,000 cfs at Hamilton City) generally have been limited to less than 5% of the flow (Figure ham%).

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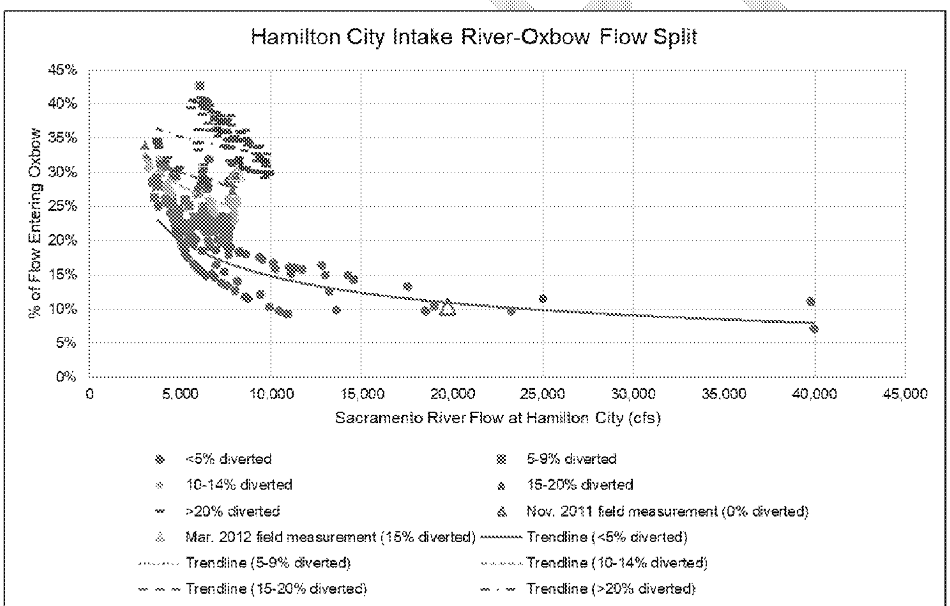


Source: Developed by ICF based on data provided by Kline (pers. comm.). Notes: Circles indicate daily gauge data. During 2018, the oxbow was 15% obstructed, which would tend to somewhat lower the percentage of flow entering it compared to an unobstructed channel. Triangles indicate field measurements from 2011/2012 (McMillen, LLC 2013). Trendlines are power functions generated in Microsoft Excel.

Figure ham%. Daily Percentage of Sacramento River Flow Entering the Oxbow Containing the Hamilton City Intake, 2018, Divided into Five Groups Based on Percentage of Hamilton City River Flow Diverted by the Intake.

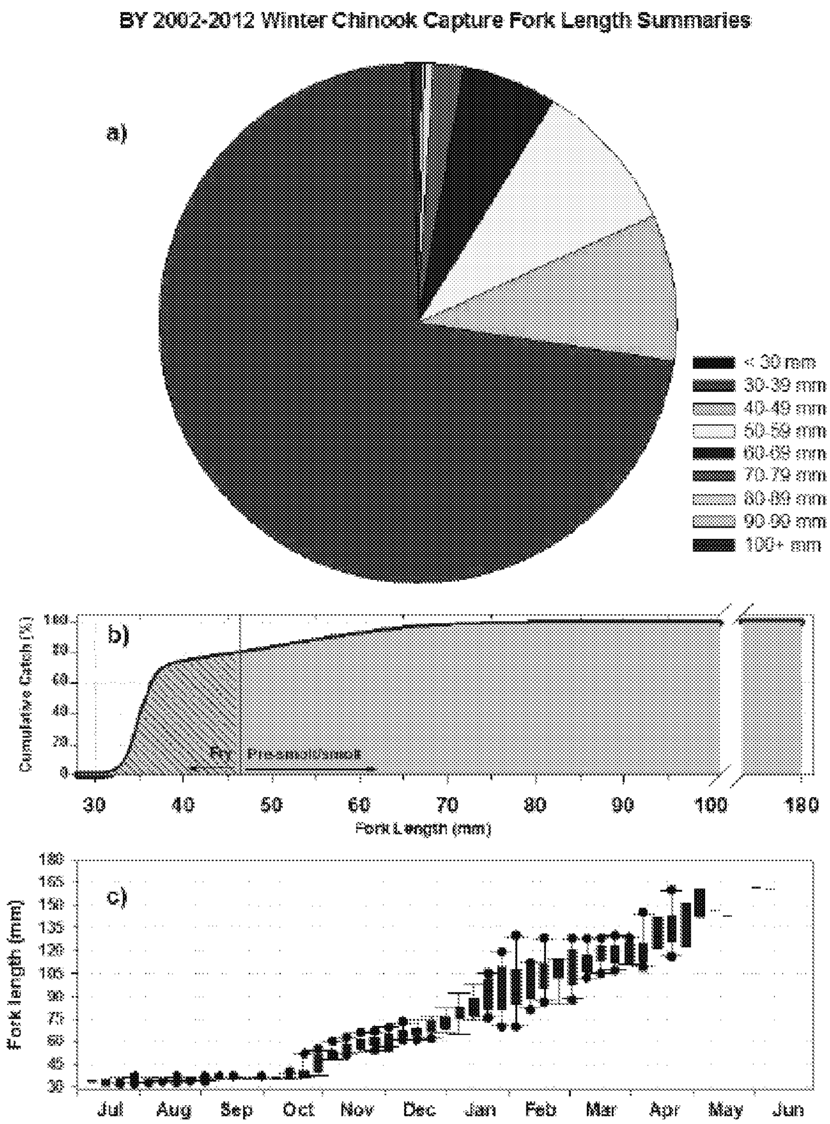
In addition to horizontal distribution, an important consideration for potential screen exposure of juvenile salmonids, including winter-run Chinook salmon, is the vertical distribution of fish in relation to the proposed action's intakes. In general, migrating juvenile salmonids are located in the upper portion of the water column (Smith et al. 2009). This was illustrated locally in the hydroacoustic study near the Delta Cross Channel, for which fish were particularly abundant between around 4 to 7 meters (13–23 feet) below the surface of the 13-meter-deep (43 feet) water column (Blake and Horn 2006: Figure 41), i.e., greatest abundance was at about 33–50% of the water column. Preliminary information from annual stage frequency curves at Red Bluff (Kapla, pers. comm., June 2019) suggests that juvenile Chinook salmon occurring at between 33–50% of the water column depth could be at a similar depth to the intake screen much of the time. This preliminary stage frequency information includes all months of the year and will be refined to focus only on the main months of the alternatives' diversions (i.e., November–April), as well as to include information for the Hamilton City intake (Kapla, pers. comm., June 2019).

Potential exposure of juvenile salmonids to the Red Bluff and Hamilton City fish screens would be addressed by technical studies to inform spatial distribution and other factors, as outlined in Appendix 2D.

Entrainment Through Screens

Commented [CC47]: In addition to the studies described in the following section, NMFS and CDFW have fish screen criteria that may be referenced here.

Juvenile salmonids, including winter-run Chinook salmon, migrating downstream past the Red Bluff and Hamilton City intakes would be susceptible to entrainment through the fish screens if sufficiently small. Calculations suggest that a 1.75-mm opening would be effective at excluding juvenile salmonids of 22-mm standard length and greater (ICF International 2016: 5-103), which is around 25-mm fork length (FL). The Freeport Regional Water Authority's intake on the Sacramento River has a similar design of fish screen to the Red Bluff and Hamilton City intakes, with a 1.75-mm vertical bar opening. The most comprehensive assessment of juvenile salmonid length distribution in the vicinity of the Red Bluff and Hamilton City intakes is from sampling at the Red Bluff Diversion Dam rotary screw traps. These data suggest a very small proportion of juvenile winter-run Chinook salmon would be of sufficiently small size to be susceptible to entrainment by the intakes' diversions if occurring at the faces of the fish screens, given that very few fish were less than 30-mm FL (Figure length_WR). The very small proportion of juvenile winter-run sufficiently small-sized to potentially be susceptible to entrainment occurred in July/August (Figure length_WR), a time period during which the alternatives' diversions generally would be very similar—or in some cases somewhat lower for Alternative 3—in magnitude to the NAA (Tables RB% and HC%). Entrainment risk would be expected to be similar between NAA and the alternatives for juvenile winter-run Chinook salmon. Entrainment would be monitored at the Red Bluff and Hamilton City intakes (see Appendix 2D).



Source: Poytress et al. (2014: 84). Note: BY = brood year.

Figure length_WR. Winter-Run Chinook Salmon Fork Length (a) Capture Proportions, (b) Cumulative Capture Size Curve, and (c) Average Weekly Median Boxplots, As Sampled at Red Bluff Diversion Dam Rotary Screw Traps, July 2002–June 2013.

Table RB%. Red Bluff Diversion as Percentage of Sacramento River Flow, Averaged by Month and Water Year Type, from CalSim Modeling.

Water Year Type	Month	NAA	Alt. 1A	Alt. 1B	Alt. 2	Alt. 3
Wet	Jan	0%	4%	5%	4%	5%
Wet	Feb	0%	4%	5%	4%	5%
Wet	Mar	0%	5%	5%	5%	7%
Wet	Apr	2%	4%	4%	4%	5%
Wet	May	6%	7%	7%	7%	8%
Wet	Jun	11%	11%	11%	11%	12%
Wet	Jul	10%	10%	10%	10%	10%
Wet	Aug	9%	9%	9%	9%	9%
Wet	Sep	2%	2%	2%	2%	2%
Wet	Oct	2%	2%	2%	2%	2%
Wet	Nov	0%	4%	4%	4%	4%
Wet	Dec	0%	1%	1%	1%	1%
Above Normal	Jan	0%	7%	7%	7%	7%
Above Normal	Feb	0%	6%	6%	6%	6%
Above Normal	Mar	0%	11%	11%	11%	12%
Above Normal	Apr	4%	5%	5%	5%	5%
Above Normal	May	7%	7%	7%	7%	7%
Above Normal	Jun	11%	11%	8%	11%	9%
Above Normal	Jul	9%	8%	7%	8%	4%
Above Normal	Aug	9%	9%	9%	9%	6%
Above Normal	Sep	3%	3%	3%	3%	2%
Above Normal	Oct	2%	2%	2%	2%	2%
Above Normal	Nov	0%	1%	1%	1%	2%
Above Normal	Dec	0%	2%	2%	2%	2%
Below Normal	Jan	0%	5%	5%	5%	5%
Below Normal	Feb	0%	8%	8%	8%	8%
Below Normal	Mar	1%	13%	13%	13%	14%
Below Normal	Apr	4%	5%	4%	5%	5%
Below Normal	May	7%	7%	6%	7%	6%
Below Normal	Jun	8%	9%	8%	9%	6%
Below Normal	Jul	8%	8%	7%	8%	5%
Below Normal	Aug	9%	8%	8%	8%	8%

Water Year Type	Month	NAA	Alt. 1A	Alt. 1B	Alt. 2	Alt. 3
Below Normal	Sep	3%	2%	2%	2%	2%
Below Normal	Oct	2%	1%	1%	1%	1%
Below Normal	Nov	0%	0%	0%	1%	1%
Below Normal	Dec	0%	1%	1%	1%	2%
Dry	Jan	0%	4%	4%	4%	4%
Dry	Feb	0%	5%	5%	5%	5%
Dry	Mar	0%	9%	10%	9%	10%
Dry	Apr	3%	3%	3%	3%	3%
Dry	May	4%	5%	4%	5%	3%
Dry	Jun	5%	6%	5%	6%	4%
Dry	Jul	6%	5%	5%	5%	5%
Dry	Aug	6%	5%	6%	5%	5%
Dry	Sep	3%	1%	1%	1%	2%
Dry	Oct	2%	1%	1%	1%	1%
Dry	Nov	0%	0%	0%	0%	0%
Dry	Dec	0%	2%	2%	2%	2%
Critically Dry	Jan	0%	4%	4%	4%	4%
Critically Dry	Feb	0%	2%	2%	2%	2%
Critically Dry	Mar	0%	4%	4%	4%	4%
Critically Dry	Apr	2%	2%	2%	2%	2%
Critically Dry	May	1%	2%	1%	2%	2%
Critically Dry	Jun	2%	1%	1%	1%	2%
Critically Dry	Jul	2%	2%	2%	2%	2%
Critically Dry	Aug	2%	2%	2%	2%	2%
Critically Dry	Sep	1%	1%	1%	1%	1%
Critically Dry	Oct	1%	1%	1%	1%	1%
Critically Dry	Nov	0%	0%	0%	0%	0%
Critically Dry	Dec	0%	6%	6%	6%	6%

Note: Percentage is calculated based on diversion (CalSim node D112) divided by (diversion at D112 + Sacramento River below Red Bluff Diversion Dam flow [CalSim channel C112]).

Table HC%. Hamilton City Diversion as Percentage of Sacramento River Flow, Averaged by Month and Water Year Type, from CalSim Modeling.

Water Year Type	Month	NAA	Alt. 1A	Alt. 1B	Alt. 2	Alt. 3
Wet	Jan	0%	1%	1%	1%	1%
Wet	Feb	0%	1%	2%	1%	2%
Wet	Mar	0%	2%	2%	1%	2%
Wet	Apr	3%	6%	6%	6%	7%

Water Year Type	Month	NAA	Alt. 1A	Alt. 1B	Alt. 2	Alt. 3
Wet	May	17%	18%	18%	18%	19%
Wet	Jun	22%	24%	24%	24%	24%
Wet	Jul	21%	21%	21%	21%	21%
Wet	Aug	21%	21%	21%	21%	21%
Wet	Sep	6%	6%	6%	6%	6%
Wet	Oct	7%	8%	8%	8%	8%
Wet	Nov	8%	8%	8%	8%	8%
Wet	Dec	3%	3%	3%	3%	3%
Above Normal	Jan	1%	2%	2%	2%	2%
Above Normal	Feb	0%	1%	1%	1%	1%
Above Normal	Mar	0%	4%	4%	4%	4%
Above Normal	Apr	4%	6%	6%	6%	6%
Above Normal	May	19%	20%	20%	20%	20%
Above Normal	Jun	23%	23%	23%	23%	21%
Above Normal	Jul	19%	19%	18%	19%	12%
Above Normal	Aug	20%	20%	20%	20%	18%
Above Normal	Sep	7%	7%	7%	7%	7%
Above Normal	Oct	8%	8%	8%	8%	8%
Above Normal	Nov	8%	7%	7%	7%	7%
Above Normal	Dec	2%	2%	2%	2%	2%
Below Normal	Jan	1%	1%	1%	1%	1%
Below Normal	Feb	1%	1%	1%	1%	1%
Below Normal	Mar	0%	2%	2%	2%	2%
Below Normal	Apr	6%	7%	7%	7%	7%
Below Normal	May	24%	25%	23%	25%	22%
Below Normal	Jun	24%	25%	25%	25%	22%
Below Normal	Jul	21%	21%	21%	21%	18%
Below Normal	Aug	22%	22%	21%	22%	21%
Below Normal	Sep	10%	9%	9%	9%	9%
Below Normal	Oct	8%	6%	6%	6%	6%
Below Normal	Nov	9%	8%	8%	8%	7%
Below Normal	Dec	2%	2%	2%	2%	2%
Dry	Jan	1%	1%	1%	1%	1%
Dry	Feb	1%	1%	1%	1%	1%
Dry	Mar	0%	2%	2%	2%	2%
Dry	Apr	6%	6%	6%	6%	6%
Dry	May	24%	23%	23%	23%	21%
Dry	Jun	24%	22%	23%	23%	21%

Water Year Type	Month	NAA	Alt. 1A	Alt. 1B	Alt. 2	Alt. 3
Dry	Jul	21%	16%	17%	16%	16%
Dry	Aug	21%	16%	16%	17%	17%
Dry	Sep	11%	8%	8%	8%	9%
Dry	Oct	9%	7%	7%	7%	7%
Dry	Nov	9%	8%	8%	8%	8%
Dry	Dec	3%	3%	3%	3%	3%
Critically Dry	Jan	1%	1%	1%	1%	1%
Critically Dry	Feb	1%	1%	1%	1%	1%
Critically Dry	Mar	1%	1%	1%	1%	1%
Critically Dry	Apr	9%	8%	8%	8%	9%
Critically Dry	May	24%	23%	23%	23%	22%
Critically Dry	Jun	25%	24%	24%	25%	24%
Critically Dry	Jul	23%	18%	18%	19%	19%
Critically Dry	Aug	21%	18%	17%	18%	19%
Critically Dry	Sep	11%	9%	9%	9%	9%
Critically Dry	Oct	8%	6%	6%	6%	7%
Critically Dry	Nov	9%	9%	9%	9%	9%
Critically Dry	Dec	3%	2%	2%	2%	2%

Note: Percentage is calculated based on diversion (CalSim node D114) divided by (diversion at D114 + Sacramento River at Hamilton City flow [CalSim channel C114]).

Impingement, Screen Contact, and Screen Passage

Juvenile salmonids, including winter-run Chinook salmon, could be injured or die after coming into contact with the Red Bluff and Hamilton City intake fish screens. The best available information to inform this risk for juvenile Chinook salmon comes from the laboratory-based study of Swanson et al. (2004) undertaken at the UC Davis Fish Treadmill facility. These authors found that juvenile Chinook salmon experienced frequent contact with the simulated fish screen but were rarely impinged (defined as prolonged screen contacts >2.5 minutes) and impingement was not related to any of the experimental variables examined. Swanson et al. (2004: 274) noted:

> The injury rates of both preexperiment and experimental fish were generally high but most injuries consisted of minor damage to fins and scales. Among the four treatments, significant differences in injury indices were apparently related to the duration of laboratory holding, with larger, older fish exhibiting more damage... Within treatments, the injury index was not significantly affected by either flow regime or screen contact rate (regression and correlation, P > 0.3, all tests) and, in general, preexperimental indices were similar to those measured for fish after exposure in the Fish Treadmill.

Of the more than 3,200 fish tested, only five fish from four experiments died during the experiment and one fish, from a fifth experiment, during the 48-h postexperiment period. Two of the mortalities were from daytime experiments and four were from nighttime experiments. All mortalities were from flow treatments with a sweeping flow component, but the small number precluded the detection of significant flow effects on survival. The death of these fish did not appear to be related to observed impingements.

Swanson et al. (2004) concluded that fish screen designs that minimize screen exposure duration (e.g., via reduced screen length or increased sweeping velocities) should optimally protect juvenile Chinook salmon. To inform potential juvenile Chinook salmon screen passage time past the Red Bluff and Hamilton City intakes, for this BA the methods applied in the California WaterFix BA (ICF International 2016, Appendix 5.D: 5.D-1) based on Swanson et al. (2004: 272) were used. In addition, to estimate potential number of screen contacts for juvenile Chinook salmon, the daytime and nighttime contact rate equations from Swanson et al. (2004: 272) were used:

Contact rate (daytime) = 0.158(SL) - 0.008(SWP) - 0.006(D) - 0.001(SL*T)

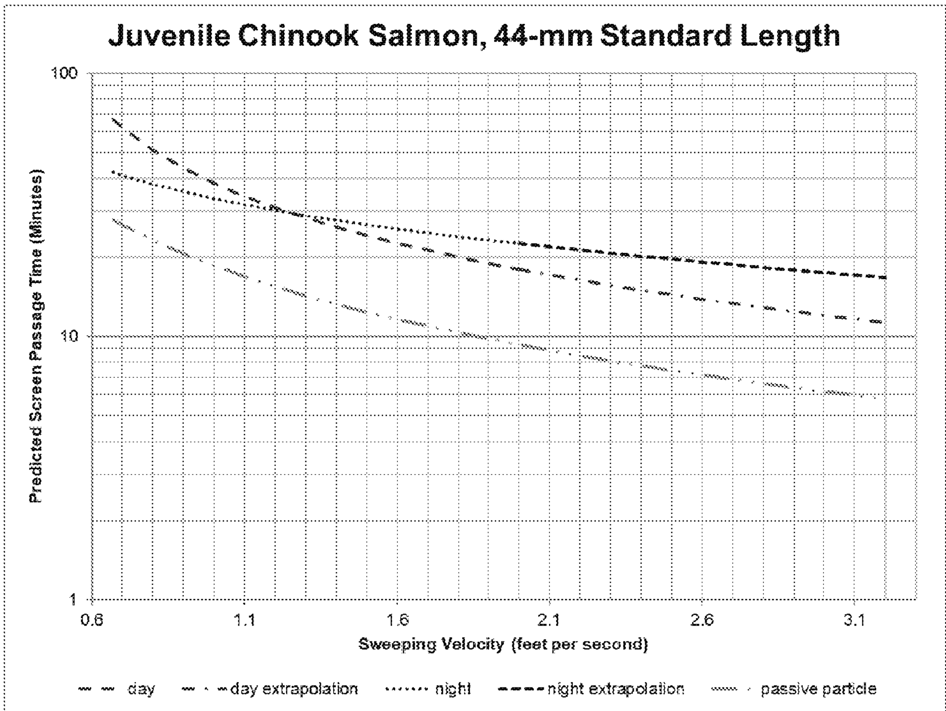
Contact rate (nighttime) = 0.146(SL)

where SL = standard length (calculated for 4.4-cm [44-mm] and 7.9-cm [79-mm] fish, the minimum and maximum tested), SWP = sweeping velocity (cm/s), D = distance from screen (assumed to be 31 cm, which is halfway across the test channel), T = temperature (°C, assumed to be 12°C). The contact rates (contacts/minute) were multiplied by the screen passage time to give the estimated total number of contacts.

For this assessment, the analyses based on Swanson et al. (2004) were applied to total fish screen lengths of 1,100 feet (i.e., representative of the Red Bluff and Hamilton City intakes; Reclamation [2017] and NCWA [2017]) for a range of sweeping velocities from 0.67 to 3.2 feet per second (ft/s); this range covers the lowest sweeping velocity at which diversions could occur (i.e., two times the allowable approach velocity of 0.33 ft/s) up to the estimated surface water velocity during a site visit to the Sacramento River near Maxwell in February 2019 when river flow was approximately 25,000 cfs. The extent to which the relatively benign experimental environment of Swanson et al. (2004) is representative of Sacramento River conditions is uncertain, but the Red Bluff and Hamilton City fish screens have a smooth screen surface and frequent screen cleaning, which would provide additional protection to minimize screen surface impingement of fish, including winter-run Chinook salmon. The smooth surface also would serve to reduce the risk of abrasion and scale loss for any fish that does come into contact with the screens (Swanson et al. 2004). Note also that Swanson et al. (2004) only tested sweeping velocity up to 2 ft/s, so there is added uncertainty in extrapolations above this range. It is important to recognize that the results of these analyses are only relevant to fish passing close to the screens, as the test facility under which the observations were made had a flume width of 1.2 meters (3.9 feet; Swanson et al. 2004).

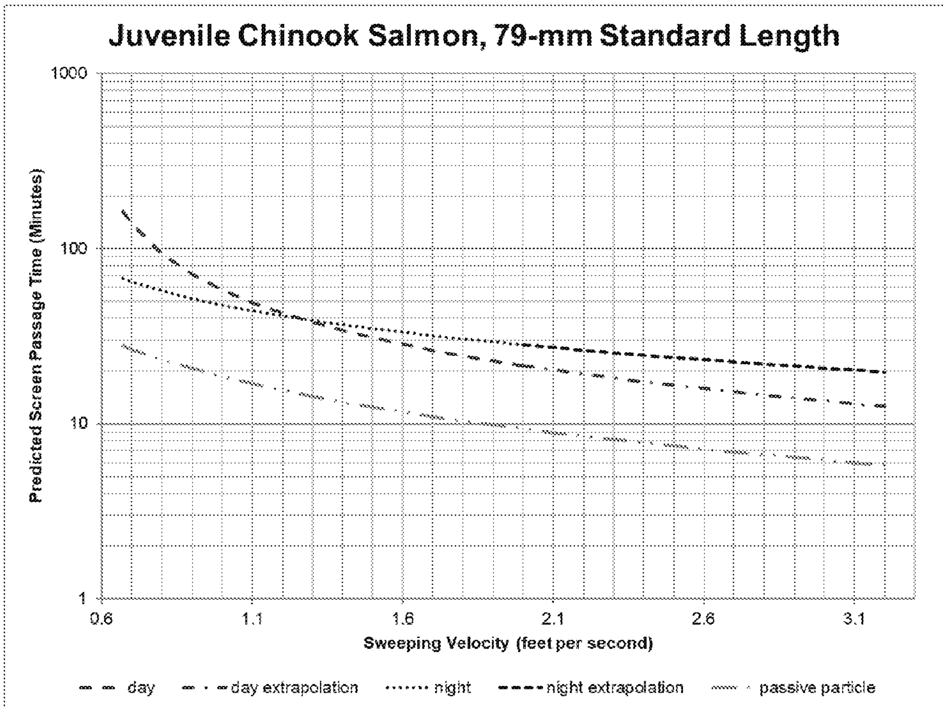
The results of the screen passage time analyses based on equations presented by Swanson et al. (2004) suggest that 44-mm juvenile Chinook salmon screen passage time could range from just over 10 minutes at 3.2-ft/s sweeping velocity by day to around 67 minutes at 0.67-ft/s sweeping velocity by day (Figure 44_passage). These estimates are appreciably longer than the rates of passage of passive particles linearly moving past the intakes without being entrained, for which the estimates based on screen length divided by sweeping velocity range from less than 6 minutes to nearly 28 minutes (Figure 44_passage). Relative to passive particles, longer passage times for fish calculated based on laboratory experiments reflect the swimming response of the tested juvenile Chinook salmon, which was generally rheotactic (i.e., swimming against the prevailing current). Based on Swanson et al.'s (2004) equations, the screen passage time of 79-mm juvenile Chinook salmon was estimated to range from 12.6 minutes at 3.2-ft/s sweeping velocity during the day to over 160 minutes at 0.67-ft/s sweeping velocity during the day (Figure 79_passage). Swanson et al. (2004) found that at warmer temperatures (19°C), larger juvenile Chinook salmon had a greater tendency to move downstream with the current (i.e., negative rheotaxis), consistent with a behavioral shift to outmigration; this would result in considerably lower screen passage times. This appears to be consistent with studies of PIT-tagged juvenile Chinook salmon undertaken at the Hamilton City intake[4] in July 1995, which indicated that median passage time was generally similar to sweeping velocity (Vogel and Marine 1995: Figure 21).

[4] This study occurred when the intake screens were just over 800-feet long, prior to screen lengthening to current 1,100-foot length, but remains useful for assessing screen passage rate.



Note: The total screen length for the Red Bluff and Hamilton City fish screens is approximately 1,100 feet. Plot only includes mean responses and does not consider model uncertainty. 'Extrapolation' indicates range of predictions beyond range of laboratory-tested sweeping velocities. Passive particle passage time was calculated as screen length divided by sweeping velocity.

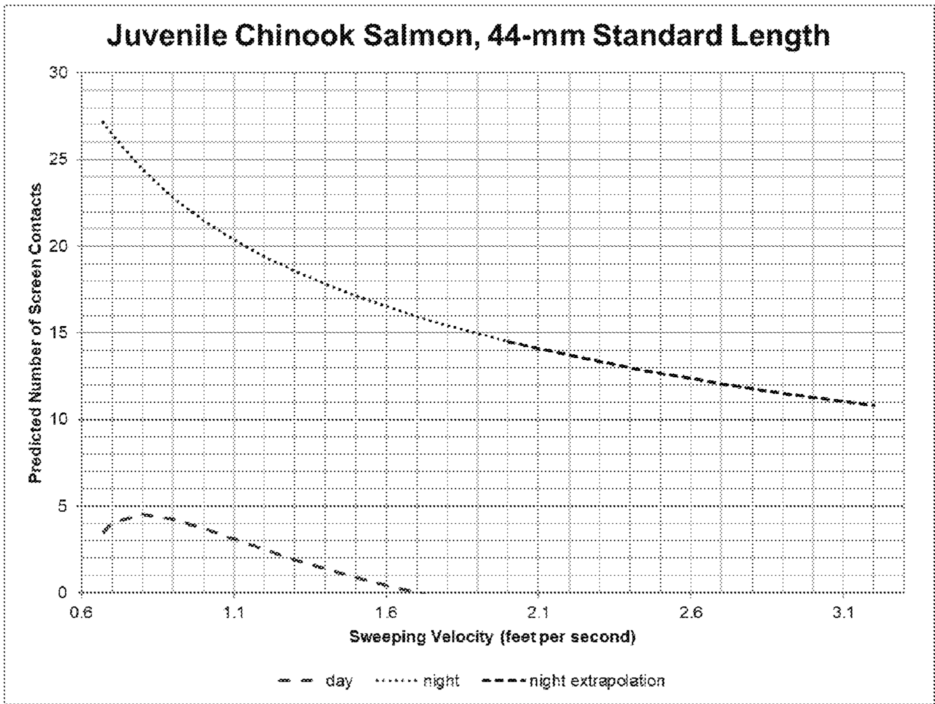
Figure 44_passage. Predicted Screen Passage Time for Juvenile Chinook Salmon (44-mm Standard Length) Encountering the Red Bluff and Hamilton City Fish Screens at Approach Velocity of 0.33 Feet per Second During the Day and Night.



Note: The total screen length for the Red Bluff and Hamilton City fish screens is approximately 1,100 feet. Plot only includes mean responses and does not consider model uncertainty. 'Extrapolation' indicates range of predictions beyond range of laboratory-tested sweeping velocities. Passive particle passage time was calculated as screen length divided by sweeping velocity.

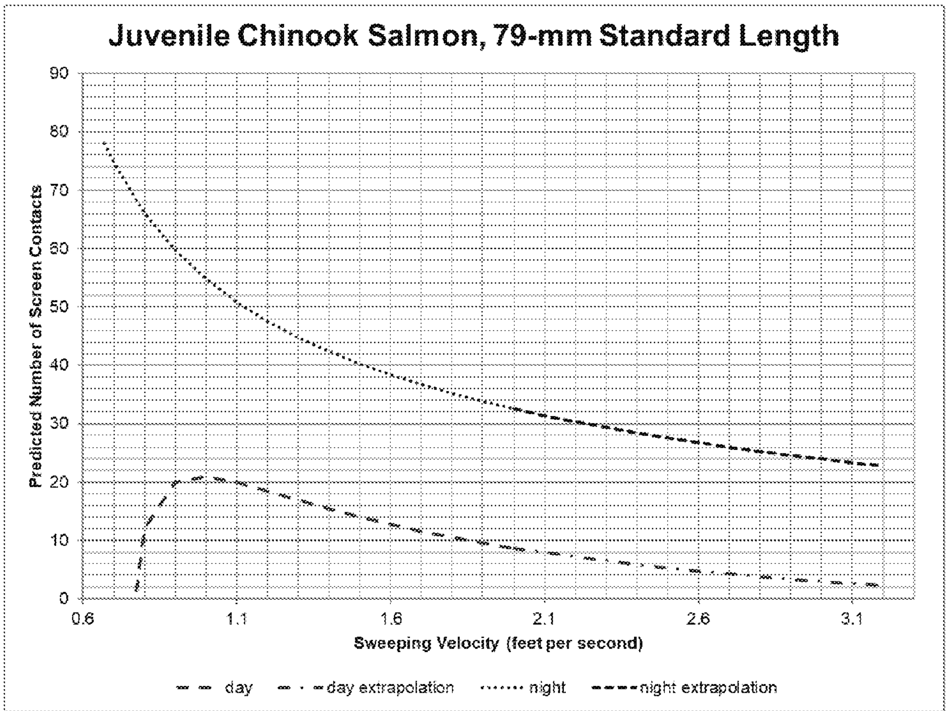
Figure 79_passage. Predicted Screen Passage Time for Juvenile Chinook Salmon (79-mm Standard Length) Encountering the Red Bluff and Hamilton City Fish Screens at Approach Velocity of 0.33 Feet per Second During the Day and Night.

The results of the screen contact analysis based on the equations from Swanson et al. (2004) suggested that the total number of screen contacts for juvenile Chinook salmon could range from 0 contacts to nearly 80 contacts, depending on fish size and sweeping velocity (Figures 44_contact and 79_contact).



Note: The total screen length for the Red Bluff and Hamilton City fish screens is approximately 1,100 feet. Plot only includes mean responses and does not consider model uncertainty. 'Extrapolation' indicates range of predictions beyond range of laboratory-tested sweeping velocities.

Figure 44_contact. Predicted Number of Screen Contacts for Juvenile Chinook Salmon (44-mm Standard Length) Encountering the Red Bluff and Hamilton City Fish Screens at Approach Velocity of 0.33 Feet per Second During the Day and Night.



Note: The total screen length for the Red Bluff and Hamilton City fish screens is approximately 1,100 feet. Plot only includes mean responses and does not consider model uncertainty. 'Extrapolation' indicates range of predictions beyond range of laboratory-tested sweeping velocities.

Figure 79_contact. Predicted Number of Screen Contacts for Juvenile Chinook Salmon (79-mm Standard Length) Encountering the Red Bluff and Hamilton City Fish Screens at Approach Velocity of 0.33 Feet per Second During the Day and Night.

Examination of the literature related to impingement does not appear to yield any additional information that would allow refinement of the quantitative results from Swanson et al. (2004), i.e., that injury could not easily be related to velocity or other variables. Thomas et al. (1969) found that avoidance of impingement on screens situated perpendicular to 0.8-ft/s sweeping velocity flow (no approach velocity was given) by swim-up fall-run Chinook salmon increased to ~90% or more of individuals with 70–80% absorption of the yolk sac. Avoidance of impingement decreased to ~70% of individuals as 100% of the yolk sac was absorbed, and as the fish got older (approaching 100 days post fertilization or more) avoidance of impingement returned to >90%. Thomas et al. (1969) suggested that the reduced swimming ability at or shortly after complete yolk sac absorption may be an important factor in the timing of downstream migration and survival of juvenile emigrants. Injury and mortality at vertical screens

(1.75-mm opening) guiding fish to juvenile fish passage systems were examined for juvenile salmonids at John Day Dam (Brege et al. 2005). Note that these screens consist of a quite different configuration than the Red Bluff or Hamilton City intakes, as they guide fish upward toward the bypass orifice (see Figure 2 of Brege et al. 2005) and flow and turbulence are relatively high (Brege et al. 2005: 19). Results for yearling Chinook salmon in 2002 found low mortality (0.1%) and injury (descaling: 4%). Additional testing for yearling Chinook salmon in 2004 with various vertical screen types to different prototype gate slots found that injury (descaling) ranged from 0.0% to 11.3% and mortality ranged from 0.0% to 10.4%. In 2004, subyearling Chinook salmon descaling ranged from 0.0% to 5.6% and mortality ranged from 0.0% to 11.9% (Brege et al. 2005). Zydlewski and Johnson (2002) found that vertical screens (1.75-mm opening) with approach velocity not exceeding 0.33 ft/s impinged around 12% of bull trout fry (median total length = 25 mm), but that all fry survived 24 h after the experiments were completed. Overall, considering the screen-related mortality data for juvenile Chinook salmon, the mean mortality from the studies of Swanson et al. (2004) and Brege et al. (2005) was 4.1% (median 1.2%, range 0–45.5%). The mean mortality weighted by the number of fish in each test was 1.4%.

None of the references citing Swanson et al. (2004) provided additional information on impingement-related injury/mortality beyond those listed above or found within Swanson et al. (2004). Note that Swanson et al. (2004: 266) stated: "…Hanson and Li (1978) reported that a number of fishes, including juvenile Chinook salmon, contacted a simulated fish screen or become impinged at velocities substantially below their measured swimming abilities." However, examination of Hanson and Li (1978) shows that those authors in fact had made a similar statement ("it has been shown that fish are impinged at velocities substantially lower than those in forced swimming performance trials") without themselves undertaking such studies or providing specific references to which studies were meant.

Limited examples exist for the way existing information has been used to inform effects analyses in the Central Valley and other areas. Cramer et al. (2005) assessed potential fish benefits from screening various Sacramento River diversions, and assumed various screen encounter mortality rates ranging from 2% (an unsedimented screen condition, based on the position statement of NOAA 1994) up to 30% mortality (as a result of higher approach velocity caused by sedimentation and reduction in surface area). Walters et al. (2012) assumed 99% survival per screen encountered for juvenile Chinook salmon emigrating from the heavily irrigated Lemhi River (Idaho) watershed, based on the study of Swanson et al. (2004), but also noted that there could be additional mortality because of other factors such as predation (discussed herein below).

The available information generally suggests that impingement and screen passage/contact-related negative effects of the operation of the Red Bluff and Hamilton City intakes would be limited, particularly given that these effects would only apply to the subset of juvenile winter-run Chinook salmon encountering the intakes. The Red Bluff and Hamilton City fish screens are designed to protective standards for Chinook salmon fry and so near-field effects would be expected to be limited. Impingement would be monitored at the Red Bluff and Hamilton City intakes, in addition to long-term hydraulic evaluations of screen performance (see Appendix 2D).

Predation

Red Bluff and Hamilton City Intakes

Predation of juvenile salmonids at the Red Bluff and Hamilton City intakes could occur if predatory fish aggregate along the screens. Such aggregation has been previously observed at the Hamilton City intake (Vogel 2008), which is apparently the only completed study of predation along long fish screens in the Central Valley and involved calculation of survival along the fish screen based on recapture of marked juvenile Chinook salmon released from several locations. Vogel's (2008) study found that mean survival of tagged juvenile Chinook salmon at the Hamilton City intake in 2007—this being the only year of the study in which flow-control blocks at the weir at the downstream end of the fish screen were removed, to reduce predatory fish concentration—was approximately 95% along the fish screen. However, the percentage of tagged juvenile Chinook salmon released at the upstream end of the fish screen that were recaptured at a downstream sampling location was similar or slightly greater than for fish released at the downstream end of the fish screen, when standardized for the distance that the fish had to travel to the recapture site (Table GCID1). These data suggest that survival along the screen was at least similar to survival in the portion of the channel without the screen (i.e., screen survival was similar to baseline survival, if the latter is assumed to be represented by the channel downstream of the screen). However, test fish providing the estimate of survival in the channel downstream of the screen were released prior to the fish that were released at the upstream end of the fish screen, which could have confounded comparisons of relative survival between these groups if predatory fishes became partly satiated prior to the arrival of the fish released at the upstream end of the screen (thus potentially making their survival relatively higher than otherwise would have occurred) (Vogel 2008: 12). In addition, Vogel (2008: 20) cautioned:

> …the fish mark/recapture survival experiments probably result in higher survival estimates than would be expected to occur for wild juvenile salmon migrating past the site (Vogel 2007). This circumstance is attributable to the fact that wild fish exhibit a more-protracted migration timing and do not migrate en masse like the simultaneous release of hundreds of marked hatchery fish for the short-term survival experiments. Predatory fish in the GCID oxbow channel could more readily consume greater numbers of wild fish "trickling" downstream through the oxbow as compared to an instantaneous release of hundreds of juvenile salmon that move rapidly past the site during a very short period. The acoustic telemetry experiments [undertaken in 2005] provided some empirical evidence of this phenomenon. Seasonally, large numbers of wild fish enter the oxbow inlet channel and become concentrated into a lesser amount of flow by the time the fish pass the flow-control weir because the majority of water is removed from the channel through the fish screens. Notably, this time period [referring to spring/summer diversions under baseline conditions] includes the early portion of endangered juvenile winter-run Chinook salmon migration.

Note, however, that Vogel's (2008) experiments in 2007 occurred during May-July, during which time water temperature would be expected to be greater than during the main November-March period of the alternatives' diversions, and predation may be lower because of reduced predator bioenergetic requirements (e.g., Loboschefsky et al. 2012). This, coupled with the fact that the Red Bluff intake is situated on a wider stretch of the Sacramento River than the Hamilton City intake oxbow channel, increases the uncertainty in the applicability of estimates of predation mortality from the Vogel (2008) GCID study to the Red Bluff and Hamilton City intakes.

Table GCID1. Number and Proportion of Juvenile Chinook Salmon Released and Recaptured at the Hamilton City Intake, 2007.

Date	Time	Screen Group Number of Fish Released	Screen Group Number of Fish Recaptured	Screen Group Proportion of Fish Recaptured	Screen Group Proportional Survival/ 100 m[a]	Weir Group Number of Fish Released	Weir Group Number of Fish Recaptured	Weir Group Proportion of Fish Recaptured	Weir Group Proportional Survival/ 100 m[a]
5/22/2007	Day	504	294	0.58	0.95	239	201	0.84	0.97
5/22/2007	Night	474	416	0.88	0.99	254	242	0.95	0.99
5/24/2007	Day	454	304	0.67	0.96	259	145	0.56	0.90
5/24/2007	Night	484	338	0.70	0.96	264	171	0.65	0.93
5/29/2007	Day	504	295	0.59	0.95	260	194	0.75	0.95
5/29/2007	Night	492	417	0.85	0.98	249	169	0.68	0.93
5/31/2007	Day	484	363	0.75	0.97	253	220	0.87	0.98
5/31/2007	Night	503	372	0.74	0.97	258	221	0.86	0.97
6/5/2007	Day	515	428	0.83	0.98	254	219	0.86	0.97
6/5/2007	Night	511	408	0.80	0.98	264	223	0.84	0.97
6/7/2007	Day	504	451	0.89	0.99	261	216	0.83	0.97
6/7/2007	Night	514	383	0.75	0.97	264	212	0.80	0.96
6/12/2007	Day	511	460	0.90	0.99	265	257	0.97	0.99
6/12/2007	Night	514	430	0.84	0.98	264	235	0.89	0.98
6/14/2007	Day	510	495	0.97	1.00	265	197	0.74	0.95
6/14/2007	Night	502	440	0.88	0.99	263	215	0.82	0.97
6/19/2007	Day	510	489	0.96	1.00	264	200	0.76	0.95
6/19/2007	Night	511	434	0.85	0.98	263	214	0.81	0.96
6/21/2007	Day	515	495	0.96	1.00	265	242	0.91	0.98
6/21/2007	Night	512	394	0.77	0.97	264	200	0.76	0.95
6/26/2007	Day	515	495	0.96	1.00	265	256	0.97	0.99
6/26/2007	Night	509	409	0.80	0.98	259	207	0.80	0.96
6/28/2007	Day	507	432	0.85	0.98	265	227	0.86	0.97
6/28/2007	Night	505	396	0.78	0.98	264	189	0.72	0.94

This Chapter is not yet edited. Provided for preliminary review and discussion.

Date	Time	Screen Group Number of Fish Released	Screen Group Number of Fish Recaptured	Screen Group Proportion of Fish Recaptured	Screen Group Proportional Survival/ 100 m[a]	Weir Group Number of Fish Released	Weir Group Number of Fish Recaptured	Weir Group Proportion of Fish Recaptured	Weir Group Proportional Survival/ 100 m[a]
7/3/2007	Day	507	460	0.91	0.99	265	232	0.88	0.98
7/5/2007	Day	515	499	0.97	1.00	265	245	0.92	0.99
7/5/2007	Night	504	344	0.68	0.96	264	195	0.74	0.95
7/10/2007	Day	509	493	0.97	1.00	228	184	0.81	0.96
7/10/2007	Night	513	368	0.72	0.97	263	185	0.70	0.94
7/12/2007	Day	513	471	0.92	0.99	262	226	0.86	0.97
7/24/2007	Day	497	405	0.81	0.98	248	207	0.83	0.97
7/24/2007	Night	508	337	0.66	0.96	257	161	0.63	0.92
7/26/2007	Day	500	380	0.76	0.97	263	223	0.85	0.97
7/31/2007	Day	509	361	0.71	0.97	253	190	0.75	0.95
7/31/2007	Night	503	378	0.75	0.97	264	194	0.73	0.95
8/2/2007	Day	498	420	0.84	0.98	219	166	0.76	0.95
8/7/2007	Night	511	397	0.78	0.97	246	189	0.77	0.96
8/9/2007	Day	504	415	0.82	0.98	265	212	0.80	0.96
8/9/2007	Night	478	307	0.64	0.96	255	169	0.66	0.93
8/21/2007	Night	514	338	0.66	0.96	263	152	0.58	0.91
8/23/2007	Day	429	298	0.69	0.96	247	139	0.56	0.91
8/23/2007	Night	507	323	0.64	0.95	258	142	0.55	0.90
8/27/2007	Day	465	342	0.74	0.97	261	227	0.87	0.98
			Mean	0.80	0.98			0.78	0.96
			Median	0.80	0.98			0.80	0.96
			Min.	0.58	0.95			0.55	0.90
			Max.	0.97	1.00			0.97	0.99

The recent study of acoustically tagged juvenile late fall–run Chinook salmon survival by Henderson et al. (2019) primarily provides information regarding far-field effects of flow (see *Migration Flow-Survival* section below), but also has value in allowing inference regarding near-field effects of diversions. Henderson et al. (2019, their Table 1) hypothesized that the density of diversions (number per km) would be negatively related to survival because of higher predator densities near the diversions. In fact, they found the opposite, and speculated that greater survival with higher diversion density may be more a function of habitat conditions where diversions are more abundant, e.g., armored banks resulting in reduced predator density and predation mortality (Henderson et al. 2019: 1558). Reach-specific survival estimates by Henderson et al. (2019) provide context for the near-field effects provided by the physical structure of the existing Red Bluff and Hamilton City intakes, albeit during the non-diversion season. During the 2007-2011 study years, survival in the reach including the Red Bluff intake ranged in rank from highest survival (2007, 2011) to second lowest survival of 19 reaches in 2008. Survival in the Hamilton City reach ranged from highest survival (2010, 2011) to 12th highest survival of 19 reaches in 2008. Overall, the studies by Henderson et al. (2019) and Vogel (2008) are not inconsistent in suggesting that near-field survival along large fish screens does not appear to be greatly different from reaches without intakes. This could be because the flat surface of the screens gives relatively high sweeping velocity, which may be greater than the velocity preference of predatory fishes such as Sacramento pikeminnow, for which adult fish generally occur at velocity below 30 cm/s (1 ft/s) and for which critical swimming velocity is around 0.4-0.6 m/s (1.3-2 ft/s; Myrick and Cech 2000) for individuals of the size at which piscivory is common (Nobriga et al. 2006).

The available information suggests that the effects of intakes on predation is limited and so the effects of the alternatives' diversions from the Red Bluff and Hamilton City intakes would be limited. Note that in-water structure at the intakes would have the same extent under existing conditions and the alternatives, so this aspect of potential predation would not change as a result of the alternatives. Technical studies would be undertaken to assess predator density and distribution at the Red Bluff and Hamilton City intakes (see Appendix 2D).

Dunnigan Pipeline Reservoir Discharge to Sacramento River (Alternative 2)

As described in Chapter 2, the discharge structure to the Sacramento River from the Dunnigan Pipeline at approximately River Mile 100.8 would include a 20,000-square foot area of riprap extending to the river (see Figure 2-58 in Chapter 2). Riprapped areas tend to have lower habitat occupancy by juvenile Chinook salmon than areas of natural features and rocky substrate is favored by predatory species such as smallmouth bass (Hellmair et al. 2018). The riprapping of the reservoir discharge area thus has the potential to increase predation risk to juvenile winter-run Chinook salmon; however, any negative effects would be extremely limited relative to the overall extent of the Sacramento River and other areas used for rearing by juvenile winter-run (Phillis et al. 2018).

Stranding Behind Screens

At very high flows, river flow may overtop the fish screens and associated decks of the intakes. At this point, water spills into the forebay behind the screens. Juvenile salmonids, including winter-run Chinook salmon, entering the forebays in the streamflow overtopping the inundated fish screen structures could be stranded once the stream flows have receded. At the Hamilton City intake, the deck above the fish screens (elevation 154.8 feet NAVD 88) is overtopped at streamflows greater than approximately 100,000 cfs, as occurred in February 2017 (Figure GCID_overtop). At the Red Bluff intake, the top of the deck is at a similar elevation to the 100-year flood flow (220,000 cfs), so that overtopping would be rare. The portion of the water column that exceeds the elevation of the top of the decks is small relative to the total water column, suggesting that only a limited portion of juvenile winter-run Chinook salmon in the upper water column may be susceptible. Of those juvenile salmon that are susceptible, the turbulence caused by the water passing over the decks (Figure GCID_overtop) may trigger an avoidance response to swim away from the overtopping area. Although overtopping can occur at the Red Bluff and Hamilton City intakes, these are relatively infrequent events that occur under existing conditions and would not be changed by the alternatives. Stranding behind screens would be monitored at the Red Bluff and Hamilton City intakes (see Appendix 2D).

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Source: Glenn-Colusa Irrigation District, https://www.youtube.com/watch?v=u_DOLE7QXa8 Accessed: February 11, 2021. Note: Oxbow from which water is diverted is to the left of the picture, with streamflow moving to the right into the forebay behind the screens.

Figure GCID_overtop. Streamflow Overtopping the Fish Screen Structure at Glenn-Colusa Irrigation District Hamilton City Pumping Plant, February 18, 2017.

Attraction to Reservoir Discharge and Pipeline Entry (Alternative 2)

Water discharged from the Dunnigan Pipeline to the Sacramento River under Alternative 2 would primarily originate from the Sacramento River and as such may attract upstream-migrating salmonids, including adult winter-run Chinook salmon, which inhabit the upper Sacramento River and tributaries upstream of the Red Bluff and Hamilton City intakes as natal habitat. As described in Chapter 2, the discharge structure to the Sacramento River from the Dunnigan Pipeline at approximately River Mile 100.8 would include a vertical drop exclusion barrier to prevent the passage of anadromous fish, including adult winter-run Chinook salmon, into the pipeline. The twenty 36-inch pipes would discharge into a stilling basin, with a 4-foot weir at the basin's downstream end, on the other side of which would be a 16:1-gradient, 60-foot-long apron (see Figure XX in Chapter 2). The discharge facility meets draft NMFS (2018a: 85–89) criteria for anadromous fish protection. Given that discharges would occur during low-water conditions (May–October/November) and the river would be more than 100 feet away from the pipes discharging water, there would be no risk of entry into the pipeline. The timing of adult winter-run Chinook salmon upstream migration generally has some overlap with the initial period of reservoir discharge in April/May, although peak migration occurs earlier (Vogel and Marine 1991: 4; see also Appendix 11A). Although discharge flow would be dissipated by the riprap, the rate of flow discharged in April/May (e.g., several hundred cfs in critically dry years; see Table Sites_SR in Chapter 5) could attract some late-migrating adult winter-run Chinook salmon that might attempt to move upstream by leaping out of the river toward the discharge flow, but the design of the apron and weir of the discharge structure would eliminate the risk of stranding for any fish attempting to move up the flow.

Far-Field Effects

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Sacramento River below Keswick, at Balls Ferry, at Bend Bridge, below RBDD, and at Butte City indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of winter-run Chinook salmon (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-5-1a to 6C-5-4c, Tables 6C-7-1a to 6C-7-4c, Tables 6C-9-1a to 6C-9-4c, Tables 6C-10-1a to 6C-10-4c, Tables 6C-12-1a to 6C-12-4c; Figures 6C-5-1 to 6C-5-18, Figures 6C-7-1 to 6C-7-18, Figures 6C-9-1 to 6C-9-1, Figures 6C-10-1 to 6C-10-18, Figures 6C-12-1 to 6C-12-18). At all locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±0.5°F of the NAA Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at all locations.

Results of the analysis of exceedance above water temperature index values for winter-run Chinook salmon in the Sacramento River from Appendix 11B, *Fisheries Impact Assessment*

Methods, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X and summarized in Table 11-temp1. For each life stage and at all locations evaluated, there were no month and water year type combinations in which both: (1) the percent of days that exceeded the index values was more than 5% greater under the alternative than under the NAA, and (2) the exceedance per day was more than 0.5°F greater under the alternative than under the NAA. Results of the exceedance analysis for Alt 2 are similar to Alt 1 with no month and water year type combinations in which both criteria were met for any life stage at all locations. For Alt 3, there was one month and water year type combination (July of Above Normal Water Years) at Hamilton City for the juvenile rearing and migration life stages in which there were 11.6% more days than the NAA exceeding the 64°F 7DADM index value and the mean daily exceedance on those days was 0.7°F greater than the NAA. There was also one month and water year type combination (August of Critically Dry Water Years) in which both criteria met in a beneficial way (the percent of days that exceeded the index values was more than 5% lower under Alt 3 than under the NAA, and the exceedance per day was more than 0.5°F lower under Alt 3 than under the NAA) for at least one life stage at 4 of the 6 locations evaluated.

Table 11-temp1. Number of month and water year type combinations that satisfy both criteria for being biologically meaningful in the water temperature index value analysis, Winter-run Chinook salmon, Sacramento River[1,2,3]

Location	Spawning and Egg Incubation	Juvenile Rearing and Emigration	Adult Immigration	Adult Holding
Below Keswick	Alt 1A, 1B, 2 – 0 Alt 3 – 1 beneficial (August, Critical years)	Alt 1A, 1B, 2, 3 –0	Alt 1A, 1B, 2, 3 –0	Alt 1A, 1B, 2, 3 –0
Below Clear Creek	Alt 1A, 1B, 2, 3 –0	Alt 1A, 1B, 2, 3 –0	N/A	N/A
Balls Ferry	Alt 1A, 1B, 2 – 0 Alt 3 – 1 beneficial (August, Critical years)	Alt 1A, 1B, 2 – 0 Alt 3 – 1 beneficial (August, Critical years)	N/A	Alt 1A, 1B, 2 – 0 Alt 3 – 1 beneficial (August, Critical years)
Bend Bridge	Alt 1A, 1B, 2, 3 –0	Alt 1A, 1B, 2, 3 –0	Alt 1A, 1B, 2, 3 –0	N/A
Below Red Bluff Diversion Dam	Alt 1A, 1B, 2, 3 –0	Alt 1A, 1B, 2 – 0 Alt 3 – 1 beneficial (August, Critical years)	Alt 1A, 1B, 2, 3 –0	Alt 1A, 1B, 2 – 0 Alt 3 – 1 beneficial (August, Critical years)
Hamilton City	N/A	Alt 3 - 1 negative (July, Above normal years)	N/A	N/A

1 Criteria include: (1) the difference in frequency of exceedance between NAA and the alternative was greater than 5%, and (2) the difference in average daily exceedance between NAA and the alternative was greater than 0.5°F.
2 Index values for each life stage are located in Appendix 11B, Fisheries Impact Assessment Methods, Table 11.##.
3 Full results presented in Appendix 11D, Fisheries Water Temperature Assessment, Table X through Table X

The Martin and Anderson models estimate water temperature-related mortality of winter-run Chinook salmon eggs to fry (Martin et al. 2017, Anderson 2018). Results of these models are presented in Appendix 11O, *Anderson-Martin Models*. Differences between the Martin and Anderson model results are generally small other than in Critically Dry Water Years, in which the Martin model predicts nearly twice the egg mortality that the Anderson model under all alternatives (Appendix 11O, *Anderson-Martin Models*, Table 1-1a, Table 1-1b, Table 1-2a, Table 1-2b, Table 1-3a, Table 1-3b, Table 1-4a, Table 1-4b). Combining all months during the egg incubation period analyzed (May through September), Alt 1A and Alt 1B would have very small effects (±0.1% difference from NAA) on egg mortality in most water year types (Appendix 11O, *Anderson-Martin Models*, Table 1-1c, Table 1-2c). In Critically Dry Water Years, egg mortality under Alt 1A and Alt 1B would be 0.8% and 0.9% lower, respectively, according to the Martin model and 0.8% and 1.4% lower, respectively, according to the Anderson model. Exceedance plots (Appendix 11O, *Anderson-Martin Models*, Figures 1-1 through 1-6 and Figures 2-1 through 2-6) indicate that the majority of variance between the NAA vs. Alt 1A and Alt 1B would occur between August and October in critical dry years, which minimally overlaps with the peak of winter-run Chinook salmon spawning and egg incubation (June through August).

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The Martin and Anderson models predict largely similar results for Alt 2 and Alt 3 compared to Alt 1, although egg mortality under Alt 3 would be slightly lower than in the NAA and other alternatives in Critically Dry Water Years (Appendix 11O, *Anderson-Martin Models*, Table 1-1a, Table 1-1b, Table 1-2b, Table 1-3b, Table 1-4b).

Redd Scour Entombment

Loss of redds to scouring and entombment occurs when flows are high enough to mobilize sediments, destroying redds and their incubating eggs and alevins, or entombing the redds when sediments are redeposited. A flow of 40,000 cfs was selected as the scour flow threshold for the Sacramento River based on estimates in the literature (Table 11N-10).

The probability of redd scour and entombment was estimated for winter-run by computing the percentage of days with flows exceeding 40,000 cfs in the USRDOM 82-year daily flow record (29,952 days in total) at four locations between Keswick Dam and the RBDD during the months of winter-run spawning and incubation. The results for all alternatives (NAA and Alternatives 1–3) show that the probability of scour and entombment is consistently low for winter-run (Table 11N-22 through Table 11N-25). Alternatives 1–3 have very little effect on the frequency of scouring and entombment flows and almost all differences result from a reduction in the probability of such flows. The results indicate that Alternatives 1–3 would have little effect on redd scour and entombment for winter-run in the Sacramento River.

Redd Dewatering

The percentage of redds in the Sacramento River lost to dewatering was estimated using tables in USFWS (2006) that relate spawning and dewatering flows to percent reductions in species-specific spawning habitat WUA (see Appendix 11-N). The field studies used for USFWS (2006) were conducted in the Sacramento River between Keswick Dam and Battle Creek. USRDOM flow data, which has a daily time-step, are available for three locations in this river section: Keswick Dam (River Mile [RM] 302), the Sacramento River at Clear Creek (RM 289), and the Sacramento River at Battle Creek (RM 271). A single relationship for flows was developed for the entire river section, but the flows used to estimate redd dewatering in the current analysis were those that best matched the longitudinal distribution of the redds of the different salmon runs in the river as estimated from aerial redd surveys conducted by CDFW from 2003 through 2019. Spawning of winter-run occurs primarily between Keswick Dam and the confluence with Clear Creek (Table 11-1), so Keswick Dam flows were used to analyze winter-run redd dewatering.

Commented [CC51]: Please, expand- what were the flows used to estimate dewatering- where can we find them? How do these flows differ from those developed as a single relationship to the entire river section (i.e., quantified differences)?

Table 11-1. Distributions of Spawning Redds among WUA River Segments as Percent of Total in the Sacramento River for Chinook Salmon Runs.

Segment	Description	River Miles	Winter-run	Spring-run	Fall-run	Late fall–run
6	Keswick to ACID[a]	302-298.5	45.0%	12.4%	16.3%	67.6%
5	ACID to Cow Creek	298.5-280	54.6%	66.0%	25.9%	12.7%
4	Cow Creek to Battle Creek	280-271	0.4%	12.8%	18.4%	9.2%
3	Battle Creek to RBDD	271-243	0.0%	4.9%	22.8%	4.3%
—	Downstream of RBDD	—	0.0%	4.0%	16.6%	6.2%

[a] ACID = Anderson-Cottonwood Irrigation District

Results are presented using the grand mean percentages of redds dewatered for each month of spawning, April through July, and each water year type and all water year types combined. The complete spawning and egg/alevin incubation periods are provided in the results (Table 11N-13) because changes in Project-related flow any time during these periods can affect the redd dewatering results. The means of the redd dewatering estimates under the NAA and Alternatives 1–3 are compared using absolute differences rather than relative differences (percent change) because many of the values for percentages of redds dewatered are small. Expressing changes of small values as percent changes may result in very large values that may be misleading.

Commented [CC52]: Please, clarify, as this statement does not make sense.

The results for winter-run show few large changes in redd dewatering between the NAA and Alternatives 1–3 (Table 11N-13). The largest reductions in redd dewatering occur under Alternative 3 during the spawning and incubation period for eggs spawned in June of Above Normal and Below Normal Water Years and in July of Above Normal Water Years. Changes for most months and water year types under all the alternatives are less than 2%. Overall, the effects of Alternatives 1–3 on winter-run redd dewatering are minor.

Commented [CC53]: Why highlight reductions in redd dewatering and not increases in redd dewatering?

Habitat Availability

The suitability of physical habitat for salmonid spawning is largely a function of the availability of clean, coarse gravel for constructing redds, favorable depths, and suitable flow velocities. The suitability of physical habitat for salmonid rearing is largely a function of water depth, flow velocity, and the availability and type of cover. Instream flow potentially affects all these habitat characteristics and often affects the availability of suitable habitat. Habitat suitability for spawning and rearing were analyzed using weighted usable area (WUA) curves developed by USFWS and others from results of field studies and hydraulic modeling (see Appendix 11K).

Spawning Habitat Weighted Usable Area

Spawning WUA for winter-run Chinook salmon was determined by USFWS (2003a, 2006) for a range of flows in three segments of the Sacramento River between Keswick Dam and the Battle Creek confluence (Figure 11-1). To estimate changes in winter-run spawning WUA that would result from Alternatives 1–3, the winter-run flow versus spawning habitat WUA relationship developed for each of the three segments was used with mean monthly CALSIM II flows for the winter-run spawning and incubation period (April through October) under Alternatives 1–3 and the NAA in the corresponding segments of the river.

Commented [CC54]: Generally, median monthly flows (the 50% exceedance flow) are used to better represent the true average flow expected to be present each month. As mean is the average, it can be influenced by outliers and may not reflect expected conditions.

Differences in spawning WUA under Alternatives 1–3 and the NAA were examined using the grand mean spawning WUA for each month of the spawning period under each water year type and all water year types combined. In the tables of results, means that differed by >5% were highlighted in red for reductions or green for increases. The highlighting is provided to flag the largest differences, as a convenience to the reader.

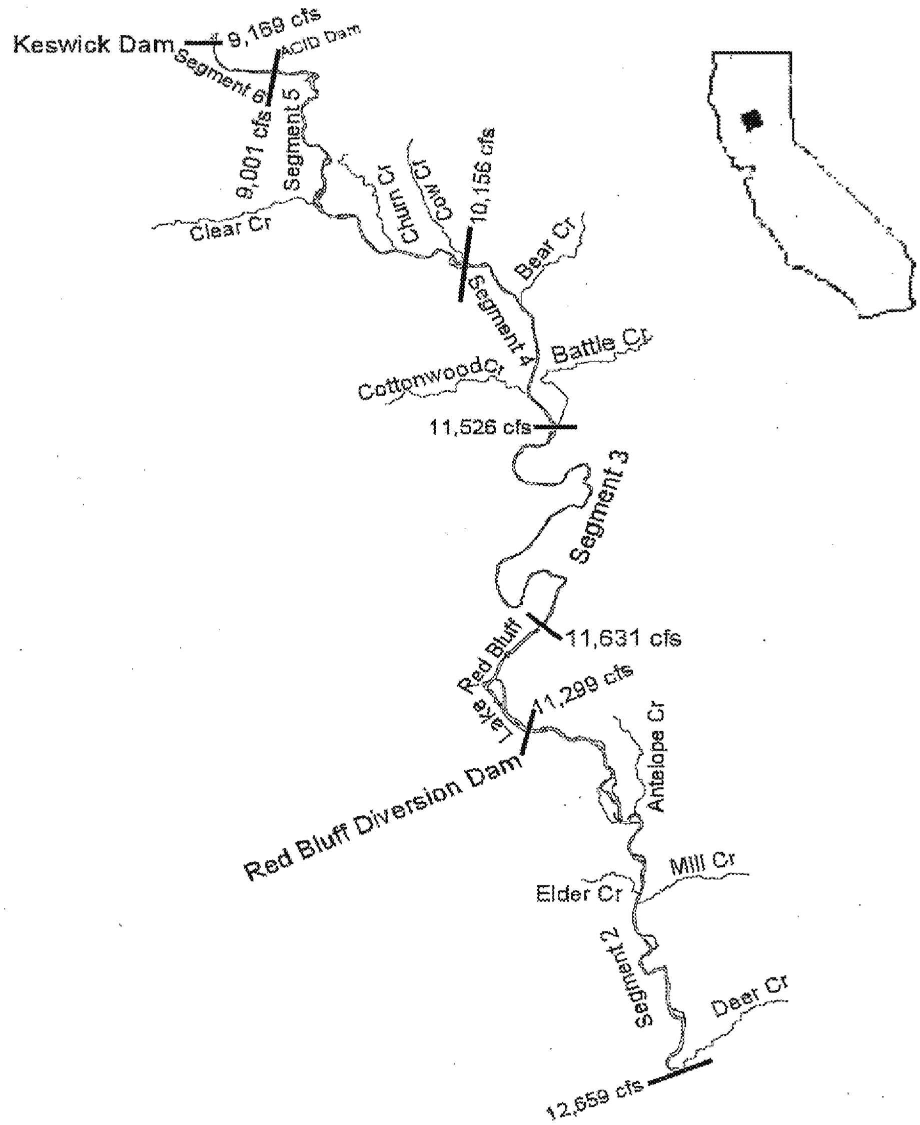


Figure 11-1. Segments 2–6 of the Sacramento River Used in U.S. Fish and Wildlife Service Studies to Determine Spawning and Rearing Weighted Usable Area (WUA) (flows in the

figure are the average flows at the upstream boundary of each segment for October 1974 to September 1993). Source: U.S. Fish and Wildlife Service 2003a.

Almost all spawning by winter-run occurs in the upper two segments (Segments 6 and 5) of the Sacramento River, between Keswick Dam and Cow Creek, with spawning density (redds per river mile) especially high in Segment 6 (Table 11-1). Winter-run spawning WUA under Alternatives 1–3 and the NAA were estimated using CALSIM II flow estimates for Segments 4–6 for the winter-run spawning and incubation period (April through October).

Mean winter-run spawning WUA differs by less than 5% for most months and water year types, but mean WUA in Segment 6 under Alternatives 1–3 is 5% to 6% lower than WUA under the NAA in May of Critically Dry Water Years and is 5% to 8% higher in September and October of Critically Dry Water Years (Table 11K-2). WUA is also up to 9% higher for Alternative 3 in Above Normal Water Years in September and October. In Segment 5, WUA consistently differs little between Alternatives 1–3 and the NAA (Table 11K-3). In Segment 4, WUA in May of Critically Dry Water Years under Alternatives 1–3 and WUA in June and August of Above Normal and/or Below Normal Water Years under Alternative 3, is slightly greater than WUA under the NAA (Table 11K-4). In September of Above Normal Water Years WUA under Alternative 3 is about 7% lower than that under the NAA.

These results indicate that in May of Critically Dry Water Years, Alternatives 1–3 would result in reductions of spawning habitat in Segment 6 and increases of spawning habitat in Segment 4. In most other months, more increases than decreases in spawning habitat were predicted. Note that spawning habitat conditions for winter-run are much more important in Segment 6 than in Segment 4. In general, Alternatives 1–3 are not expected to substantially affect winter-run spawning WUA.

Rearing Habitat Weighted Usable Area

Rearing WUA for fry and older juvenile life stages of winter-run in the Sacramento River was determined by USFWS (2005b) for a range of flows in three segments of the Sacramento River between Keswick Dam and the Battle Creek confluence (Figure 11K-1). For this analysis, fry are defined as fish less than 60 mm and juveniles are young fish (young-of-the-year) greater than 60 mm. To estimate changes in winter-run rearing WUA that would result from Alternatives 1–3, the winter-run flow versus rearing habitat WUA relationships developed for each of the three segments was used with mean monthly CALSIM II flows for the winter-run fry (July through October) and juvenile (September through November) rearing period under Alternatives 1–3 and the NAA in the corresponding segments of the river.

Differences in winter-run fry and juvenile rearing habitat WUA in each river segment under Alternatives 1–3 compared to the NAA were examined using the grand mean rearing WUA for each month of the fry and juvenile rearing periods under each water year type and all water year types combined (Table 11K-23 through Table 11K-28). In the tables, means that differed by >5%

were highlighted in red for reductions or green increases. The highlighting is provided to flag the largest differences, as a convenience to the reader.

All the means for fry rearing WUA differ by less than 5% between Alternatives 1–3 and the NAA in Segments 5 and 4 (Table 11K-24 and Table 11K-25). In Segment 6, three of the means under Alternative 1-3 are >5% lower than the NAA mean (Table 11K-23). The largest reduction is 7% for October of Below Normal Water Years under Alternative 3. These results indicate that Alternative 3 would have a moderate effect on rearing habitat for winter-run fry in the Sacramento River during October of Below Normal Water Years and the other alternatives would have little effect.

All the means for juvenile rearing WUA differ by <5% between Alternatives 1–3 and the NAA, except for a 5% increase in Segment 6 for October of Critically Dry Water Years under Alternative 3 and a 5% reduction in Segment 4 for September of Above Normal Water Years under Alternative 3 (Table 11K-26 and Table 11K-28). These results indicate that Alternatives 1–3 would have minor effects on rearing habitat for winter-run juveniles in the Sacramento River.

Commented [CC55]: If the trend is lower rearing WUA then the actual number is probably higher since this uses monthly average flows differences.

Juvenile Stranding

The juvenile stranding estimation procedure for the Sacramento River computes the surface area of salmonid rearing habitat inundated at an initial flow that is dewatered at a subsequent minimum (stranding) flow, and then converts this area to number of stranded juveniles using estimates of habitat capacity based on field study observations (USFWS 2006). A period of 3 months is used for the juvenile stranding analysis in this report because the juveniles are presumed to be most vulnerable to stranding during their first 3 months (i.e., fry stage).

Juvenile stranding is computed using USRDOM daily flow estimates for Alternatives 1–3 and the NAA at three locations in the upper Sacramento River: Keswick Dam, Clear Creek, and Battle Creek. Separate tables for converting initial and stranding flows to number of juveniles stranded were developed for periods when the ACID Dam boards are in and when they are out (Table 11N-11 and Table 11N-12). Both tables are used for all the salmonid species and races.

The results are presented using the grand mean number of juveniles stranded for each month of emergence under each water year type and all water year types combined (Table 11N-28 through Table 11N-30). The analysis assumes that under equal flow conditions the fry and early juvenile stage of all runs and species are equally vulnerable to stranding. To determine the results for a given species or run, the estimated months for which the fry typically emerge (Table 11N-27), are consulted in the tables of results. The effects of dewatering flows are tracked by the analysis from the month of emergence through the three months (90 days) following. These periods are given in the tables.

All three river locations show the largest differences between Alternatives 1–3 and the NAA for the cohorts of fry that emerged during the months of April, May, June, and July (Table 11N-28 through Table 11N-30). The May cohort generally shows the biggest differences and all the May

Commented [CC56]: This section seems pretty important- perhaps expand to include the differences (numerically) and/or add in details to better describe the potential impacts/improvements such as percentages, locations, etc.

differences are reductions in juvenile stranding, with the largest reduction, 55%, occurring at the Battle Creek location under Alternative 1B in May of Critically Dry Water Years. The largest increases in juvenile stranding occur for the April cohort at all three locations, ranging as high as 30% in dry years under Alternatives 1A, 1B and 2 at the Keswick Dam location. The principal period of stranding vulnerability for winter-run is for cohorts emerging in July through October, when some large reductions and increases in juvenile stranding occur, but large reductions in juvenile stranding are more frequent than large increases. Alternatives 1–3 are not expected to affect winter-run juvenile stranding (Table N11-28 through Table 11N-30).

SALMOD

The SALMOD model outputs for winter-run Chinook salmon are presented in Appendix 11H, *SALMOD,* Table 1a-1 through Table 1a-4, Table 2a-1 through Table 2a-4, and Figure B-a-1 through Figure B-a-19. For all water years combined for all life stages and source of mortality, mean annual winter-run Chinook salmon potential production would be similar under Alt 1A (0.4% greater) and Alt 1B (0.6% greater) relative to the NAA (Appendix 11H, *SALMOD,* Table 2a-1 and Table 2a-2, Figure B-a-1). Further, differences within each water year type in mean annual potential production between Alt 1A and the NAA and between Alt 1B and the NAA would be small (<2%). Alt 2 results would be similar to those of Alt 1A and 1B (Appendix 11H, *SALMOD,* Table 2a-3, Figure B-a-1). Beneficial effects on mean annual production under Alt 3 would be slightly greater than those under Alt 1A and Alt 1B, although still very small (≤3%; Appendix 11H, *SALMOD,* Table 2a-4, Figure B-a-1).

Results by life stage and mortality source are reported in Appendix 11H, *SALMOD,* Table 1a-1 through Table 1a-4 and Figure B-a-8 through Figure B-a-19. Depending on the life stage and source of mortality (flow-/habitat-based or temperature-based), mean annual mortality under Alt 1A would be between 63% lower to 60% greater than that under the NAA and mortality under Alt 1B would be between 99% lower to 90% higher than that under the NAA (Appendix 11H, *SALMOD,* Table 1a-1, Table 1a-2). However, it is important to understand that the model is seeded with 5,913,000 winter-run eggs each year. Although there may be larger percent differences in mean annual mortality between an alternative and the NAA by source and life stage, these differences typically represent a very small proportion of overall individuals when put in a broader population-wide context. The largest difference in mean annual mortality would be in flow-related egg mortality between Alt 1A and the NAA in Critically Dry Water Years. In this case, there would be a reduction in mean annual egg mortality of 28,364 eggs under Alt 1A relative to the NAA, accounting for just 0.05% of the 5,913,000 winter-run Chinook salmon eggs annually seeded into the model. Combining all sources of mortality and life stages together, mean annual mortality under Alt 1A and Alt 1B would be 3% and 5% lower, respectively, than that under the NAA for the full simulation period (all water year types combined) and 1% to 5% and 2% to 8% lower, respectively, than that under the NAA depending on water year type. Mortality results for Alt 2 and Alt 3 are generally similar to those of Alt 1A and Alt 1B (Appendix 11H, *SALMOD,* Table 1a-3, Table 1a-4). Combining all sources of mortality and life stages together, mean annual mortality under Alt 2 and Alt 3 would be 3% and 8% lower, respectively, than under the NAA for the full simulation period (all water year types combined)

Commented [CC57]: These are huge ranges, can more detail be described as to the reasoning/uncertainty? Can the model be improved to better forecast mortality- I'm not sure how much can be determined based on these results.

and 1% to 5% and 3% to 14% lower, respectively, than under the NAA depending on water year type.

Overall, SALMOD results show a minimal beneficial effect of each alternative on winter-run Chinook salmon mortality and potential production in the Sacramento River.

Commented [CC58]: So no environmental benefit either?

Floodplain Inundation and Access

Commented [CC59]: This section (and similar sections for other relevant species) lacks a discussion/analysis on the potential effects of reduced flows over Fremont Weir on adult fish passage. It is important to remember that the objectives of the Fremont Weir Big Notch Project are two-fold: 1. To increase the availability of juvenile rearing habitat, and 2. To improve migratory delays and loss of fish at Fremont Weir. Therefore, if you are claiming that the Fremont Weir notch protections were developed to avoid impacts to the Big Notch Project, then the potential impacts to adult fish passage must also be addressed.

As described in Chapter 2, Fremont Weir notch protections are included in the diversion criteria to reduce changes to spill frequency and duration under Alternatives 1–3 relative to existing conditions. In particular, these criteria avoid impacts on Reclamation's ability to implement its obligations in the 2019 NMFS ROC on LTO Biological Opinion to implement the Yolo Bypass Restoration Salmonid Habitat Restoration and Fish Passage Implementation Plan and provide 17,000+ acres of inundation in the Yolo Bypass from December to April (NMFS 2019). As such, Alternatives 1–3 would have limited potential for negative effects to Yolo Bypass floodplain inundation and access for winter-run Chinook salmon.

Commented [CC60]: This paragraph makes it seem as if protecting operations of the Big Notch Project are the same as protecting the larger process of floodplain inundation in the Yolo Bypass and access for juvenile salmonids. It is important to note that the proposed Fremont Weir notch protections do not provide protections when flows through the Big Notch are >6,000 cfs (the maximum operational flow of the Big Notch). This is potentially an issue as the greatest floodplain benefits and best fish access to the Yolo Bypass occurs when Fremont Weir overtops. Recent research by Pope et al. (2021) found that 80% of acoustically tagged fish from a release group released during peak flooding ended up in the Yolo Bypass, compared to less than 5% released either before or after the peak flood. The authors suggest that there is a threshold in flow or stage height beyond which a pronounced change in entrainment probability occurs. This may be explained in part by a complementary study that showed that as discharge over Fremont Weir increased, mean cross-sectional fish position moved closer to the weir (Blake et al. 2017). Therefore, Pope et al. (2021) suggests that at certain overtopping flow levels, despite there being a large fraction of river flow entering the Yolo Bypass, Chinook salmon are not close enough to Fremont Weir to become entrained over the weir. Given the difference in fish access to the Yolo Bypass during peak and non-peak flow it is prudent to ensure that proposed project operations do not impact peak Fremont Weir overtopping events and thus juvenile entrainment into the Yolo Bypass.

Yolo Bypass and Fremont Weir Spill Flow and Duration

As described further in Appendix 11M, this analysis examined the frequency and duration of spills over the Fremont Weir as well as the total flows in the Yolo Bypass that would provide rearing habitat for salmonids. The number of years in the 82-year simulation period where there was at least one Fremont Weir spill of varying amounts (0; 2,000; 4,000; 6,000; 8,000; and 10,000 cfs) with a duration of 0-10 days, 11-20 days, 21-30 days, 31 to 45 days, and greater than 45 days were calculated from daily results.

Commented [CC61]: Please provide Appendix 11M for review.

Commented [CC62]: Crosswalk with DWR Yolo Bypass project information

The analysis suggested that the alternatives could have several days less Yolo Bypass inundation for shorter duration flows than the NAA for various combinations of flow and duration (see Table 1 in Attachment 11M-1 to Appendix 11M). For flows resulting in larger inundation acreage (i.e., >20,000 acres), the number of events with duration up to 10 days or duration of 11 days and greater was marginally less under the alternatives (see Tables 2–5 in Attachment 11M-1 to Appendix 11M).

Yolo Bypass Inundated Area

Modeling suggests that the mean area inundated in the Yolo Bypass during days of Yolo Bypass flooding in the main juvenile salmon rearing period (January–June) would be around 1–6% less under the alternatives compared to the NAA, amounting to ~12–116 acres less depending on alternative and water year type (see Tables 6 in Attachment 11M-1 to Appendix 11M).

Number of Days of Yolo Bypass Inundation

Takata et al. (2017) examined various juvenile Chinook salmon biological responses to Yolo Bypass flooding, which they defined as the number of days during January–June with daily mean flows at the downstream end of Yolo Bypass >4,000 cfs; this is the flow at which floodplain inundation occurs. Takata et al. (2017) found that growth and floodplain residence of coded-wire-tagged juvenile Chinook salmon and catch per unit effort of wild juvenile Chinook salmon are significantly positively related to the annual duration of Yolo Bypass flooding (Takata et al. 2017: their figures 3 and 4c). Daily-downscaled CalSim modeling suggests that operations under Alternatives 1–3 may reduce Yolo Bypass inundation in January–June by approximately one day across most water year types (Table yoloind1). Given the variability in the observed biological relationships indicated by the spread in the data (see Takata et al. 2017: their figures 3 and 4c), and no significant difference in survival to capture in ocean fisheries between coded-wire-tagged juvenile Chinook salmon released in the Yolo Bypass and those released at the same time in the Sacramento River (Takata et al. 2017), the small differences in Yolo Bypass inundation indicated by the CalSim modeling suggest that the alternatives are limited in their potential for negative effects to juvenile Chinook salmon, including winter-run.

Commented [CC63]: Hatchery

Commented [CC64]: Please, elaborate on what constitutes daily-downscaled CalSim modeling. Were monthly flows in CalSim simply divided by days of the month?

Commented [CC65]: Please provide this data for review.

Commented [CC66]: CalSim is not the best model to use when analyzing impacts to daily changes in flow. This coupled with the fact that the assessment seems to have averaged all of the data by water year types, in presenting its conclusions, reduces confidence in the analysis. At a minimum, displaying the maximum number of days that the project would reduce Yolo Bypass inundation, under each water year type, would be useful.

Commented [CC67]: Suggest is the operative word in this conclusion. We will need to operationalize these modeling results in the subsequent ITP conditions to ensure there is no to minimal effect on Yolo inundation.

Commented [CC68]: Without being able to see the raw data that was used to develop this table, it is difficult to understand how variable these trends might be within water year types. Please include standard deviation so we can get a better idea of the variability.

Table yoloind1. Mean Annual Number of Days in January–June With Yolo Bypass Floodplain Inundation by Alternative and Water Year Type.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	71	70 (-2%)	70 (-2%)	70 (-2%)	70 (-2%)
Above Normal	52	51 (-2%)	51 (-2%)	51 (-2%)	52 (-1%)
Below Normal	19	18 (-4%)	18 (-4%)	18 (-4%)	18 (-4%)
Dry	8	7 (-7%)	7 (-7%)	7 (-7%)	7 (-7%)
Critically Dry	4	4 (-2%)	4 (-2%)	4 (-2%)	4 (-2%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Floodplain inundation is Yolo Bypass flow >4,000 cfs per Takata et al. (2017).

Sutter Bypass and Fremont Weir Spill Flow and Duration

[TO COME]

Migration Flow-Survival

Diversions from the Sacramento River to Sites Reservoir under Alternatives 1, 2, and 3 have the potential to affect survival of juvenile salmonids, including winter-run Chinook salmon, based on flow-survival relationships. Several recent analyses provided evidence for positive correlations between Sacramento River flow and survival of Chinook salmon (Michel 2018; Henderson et al. 2019; Michel et al. 2021). Henderson et al. (2019) found that riverine flows—along with a number of other covariates related to individual, release group, reach-specific, and time-varying factors—were positively correlated with survival of acoustically tagged late fall–run Chinook salmon juveniles in nineteen Sacramento River reaches from Battle Creek to the Delta. Michel (2018) found correlations between mean streamflow at Bend Bridge and survival to adulthood of hatchery-origin juvenile fall-run ($r^2 = 0.35$), late fall–run ($r^2 = 0.45$), and winter-run ($r^2 = 0.57$) Chinook salmon, which were stronger predictors of survival than ocean conditions. Michel et al. (2021) examined survival of a mixture of acoustically tagged hatchery-origin and wild-origin fall-run, spring-run, and winter-run juvenile Chinook salmon in the Sacramento River from the

Deer Creek confluence to the Feather River confluence during late March to early June, 2013–2019. They explored various forms of flow-survival relationship based on Sacramento River at Wilkins Slough flow and found the best to be a function based on three flow thresholds, which they defined as minimum (4,259 cfs), historical mean (10,712 cfs), and high (22,872 cfs). Survival varied by flow threshold: 3.0% below minimum, 18.9% between minimum and historical mean, 50.8% between historical mean and high, and 35.3% above high. Although the modeling focused on the spring period, it is hypothesized that similar relationships may occur during other months of juvenile salmon migration (Michel, pers. comm.).

Commented [CC69]: There is new data every year that is available, but not yet published that should be considered

As described in Chapter 2 Section 2.5.2.1 *Water Operations*, all alternatives include pulse flow protection measures to be applied to precipitation-generated pulse flow events from October through May. In addition, and as described in more detail in Chapter 2, the alternatives would include a fish monitoring program capable of detecting a migratory response during the beginning of a precipitation-generated high flow event and continuing research would be utilized to operate to, and further refine the pulse flow protection strategy. The discussion in Appendix 11P, Section 2 *Flow Threshold Survival Analysis to Assess Potential Effects of Sites Reservoir Project Diversion Criteria Based on Historical Juvenile Chinook Salmon Monitoring Data* illustrates that the Sites diversion criteria generally minimize diversions during the historical periods of fish movement as reflected in Red Bluff rotary screw trap data, and application of the flow-threshold criteria from Michel et al. (2021) suggests that flow-survival effects on juvenile Chinook salmon (including winter-run Chinook salmon) would be greatly limited by the diversion criteria.

Sites Reservoir Release Effects

Sites Reservoir releases could temporally overlap with winter-run Chinook salmon presence near the release location in the Sacramento River, specifically migrating adults during November through May and juveniles rearing or migrating during October through March (Appendix 11A, Table 11A-2), although beach seine data suggest juveniles only occur downstream of the discharge location at approximately River Mile 100 from November onwards (Figure WR_DJFMP).

Commented [CC70]: Conflicts with RST data at KL which shows presence in September.

Sites Reservoir releases into the Yolo Bypass via the CBD would occur during August–October. These releases could temporally overlap with juvenile rearing and emigration of winter-run Chinook salmon during October. Adults would not be present in the Yolo Bypass during August through October (Appendix 11A, Table 11A-2).

Commented [CC71]: However, there is an overlap with fall run chinook and steelhead.

Temperature Effects

As discussed in Chapter 6, *Surface Water Quality*, the effect of Alternatives 1A, 1B, 2, and 3 on water temperatures at the Sites Reservoir release site in the Sacramento River would be relatively small with the releases generally tending to cause a slight reduction in water temperature (Tables 6-12a through 6-12d). Therefore, temperature-related effects of Alternatives 1A, 1B, 2, and 3 on winter-run Chinook salmon at the Sacramento River release site would be minimal.

Commented [C72]: Please, see CDFW's comments in chapter 6.

Estimated changes in CBD water temperatures due to Sites Reservoir releases during August through October are presented in Table CBD_temp. These temperatures would be expected where water first enters the Yolo Bypass from the CBD but would mix with existing Yolo Bypass water as well as equilibrate as it moves through the Yolo Bypass. All changes in water temperature would be zero or negative for Alternatives 1A, 1B, 2, and 3. Specifically for juvenile winter-run Chinook salmon the small water temperature reductions during October will not increase the risk of mortality. Lower temperatures could reduce their growth somewhat due to reduced metabolism. However, the small reduction in water temperatures is expected to occur during one month and in a limited area of the Yolo Bypass before it equilibrates with atmospheric temperatures. As a result, temperature-related effects of Alternatives 1A, 1B, 2, and 3 in the Yolo Bypass due to Sites Reservoir releases via the CBD would be minimal at a population level.

Table CBD_temp. Mean and Median of Estimated Change in Colusa Basin Drain Water Temperature (°F) from Sites Reservoir Releases, August–October

Commented [CC73]: Please, list the actual temperature as well.

Month and Statistic	Alternative 1A	Alternative 1B	Alternative 2	Alternative 3
August Mean	-2.4	-2.5	-1.6	-2.4
August Median	-2.5	-2.4	-2.0	-2.5
September Mean	-1.6	-1.6	-1.3	-1.5
September Median	-1.5	-1.5	-1.3	-1.4
October Mean	-1.3	-1.6	-1.4	-1.3
October Median	-0.3	-0.6	0.0	0.0

As discussed in Chapter 6, Yolo Bypass flows account for only about 5% of the water in the Sacramento River downstream of the Yolo Bypass (e.g., Rio Vista) at this time of year. Even if releases into the Yolo Bypass coincided with large (~5 °F) temperature differentials between the Sacramento River and the Yolo Bypass, the maximum change in Sacramento River water temperatures at the mouth of the Yolo Bypass would be 0.25 °F (i.e., 0.05*5°F), with the effect potentially being somewhat diminished by tidal fluxes. This suggests that there would be minimal temperature-related effects of Alternatives 1A, 1B, 2, and 3 to winter-run Chinook salmon related to Sites Reservoir releases via the CBD and Yolo Bypass in this reach of the Sacramento River.

Water Quality Effects

As described in Appendix 6F and Chapter 6, surface water mercury levels in the Delta could increase during the July–November export period as a result of Alternatives 1–3 relative to existing conditions/NAA. Given the relatively short temporal overlap of winter-run Chinook salmon with the export period, and the low observed levels of mercury in Chinook salmon generally (see Table 8 in Appendix 6F) in relation to levels of mercury that may result in sublethal effects (Beckvar et al. 2005), it is expected that water quality effects of mercury from releases as a result of Alternatives 1–3 would be minimal.

The Project would be expected to have limited effects on the salinity aspect of water quality, given that potential increases in Sacramento River salinity as a result of Salt Lake influence on Sites Reservoir salinity are anticipated to be minimal based on analyses in Chapter 6 Surface Water Quality.

Water released from Sites Reservoir into the Sacramento River primarily would originally be from the Sacramento River, with a minor contribution from local tributary inflow, so that far-field olfactory cues for upstream-migrating adult salmonids, including winter-run Chinook salmon, from reservoir releases would not be expected to be greatly different than Sacramento River water. Reservoir releases through the CBD and thence the Yolo Bypass to improve food web productivity in the north Delta for delta smelt would increase flow from the Yolo Bypass, but not during the upstream migration period of adult winter-run Chinook salmon or migration/rearing period of juvenile winter-run.

As discussed further in Chapter 6 *Surface Water Quality* and below for delta smelt, Sites Reservoir releases under Alternatives 1–3 would not be expected to increase risk of exposure to pesticides.

Feather River

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Feather River low flow channel (LFC) at Robinson Riffle and in the high flow channel (HFC) at Gridley Bridge indicates that water temperatures would be predominantly similar among alternatives during the period of winter-run Chinook salmon non-natal rearing (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, 6C-17-1a to 6C-17-4c, 6C-18-1a to 6C-18-4c; Figures 6C-17-1 to 6C-17-18, 6C-18-1 to 6C-18-18). At both locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±1°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at both locations.

Results of the analysis of exceedance above the 64°F 7DADM water temperature index value for winter-run Chinook salmon non-natal rearing in the Feather River (Appendix 11B, *Fisheries Impact Assessment Methods,* Table X) are presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X and Table X. At both locations evaluated, there were no month and water year type combinations in which both: (1) the percent of months that exceeded the index value was more than 5% greater under the alternative than under the NAA, and (2) the exceedance per month was more than 0.5°F greater under the alternative than under the NAA. Results of the exceedance analysis for Alt 2 and Alt 3 are similar to Alt 1 with no month and water year type combinations in which both criteria were met at both locations.

Redd Scour and Entombment

Winter-run do not spawn in the Feather River.

Redd Dewatering

Winter-run do not spawn in the Feather River.

Habitat Availability

Winter-run do not spawn in the Feather River and no valid rearing habitat WUA curves are available for the Feather River (see Appendix 11K, *Methods*).

Juvenile Stranding

No formal method for analyzing juvenile stranding analysis has been developed for the Feather River.

American River

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the American River at Watt Ave indicates that water temperatures would be predominantly similar among alternatives during the the period of winter-run Chinook salmon non-natal rearing (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model),* Tables 6C-14-1a to 6C-14-4c; Figures 6C-14-1 to 6C-14-18). Mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±0.5°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1.

Commented [CC74]: Earlier in the document it lists outdated flow requirements. We need to know what was used in the modeling. Obsolete or current operations?

Results of the analysis of exceedance above the 64°F 7DADM water temperature index value for winter-run Chinook salmon non-natal rearing in the American River (Appendix 11B, *Fisheries Impact Assessment Methods*, Table X) are presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X and summarized in Table 11-temp7. There were no month and water year type combinations in which both: (1) the percent of days that exceeded the index value was more than 5% greater under the alternative than under the NAA, and (2) the exceedance per day was more than 0.5°F greater under the alternative than under the NAA. Results of the exceedance analysis for Alt 2 and Alt 3 are similar to Alt 1 with no month and water year type combinations in which both criteria were met.

Redd Scour and Entombment

Winter-run do not spawn in the American River.

Redd Dewatering

Winter-run do not spawn in the American River.

Habitat Availability

Winter-run do not spawn in the American River and no valid rearing habitat WUA curves are available for the American River (see Appendix 11K, *Methods*).

Juvenile Stranding

No formal method for analyzing juvenile stranding analysis has been developed for the American River.

Delta

Juvenile Through-Delta Survival

Operations of the alternatives could affect juvenile winter-run Chinook salmon through changes in Sacramento River flow entering the Delta, which could influence through-Delta survival based on flow-survival relationships. The potential for such effects was assessed using a spreadsheet implementation of the through-Delta survival function formulated by Perry et al. (2018)[5], which estimates through-Delta survival as a function of daily Sacramento River flow at Freeport as well as Delta Cross Channel gate position (see Appendix 11J). The results of this analysis showed that during the main period of juvenile winter-run Chinook salmon occurrence in the Delta (i.e., December–April; see Table 11A-3 in Appendix 11A), there was little difference (0–2%) in mean through-Delta survival between Alternatives 1–3 and the NAA (Table perry1). The largest differences in through-Delta survival occurred in October (up to 6% greater than NAA under Alternative 1 in Dry or Critically Dry Water Years), which is a period with lower abundance of juvenile winter-run (see also Attachment 1 to Appendix 11A).

Table perry1. Probability of Juvenile Chinook Salmon Through-Delta Survival, Averaged by Month and Water Year Type, Based on Perry et al. (2018).

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Sep	Wet	0.39	0.39 (0%)	0.39 (0%)	0.39 (0%)	0.39 (0%)
Sep	Above Normal	0.39	0.39 (0%)	0.39 (0%)	0.39 (0%)	0.40 (1%)
Sep	Below Normal	0.30	0.31 (1%)	0.31 (2%)	0.31 (1%)	0.31 (2%)
Sep	Dry	0.27	0.28 (4%)	0.28 (4%)	0.28 (4%)	0.28 (3%)
Sep	Critically Dry	0.30	0.30 (1%)	0.31 (4%)	0.30 (0%)	0.30 (3%)
Oct	Wet	0.37	0.37 (0%)	0.37 (-1%)	0.37 (0%)	0.37 (0%)
Oct	Above Normal	0.32	0.32 (1%)	0.32 (1%)	0.32 (1%)	0.33 (5%)
Oct	Below Normal	0.31	0.32 (2%)	0.32 (2%)	0.32 (2%)	0.33 (4%)
Oct	Dry	0.28	0.30 (6%)	0.30 (6%)	0.29 (4%)	0.28 (0%)
Oct	Critically Dry	0.25	0.26 (6%)	0.26 (5%)	0.26 (5%)	0.25 (2%)
Nov	Wet	0.41	0.40 (-2%)	0.40 (-2%)	0.40 (-2%)	0.40 (-2%)

[5] The spreadsheet model was provided by Perry (pers. comm.) and reproduces the mean response of the STARS (Survival, Travel time, And Routing Simulation) model (Perry et al. 2019).

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Nov	Above Normal	0.39	0.39 (0%)	0.39 (0%)	0.39 (0%)	0.39 (1%)
Nov	Below Normal	0.39	0.39 (2%)	0.40 (2%)	0.39 (2%)	0.40 (3%)
Nov	Dry	0.35	0.36 (3%)	0.36 (2%)	0.35 (1%)	0.35 (1%)
Nov	Critically Dry	0.30	0.29 (0%)	0.30 (0%)	0.29 (0%)	0.30 (0%)
Dec	Wet	0.47	0.47 (0%)	0.47 (0%)	0.47 (0%)	0.47 (0%)
Dec	Above Normal	0.47	0.47 (-1%)	0.47 (0%)	0.47 (-1%)	0.47 (0%)
Dec	Below Normal	0.47	0.47 (0%)	0.47 (0%)	0.47 (0%)	0.47 (1%)
Dec	Dry	0.44	0.44 (0%)	0.44 (0%)	0.44 (0%)	0.44 (0%)
Dec	Critically Dry	0.38	0.38 (-1%)	0.38 (-1%)	0.38 (-1%)	0.38 (-1%)
Jan	Wet	0.60	0.59 (0%)	0.59 (0%)	0.59 (0%)	0.59 (0%)
Jan	Above Normal	0.55	0.55 (-1%)	0.55 (0%)	0.55 (-1%)	0.55 (0%)
Jan	Below Normal	0.49	0.48 (-1%)	0.49 (-1%)	0.49 (-1%)	0.49 (0%)
Jan	Dry	0.44	0.44 (-1%)	0.44 (-1%)	0.44 (-1%)	0.44 (0%)
Jan	Critically Dry	0.42	0.42 (0%)	0.42 (-1%)	0.42 (-1%)	0.42 (-1%)
Feb	Wet	0.63	0.63 (0%)	0.63 (0%)	0.63 (0%)	0.63 (0%)
Feb	Above Normal	0.59	0.59 (0%)	0.59 (0%)	0.59 (0%)	0.59 (0%)
Feb	Below Normal	0.54	0.54 (-1%)	0.54 (-1%)	0.54 (-1%)	0.54 (-1%)
Feb	Dry	0.49	0.49 (-1%)	0.49 (0%)	0.49 (-1%)	0.49 (0%)
Feb	Critically Dry	0.45	0.45 (-1%)	0.45 (0%)	0.45 (0%)	0.45 (-1%)
Mar	Wet	0.60	0.60 (0%)	0.60 (0%)	0.60 (0%)	0.60 (-1%)
Mar	Above Normal	0.59	0.58 (-1%)	0.58 (-1%)	0.58 (-1%)	0.58 (-1%)
Mar	Below Normal	0.49	0.48 (-2%)	0.48 (-2%)	0.48 (-2%)	0.48 (-2%)
Mar	Dry	0.47	0.47 (-1%)	0.47 (-1%)	0.47 (-1%)	0.47 (-1%)
Mar	Critically Dry	0.42	0.42 (0%)	0.42 (0%)	0.42 (0%)	0.42 (0%)
Apr	Wet	0.57	0.57 (0%)	0.57 (0%)	0.57 (0%)	0.57 (0%)
Apr	Above Normal	0.52	0.52 (0%)	0.52 (0%)	0.52 (0%)	0.52 (0%)
Apr	Below Normal	0.47	0.47 (0%)	0.47 (0%)	0.47 (0%)	0.47 (0%)
Apr	Dry	0.43	0.43 (0%)	0.43 (0%)	0.43 (0%)	0.43 (0%)
Apr	Critically Dry	0.40	0.40 (0%)	0.40 (0%)	0.40 (0%)	0.40 (0%)
May	Wet	0.55	0.55 (0%)	0.55 (0%)	0.55 (0%)	0.55 (0%)
May	Above Normal	0.49	0.49 (0%)	0.49 (0%)	0.49 (0%)	0.49 (0%)
May	Below Normal	0.45	0.45 (0%)	0.45 (0%)	0.45 (0%)	0.45 (0%)
May	Dry	0.41	0.41 (0%)	0.41 (0%)	0.41 (0%)	0.41 (0%)
May	Critically Dry	0.37	0.37 (0%)	0.37 (0%)	0.37 (0%)	0.37 (0%)
Jun	Wet	0.43	0.43 (-1%)	0.43 (-1%)	0.43 (-1%)	0.43 (-1%)
Jun	Above Normal	0.37	0.36 (-2%)	0.36 (-2%)	0.36 (-2%)	0.36 (-2%)
Jun	Below Normal	0.34	0.33 (-1%)	0.33 (-1%)	0.33 (-1%)	0.33 (-1%)
Jun	Dry	0.33	0.33 (0%)	0.33 (0%)	0.33 (0%)	0.33 (0%)

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Jun	Critically Dry	0.29	0.29 (0%)	0.29 (0%)	0.29 (0%)	0.29 (0%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA.

Note that the spreadsheet implementation of the Perry et al. (2018) model does not account for the variability in coefficient estimates (Figure 6 of Perry et al. 2018), which would likely give appreciable overlap of estimates in through-Delta survival between the NAA and the alternative scenarios, particularly in relation to the relatively small differences between alternatives. Note also that the California Department of Fish and Wildlife (2020) SWP ITP requires a Georgiana Slough Migratory Barrier to be installed to reduce juvenile winter- and spring-run Chinook salmon entry into Georgiana Slough. This barrier is part of existing conditions and would be present under the NAA and Alternatives 1–3. The above analysis with the spreadsheet implementation of the Perry et al. (2018) model did not include a representation of the barrier because the specific operating criteria (e.g., months for installation) are not yet known. However, to illustrate the potential effects of the barrier on relative survival differences between the NAA and Alternatives 1–3, a sensitivity analysis was undertaken assuming the barrier was installed and reduced proportional entry into Georgiana Slough by 50% compared to no barrier (see Appendix 11J). Although the sensitivity analysis gave higher absolute estimates of through-Delta survival, as expected, there was very little change in the relative pattern of differences between NAA and Alternatives 1–3 (compare Table perry1_GSMB in Appendix 11J with Table perry1 above). Results without the barrier in place are representative of differences with the barrier in place, which is the result of the barrier being in place for all alternatives.

In addition to the analysis based on Perry et al. (2018), the IOS life cycle model includes a through-Delta survival analysis (the Delta Passage Model), discussed below in *Life Cycle Models*.

Juvenile Rearing Habitat

Changes in flow entering the Delta as a result of the operations of the alternatives would be expected to give only limited changes to rearing habitat for juvenile winter-run Chinook salmon in the Delta. The National Marine Fisheries Service Winter-Run Chinook Salmon Life Cycle Model (WRLCM) addresses Delta rearing habitat capacity through consideration of channel type (high quality: blind channels; low quality: mainstem river, distributaries, open water), cover (high quality: vegetated; low quality: not vegetated), and water depth (high quality: >0.2 meters, ≤ 1.5 meters; low quality: ≤ 0.2 meters, >1.5 meters) (Hendrix et al. 2014). In recent analyses for the California WaterFix project, which would have reduced flow into the Delta in an analogous manner to the alternatives, the WRLCM did not suggest that changes in Delta rearing capacity would have appreciable effects on the species from less flow entering the Delta. This indicates that the alternatives would not substantially change rearing habitat for juvenile winter-run Chinook salmon.

South Delta Entrainment

Juvenile salmonids, including winter-run Chinook salmon, can be entrained at the south Delta export facilities, principally during the winter/spring (e.g., Williams 2006). There would be little difference in indicators of entrainment risk (south Delta exports and Old and Middle River flows) during winter/spring between the NAA and Alternatives 1–3 (see Appendix 5B3: Tables 5B3-6-1a through 5B3-6-4c; Figures 5B3-6-1 through 5B3-6-18; and Appendix 5B4: Tables 5B4-1-1a through 5B4-1-4c; Figures 5B4-1-1 through 5B4-1-18), and existing restrictive criteria from the NMFS (2019) SWP/CVP BiOp and CDFW (2020) SWP ITP would limit entrainment risk for winter-run under all alternatives. South Delta export of water released from Sites Reservoir would have little to no overlap with winter-run Chinook salmon. This is illustrated by the results of the salvage-density analysis (see description in Appendix 11Q), which weights south Delta exports at SWP (Banks) and CVP (Jones) export facilities by historical salvage[6] per unit volume (i.e., salvage density) of juvenile winter-run Chinook salmon. There were minimal differences between NAA and the alternatives from the results of the salvage-density analysis (Table wr_banks; Table wr_jones).

Table wr_banks. Entrainment Loss of Juvenile Winter-Run Chinook Salmon At SWP Banks Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	2,383	2,375 (0%)	2,376 (0%)	2,375 (0%)	2,399 (1%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	2,053	2,029 (-1%)	2,048 (0%)	2,033 (-1%)	2,112 (3%)
Dry	1,098	1,100 (0%)	1,082 (-1%)	1,100 (0%)	1,117 (2%)
Critically Dry	1,014	1,014 (0%)	1,023 (1%)	1,028 (1%)	1,002 (-1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

Table wr_jones. Entrainment Loss of Juvenile Winter-Run Chinook Salmon At CVP Jones Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	254	254 (0%)	254 (0%)	254 (0%)	251 (-1%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	526	526 (0%)	527 (0%)	527 (0%)	527 (0%)
Dry	306	307 (0%)	306 (0%)	308 (0%)	306 (0%)
Critically Dry	79	81 (2%)	80 (1%)	80 (1%)	80 (1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any Above Normal Water Years, hence that row of

[6] The salvage-density analysis is sometimes also called the loss-density analysis when applied to juvenile salmonids, because salvage is extrapolated into total entrainment loss by accounting for estimates of predation and other factors during entrainment; however, this extrapolation is consistent between scenarios and the focus is on the relative difference between scenarios (as opposed to absolute differences).

the table is noted as 'NA'.

Life Cycle Models

The IOS and OBAN winter-run Chinook salmon life cycle models were run to provide an analysis of the potential integrated effects of the alternatives on the species. Appendix 11I includes technical memoranda describing the IOS and OBAN modeling. The IOS model includes flow-survival relationships for migrating juvenile winter-run Chinook salmon in the Delta, whereas the OBAN model does not. The IOS model includes a flow-survival relationship based on Sacramento River at Bend Bridge flows and does not account for the potential effects on migration survival as a result of the Red Bluff and Hamilton City diversions. As discussed below, a sensitivity analysis was undertaken wherein the Red Bluff and Hamilton City diversions were subtracted from the Bend Bridge flows to provide an assessment of potential flow-survival effects.

IOS

Commented [CC75]: IOS is showing an impact to the bottom line which is returning adult females.

IOS modeling results for female adult winter-run Chinook salmon escapement reflect the integration of all modeled effects of the alternatives, as discussed in detail in Appendix 11I. Relative to the NAA, the mean female escapement ranged from 2% greater under Alternative 2 in critically dry years to 5% less under Alternatives 1A, 1B, and 2 in above normal and/or below normal years. As shown in Appendix 11I, there is considerable overlap in results between the alternatives. The different life stage components of the IOS modeling generally had limited differences between Alternatives 1–3 and the NAA, with the largest differences being 3–4% greater mean egg and fry survival under Alterative 3 in critically dry years (Tables IOS_wr_egg; IOS_wr_fry; IOS_wr_riv_surv; IOS_wr_delta_surv). Because the IOS model includes a Sacramento River flow-survival relationship based on Bend Bridge flow, a sensitivity analysis was undertaken wherein the Red Bluff and Hamilton City diversions were subtracted from the Bend Bridge flows to provide an assessment of potential flow-survival effects of these diversions. As shown in Appendix 11I (IOS memorandum attachment), differences in escapement between the scenarios with modified and unmodified flows were around 100 fish or less. This amounts to percentage differences compared to NAA ranging from approximately 2% greater under Alternatives 2 and 3 in critically dry years up to 7% less under Alternatives 1A above normal years and Alternative 1B in above normal and critically dry years.

Table IOS_wr. Mean Female Adult Winter-Run Chinook Salmon Escapement by Water Year Type Based on IOS.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	3,912	3,757 (-4%)	3,768 (-4%)	3,784 (-3%)	3,887 (-1%)
Above Normal	3,336	3,174 (-5%)	3,165 (-5%)	3,236 (-3%)	3,225 (-3%)
Below Normal	3,521	3,409 (-3%)	3,336 (-5%)	3,354 (-5%)	3,404 (-3%)
Dry	3,244	3,153 (-3%)	3,221 (-1%)	3,172 (-2%)	3,317 (2%)
Critically Dry	2,131	2,134 (0%)	2,082 (-2%)	2,169 (2%)	2,186 (3%)

Total	3,229	3,126 (-3%)	3,114 (-4%)	3,143 (-3%)	3,204 (-1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty.

Table IOS_wr_egg. Mean Winter-Run Chinook Salmon Proportional Egg Survival by Water Year Type Based on IOS.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	1.00	1.00 (0%)	1.00 (0%)	1.00 (0%)	1.00 (0%)
Above Normal	1.00	1.00 (0%)	1.00 (0%)	1.00 (0%)	1.00 (0%)
Below Normal	1.00	1.00 (0%)	1.00 (0%)	1.00 (0%)	1.00 (0%)
Dry	1.00	1.00 (0%)	1.00 (0%)	1.00 (0%)	1.00 (0%)
Critically Dry	0.94	0.95 (1%)	0.95 (1%)	0.95 (1%)	0.98 (4%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty.

Table IOS_wr_fry. Winter-Run Chinook Salmon Proportional Fry Survival by Water Year Type Based on IOS.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	0.96	0.96 (0%)	0.96 (0%)	0.96 (0%)	0.96 (0%)
Above Normal	0.96	0.96 (0%)	0.96 (0%)	0.96 (0%)	0.96 (0%)
Below Normal	0.96	0.96 (0%)	0.96 (0%)	0.96 (0%)	0.96 (0%)
Dry	0.96	0.96 (0%)	0.96 (0%)	0.96 (0%)	0.96 (0%)
Critically Dry	0.89	0.90 (1%)	0.90 (1%)	0.89 (0%)	0.91 (3%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty.

Table IOS_wr_riv_surv. Winter-Run Chinook Salmon Proportional Juvenile River Migration Survival by Water Year Type Based on IOS.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	0.30	0.30 (-1%)	0.30 (-1%)	0.30 (-1%)	0.30 (-1%)
Above Normal	0.27	0.27 (-1%)	0.27 (-1%)	0.27 (-1%)	0.27 (-1%)
Below Normal	0.26	0.26 (-1%)	0.26 (-1%)	0.26 (0%)	0.26 (-1%)
Dry	0.25	0.25 (0%)	0.25 (0%)	0.25 (0%)	0.25 (0%)
Critically Dry	0.25	0.25 (0%)	0.25 (0%)	0.25 (0%)	0.25 (0%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty.

Table IOS_delta_surv. Winter-Run Chinook Salmon Proportional Juvenile Through-Delta Migration Survival by Water Year Type Based on IOS.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	0.34	0.34 (-1%)	0.34 (0%)	0.34 (0%)	0.34 (0%)
Above Normal	0.31	0.31 (-1%)	0.31 (-1%)	0.31 (-1%)	0.31 (0%)
Below Normal	0.24	0.24 (-2%)	0.24 (-1%)	0.24 (-1%)	0.24 (-1%)
Dry	0.20	0.20 (-1%)	0.20 (-1%)	0.20 (-1%)	0.20 (-1%)
Critically Dry	0.17	0.17 (-1%)	0.17 (-1%)	0.17 (-1%)	0.17 (-1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty.

OBAN

OBAN modeling results are discussed in detail in Appendix 11I. The modeling results showed that the alternatives tended to have slightly higher median adult spawner abundance relative to the NAA. Alternative 1B appeared to have lower probability of quasi-extinction (probability of spawner abundance below 100 fish) than the other alternatives. As noted above, the OBAN model does not include flow-survival relationships and the modeling does not account for the potential effects of Sites Reservoir diversions on rearing and migration survival in the Sacramento River or Delta.

Commented [CC76]: Appendix 11I was not provided. However, because OBAN doesn't include flow survival relationships and the effects of Sites Diversions, OBAN really doesn't have any value here because flow and diversions pretty much are the main impacts of this project.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

In-Delta and upstream operational impacts of Alternatives 1-3 on winter-run Chinook salmon would be negligible. Impacts associated with operations of Alternatives 1–3 would be less than significant.

Commented [CC77]: As stated above, IOS indicates a decrease in Mean Female Adult Winter-Run Chinook Salmon Escapement by Water Year Type by up to 5% in certain water year types under certain alternatives.

Please describe how a decrease of 5% is considered less than significant. Further minimization measures may be needed to address this impact.

[Note to Reviewers: This conclusion is preliminary and is dependent on an upcoming side-channel analysis]

Commented [CC78]: Winter-run rear in more than side channels.

NEPA Conclusion for Alternatives 1, 2, and 3

In-Delta and upstream operational impacts of Alternatives 1-3 on winter-run Chinook salmon would be negligible. Impacts associated with operations of Alternatives 1–3 would be less than significant.

Commented [CC79]: These analyses don't really evaluate impacts on juvenile rearing and migration survival which would be the primary impacts on winter-run for when this project is diverting. Side channel analysis is useful, but won't be definitive because winter-run use other habitats for rearing besides side channel habitat. We will also need to examine the bottleneck effect which is the overall impact of the lowest flow experienced by the river, not 82 year averages of monthly flows.

[Note to Reviewers: This conclusion is preliminary and is dependent on an upcoming side-channel analysis]

Impact FISH-3: Operations Effects on Spring-Run Chinook Salmon

Alternatives 1, 2, and 3

Effects of Alternatives 1, 2, and 3

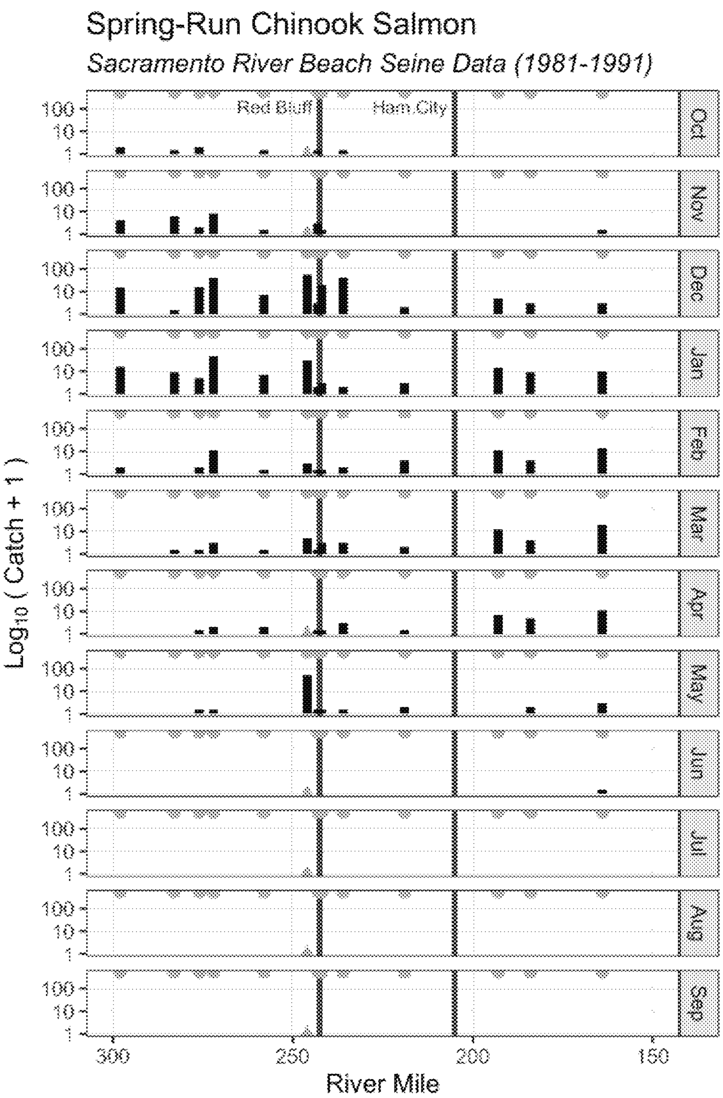
Potential exposure of spring-run Chinook salmon to the effects of Alternatives 1, 2, and 3 is dependent on the species' spatiotemporal distribution. As described for winter-run Chinook salmon, several sources of information provide important context.

The main patterns of juvenile spring-run Chinook salmon occurrence at the locations documented in the SacPAS summary in Appendix 11A include:

- Red Bluff Diversion Dam rotary screw traps (Figure SR_RBST Appendix 11A): Passage consistently begins mid-October, apart from the 2017 cohort which did not start until mid-November, ending in early May to the first of August. The first half (50%) passes from mid-November to early April. Prior to 2014, the main portion (90%) began passing from mid-October to late December, though from 2015 to 2017 the main portion began in mid-March. All years, the main portion (90%) ended from mid-April to early May, except for the 2007 cohort which finished in late December.
- Tisdale Weir rotary screw traps (Figure SR_TWRST Appendix 11A): Passage begins each year from early November to mid-March and is completed in late April to early May. Half of the fish (50%) have passed the weir typically in early April but may be as early as early January. The main portion (90%) of the fish begin to pass in early November to late March and finish from mid-March to late April.
- Knights Landing rotary screw traps (Figure SR_KLRST, Appendix 11A): Passage begins in early October to mid-December and ends from late April to early May. The first half (50%) passes from mid-December to mid-April. The main portion (90%) begins in early December to mid-April and ends in April. The exception to these trends were the 2012 and 2015 cohorts. The 2012 cohort began in late November and finished within approximately three weeks (first to last), with the first half (50%) passing in early December. The 2015 cohort completed its entire passage in approximately two weeks (first to last) at the end of December.
- Sacramento beach seines (Figure SR_Seines, Appendix 11A): Occurrence begins the first of November to mid-January and finishes in late March to early May. The first half (50%) of the fish occurs from mid-December to late March. The main portion (90%) begins to occur in early December to early March and finishes from late January to mid-April.
- Sacramento trawls (Sherwood Harbor) (Figure SR_Sherwood, Appendix 11A): Occurrence begins in late November to late February and ends from late April to late June. The first half (50%) of the fish occurs by April. The main portion (90%) starts in mid-December to the first of April and ends in about 3 weeks from mid-April to early May.

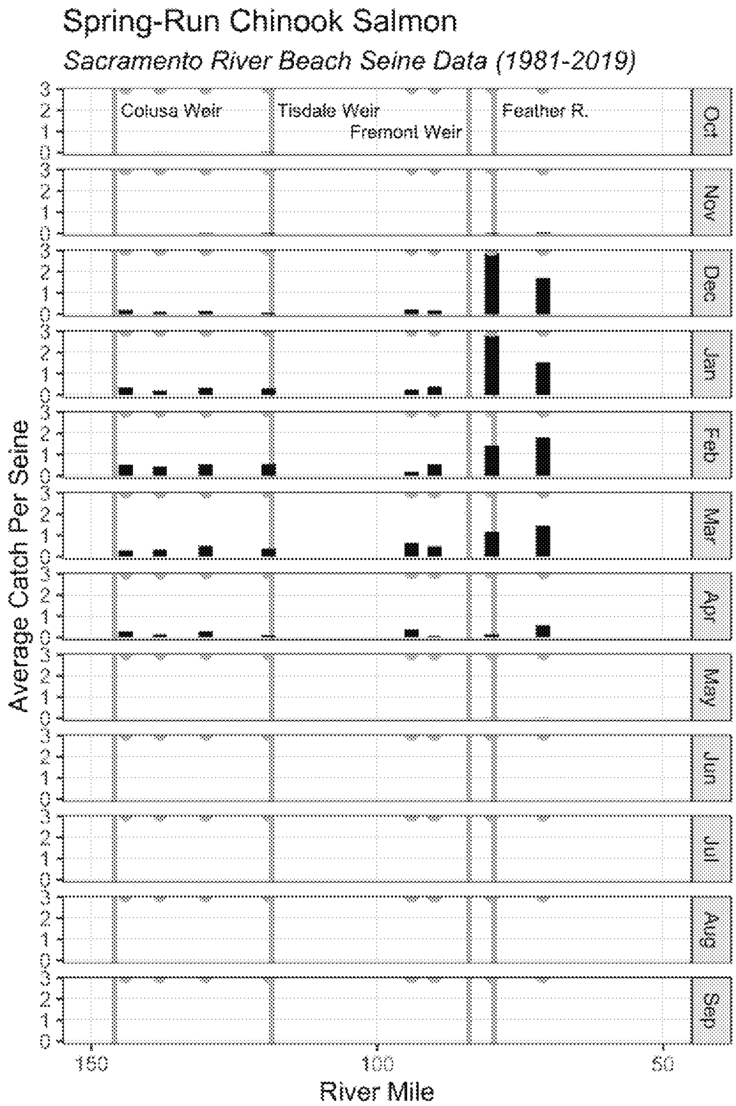
- Chipps Island trawls (Figure SR_Chipps, Appendix 11A): Occurrence begins from mid-December to early April and ends from mid-May to the end of September. The first half (50%) occurs by April. The main portion (90%) occurs within a small window of approximately 6 weeks or less that begins in late March to early April and ends at the end of April to mid-May.
- Salvage (unclipped, length-at-date) (Figure SR_salvage_unclipped_date, Appendix 11A): Salvaged begins in the first of January to late March, except for the 2000 cohort which started in late September. Salvage ends in mid-May to mid-June. The first half (50%) occurs by early April to mid-May. The main portion (90%) of the fish begin to be salvaged in mid-March to mid-April and finishes from mid-April to the first of June.
- Salvage (clipped, length-at-date) (Figure SR_salvage_clipped_date, Appendix 11A): Salvage begins in late February to the first of May and ends from early April to mid-June. The first half (50%) occurs by late March to early June. The main portion (90%) begin to occur in early March to early May and ends from late March to early June.
- Salvage (clipped, CWT-Race) (Figure SR_salvage_clipped_CWT_race, Appendix 11A): Salvage begins in mid-March to mid-May and ends from mid-April to early June. The first half (50%) occurs by late March to mid-May. The main portion (90%) begins to occur by mid-March to mid-May and finishes from late March to late May.

Juvenile spring-run Chinook salmon catches in extensive beach seining during 1981–1991 had a similar pattern to winter-run, where catches spread downstream from the upper reaches through time (Figure SR_johnson). The peaks in Spring-Run catches, however, lagged behind winter-run by about 2-3 months. In both data sets, there appears to be spatial and temporal overlap between juveniles of winter- and Spring-run during the winter. Spring-run juveniles were absent during summer and fall in the lower reaches of the Sacramento River during 1981–2019 sampling (Figure SR_DJFMP).



Source: Johnson et al. (1992; their Table 4). Note: Sampled sites are denoted by grey semicircles at the top of each plot. Sites that were not sampled in a given month are denoted by grey triangles at the bottom of a panel. Values denoted as "<1" by Johnson et al. are shown as 0.5. Red lines indicate locations of Red Bluff and Hamilton City diversions.

Figure SR_johnson. Mean Monthly Catch Per Beach Seine of Juvenile Spring-Run Chinook Salmon in the Sacramento River Between River Mile 164 and River Mile 298, 1981–1991.



Source: https://www.fws.gov/lodi/juvenile_fish_monitoring_program/jfmp_index.htm . Note: Sampled sites are denoted by grey semicircles at the top of each plot. Grey lines indicate locations of Colusa, Tisdale, and Fremont Weirs, and the confluence with the Feather River.

Figure SR_DJFMP. Mean Monthly Catch Per Beach Seine of Juvenile Spring-Run Chinook Salmon in the Sacramento River Between River Mile 71 and River Mile 144, 1981–2019.

Between 2009 and 2018, the mean percentage of in-river spawning adult spring-run Chinook salmon returning to tributaries upstream of Red Bluff was 7%, and upstream of Hamilton City was 25%; the percentage of total fish (hatchery + in-river) was 4% upstream of Red Bluff and 11% upstream of Hamilton City (Table SRGrandTab). This indicates that appreciable portions of spring-run Chinook salmon would not be expected to have the potential for near-field effects from the diversions, with most of the ESU occurring downstream in tributaries such as Butte Creek, for example. These downstream fish would have the potential for far-field effects from the Project (e.g., flow-survival effects for juveniles migrating downstream, discussed further below).

Table SRGrandTab. Abundance and Percentage of Spring-Run Chinook Salmon Adult Escapement Upstream and Downstream of the Red Bluff and Hamilton City Intakes, 2009–2018.

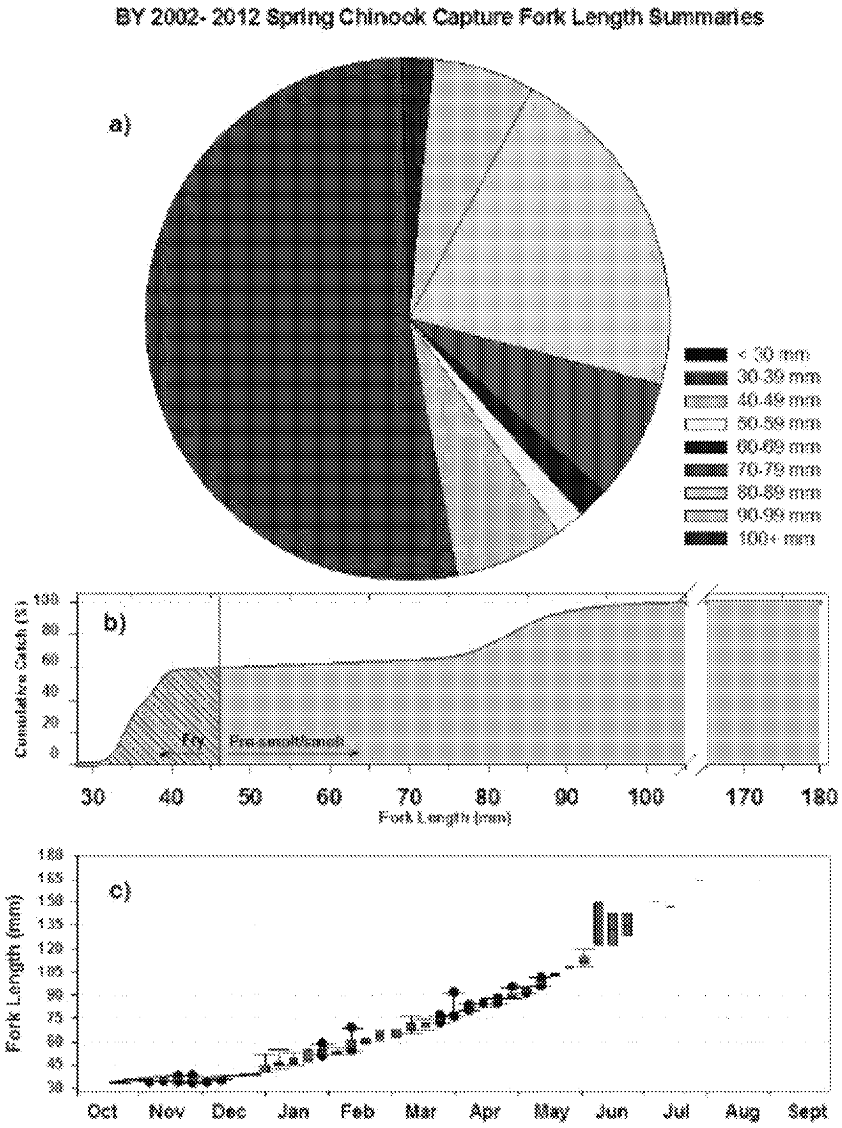
Year	All Fish Abundance Upstream of Red Bluff	% of All Fish Upstream of Red Bluff	In-River Abundance Upstream of Red Bluff	% of In-River Upstream of Red Bluff	All Fish Abundance Upstream of Hamilton City	% of All Fish Upstream of Hamilton City	In-River Abundance Upstream of Hamilton City	% of In-River Upstream of Hamilton City	All Fish Abundance Downstream of Hamilton City	% of All Fish Downstream of Hamilton City	In-River Abundance Downstream of Hamilton City	% of In-River Downstream of Hamilton City
2009	314	7%	314	9%	764	17%	764	22%	3,676	83%	2,687	78%
2010	208	5%	208	7%	969	21%	969	33%	3,652	79%	1,991	67%
2011	167	2%	167	3%	810	11%	810	14%	6,840	89%	4,871	86%
2012	868	4%	868	5%	2,371	11%	2,371	13%	20,055	89%	16,317	87%
2013	1,382	6%	1,382	7%	2,734	11%	2,734	14%	21,076	89%	16,782	86%
2014	526	5%	526	7%	2,042	21%	2,042	29%	7,859	79%	5,083	71%
2015	226	4%	226	19%	626	11%	626	52%	5,009	89%	569	48%
2016	209	3%	209	3%	722	9%	722	11%	7,390	91%	5,731	89%
2017	59	3%	59	6%	544	31%	544	51%	1,206	69%	515	49%
2018	100	2%	100	4%	412	8%	412	15%	4,472	92%	2,362	85%
Mean	406	4%	406	7%	1,199	15%	1,199	25%	8,124	85%	5,691	75%
Median	218	4%	218	6%	787	11%	787	18%	5,925	89%	3,779	81%

Source: Adapted from Azat (2019). Note: All fish = hatchery fish + in-river fish. Totals upstream of Red Bluff and Hamilton City are cumulative, so that fish counted as upstream of Red Bluff are also counted as upstream of Hamilton City. Table does not include any estimates of fish introduced as part of the San Joaquin River Restoration Program, or spring-running fish in San Joaquin River basin tributaries.

Sacramento River

Near-Field Effects

Spring-run Chinook salmon would have the potential for similar types of near-field effects to those previously discussed for winter-run Chinook salmon (i.e., entrainment; impingement and screen contact; predation; stranding behind screens; and attraction to reservoir discharge). The potential for effect would differ relative to winter-run Chinook because of spatiotemporal differences in species occurrence. In particular, as discussed above, less than one quarter of spring-run Chinook salmon would be expected to pass the intakes (Table SRGrandTab). As discussed for winter-run, very few spring-run Chinook juveniles would have the potential for entrainment given their size (Figure length_SR). The Red Bluff and Hamilton City fish screens are designed to protective standards for Chinook salmon fry and so near-field effects would be expected to be limited. There would be greater temporal overlap of adult spring-run Chinook with reservoir releases potentially beginning in April/May than for winter-run Chinook (see Appendix 11A), although again this would only apply to up to 25% of adult spring-run returning to tributaries upstream of the Sacramento River discharge. (There are no spring-run Chinook-bearing tributaries between Hamilton City and the Sacramento River discharge.) As described for winter-run Chinook salmon, adult spring-run Chinook salmon could be attracted to the flow from the Sacramento River discharge under Alternative 2. The design of the apron and weir designed to exclude anadromous fish would eliminate stranding risk.



Source: Poytress et al. (2014: 85). Note: BY = brood year.

Figure length_SR. Spring-Run Chinook Salmon Fork Length (a) Capture Proportions, (b) Cumulative Capture Size Curve, and (c) Average Weekly Median Boxplots, As Sampled at Red Bluff Diversion Dam Rotary Screw Traps, October 2002–June 2013.

Far-Field Effects

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Sacramento River below Keswick, at Balls Ferry, at Bend Bridge, below RBDD, and at Butte City indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of spring-run Chinook salmon (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-5-1a to 6C-5-4c, Tables 6C-7-1a to 6C-7-4c, Tables 6C-9-1a to 6C-9-4c, Tables 6C-10-1a to 6C-10-4c , Tables 6C-12-1a to 6C-12-4c; Figures 6C-5-1 to 6C-5-18, Figures 6C-7-1 to 6C-7-18, Figures 6C-9-1 to 6C-9-1, Figures 6C-10-1 to 6C-10-18, Figures 6C-12-1 to 6C-12-18). At all locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±0.5°F of the NAA water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at all locations.

Results of the analysis of exceedance above water temperature index values for spring-run Chinook salmon in the Sacramento River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X and summarized in Table 11-temp2. For each life stage and at all locations evaluated, there were no month and water year type combinations in which both: (1) the percent of days that exceeded the index values was more than 5% greater under the alternative than under the NAA, and (2) the exceedance per day was more than 0.5°F greater under the alternative than under the NAA. Results of the exceedance analysis for Alt 2 are similar to Alt 1 with no month and water year type combinations in which both criteria were met for any life stage at all locations. For Alt 3, there was one month and water year type combination (July of Above Normal Water Years) at Hamilton City for the juvenile rearing and migration life stages in which there were 11.6% more days than the NAA exceeding the 64°F 7DADM index value and the mean daily exceedance on those days was 0.7°F greater than the NAA. There was also one month and water year type combination (August of Critically Dry Water Years) in which both criteria met in a beneficial way (the percent of days that exceeded the index values was more than 5% lower under Alt 3 than under the NAA, and the exceedance per day was more than 0.5°F lower under Alt 3 than under the NAA) for at least one life stage at 4 of the 6 locations evaluated.

Table 11-temp2. Number of month and water year type combinations that satisfy both criteria for being biologically meaningful in the water temperature index value analysis, Spring-run Chinook salmon, Sacramento River[1,2,3]

Location	Spawning and Egg Incubation	Juvenile Rearing and Emigration	Adult Immigration	Adult Holding
Below Keswick	Alt 1A, 1B, 2 – 0 Alt 3 – 1 beneficial (August, Critical years)	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0
Below Clear Creek	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	N/A	N/A
Balls Ferry	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2 – 0 Alt 3 – 1 beneficial (August, Critical years)	N/A	Alt 1A, 1B, 2 – 0 Alt 3 – 1 beneficial (August, Critical years)
Bend Bridge	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2 – 0 Alt 3 – 1 beneficial (August, Critical years)	Alt 1A, 1B, 2, 3 – 0	N/A
Below Red Bluff Diversion Dam	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2 – 0 Alt 3 – 1 beneficial (August, Critical years)	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2 – 0 Alt 3 – 1 beneficial (August, Critical years)
Hamilton City	N/A	Alt 1A, 1B, 2 – 0 Alt 3 – 1 negative (July, Above normal years)	N/A	N/A

[1] Criteria include: (1) the difference in frequency of exceedance between NAA and the alternative was greater than 5%, and (2) the difference in average daily exceedance between NAA and the alternative was greater than 0.5°F.
[2] Index values for each life stage are located in Appendix 11B, Fisheries Impact Assessment Methods, Table 11.##.
[3] Full results presented in Appendix 11D, Fisheries Water Temperature Assessment, Table X through Table X

Redd Scour/Entombment

Loss of redds to scouring or entombment occurs when flows are high enough to mobilize sediments, destroying redds and their incubating eggs and alevins, or entombing the redds when sediments are redeposited. A flow of 40,000 cfs was selected as the scour flow threshold for the Sacramento River based on estimates in the literature (Table 11N-10).

Commented [CC80]: Please, add references (i.e., what literature).

The probability of redd scour and entombment was estimated for winter-run by computing the percentage of days with flows exceeding 40,000 cfs in the USRDOM 82-year daily flow record (29,952 days in total) at four locations between Keswick Dam and the RBDD during the months of spring-run spawning and incubation. The results for all alternatives (NAA and Alternatives 1–3) show that the probability of scour and entombment is consistently low for spring-run (Table 11N-22 through Table 11N-25). Alternatives 1–3 have very little effect on the frequency of scouring and entombment flows and almost all differences result from a reduction in the probability of such flows. The results indicate that Alternatives 1–3 would have little effect on redd scour and entombment for spring-run in the Sacramento River.

Redd Dewatering

The percentage of redds in the Sacramento River lost to dewatering was estimated using tables in USFWS (2006) that relate spawning and dewatering flows to percent reductions in species-specific spawning habitat WUA (see Appendix 11-N). USRDOM flow data, which has a daily time-step, are available for three locations in this river section: Keswick Dam (RM 302), the Sacramento River at Clear Creek (RM 289), and the Sacramento River at Battle Creek (RM 271). A single relationship for flows was developed for the entire river section, but the flows used to estimate redd dewatering in the current analysis were those that best matched the longitudinal distribution of the redds of the different salmon runs in the river as estimated from aerial redd surveys conducted by CDFW from 2003 through 2019. Spawning of spring-run occurs primarily between the ACID Dam and Airport Rd. (Table 11-1), so Sacramento River at Clear Creek flows were used to analyze spring-run redd dewatering. As discussed in Appendix 11N, percentage of redd dewatering for spring-run was computed from the Sacramento at Clear Creek flows using the fall-run flows vs. redd dewatering relationship. This substitution was made because field data for spring-run were inadequate for developing the relationship, and fall-run spawning distributions and timing are most similar to those of spring-run (USFWS 2006).

Results are presented using the grand mean percentages of redds dewatered for each month of spawning, August and September, and each water year type and all water year types combined. The complete spawning and egg/alevin incubation periods are provided in the results (Table 11N-14) because changes in Project-related flow any time during these periods can affect the redd dewatering results. The means of the redd dewatering estimates under the NAA and Alternatives 1–3 are compared using absolute differences rather than relative differences (percent change) because many of the values for percentages of redds dewatered are small. Expressing changes of small values as percent changes may result in very large values that may be misleading.

The results of the redd dewatering analysis for spring-run (Table 11N-14) show moderate (>2%) increases in redd dewatering for eggs spawned in September of Above Normal Water Years under Alternatives 1B and 3, and reductions in redd dewatering for eggs spawned in August of Above Normal Water Years under Alternative 3. Changes for most months and water year types under all the alternatives are less than 2%. In general, Alternatives 1–3 are not expected to substantially affect spring-run redd dewatering.

Habitat Availability

The suitability of physical habitat for salmonid spawning is largely of function of the availability of clean, coarse gravel for constructing redds, favorable depths, and suitable flow velocities. The suitability of physical habitat for salmonid rearing is largely a function of water depth, flow velocity, and the availability and type of cover. Instream flow potentially affects all these habitat characteristics and often affects the availability of suitable habitat. Habitat suitability for spawning and rearing were analyzed using weighted usable area (WUA) curves developed by USFWS and others from results of field studies and hydraulic modeling (see Appendix 11K).

Spawning Habitat Weighted Usable Area

Spawning habitat for spring-run Chinook salmon was not estimated directly by USFWS (2003a, 2006) and no spring-run Chinook salmon WUA curves for the Sacramento River are available, so spring-run spawning habitat was modeled using the WUA curves provided by USFWS (2003b, 2006) for fall-run Chinook salmon. As noted by USFWS (2003a), the validity of using the fall-run WUA curves to characterize spring-run spawning habitat is uncertain.

Commented [CC81]: Please, add in justification for their use.

To evaluate the effects of the NAA and Alternatives 1–3 on spring-run spawning habitat, spring-run spawning WUA was estimated for flows during the August through December spawning and incubation period under Alternatives 1–3 and the NAA in the same three segments of the Sacramento River that were used for winter-run (Figure 11K-1). The redd distribution data for spring-run indicate that about 12%, 66% and 13% of spring-run redds occur within Segments 6, 5, and 4, respectively (Table 11K-1).

Mean spawning WUA for spring-run under Alternatives 1–3 differs from the NAA by more than 5% for only a few months and water year types, with most of these differences occurring under Alternative 3 (Table 11K-5 through Table 11K-7). Reductions in WUA are more frequent than increases, but the largest difference is a 17% increase under Alternative 3 in Segment 5 for August of above normal water years (Table 11K-6). The largest reduction in spawning WUA for spring-run is a 9% reduction, under Alternative 3 in Segment 5 for September of Above Normal Water Years. October of critically dry years shows reductions of >5% under Alternatives 1–3 in Segment 4.

These results indicate that Alternatives 1–3 would lead to some moderate reductions of spawning habitat WUA during September through December, primarily under Alternative 3. Spawning habitat conditions for spring-run are most important in Segment 5 (Table 11-1), which has no changes in WUA >5%, except for one large increase and one large reduction (Table 11K-6). Alternatives 1–3 are expected to have little effect on spring-run spawning in the Sacramento River.

Rearing Habitat Weighted Usable Area

Rearing habitat WUA for spring-run was not estimated directly but was modeled using the fry and juvenile rearing habitat WUA curves obtained for fall-run Chinook salmon in Segments 4, 5 and 6 (USFWS 2005b). The validity of using the fall-run Chinook salmon rearing WUA curves to characterize spring-run Chinook salmon rearing habitat is uncertain (USFWS 2005b).

Rearing WUA in the Sacramento River was separately determined for spring-run fry and juveniles for a range of flows in Segments 4, 5 and 6. To estimate changes in rearing WUA that would result from Alternatives 1–3 relative to the NAA, the fry and juvenile rearing habitat WUA curves developed for each of these segments were used with mean monthly CALSIM II flow estimates for the corresponding segments of the river under Alternatives 1–3 and the NAA during the spring-run fry (November through February) and juvenile (year-round) rearing periods.

Mean fry rearing WUAs differ by less than 5% between Alternatives 1–3 and the NAA in Segments 6 and 4 (Table 11K-29 and Table 11K-31), and only one mean in Segment 5 (November of above normal years under Alternative 3) is >5% different (lower) than the NAA mean (Table 11K-30). These results indicate that Alternatives 1–3 would have minor effects on rearing habitat for spring-run fry in the Sacramento River.

Because some rearing by spring-run juveniles occurs throughout the year, all months are included in the spring-run juvenile rearing WUA analysis (Table 11K-32 through Table 11K-34). In Segment 6, a few of the means for Alternatives 1–3 differ from the NAA means by more than 5%, and all these differences result from increased rearing WUA under Alternatives 1–3 (Table 11K-32). Four of the five increases occur under Alternative 3. The pattern for >5% difference in Segment 5 is similar to that in Segment 6, but in Segment 5 all of the differences occur under Alternative 3 and one of them (September of above normal years) results from reduced rearing WUA under Alternative 3 (Table 11K-33). Segment 4 has many more large differences in juvenile rearing WUA than either of the other segments (Table 11K-34). Almost all these differences occur under Alternatives 1B and 3 and include some relatively large differences (including a 17% increase for Alternative 3 in August of above normal years and 17% reduction for Alternative 3 in September of above normal years). Increases >5% in rearing WUA outnumber reductions >5%, with all increases occurring in the spring and summer months and all reductions occurring in the fall (Table 11K-34).

Commented [CC82]: All sections seem to have a reduction in rearing habitat yet there is no significant impact of any fish species.

The results for spring-run juvenile rearing WUA indicate that Alternatives 1–3 would generally have minor effects on rearing habitat in Segments 6 and 5, but Alternatives 1B and 3 would have some large effects in Segment 4, including substantial increases in rearing WUA during spring and summer and substantial reductions in rearing WUA during the fall. Increases in WUA outnumber reductions and more of them are especially large (>10%). Furthermore, the increases occur during spring and summer, when the juveniles are younger and perhaps more vulnerable to reductions in habitat availability. On balance, Alternatives 1–3 are expected to have a positive effect on spring-run rearing habitat WUA.

Juvenile Stranding

The juvenile stranding estimation procedure for the Sacramento River computes the surface area of salmonid rearing habitat inundated at an initial flow that is dewatered at a subsequent minimum (stranding) flow, and then converts this area to number of stranded juveniles using estimates of habitat capacity based on field study observations (USFWS 2006). A period of three months is used for the juvenile stranding analysis in this report because the juveniles are presumed to be most vulnerable to stranding during their first three months after emerging from the redds (i.e., fry stage).

Juvenile stranding is computed using USRDOM daily flow estimates for Alternatives 1–3 and the NAA at three locations in the upper Sacramento River: Keswick Dam, Clear Creek, and Battle Creek. Separate tables for converting initial and stranding flows to number of juveniles stranded were developed for periods when the ACID Dam boards are in and when they are out (Table 11N-11 and Table 11N-12). Both tables are used for all the salmonid species and races. The results are presented using the grand mean number of juveniles stranded for each month of emergence under each water year type and all water year types combined (Table N11-28 through Table 11N-30). The analysis assumes that under equal flow conditions the fry and early juvenile stage of all runs and species are equally vulnerable to stranding. To determine the results for a given species or run, the estimated months for which the fry typically emerge (Table 11N-27), are consulted in the tables of results. The effects of dewatering flows are tracked by the analysis from the month of emergence through the 90 days following. These periods are given in the tables.

All three river locations show the greatest differences between Alternatives 1–3 and the NAA for the cohorts of fry that emerged during the months of April, May, June, and July (Table 11N-28 through Table 11N-30). The May cohort generally shows the biggest differences, and all the May differences are reductions in juvenile stranding, with the largest reduction, 55%, occurring at the Battle Creek location under Alternative 1B in May of critically dry years. The largest increases in juvenile stranding occur for the April cohort at all three locations, ranging as high as 30% in dry years under Alternatives 1A, 1B and 2 at the Keswick Dam location. The principal period of stranding vulnerability for spring-run is for cohorts emerging in November through February. Few large changes in stranding are expected during this period and Alternatives 1–3 are not expected to affect spring-run juvenile stranding (Table N11-28 through Table 11N-30).

SALMOD

The SALMOD model outputs for spring-run Chinook salmon are presented in Appendix 11H, *SALMOD,* Table 1b-1 through Table 1b-4, Table 2b-1 through Table 2b-4, and Figure B-b-1 through Figure B-b-19. For all water years combined for all life stages and source of mortality, mean annual spring-run Chinook salmon potential production would be similar under Alt 1A (0% difference) and Alt 1B (0% greater) relative to the NAA (Appendix 11H, *SALMOD,* Table 2b-1 and Table 2b-2, Figure B-a-1). Further, differences within each water year type in mean annual potential production between Alt 1A and the NAA and between Alt 1B and the NAA would be small (<1%). Alt 2 and Alt 3 results would be similar to those of Alt 1A and 1B (Appendix 11H, *SALMOD,* Table 2b-3, Table 2b-4, Figure B-b-1) in that differences in production relative to the NAA would be very small (generally <1%).

Commented [CC83]: No environmental benefit for spring run?

Results by life stage and mortality source are reported in Appendix 11H, *SALMOD,* Table 1b-1 through Table 1b-4 and Figure B-b-8 through Figure B-b-19. Depending on the life stage and source of mortality (flow-/habitat-based or temperature-based), mean annual mortality under Alt

1A would be between 47% lower to 233 greater than that under the NAA and mean annual mortality under Alt 1B would be between 61% lower to 240% higher than that under the NAA (Appendix 11H, *SALMOD,* Table 1b-1, Table 1b-2). However, it is important to understand that the model is seeded with 1,210,000 spring-run eggs each year. Although there may be larger percent differences in mean annual mortality between an alternative and the NAA by source and life stage, these differences typically represent a very small proportion of overall individuals when put in a broader population-wide context. The largest raw difference in mortality would be in pre-spawn mortality between Alt 1B and the NAA in above normal years. In this case, there would be a reduction in mean annual egg mortality of 25,004 eggs under Alt 1B relative to the NAA, accounting for just 0.02% of the 1,210,000 ~~winter~~spring-run Chinook salmon eggs annually seeded into the model. Combining all sources of mortality and life stages together, mean annual mortality would be 1% lower under both Alt 1A and Alt 1B than the NAA for the full simulation period (all water year types combined). By water year type, mean annual mortality under Alt 1A would be between 5% lower (in Wet Water Years) and 14% greater (in Below Normal Water Years) than the NAA. Mean annual mortality under Alt 1B would be between 8% lower (in Wet Water Years) and 36% greater (in Below Normal Water Years). Mean annual mortality results for Alt 2 and Alt 3 are generally similar to those of Alt 1A and Alt 1B (Appendix 11H, *SALMOD,* Table 1b-3, Table 1b-4). Combining all sources of mortality and life stages together, mean annual mortality under Alt 2 would be 4% higher than under the NAA for the full simulation period (all water year types combined) and 4% lower to 59% higher than under the NAA depending on water year type. Mean annual mortality under Alt 3 would be 3% lower than under the NAA for the full simulation period (all water year types combined) and 13% lower to 48% higher than under the NAA depending on water year type.

Commented [CC84]: Not a true life cycle model.

Overall, SALMOD results show a minimal beneficial effect of Alt 1A, Alt 1B, and Alt 3 and a minimal negative effect of Alt 2 on spring-run Chinook salmon mortality and potential production in the Sacramento River.

Floodplain Inundation and Access

As described in Chapter 2 and as discussed for winter-run Chinook salmon, Fremont Weir notch protections are included in the diversion criteria to reduce changes to spill frequency and duration under Alternatives 1–3 relative to existing conditions. In particular, these criteria avoid impacts on Reclamation's ability to implement its obligations in the 2019 NMFS ROC on LTO Biological Opinion to implement the Yolo Bypass Restoration Salmonid Habitat Restoration and Fish Passage Implementation Plan and provide 17,000+ acres of inundation in the Yolo Bypass from December to April (NMFS 2019). As such, Alternatives 1–3 would have limited potential for negative effects to Yolo Bypass floodplain inundation and access for spring-run Chinook salmon. This was confirmed with the modeling summarized in the winter-run Chinook salmon section (see also Attachments 11M-1 and 11M-2 to Appendix 11M).

Migration Flow-Survival

As described in more detail for winter-run Chinook salmon, all alternatives include pulse flow protection measures to be applied to precipitation-generated pulse flow events from October through May. In addition and as described in more detail in Chapter 2, the alternatives would include a fish monitoring program capable of detecting a migratory response during the beginning of a precipitation-generated high flow event and continuing research would be utilized to operate to, and further refine the pulse flow protection strategy. The discussion in Appendix 11P, Section 2 *Flow Threshold Survival Analysis to Assess Potential Effects of Sites Reservoir Project Diversion Criteria Based on Historical Juvenile Chinook Salmon Monitoring Data* illustrates that the Sites diversion criteria generally minimize diversions during the historical periods of fish movement as reflected in Red Bluff rotary screw trap data, and application of the flow-threshold criteria from Michel et al. (2021) suggests that flow-survival effects on juvenile Chinook salmon (including spring-run Chinook salmon) would be greatly limited by the diversion criteria.

Sites Reservoir Release Effects

Sites reservoir releases could temporally overlap with spring-run Chinook salmon presence near the release location in the Sacramento River, specifically migrating adults during approximately February through July and juveniles rearing or migrating during November through May (Appendix 11A, Table 11A-4; Figure SR_DJFMP).

Sites Reservoir releases into the Yolo Bypass via the CBD would occur during August–October, which will not coincide with juvenile or adult spring-run Chinook salmon presence in the Yolo Bypass (Appendix 11A, Table 11A-4; Figure SR_DJFMP).

Temperature Effects

As discussed in Chapter 6, *Surface Water Quality*, the effect of Alternatives 1A, 1B, 2, and 3 on water temperatures at the Sites Reservoir release site in the Sacramento River would be relatively small with the releases generally tending to cause a slight reduction in water temperature (Tables 6-12a through 6-12d). Temperature-related effects of Alternatives 1A, 1B, 2, and 3 on spring-run Chinook salmon at the release site in the Sacramento River would be minimal.

There would be no temperature-related effects of Sites Reservoir releases in the Yolo Bypass via the CBD and in the Sacramento River below the Yolo Bypass under Alternatives 1A, 1B, 2, and 3 to spring-run Chinook salmon because no spring-run would be present in these locations during August through October when the Yolo Bypass would receive Sites Reservoir releases.

Feather River

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Feather River low flow channel (LFC) below the Fish Barrier Dam and in the high flow channel (HFC) at Gridley Bridge indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of spring-run Chinook salmon (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-16-1a to 6C-16-4c, Tables 6C-18-1a to 6C-18-4c; Figures 6C-16-1 to 6C-16-18, Tables 6C-18-1 to 6C-18-18). At both locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±1°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at both locations.

Results of the analysis of exceedance above water temperature index values for spring-run Chinook salmon in the Feather River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X and summarized in Table 11-temp3. For each life stage and at all locations evaluated, there were no month and water year type combinations in which both: (1) the percent of months that exceeded the index values was more than 5% greater under the alternative than under the NAA, and (2) the exceedance per month was more than 0.5°F greater under the alternative than under the NAA. Results of the exceedance analysis for Alt 2 and Alt 3 are similar to Alt 1 with no month and water year type combinations in which both criteria were met for any life stage at all locations.

Table 11-temp3. Number of month and water year type combinations that satisfy both criteria for being biologically meaningful in the water temperature index value analysis, Spring-run Chinook salmon, Feather River[1,2,3]

Location	Spawning and Egg Incubation	Juvenile Rearing and Migration	Adult Immigration	Adult Holding
Low Flow Channel Below Fish Barrier Dam	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0
High Flow Channel Below Thermalito Afterbay outlet	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0

[1] These include: (1) the difference in frequency of exceedance between NAA and the alternative was greater than 5%, and (2) the difference in average monthly exceedance between NAA and the alternative was greater than 0.5°F.
[2] Index values for each life stage are located in Appendix 11B, Fisheries Impact Assessment Methods, Table 11.##.
[3] Full results presented in Appendix 11D, Fisheries Water Temperature Assessment, Table X through Table X

The probability that each alternative would meet water temperature targets to support anadromus fish in the Feather River included the Settlement Agreement for Licensing of the Oroville Facilities (Appendix 11B, *Fisheries Impact Assessment Methods*, Tables X and X; DWR 2006, pp. A-18 to A-24) was evaluated with monthly water temperature model outputs above Thermalito Afterbay for the LFC and below Thermalito Afterbay for the HFC. Results for each alternative are provided in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X.

The percent of months above the LFC temperature targets under Alt 1A and Alt 1B were predominantly similar to those under the NAA with few exceptions. The percent of months above the temperature target in June of dry and critical years and in November of critical years under Alt 1A would be 5.6% to 25% higher than those under the NAA. The percent of months above the temperature target in June of critical years and in November of critical years under Alt 1B would be 16.7% and 8.3% higher, respectively, than those under the NAA. The percent of months above the temperature target in April of critical years and in October of below normal and dry years under Alt 1A and Alt 1B would be 5.6% to 8.3% lower than those under the NAA. Despite these changes in frequency of exceedance, the magnitude of exceedance during these month and water year type combinations would be within ±0.5°F/month, suggesting that these differences could be resolved through real-time reservoir operations.

The percent of months above the HFC temperature targets under Alt 1A and Alt 1B were predominantly similar to those under the NAA with few exceptions. The percent of months above the temperature target in June of Dry Water Years and in October of Critically Dry Water Years would be 5.6% and 8.3% higher, respectively, under both Alt 1A and Alt 1B compared to those under the NAA. The percent of months above the temperature target in April of Critically Dry Water Years would be 8.3% lower under both Alt 1A and Alt 1B compared to those under the NAA. Despite these changes in frequency of exceedance, the magnitude of exceedance during these months would be within ±0.5°F/month, suggesting that these differences could be resolved through real-time reservoir operations.

Results of the evaluation of exceedance of Oroville Settlement Agreement water temperature targets in the LFC and HFC for Alt 2 and Alt 3 would be similar to those for Alt 1.

Redd Scour and Entrainment

Frequency of scouring flows was not estimated for the Feather River because information on minimum flows required to mobilize sediments is not available for the Feather River.

Redd Dewatering

No redd dewatering field data similar to that used for the Sacramento or American Rivers (see Appendix 11K) are available for salmon or steelhead in the Feather River. The reduction in flow from the spawning to the dewatering flow was used directly as a proxy for redd dewatering. Redd dewatering was evaluated only for the High Flow Channel (HFC) of the river (downstream of Thermalito Afterbay Outlet) because none of the Project alternatives affects flow in the Low Flow Channel (LFC). The spawning and dewatering flows downstream of the Thermalito Afterbay outlet for each month of spring-run spawning, as estimated by CALSIM II, were used to compute the reduction in flow under Alternatives 1–3 and the NAA. Larger reductions are assumed to increase the percent of redds dewatered and to have a potentially negative effect on the species' populations. The use of monthly time-step flow estimates like those obtained from CALSIM II modeling likely underestimates redd dewatering rates. This potential bias is expected to equally affect the NAA and Alternatives.

The results for the Feather River spring-run spawning and incubation period (September through February) show large reductions in Feather River flow for Alternatives 1–3 following September through November spawning (Table 11N-18). These reductions potentially result in high levels of redd dewatering for spring-run spawning in the HFC. The reductions are especially large in October, when the majority of the mean reductions under Alternatives 1–3 are more than 200 cfs greater than those under the NAA. The greatest reductions are in Dry Water Years. These results indicate that Alternatives 1–3 would potentially increase spring-run redd dewatering in the Feather River. However, most spawning of Feather River salmonids occurs in the LFC (Figure 11N-1). Thus, any anticipated increase in HFC red dewatering under Alternatives 1-2 is not expected to affect the overall Feather River spring-run population.

Habitat Availability

Spawning Habitat Weighted Usable Area

Spring-run and fall-run are often difficult to distinguish in the Feather River, so a single WUA curve was developed for both runs (Payne and Allen 2004) (Figure 11K-7). The curve was used to compute spawning WUA with flows specific to the months of spawning and incubation for the run analyzed. To evaluate the effects of Alternatives 1–3 on spring-run spawning habitat in the Feather River, the spawning WUA was estimated under Alternatives 1–3 and the NAA for CALSIM II flows below Thermalito Afterbay during September through December, the Feather River spring-run spawning and incubation period. Differences in spawning WUA between Alternatives 1–3 and the NAA were examined using the grand mean spawning WUA for each month of the spawning period under each water year type and all water year types combined (Table 11K-18 and Table 11K-19). In the tables of results, means that differed by >5% were highlighted in red for reductions or green for increases to flag the largest differences.

The only differences >5% between Alternatives 1–3 and the NAA means were 6% to 7% reductions in October of Below Normal Water Years under Alternatives 1A, 1B, and 2, but not under Alternative 3. These results suggest that Alternatives 1–3 have mostly minor effects on spring-run spawning WUA in the Feather River.

Rearing Habitat Weighted Usable Area

No valid rearing habitat WUA curves are available.

Juvenile Stranding

No formal method for analyzing juvenile stranding analysis has been developed for the Feather River.

for the Feather River (see Appendix 11K, Methods).

American River

Redd Scour and Entombment

Spring-run do not spawn in the American River.

Redd Dewatering

Spring-run do not spawn in the American River.

Habitat Availability

Spring-run do not spawn in the American River and no rearing WUA curves are available for the American River (see Appendix 11K, *Methods*).

Juvenile Stranding

No formal method for analyzing juvenile stranding analysis has been developed for the American River.

Delta

Juvenile Through-Delta Survival

The analysis of the potential for negative effects to juvenile Chinook salmon through-Delta survival, as assessed by the spreadsheet implementation of the through-Delta survival function formulated by Perry et al. (2018; see further discussion for winter-run Chinook salmon), found that during the main period of juvenile spring-run Chinook salmon occurrence in the Delta (i.e., April–May; see Table 11A-5 in Appendix 11A), there was essentially no difference in mean through-Delta survival between Alternatives 1–3 and the NAA (see Table perry1 in winter-run analysis). Overall, during the broader spring-run juvenile migration including the earlier winter/early spring period of lower abundance (i.e., December–March), differences were small (0–2% less under the alternatives; Table perry1).

As described for winter-run Chinook salmon, note that the spreadsheet implementation of the Perry et al. (2018) model does not account for the variability in coefficient estimates (Figure 6 of Perry et al. 2018), which would likely give appreciable overlap of estimates in through-Delta survival between the NAA and the alternative scenarios, particularly in relation to the relatively small differences between alternatives.

Juvenile Rearing Habitat

As discussed in more detail for winter-run Chinook salmon, available information from previous analyses of analogous flow-related impacts suggests that the alternatives would not significantly change rearing habitat for juvenile spring-run Chinook salmon.

South Delta Entrainment

There would be little difference in indicators of entrainment risk (south Delta exports and Old and Middle River flows) during winter/spring between the NAA and Alternatives 1–3 see Appendix 5B3: Tables 5B3-6-1a through 5B3-6-4c; Figures 5B3-6-1 through 5B3-6-18; and Appendix 5B4: Tables 5B4-1-1a through 5B4-1-4c; Figures 5B4-1-1 through 5B4-1-18), and existing restrictive criteria from the NMFS (2019) SWP/CVP BiOp and CDFW (2020) SWP ITP would limit entrainment risk for spring-run under all alternatives. South Delta export of water released from Sites Reservoir would have little to no overlap with spring-run Chinook salmon. This is illustrated by the results of the salvage-density analysis (see description in Appendix 11Q) for which there were minimal differences between NAA and the alternatives (Table sr_banks; Table sr_jones).

Table sr_banks. Entrainment Loss of Juvenile Spring-Run Chinook Salmon At SWP Banks Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	45,489	45,414 (0%)	45,408 (0%)	45,410 (0%)	44,500 (-2%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	4,824	4,827 (0%)	4,837 (0%)	4,834 (0%)	4,834 (0%)
Dry	2,710	2,718 (0%)	2,721 (0%)	2,718 (0%)	2,722 (0%)
Critically Dry	2,289	2,301 (1%)	2,303 (1%)	2,304 (1%)	2,300 (0%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any Above Normal Water Years, hence that row of the table is noted as 'NA'. High absolute estimates of spring-run Chinook salmon juvenile loss reflect length-at-date misclassification of fall-run Chinook salmon (Harvey et al. 2014); note, however, that focus should be placed on relative differences as opposed to absolute estimates.

Table sr_jones. Entrainment Loss of Juvenile Spring-Run Chinook Salmon At CVP Jones Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	8,075	8,070 (0%)	8,067 (0%)	8,070 (0%)	8,064 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	3,155	3,124 (-1%)	3,146 (0%)	3,124 (-1%)	3,178 (1%)
Dry	2,915	2,881 (-1%)	2,904 (0%)	2,881 (-1%)	2,932 (1%)
Critically Dry	125	127 (1%)	127 (1%)	127 (2%)	128 (2%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any Above Normal Water Years, hence that row of the table is noted as 'NA'. High absolute estimates of spring-run Chinook salmon juvenile loss reflect length-at-date misclassification of fall-run Chinook salmon (Harvey et al. 2014); note, however, that focus should be placed on relative differences as opposed to absolute estimates.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

In-Delta and upstream operational impacts of Alternatives 1-3 on spring-run Chinook salmon would be negligible. Impacts associated with operations of Alternatives 1–3 would be less than significant.

[Note to Reviewers: This conclusion is preliminary and is dependent on an upcoming side-channel analysis]

NEPA Conclusion for Alternatives 1, 2, and 3

Operational effects on spring-run Chinook salmon under Alternative 1, 2, or 3 would be the same as described above for CEQA. Operation of Alternative 1, 2, or 3 would not result in adverse effects on winter-run Chinook salmon.

[Note to Reviewers: This conclusion is preliminary and is dependent on an upcoming side-channel analysis]

Impact FISH-4: Operations Effects on Fall-Run/Late Fall–Run Chinook Salmon

Alternatives 1, 2, and 3

Potential exposure of fall-run/late fall–run Chinook salmon to the effects of Alternatives 1, 2, and 3 is dependent on the species' spatiotemporal distribution. As described for winter-run Chinook salmon, several sources of information provide important context.

The main patterns of juvenile fall-run/late fall–run Chinook salmon occurrence at the locations documented in the SacPAS summary in Appendix 11A include:

- Fall-run Chinook:
  - Red Bluff Diversion Dam rotary screw traps (Figure FR_RBRST, Appendix 11A): Passage begins around December 1st and finishes in early November (i.e., essentially year-round). The first half (50%) has passed from mid-January to the first of May. The main portion (90%) begins to pass in mid-December to the first of February and finishes passing from mid-March to the end of June.
  - Tisdale Weir rotary screw traps (Figure FR_TWRST, Appendix 11A): Passage begins in early December to mid-January and finishes by early May to early July, except the 2010 cohort, which finishes mid-November. The first half (50%) passes by mid-January to mid-March. The main portion (90%) begins to pass in late December to mid-February and finishes from mid-February to early May.
  - Knights Landing rotary screw traps (Figure FR_KLRST, Appendix 11A): First passage begins from early December to late January and passage finishes from the end of May to late June. The first half (50%) passes by mid-January to mid-April. The main portion (90%) begins to pass in late December to mid-February and finishes

from the end of February to the end of April. The exception to these trends are the 2012 and 2015 cohorts. In 2012 the entire cohort passed in approximately 10 days in early December. In 2015 the fish began to pass in mid-December and finished approximately 4 weeks later, with half the fish passing by the end of December.

- Sacramento beach seines (Figure FR_Seines, Appendix 11A): Occurrence begins in December and ends from late April to the end of October. The first half (50%) occurs by early February to early March. The main portion (90%) occur beginning in late December to late February and finishes from mid-March to early May.
- Sacramento trawls (Sherwood Harbor) (Figure FR_Sherwood, Appendix 11A): Occurs begins from early December to early February and finishes from late May to early September, except the 1995 cohort which finished at the end of November. The first half (50%) occurs from early February to late April. The main portion (90%) of fish occurs by mid-December to the first of March and ends from early March to early June.
- Chipps Island trawls (Figure FR_Chipps, Appendix 11A): Occurrence begins in mid-December to late April and finishes from early July to late November. The first half (50%) occurs by a short window from late May to mid-June. The main portion (90%) begins to occur in late April and finishes in mid-May to early June.
- Salvage (unclipped, length-at-date) (Figure FR_salvage_unclipped_date, Appendix 11A): Salvage begins from early August to late March and is complete from early May to late July, except the 2014 cohort, which finished by early March. The first half (50%) of the fish are salvaged by early February to the end of June. The main portion (90%) is salvaged beginning from mid-January to mid-May and finishing from early May to late June, except the 2014 cohort which finished being salvaged in early March.
- Salvage (clipped, length-at-date) (Figure FR_salvage_clipped_date, Appendix 11A): Salvage is highly variable and can being in late September to mid-May and finish from mid-December to late June. The first half (50%) occurs by early November to early June. The main portion (90%) begins to occur in late September to mid-May and finishes from mid- December to mid-June.
- Salvage (clipped, CWT-Race) (Figure FR_salvage_clipped_CWT_race, Appendix 11A): Salvage begins in early December to mid-May is finished from mid-December to mid-June. The first half (50%) occurs by mid-December to mid-May. The main portion of salvage begins to occur from early December to mid-May and finishes from mid-December to early June.

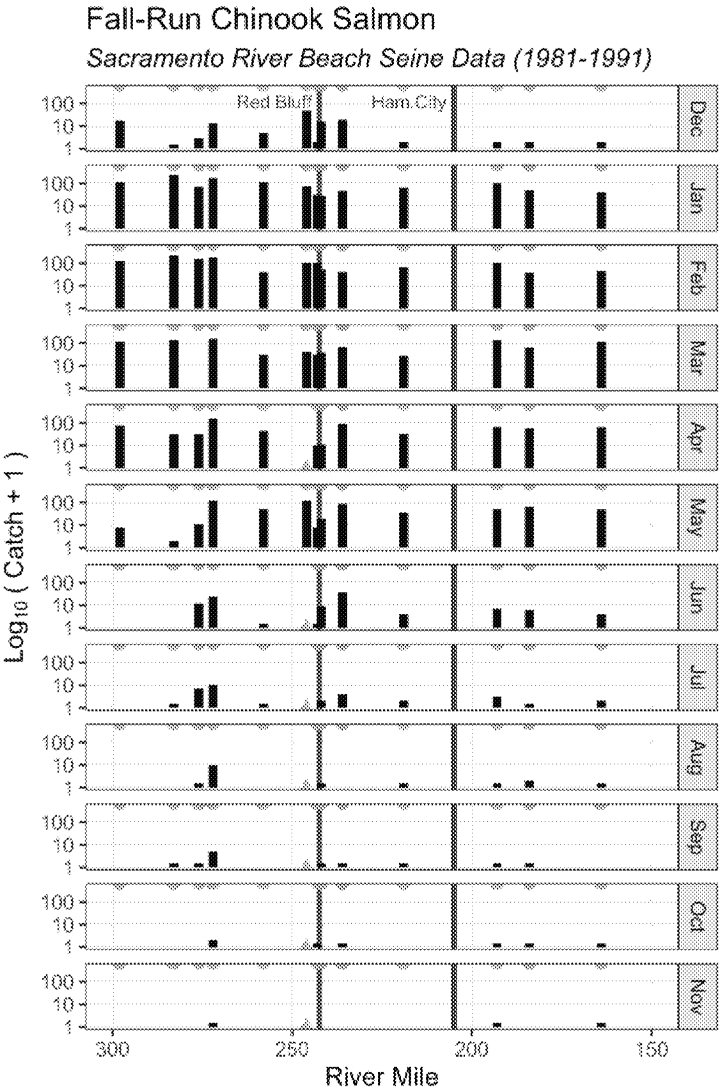
- Late fall–run Chinook:
  - Red Bluff Diversion Dam rotary screw traps (Figure LFR_RBRST, Appendix 11A): Passage begins by the first of April to the end of June and finishes from the first of January to early March. The first half (50%) of passage occurs by mid-May to mid-

November. The main portion (90%) begins to pass in early April to late September and finishes from early September to mid-December.

- Tisdale Weir rotary screw traps (Figure LFR_TWRST, Appendix 11A): Passage is highly dynamic, beginning as early as the first of April to the end of January nine months later. Passage finishes from late November to the first of February. The first half (50%) of the fish passes from mid-April to late January, nine months later. The main portion of passage (90%) is similar to the first and last fish passing, i.e., the first of April to the end of January, nine months later.
- Knights Landing rotary screw traps (Figure LFR_KLRST, Appendix 11A): Passage begins around the first of April to late November and finishes from mid-December to the first of April of the following year. The first half (50%) passes by mid-April to early January, nine months later. The main portion begins to pass in mid-April to early December and finishes passing from early May to late January, eight months later.
- Sacramento beach seines (Figure LFR_Seines, Appendix 11A): Occurrence begins in early April to mid-January, nine months later, and finishes from the end of November to early February. The first half (50%) passes by early April to mid-January. The main portion (90%) begins to pass in early April to mid-December and finishes passing from early May to early February, nine months later.
- Sacramento trawls (Sherwood Harbor) (Figure LFR_Sherwood, Appendix 11A): Occurrence begins in early May to mid-December and finishes from late October to late March. The first half (50%) occurs by mid-May to mid-January, eight months later. The main portion (90%) begins to occur from early April to late December and finishes occurring from late July to the end of March.
- Chipps Island trawls (Figure LFR_Chipps, Appendix 11A): Occurrence begins in early May to mid-January and finishes from early January to early March. The first half (50%) occurs from early December to mid-January, whereas the main portion (90%) begins to occur from mid-September to mid-January and finishes from late December to mid-February.
- Salvage (unclipped) (LFR_salvage_unclipped_date, Appendix 11A): Salvage begins in last-August to mid-February and finishes from mid-December to mid-June. The first half (50%) is salvaged by mid-November to mid-April. The main portion (90%) begin to be salvaged in early October to mid-February and finishes from mid-December to mid-June.
- Salvage (clipped) (Figure LFR_salvage_clipped_date, Appendix 11A): Salvage begins in mid-November to mid-January and finishes from early January to mid-February. The first half (50%) is salvaged by mid-December to around the first of February. The main portion (90%) begin to be salvaged by the first of December to mid-January and finishes being salvaged from mid-December to mid-February.

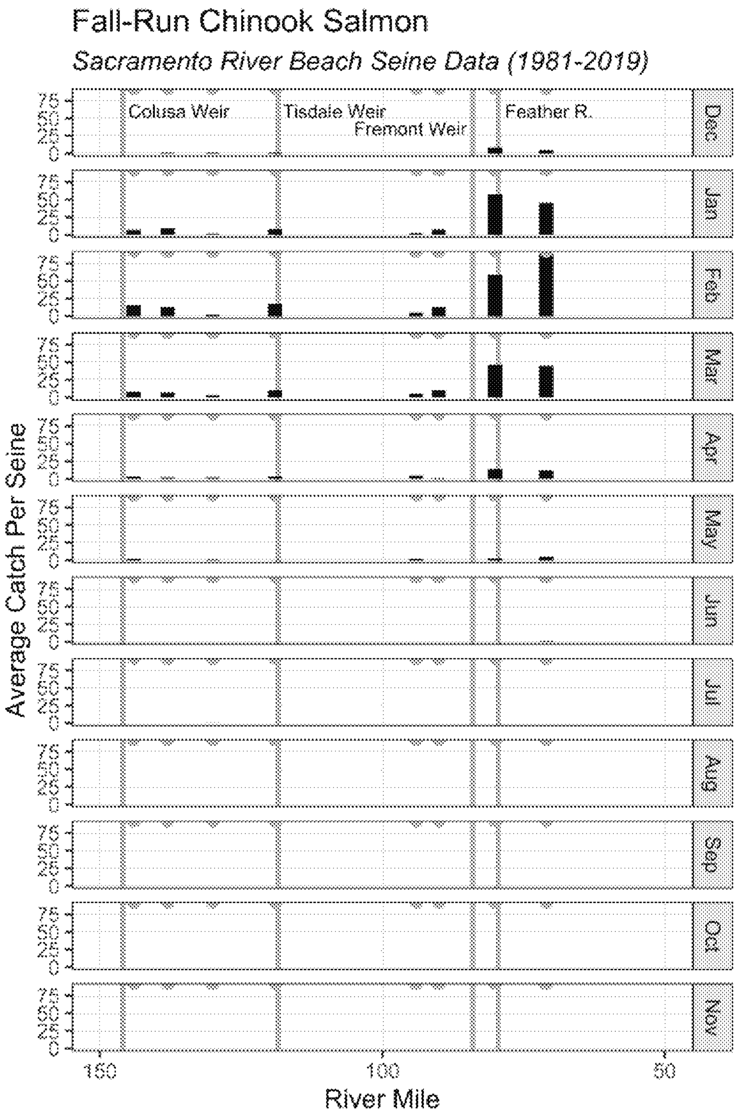
- Salvage (clipped, CWT-Race) (Figure LFR_salvage_clipped_CWT_race, Appendix 11A): Salvage begins in early December to mid-January and finishes from early January to around the first of February. The first half (50%) of salvage occurs by mid-December to mid-January. The main portion (90%) of salvage is from early December to mid-January and is finished from mid-December to the first of February.

Fall-run beach seine catches were quite uniformly high across the sites included in extensive beach seining during 1981–1991 in December–May, and decreased beginning in June (Figure FR_johnson). Further downstream at beach seine sites sampled 1981–2019, fall-run catch rates peaked during January–March, and then decreased to zero during the spring and summer (Figure FR_DJFMP). Late-fall-run beach seine catches were relatively high in the upper reaches of the 1981–1991 study area during April–September, and then started to increase further downstream in October (Figure LFR_johnson). This pattern is consistent with catch rates peaking further downstream at the 1991–2019 sample sites in November–December, although there were also peaks at those locations in April and May (Figure LFR_DJFMP).



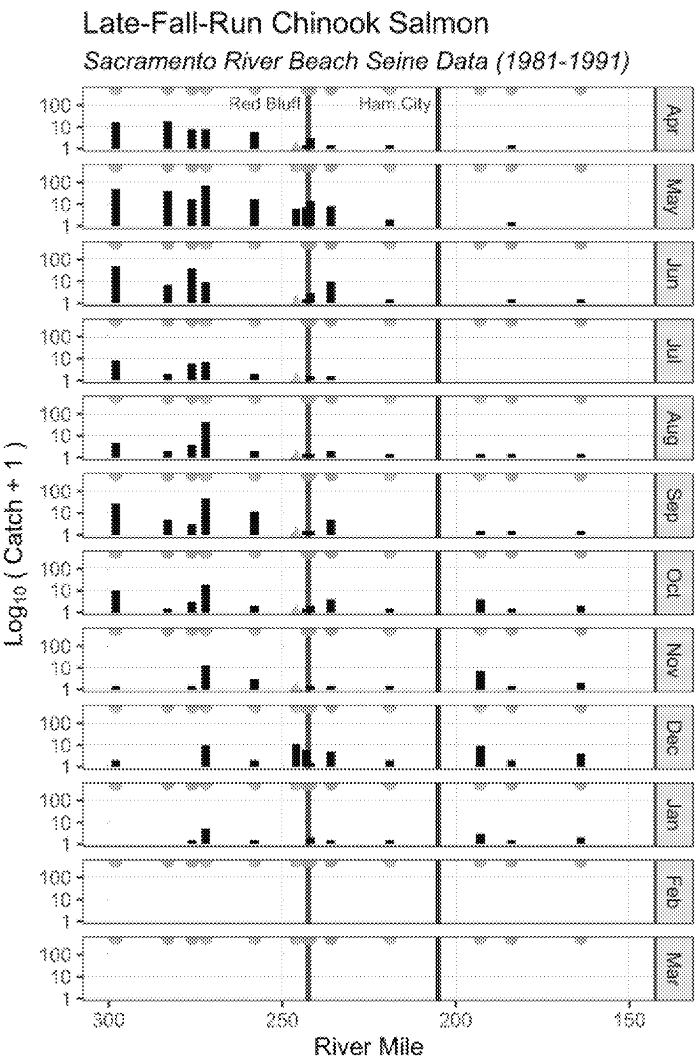
Source: Johnson et al. (1992; their Table 4). Note: Sampled sites are denoted by grey semicircles at the top of each plot. Sites that were not sampled in a given month are denoted by grey triangles at the bottom of a panel. Values denoted as "<1" by Johnson et al. are shown as 0.5. Red lines indicate locations of Red Bluff and Hamilton City diversions.

Figure FR_johnson. Mean Monthly Catch Per Beach Seine of Juvenile Fall-Run Chinook Salmon in the Sacramento River Between River Mile 164 and River Mile 298, 1981–1991.



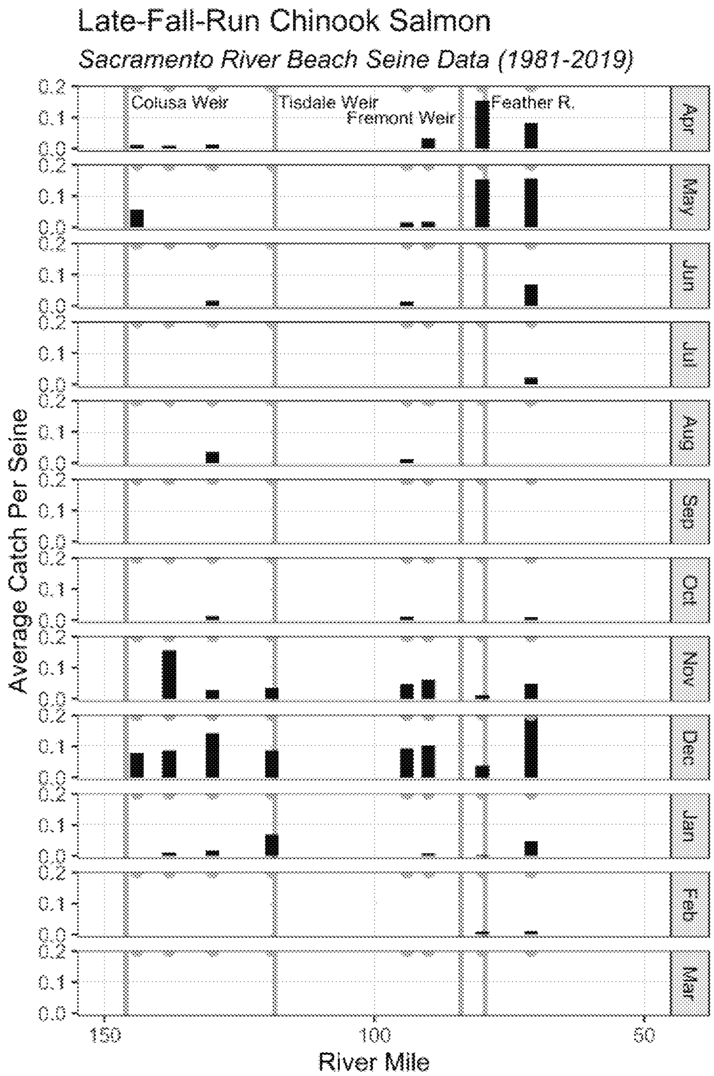
Source: https://www.fws.gov/lodi/juvenile_fish_monitoring_program/jfmp_index.htm . Note: Sampled sites are denoted by grey semicircles at the top of each plot. Grey lines indicate locations of Colusa, Tisdale, and Fremont Weirs, and the confluence with the Feather River.

Figure FR_DJFMP. Mean Monthly Catch Per Beach Seine of Juvenile Fall-Run Chinook Salmon in the Sacramento River Between River Mile 71 and River Mile 144, 1981–2019.



Source: Johnson et al. (1992; their Table 4). Note: Sampled sites are denoted by grey semicircles at the top of each plot. Sites that were not sampled in a given month are denoted by grey triangles at the bottom of a panel. Values denoted as "<1" by Johnson et al. are shown as 0.5. Red lines indicate locations of Red Bluff and Hamilton City diversions.

Figure LFR_johnson. Mean Monthly Catch Per Beach Seine of Juvenile Late Fall-Run Chinook Salmon in the Sacramento River Between River Mile 164 and River Mile 298, 1981–1991.



Source: https://www.fws.gov/lodi/juvenile_fish_monitoring_program/jfmp_index.htm . Note: Sampled sites are denoted by grey semicircles at the top of each plot. Grey lines indicate locations of Colusa, Tisdale, and Fremont Weirs, and the confluence with the Feather River.

Figure LFR_DJFMP. Mean Monthly Catch Per Beach Seine of Juvenile Late Fall-Run Chinook Salmon in the Sacramento River Between River Mile 71 and River Mile 144, 1981–2019.

Between 2009 and 2018, the mean percentage of in-river spawning adult fall-run and late fall–run Chinook salmon returning to tributaries upstream of Red Bluff was 30%, and upstream of Hamilton City was 33%; the percentage of total fish (hatchery + in-river) was 40% upstream of both intakes (Table FR_LFR_GrandTab). This indicates that the majority of fall-run and late fall–run Chinook salmon would not be expected to have the potential for near-field effects from the diversions, with a greater proportion of the population occurring downstream in tributaries such as the Feather River and American River, for example. As noted for spring-run Chinook salmon, these downstream fish would have the potential for far-field effects from the alternatives, e.g., flow-survival effects for juveniles migrating downstream. Note that for hatchery-origin fish, an appreciable portion may be transported by truck for release in the Bay-Delta (Huber and Carlson 2015), thereby reducing the potential for effects of the alternatives.

Table FR_LFR_GrandTab. Abundance and Percentage of Fall-Run and Late Fall-Run Chinook Salmon Adult Escapement Upstream and Downstream of the Red Bluff and Hamilton City Intakes, 2009–2018.

Year	All Fish Abundance Upstream of Red Bluff	% of All Fish Upstream of Red Bluff	In-River Abundance Upstream of Red Bluff	% of In-River Upstream of Red Bluff	All Fish Abundance Upstream of Hamilton City	% of All Fish Upstream of Hamilton City	In-River Abundance Upstream of Hamilton City	% of In-River Upstream of Hamilton City	All Fish Abundance Downstream of Hamilton City (Sac. R.)	% of All Fish Downstream of Hamilton City (Sac. R.)	In-River Abundance Downstream of Hamilton City (Sac. R.)	% of In-River Downstream of Hamilton City (Sac. R.)	All Fish Abundance Downstream of Hamilton City (Mok. R.)	% of All Fish Downstream of Hamilton City (Mok. R.)	In-River Abundance Downstream of Hamilton City (Mok. R.)	% of In-River Downstream of Hamilton City (Mok. R.)	All Fish Abundance Downstream of Hamilton City (San J. R.)	% of All Fish Downstream of Hamilton City (San R.)	In-River Abundance Downstream of Hamilton City (San J. R.)	% of In-River Downstream of Hamilton City (San J. R.)
2009	35,345	51%	16,547	49%	35,345	51%	17,126	50%	29,837	43%	15,085	44%	2,233	3%	680	2%	1,323	2%	1,077	3%
2010	73,344	39%	33,284	29%	73,344	39%	36,271	31%	103,415	55%	74,347	64%	7,935	4%	2,660	2%	2,423	1%	2,277	2%
2011	124,240	45%	35,380	28%	124,240	45%	36,673	29%	127,555	46%	82,259	66%	18,649	7%	2,727	2%	4,144	2%	3,773	3%
2012	240,217	57%	68,544	35%	240,217	57%	74,821	38%	161,875	38%	110,458	56%	13,162	3%	6,542	3%	7,800	2%	6,800	3%
2013	231,783	45%	88,083	26%	231,783	45%	95,988	28%	263,215	51%	226,517	67%	12,252	2%	7,071	2%	8,695	2%	7,597	2%
2014	128,682	46%	85,220	43%	128,682	46%	90,840	46%	132,465	48%	100,702	50%	12,486	4%	3,670	2%	5,231	2%	4,420	2%
2015	76,152	44%	37,818	38%	76,152	44%	44,803	45%	73,524	43%	42,887	43%	13,083	8%	4,785	5%	8,702	5%	7,496	7%
2016	32,105	22%	12,355	14%	32,105	22%	12,664	15%	87,714	60%	57,931	67%	10,119	7%	3,232	4%	16,214	11%	13,218	15%
2017	22,549	20%	7,999	17%	22,549	20%	8,040	17%	56,464	51%	22,159	48%	20,633	18%	6,314	14%	11,903	11%	9,942	21%
2018	62,754	33%	30,446	26%	62,754	33%	30,960	27%	103,945	55%	70,409	60%	18,263	10%	11,082	9%	5,321	3%	4,346	4%
Mean	102,717	40%	41,568	30%	102,717	40%	44,819	33%	114,001	49%	80,275	57%	12,882	7%	4,876	5%	7,176	4%	6,095	6%
Median	74,748	45%	34,332	29%	74,748	45%	36,472	30%	103,680	55%	72,378	58%	12,785	7%	4,228	3%	6,561	3%	5,610	3%

Source: Adapted from Azat (2019). Note: All fish = hatchery fish + in-river fish. Totals upstream of Red Bluff and Hamilton City are cumulative, so that fish counted as upstream of Red Bluff are also counted as upstream of Hamilton City, for example. Table also shows percentages downstream of Hamilton City in the Sacramento River (Sac. R.) basin, downstream of Hamilton City in the Mokelumne (Mok.) River, and downstream of Hamilton City in the San Joaquin (San J.) River basin.

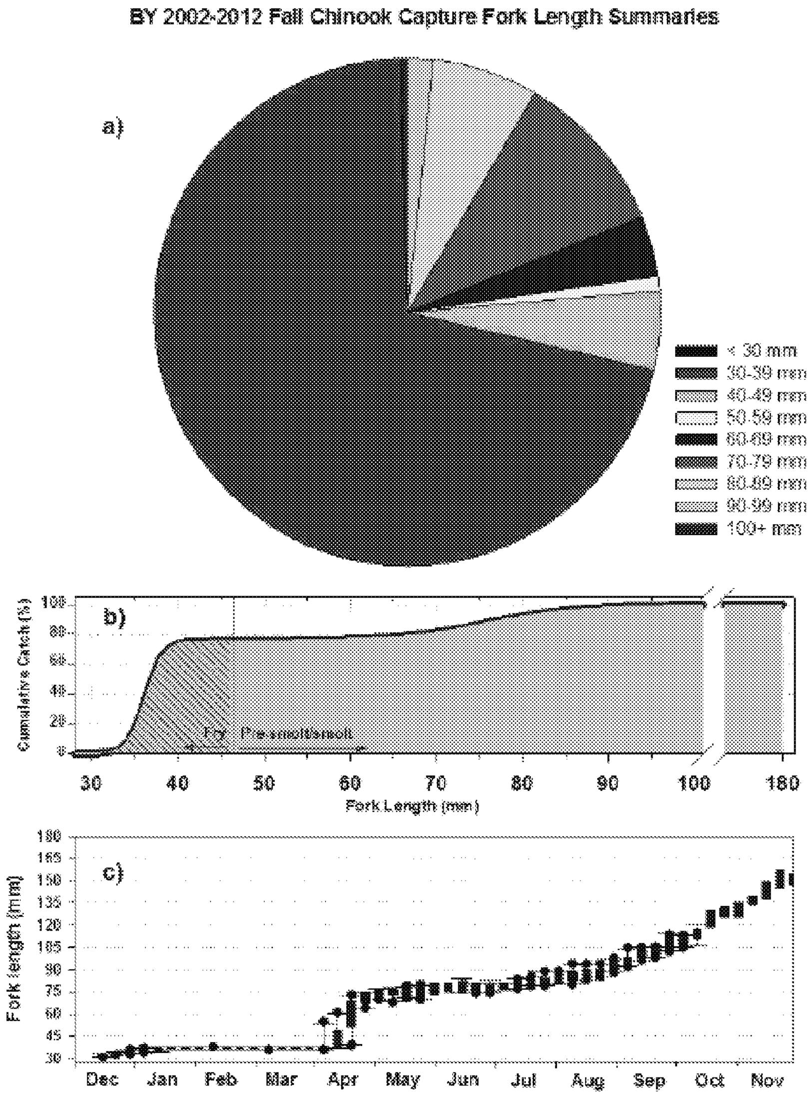
Effects of Alternatives 1, 2, and 3

Sacramento River

Near-Field Effects

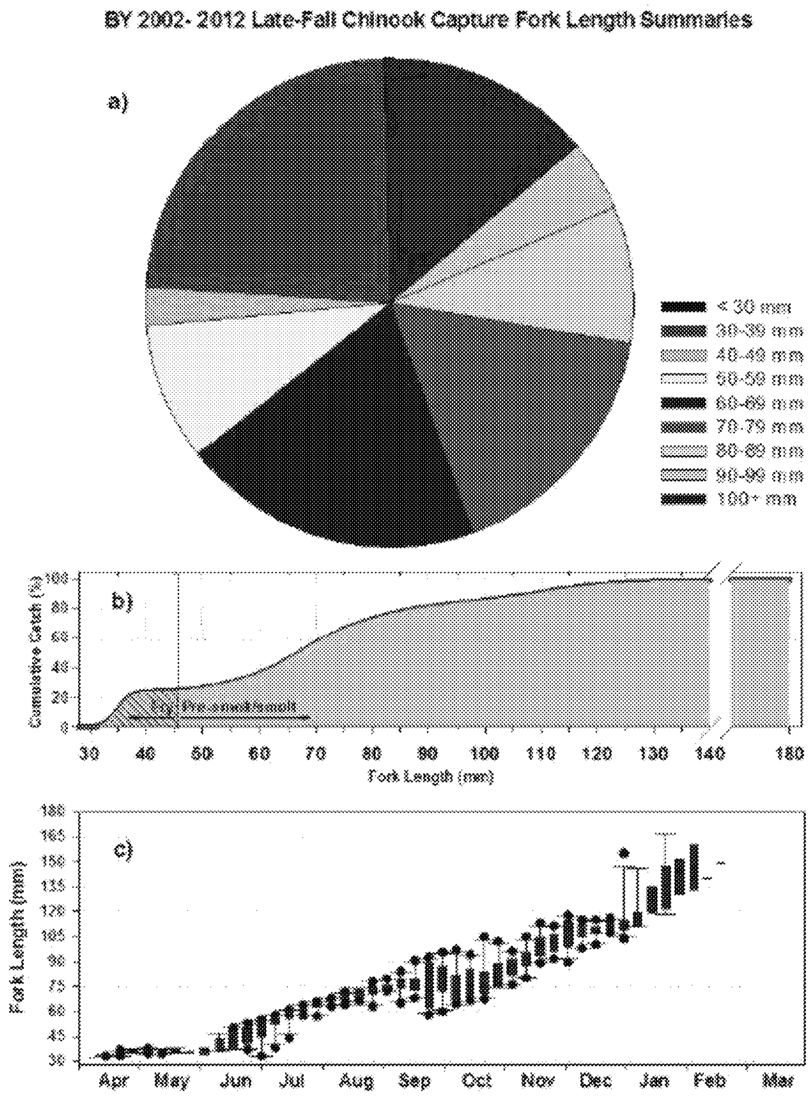
Fall-run/late fall–run Chinook salmon would have the potential for similar types of near-field effects to those previously discussed for winter-run Chinook salmon (i.e., entrainment; impingement and screen contact; predation; stranding behind screens; and attraction to the Sacramento River discharge [Alternative 2 only]). The potential for effect would differ relative to winter-run Chinook because of spatiotemporal differences in species occurrence. As discussed above, around 30–40% of fall/late fall–run Chinook salmon may pass the intakes (Table FRGrandTab). As discussed for winter-run, very few fall-run/late fall–run Chinook juveniles would have the potential for entrainment given their size (Figures length_FR and length_LFR). For late fall–run, the smallest individuals tend to pass the intakes beginning in spring, when there would be less difference in diversions between the NAA and Alternatives 1–3 (Tables RB% and HC%). The Red Bluff and Hamilton City fish screens are designed to protective standards for Chinook salmon fry and so near-field effects would be expected to be limited. There would be greater temporal overlap of adult fall-run Chinook with reservoir releases than for winter-run Chinook (see Appendix 11A). For example, earlier migrant adults (July/August) could encounter reservoir releases to the Sacramento River of several hundred cfs in critically dry years, with the main portion of the run (October/November) overlapping with generally lower releases (e.g., critical year means in October ranging from 80 cfs under Alternative 3 in October to just over 200 cfs under Alternative 1A; see Table Sites_SR in Chapter 5). Late fall-run Chinook salmon have peak migration somewhat later than fall-run, and thus have less potential to overlap reservoir releases (see Appendix 11A). As described for winter-run Chinook salmon, adult fall-run and late fall–run Chinook salmon could be attracted to the flow from the Sacramento River discharge under Alternative 2 and leap out of the river, but the apron and weir designed to exclude anadromous fish would eliminate stranding risk.

This Chapter is not yet edited. Provided for preliminary review and discussion.



Source: Poytress et al. (2014: 82). Note: BY = brood year.

Figure length_FR. Fall-Run Chinook Salmon Fork Length (a) Capture Proportions, (b) Cumulative Capture Size Curve, and (c) Average Weekly Median Boxplots, As Sampled at Red Bluff Diversion Dam Rotary Screw Traps, July 2002–June 2013.



Source: Poytress et al. (2014: 83). Note: BY = brood year.

Figure length_LFR. Late Fall-Run Chinook Salmon Fork Length (a) Capture Proportions, (b) Cumulative Capture Size Curve, and (c) Average Weekly Median Boxplots, As Sampled at Red Bluff Diversion Dam Rotary Screw Traps, July 2002–June 2013.

Far-Field Effects

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Sacramento River below Keswick, at Balls Ferry, at Bend Bridge, below RBDD, and at Butte City indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of fall-run/late fall–run Chinook salmon (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-5-1a to 6C-5-4c, Tables 6C-7-1a to 6C-7-4c, Tables 6C-9-1a to 6C-9-4c, Tables 6C-10-1a to 6C-10-4c , Tables 6C-12-1a to 6C-12-4c; Figures 6C-5-1 to 6C-5-18, Figures 6C-7-1 to 6C-7-18, Figures 6C-9-1 to 6C-9-1, Figures 6C-10-1 to 6C-10-18, Figures 6C-12-1 to 6C-12-18). At all locations, mean monthly water temperatures for all months in all water year types under Alt 1A and Alt 1B were within ±0.5°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at all locations.

Results of the analysis of exceedance above water temperature index values for fall-run Chinook salmon in the Sacramento River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X and summarized in Table 11-temp4. For each life stage and at all locations evaluated, there were no month and water year type combinations in which both: (1) the percent of days that exceeded the index values was more than 5% greater under the alternative than under the NAA, and (2) the exceedance per day was more than 0.5°F greater under the alternative than under the NAA. Results of the exceedance analysis for Alt 2 are similar to Alt 1 with no month and water year type combinations in which both criteria were met for any life stage at all locations. For Alt 3, there was one month and water year type combination (August of Critically Dry Water Years) in which both criteria met in a beneficial way (the percent of days that exceeded the index values was more than 5% lower under Alt 3 than under the NAA, and the exceedance per day was more than 0.5°F lower under Alt 3 than under the NAA) for the adult holding life stage at Balls Ferry and below RBDD.

Table 11-temp4. Number of month and water year type combinations that satisfy both criteria for being biologically meaningful in the water temperature index value analysis, Fall-run Chinook salmon, Sacramento River[1,2,3]

Location	Spawning and Egg Incubation	Juvenile Rearing and Emigration	Adult Immigration	Adult Holding
Below Keswick	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0
Below Clear Creek	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	N/A	N/A
Balls Ferry	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	N/A	Alt 1A, 1B, 2 – 0 Alt 3 - 1 beneficial (August, critical years)
Bend Bridge	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	N/A
Below Red Bluff Diversion Dam	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2 – 0 Alt 3 - 1 beneficial (August, critical years)
Hamilton City	N/A	Alt 1A, 1B, 2, 3 – 0	N/A	N/A

[1] Criteria include: (1) the difference in frequency of exceedance between NAA and the alternative was greater than 5%, and (2) the difference in average daily exceedance between NAA and the alternative was greater than 0.5°F.
[2] Index values for each life stage are located in Appendix 11B, *Fisheries Impact Assessment Methods*, Table 11.##.
[3] Full results presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X

Commented [CC85]: This is a long way downstream to see a beneficial temperature effect in a critical year, in August same as RBDD.

Commented [CC86R85]: Is this theoretical or would this be incorporated into the actual TMP for shasta operations?

Results of the analysis of exceedance above water temperature index values for late fall–run Chinook salmon in the Sacramento River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X and summarized in Table 11-temp5. For each life stage and at all locations evaluated, there were no month and water year type combinations in which both: (1) the percent of days that exceeded the index values was more than 5% greater under the alternative than under the NAA, and (2) the exceedance per day was more than 0.5°F greater under the alternative than under the NAA. Results of the exceedance analysis for Alt 2 are similar to Alt 1 with no month and water year type combinations in which both criteria were met for any life stage at all locations. For Alt 3, there was one month and water year type combination (July of Above Normal Water Years) at Hamilton City for the juvenile rearing and migration life stages in which there were 11.6% more days than the NAA exceeding the 64°F 7DADM index value and the mean daily exceedance on those days was 0.7°F greater than the NAA. There was also one month and water year type combination (August of Critically Dry Water Years) in which both criteria met in a beneficial way (the percent of days that exceeded the index values was more than 5% lower under Alt 3 than under the NAA, and the exceedance per day was more than 0.5°F lower under Alt 3 than under the NAA) for the juvenile rearing and emigration life stages at Balls Ferry and Bend Bridge.

Table 11-temp5. Number of month and water year type combinations that satisfy both criteria for being biologically meaningful in the water temperature index value analysis, Late fall-run Chinook salmon, Sacramento River[1,2,3]

Location	Spawning and Egg Incubation	Juvenile Rearing and Emigration	Adult Immigration
Below Keswick	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0
Below Clear Creek	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	N/A
Balls Ferry	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2 – 0 Alt 3 - 1 beneficial (August, Critical years)	N/A
Bend Bridge	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2 – 0 Alt 3 - 1 beneficial (August, Critical years)	Alt 1A, 1B, 2, 3 – 0
Below Red Bluff Diversion Dam	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0
Hamilton City	N/A	Alt 1A, 1B, 2 – 0 Alt 3 - 1 negative (July, Above normal years)	N/A

[1] Criteria include: (1) the difference in frequency of exceedance between NAA and the alternative was greater than 5%, and (2) the difference in average daily exceedance between NAA and the alternative was greater than 0.5°F.

[2] Index values for each life stage are located in Appendix 11B, *Fisheries Impact Assessment Methods*, Table 11.##.

[3] Full results presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X

Redd Scour Entombment

Loss of redds to scouring and entombment occurs when flows are high enough to mobilize sediments, destroying redds and their incubating eggs and alevins, or entombing the redds when sediments are redeposited. A flow of 40,000 cfs was selected as the scour flow threshold for the Sacramento River based on estimates in the literature (Table 11N-10).

The probability of redd scour and entombment was estimated for fall-run and late fall–run by computing the percentage of days with flows exceeding 40,000 cfs in the USRDOM 82-year daily flow record (29,952 days in total) at four locations between Keswick Dam and the RBDD during the months of fall-run and late fall–run spawning and incubation. The results for all alternatives (NAA and Alternatives 1–3) show that the probability of scour and entombment is consistently low for both runs, although somewhat higher for late fall–run than for fall-run (Table 11N-22 through Table 11N-25). The probabilities for both runs are higher than for winter-run and spring-run. Alternatives 1–3 have very little effect on the frequency of scouring and entombment flows and almost all differences result from a reduction in the probability of such flows. The results indicate that Alternatives 1–3 would have little effect on redd scour and entombment for fall-run and late fall–run in the Sacramento River.

Redd Dewatering

Fall-run. The percentage of redds in the Sacramento River lost to dewatering was estimated using tables in USFWS (2006) that relate spawning and dewatering flows to percent reductions in species-specific spawning habitat WUA (see Appendix 11-N). USRDOM flow data, which has a daily time-step, are available for three locations in this river section: Keswick Dam (RM 302), the Sacramento River at Clear Creek (RM 289), and the Sacramento River at Battle Creek (RM 271). A single relationship for flows was developed for the entire river section, but the flows used to estimate redd dewatering in the current analysis were those that best matched the longitudinal distribution of the redds of the different salmon runs in the river as estimated from aerial redd surveys conducted by CDFW from 2003 through 2019. Spawning of fall-run occurs primarily between Highway 44 and Jelly's Ferry (Table 11-1), so Sacramento River at Battle Creek flows were used to analyze fall-run redd dewatering.

Results are presented using the grand mean percentages of redds dewatered for each month of spawning, September and October, and each water year type and all water year types combined. The complete spawning and egg/alevin incubation periods are provided in the results (Table 11N-15) because changes in Project-related flow any time during these periods can affect the redd dewatering results. The means of the redd dewatering estimates under the NAA and Alternatives 1–3 are compared using absolute differences rather than relative differences (percent change) because many of the values for percentages of redds dewatered are small. Expressing changes of small values as percent changes may result in very large values that may be misleading.

Commented [CC87]: Please, clarify what this statement is trying to convey.

The results of the redd dewatering analysis for fall-run (Table 11N-15) show moderate (>2%) increases in redd dewatering for eggs spawned in September of Above Normal Water Years under Alternatives 1B and 3, and for eggs spawned in October of Critically Dry Water Years under Alternatives 1A and 2. Most other changes for all months and water year types under all the alternatives are less than 1%. The results indicate that Alternatives 1–3 would result in minor increases in fall-run redd dewatering during Above Normal and Critically Dry Water Years.

Commented [CC88]: How? Would these be below Sites intakes? How would Sites be diverting in September when there are generally no flow events?

Late Fall–run. Spawning of late fall–run occurs primarily between Keswick Dam and the confluence with Clear Creek (Table 11N-1), so Keswick Dam flows were used to analyze late fall–run redd dewatering. Results are presented using the grand mean percentages of redds dewatered for each month of late fall–run spawning, December through March, and each water year type and all water year types combined.

The results show little effect from the alternatives, with no >2% differences from the NAA (Table 11N-16). Alternatives 1–3 are expected to have little effect on late fall–run redd dewatering.

Habitat Availability

The suitability of physical habitat for salmonid spawning is largely of function of the availability of clean, coarse gravel for constructing redds, favorable depths, and suitable flow velocities. The suitability of physical habitat for salmonid rearing is largely a function of water depth, flow velocity, and the availability and type of cover. Instream flow potentially affects all these habitat characteristics, and often affects the availability of suitable habitat. Habitat suitability for spawning and rearing were analyzed using weighted usable area (WUA) curves developed by USFWS and others from results of field studies and hydraulic modeling (see Appendix 11K).

Spawning Habitat Weighted Usable Area

Fall-run. Spawning habitat WUA for fall-run Chinook salmon in the Sacramento River was determined by U.S. Fish and Wildlife Service (2003a, 2006) in the same manner that it was determined for winter-run Chinook salmon (Appendix 11K). To evaluate the effects of Alternatives 1–3 on fall-run spawning habitat, fall-run spawning WUA was estimated for flows during the September through January spawning and incubation period under the NAA and Alternatives 1–3 in the same three segments of the Sacramento River that were used for winter-run and spring-run Chinook salmon. However, because fall-run spawning occurs further downstream than spawning of the other runs, fall-run spawning WUA was estimated for an additional downstream segment (Segment 3) (Figure 11-1; Table 11-1).

Mean spawning WUA for fall-run under Alternatives 1–3 differs by more than 5% from the NAA mean for several months and water year types in Segments 6 and 4 (Table 11K-8 and Table 11K-10), but for Segments 5 and 3 they differ only under Alternative 3 in September of Above Normal Water Years (Table 11K-9 and Table 11K-11). All >5% changes in WUA are reductions and none are greater than 10%. Eight of the 12 reductions in means that are >5% occur under Alternative 3. Except in Segment 6, reductions of WUA of all sizes (including <5%) are about twice as numerous as increases of all sizes, which suggests that conditions under Alternatives 1–3 in Segments 5, 4, and 3 generally promote some reduction of fall-run spawning WUA, although most of the reductions are small. These results indicate that Alternatives 1–3 would result in frequent minor reductions in spawning habitat WUA for fall-run, and occasional somewhat greater reductions, primarily for Alternative 3.

Commented [CC89]: This looks like a significant reduction in fall run spawning habitat

Late Fall–run. Spawning habitat WUA for late fall–run Chinook salmon was determined by U.S. Fish and Wildlife Service (2003a, 2006) in the same manner that it was determined for winter-run and fall-run Chinook salmon. To evaluate the effects of Alternatives 1–3 on late fall–run spawning habitat, late fall–run spawning WUA was computed for flows during the December through June spawning and incubation period under Alternatives 1–3 and the NAA in all three segments of the Sacramento River that were used for the other runs, but not Segment 3, which was used for the fall-run effects analysis only. About 90% of late fall–run redds occur in the three upstream segments, and 68% are found in Segment 6 (Table 11-1).

Mean spawning WUA for late fall–run under Alternative 1–3 differs by greater than 5% from the NAA mean for several months and water year types. Increases in WUA >5% are more frequent than reductions >5%, with increases occurring during late spring to early summer (May and

June) and decreases occurring during winter (December and February). All the reductions and most of the increases are for Alternative 3, including increases slightly greater than 10% during June of Above Normal and Below Normal Water Years in Segment 5. The results indicate that Alternatives 1 and 2 would have little effect on late fall–run spawning WUA and Alternative 3 would have moderate, primarily beneficial, effects.

Commented [CC90]: Generally late fall run are not spawning at this time.

Rearing Habitat Weighted Usable Area

Fall-run. Rearing habitat WUA for fall-run fry and juveniles was determined by USFWS (2005b) in the same manner that it was determined for winter-run. To estimate changes in rearing WUA that would result from Alternatives 1–3, the fall-run WUA curves developed for each of the three river segments (Figure 11-1) were used with mean monthly CALSIM II flow estimates for corresponding river segments under Alternatives 1–3 and the NAA during the rearing periods for fry (December through March) and juveniles (February through June).

Commented [CC91]: We need to examine the lows which can bottleneck the overall population.

All the means for fry rearing WUA differ by less than 5% between Alternatives 1–3 and the NAA in all three river segments (Table 11K-35 through Table 11K-37). For juvenile rearing WUA, several of the means under Alternatives 1–3 are >5% larger than the means under the NAA (Table 11K-38 though Table 11K-40). This is particularly true for Alternatives 3 and 1B in Segment 4. All the >5% differences in means in all three segments consist of increases from the NAA to Alternatives 1–3. Some of the increases in Segment 4 are large, ranging up to 16% for June of Alternative 3. In May of Critically Dry Water Years, the means under Alternatives 1–3 were 13% to 14% higher than the NAA means. The increases in all three segments occur in May and/or June. The results for fall-run rearing WUA indicate only minor effects on fry rearing WUA and minor effects or moderate benefits on juvenile rearing habitat, especially under Alternatives 1B and 3 in Segment 4.

Late Fall-run. Rearing habitat WUA for late fall–run Chinook salmon fry and juveniles was determined by USFWS (2005a) in the same manner that it was determined for winter-run and fall-run Chinook salmon. To estimate changes in rearing WUA that would result from Alternatives 1–3, the late fall–run Chinook salmon WUA curves developed for each of the three river segments was used with mean monthly CALSIM II flow estimates for corresponding river segments under Alternatives 1–3 and the NAA during the rearing periods for late fall–run fry (March through June) and juveniles (May through October).

All differences between the Alternative 1-3 and NAA means for late fall–run fry rearing WUA that are >5% result from increases in rearing WUA. Segment 6 has seven >5% increases in the means (Table 11K-41), Segment 5 has four (Table 11K-42), and Segment 4 has one (Table 11K-43). In Segments 6 and 5, means increased >5% under Alternatives 1–3 in May of critically dry years. These results indicate that Alternatives 1–3 would have only minor effects or moderate benefits to late fall–run fry rearing habitat, depending on month and water year type.

Late fall–run juvenile rearing WUA is similar or up to 7% higher under Alternatives 1–3 than under the NAA in Segments 6 and 5 (Table 11K-44 and Table 11K-45), with all increases occurring under Alternative 3. There are many more substantial differences in juvenile rearing WUA between Alternatives 1–3 and the NAA in Segment 4 (Table 11K-46). All but two of the 18 means that differ from the NAA mean by more than 5% are increases, but one of the two reductions in WUA (September of above normal years under Alternative 3) is especially large (about 16%). Seven of the increases in rearing WUA are greater than 10%. The 16 large (>5%) increases in juvenile rearing WUA occur in the spring and summer months, especially in May and June (Table 11K-46). The results for juvenile rearing WUA indicate largely minor differences between Alternatives 1–3 and the NAA for Segments 6 and 5, but substantial differences for Segment 4. The segment would generally result in increased juvenile rearing habitat under Alternatives 1B and 3 during spring and summer, but some reduction in habitat during September of Above Normal Water Years. Alternative 3 would result in the greatest differences.

Juvenile Stranding

Fall-run. The juvenile stranding estimation procedure for the Sacramento River computes the surface area of salmonid rearing habitat inundated at an initial flow that is dewatered at a subsequent minimum (stranding) flow, and then converts this area to number of stranded juveniles using estimates of habitat capacity based on field study observations (USFWS 2006). A period of three months is used for the juvenile stranding analysis in this report because the juveniles are presumed to be most vulnerable to stranding during their first three months after emerging from the redds (i.e., fry stage).

Juvenile stranding is computed using USRDOM daily flow estimates for Alternatives 1–3 and the NAA at three locations in the upper Sacramento River: Keswick Dam, Clear Creek, and Battle Creek. Separate tables for converting initial and stranding flows to number of juveniles stranded were developed for periods when the ACID Dam boards are in and when they are out (Table 11N-11 and Table 11N-12). Both tables are used for all the salmonid species and races.

The results are presented using the grand mean number of juveniles stranded for each month of emergence under each water year type and all water year types combined (Table 11N-28 through Table 11N-30). The analysis assumes that under equal flow conditions the fry and early juvenile stage of all runs and species are equally vulnerable to stranding. To determine the results for a given species or run, the estimated months for which the fry typically emerge (Table 11N-27), are consulted in the tables of results. The effects of dewatering flows are tracked by the analysis from the month of emergence through the three months (90 days) following. These periods are given in the tables.

All three river locations show the greatest differences between Alternatives 1–3 and the NAA for the cohorts of fry that emerged during the months of April, May, June, and July (Table 11N-28 through Table 11N-30). The May cohort generally shows the largest differences, and all the May differences are reductions in juvenile stranding, with the largest reduction, 55%, occurring at the Battle Creek location under Alternative 1B in May of Critically Dry Water Years. The largest increases in juvenile stranding occur for the April cohort at all three locations, ranging as high as

30% in dry years under Alternatives 1A, 1B and 2 at the Keswick Dam location. The principal period of stranding vulnerability for fall-run is for cohorts emerging in December through March. Few large changes in stranding are expected during this period and Alternatives 1–3 are not expected to affect fall-run juvenile stranding (Table N11-28 through Table 11N-30).

Late fall-run. The principal period of stranding vulnerability for late fall–run is for fry cohorts emerging in March through June. The late fall–run fry cohorts emerging in April, May and June are likely to be affected by the large spring and summer changes in stranding under Alternatives 1–3. Although large increases and reductions in juvenile stranding are predicted for this period at all three locations, the large reductions are more frequent and larger, on average, than the increases, so Alternatives 1–3 are expected, on balance, to have no adverse effect on late fall–run juvenile stranding (Table N11-28 through Table 11N-30).

SALMOD

In this section, SALMOD results for fall-run and late fall–run Chinook salmon are presented separately in their entirety.

The SALMOD model outputs for fall-run Chinook salmon are presented in Appendix 11H, *SALMOD,* Table 1c-1 through Table 1c-4, Table 2c-1 through Table 2c-4, and Figure B-c-1 through Figure B-c-19. For all water years combined for all life stages and source of mortality, mean annual fall-run Chinook salmon potential production would be similar under Alt 1A (0.1% greater) and Alt 1B (0.1% greater) relative to the NAA (Appendix 11H, *SALMOD,* Table 2c-1 and Table 2c-2, Figure B-c-1). Differences within each water year type in mean annual potential production between Alt 1A and the NAA and between Alt 1B and the NAA would be small (<1%). Alt 2 and Alt 3 results would be similar to those of Alt 1A and 1B (Appendix 11H, *SALMOD,* Table 2c-3, Table 2c-4, Figure B-c-1) in that differences in production relative to the NAA would be very small (generally <1%, except for 3.6% higher potential production in Above Normal Water Years under Alt 3 relative to the NAA).

Results by life stage and mortality source are reported in Appendix 11H, *SALMOD,* Table 1c-1 through Table 1c-4 and Figure B-c-8 through Figure B-c-19. Depending on the life stage and source of mortality (flow-/habitat-based or temperature-based), mean annual mortality under Alt 1A would be between 100% lower to 96% greater than that under the NAA and mortality under Alt 1B would be between 62% lower to 165% higher than that under the NAA (Appendix 11H, *SALMOD,* Table 1c-1, Table 1c-2). However, it is important to understand that the model is seeded with 56,115,000 fall-run eggs each year. Although there may be larger percent differences in mean annual mortality between an alternative and the NAA by source and life stage, these differences typically represent a very small proportion of overall individuals when put in a broader population-wide context. The largest raw difference in mean annual mortality would be in pre-spawn mortality between Alt 1B and the NAA in Above Normal Water Years. In this case, there would be a reduction in mean annual egg mortality of 25,004 eggs under Alt 1B relative to the NAA, accounting for just 1.7% of the 56,115,000 winter-run Chinook salmon eggs annually seeded into the model. Combining all sources of mortality and life stages together, mean annual mortality would be 1% lower under both Alt 1A and Alt 1B than the NAA for the full simulation period (all water year types combined). By water year type, mean annual mortality under Alt 1A would be between 3% lower (in Critically Dry Water Years) and 2% greater (in Below Normal Water Years) than the NAA. Mean annual mortality under Alt 1B would be between 5% lower (in Above Normal Water Years) and 2% greater (in Below Normal Water Years). Mean annual mortality results for Alt 2 and Alt 3 are generally similar to those of Alt 1A and Alt 1B (Appendix 11H, *SALMOD,* Table 1c-3, Table 1c-4). Combining all sources of mortality and life stages together, mean annual mortality under Alt 2 would be 0% different than under the NAA for the full simulation period (all water year types combined) and 2% lower to 3% higher than under the NAA depending on water year type. Mean annual mortality under Alt 3 would be 3% lower than under the NAA for the full simulation period (all water year types combined) and 17% lower to 2% higher than under the NAA depending on water year type.

Overall, SALMOD results for fall-run Chinook salmon show a minimal effect of Alt 1A, Alt 1B, Alt 2, and Alt 3 mortality and potential production in the Sacramento River.

The SALMOD model outputs for late fall–run Chinook salmon are presented in Appendix 11H, *SALMOD,* Table 1d-1 through Table 1d-4, Table 2d-1 through Table 2d-4, and Figure B-d-1 through Figure B-d-19. For all water years combined for all life stages and source of mortality, mean annual late fall–run Chinook salmon potential production would be similar (0.3% higher) under both Alt 1A and Alt 1B relative to the NAA (Appendix 11H, *SALMOD,* Table 2d-1 and Table 2d-2, Figure B-d-1). Differences within each water year type in mean annual potential production between Alt 1A and the NAA and between Alt 1B and the NAA would be small (<2%). Alt 2 and Alt 3 results would be similar to those of Alt 1A and 1B (Appendix 11H, *SALMOD,* Table 2d-3, Table 2d-4, Figure B-d-1) in that differences in production relative to the NAA would be <2%.

Results by life stage and mortality source are reported in Appendix 11H, *SALMOD,* Table 1b-1 through Table 1d-4 and Figure B-d-8 through Figure B-d-19. Depending on the life stage and source of mortality (flow-/habitat-based or temperature-based), mean mortality under Alt 1A would be between 47% lower to 233% greater than that under the NAA and mortality under Alt 1B would be between 61% lower to 240% higher than that under the NAA (Appendix 11H, *SALMOD,* Table 1d-1, Table 1d-2). However, it is important to understand that the model is seeded with 13,325,000 late fall–run eggs each year. Although there may be larger percent differences in mean mortality between an alternative and the NAA by source and life stage, these differences typically represent a very small proportion of overall individuals when put in a broader population-wide context. The largest raw difference in mean mortality would be in fry habitat-related mortality between Alt 1B and the NAA in Above Normal Water Years. In this case, there would be a reduction in mean annual egg mortality of 82,697 individuals under Alt 1B relative to the NAA, accounting for just 0.6% of the 13,325,000 late fall–run Chinook salmon eggs annually seeded into the model. Combining all sources of mortality and life stages together, mean annual mortality would be 0% different under both Alt 1A and Alt 1B than the NAA for the full simulation period (all water year types combined). By water year type, mean annual mortality under Alt 1A would be between 5% lower (in Wet Water Years) and 14% greater (in

Below Normal Water Years) than the NAA. Mean annual mortality under Alt 1B would be between 8% lower (in Wet Water Years) and 36% greater (in Below Normal Water Years). Mean annual mortality results for Alt 2 and Alt 3 are generally similar to those of Alt 1A and Alt 1B (Appendix 11H, *SALMOD,* Table 1d-3, Table 1d-4). Combining all sources of mortality and life stages together, mean annual mortality under Alt 2 would be 0% different than under the NAA for the full simulation period (all water year types combined) and 2% lower to 1% higher than under the NAA depending on water year type. Mean annual mortality under Alt 3 would be 0% different than under the NAA for the full simulation period (all water year types combined) and 3% lower to 1% higher than under the NAA depending on water year type.

Overall, SALMOD results for late fall–run Chinook salmon show a negligible effect of Alt 1A, Alt 1B, Alt 2, and Alt 3 and a minimal negative effect of on mortality and potential production in the Sacramento River.

Floodplain Inundation and Access

As described in Chapter 2 and as discussed for winter-run Chinook salmon, Fremont Weir notch protections are included in the diversion criteria to reduce changes to spill frequency and duration under Alternatives 1–3 relative to existing conditions. In particular, these criteria avoid impacts on Reclamation's ability to implement its obligations in the 2019 NMFS ROC on LTO Biological Opinion to implement the Yolo Bypass Restoration Salmonid Habitat Restoration and Fish Passage Implementation Plan and provide 17,000+ acres of inundation in the Yolo Bypass from December to April (NMFS 2019). As such, Alternatives 1–3 would have limited potential for negative effects to Yolo Bypass floodplain inundation and access for fall/late fall–run Chinook salmon. This was confirmed with the modeling summarized in the winter-run Chinook salmon section (see also Attachments 11M-1 and 11M-2 to Appendix 11M).

Migration Flow-Survival

As described in more detail for winter-run Chinook salmon, all alternatives include pulse flow protection measures to be applied to precipitation-generated pulse flow events from October through May. In addition and as described in more detail in Chapter 2, the alternatives would include a fish monitoring program capable of detecting a migratory response during the beginning of a precipitation-generated high flow event and continuing research would be utilized to operate to, and further refine the pulse flow protection strategy. The discussion in Appendix 11P, Section 2 *Flow Threshold Survival Analysis to Assess Potential Effects of Sites Reservoir Project Diversion Criteria Based on Historical Juvenile Chinook Salmon Monitoring Data* illustrates that the Sites diversion criteria generally minimize diversions during the historical periods of fish movement as reflected in Red Bluff rotary screw trap data, and application of the flow-threshold criteria from Michel et al. (2021) suggests that flow-survival effects on juvenile Chinook salmon (including fall-run and late fall–run Chinook salmon) would be greatly limited by the diversion criteria.

Sites Reservoir Release Effects

Sites Reservoir releases could temporally overlap with fall-run/late fall-run Chinook salmon presence near the release location in the Sacramento River. For fall-run, migrating adults would be present during July through December (Appendix 11A, Table 11A-6) and rearing or emigrating juveniles would be present during December through May (Figure FR_DJFMP). For late fall-run, migrating adults would be present during October and November and rearing or emigrating juveniles could be present during all months (Appendix 11A, Table 11A-7; Figure LFR_DJFMP).

Sites Reservoir releases into the Yolo Bypass via the CBD would not overlap with the juvenile fall-run Chinook salmon rearing and emigration during August through October (Figure FR_DJFMP). Releases into the Yolo Bypass would overlap with the adult late-fall-run Chinook salmon migration period during October and the juvenile rearing and emigration period during August through October (Appendix 11A, Table 11A-7; Figure LFR_DJFMP).

In contrast to the other runs of Chinook salmon, the adult fall-run Chinook salmon upstream migration period (see Appendix 11A) coincides with increased Yolo Bypass flows in August–October as a result of reservoir releases under Alternatives 1–3 (see Appendix 5B3: Tables 5B3-3-1a through 5B3-3-4c). Johnston et al. (2020) found that the median probability of acoustically tagged adult fall-run Chinook salmon existing the Yolo Bypass after entering it was 0.74, indicating that nearly a quarter of fish entering the Toe Drain may not leave. Johnston et al. (2020) suggested that Chinook salmon adults may be drawn into the Yolo Bypass Toe Drain by the higher flows in the Cache Slough Complex relative to those in the Sacramento River; however, Alternatives 1–3 would not affect this potential mechanism. Sommer et al. (2014) did not find adult Chinook salmon catch in a fyke trap in the Toe Drain was associated with Yolo Bypass flow events, noting this may have been because most of the Chinook salmon were fall-run, a race known to migrate upstream relatively early before winter and spring flow events. Acoustic telemetry investigations in 2015–2017 found that adult Chinook salmon strongly responded to tidal switches, but these studies did not provide information on effects of the summer/fall managed flow releases, such as whether flows attract more fish into the Yolo Bypass (Singer and Frantzich 2019). Fall-run Chinook salmon entering the Toe Drain may eventually reach the Wallace Weir, where fish rescue and relocation to the Sacramento River by CDFW occurs, either at the recently completed Wallace Weir Fish Rescue Facility or by beach seine in the vicinity of the Wallace Weir. Several tens or hundreds of adult Chinook salmon were captured and relocated to the Sacramento River in 2018 and 2019 during August–October, periods including managed flow actions resulting in greater flow entering the Toe Drain (Table toedrain1). In 2019, eight of 340 Chinook salmon rescued from Wallace Weir died, a mortality rate of 2.3% (Davis et al. 2019). This rate of rescue and mortality is very low compared the overall ESU size, which numbers in the tens of thousands of fish or greater (see Table FR_LFR_GrandTab). Under the assumption that the increased rate of Chinook salmon occurrence at Wallace Weir is solely a function of the managed flow releases, which is uncertain, then this indicates that Sites Reservoir releases to the CBD and thence the Toe Drain under Alternatives 1–3 would result in only very low ESU-level effects on fall-run Chinook salmon.

Commented [C92]: This is going to lead to false attraction and straying which will need to be monitored as it is likely to lead to significant impacts.

Commented [CC93]: Has there been any thought to shifting these proposed flows back one month from Aug-Oct to Jul-Sep (as suggested in the 2016-18 NDFA Report) in an effort to avoid peak fall-run Chinook salmon upstream migration in October. Doing so would still also avoid peak spring-run Chinook upstream migration from May-Jun. The major drawback is that spring-run still have potential to be in the system in July.

Commented [CC94]: Correction: exiting.

Commented [CC95]: Johnston et al. (2020) notes that "Chinook Salmon may be fully capable of exiting unsuitable habitat if they receive signals along the migratory corridor that conditions are impassable or unsuitable for spawning, but that these signals were unavailable as a consequence of this system's altered hydrology." Regression analysis from the 2016 and 2018 NDFA also indicated that the further upstream salmon traveled, the more likely they were to get stranded in the Yolo Bypass. Further altering the system's hydrology by providing consistent flows through the Yolo Bypass over a three-month period will likely compound the problem of straying as the increased flows provide false cues to salmon about the suitability of the Yolo Bypass as a migration corridor, thus making it more likely for salmon to go further up the Yolo Bypass and ultimately more likely to become stranded.

Commented [CC96]: Looking only at the rate of rescue and mortality does not capture the true effects of straying into the Yolo Bypass for Chinook salmon populations. For example, although only 8 out of 340 rescued Chinook salmon died in 2019, how many of the "rescued" fish were subsequently able to successfully spawn in the Sacramento River? Migratory delays coupled with potentially poor water quality conditions in the Bypass may result in a wide range of sub-lethal impacts (e.g., disease, reproductive failure, increased egg mortality, etc.) that will ultimately impact reproductive success.

Commented [SB97R96]: There is really no uncertainty regarding the flow actions effect on salmonids reaching Wallace Weir, because without the flow action those fish would not be able to pass Agricultural Road Crossing at Swanston Ranch. Furthermore, it was never, and still isnt, the objective of increasing reliance of Wallace Weir for fish rescue purposes. On the contrary. The "rate of rescue" comparison to the run size is completely off the mark.

Commented [C98]: It is important to look to the future when considering the impacts of the Sites project. Conditions for fall-run Chinook continue to worsen, which likely will be further exacerbated by the effects of climate change. Over time this will put increased pressure on the population, particularly the wild spawning population. Thus, it is important to take seriously and not down play this potential project impact, as it may be more detrimental in the years to come. Additionally, Sites' proposed deliveries provide far more water on average than previous ...

Commented [C99]: These effects to fall-run Chinook still need to be weighed against the proposed Yolo Bypass Habitat benefit, which remains uncertain. Currently, evidence exists to indicate that increased flows through the Yolo Bypass may be detrimentally affecting fall-run Chinook, while there is no evidence to indicate that managed flow events are improving habitat conditions for Delta Smelt.

Table toedrain1. Number of Unmarked and Marked Chinook Salmon Collected at Wallace Weir, in Relation to Fish Trap Capture Effort (Hours).

Year	Month	Hours fished	Unmarked Salmon	Marked Salmon
2014	8	0	0	0
2014	9	332.5	0	0
2014	10	564.5	10	5
2015	8	0	0	0
2015	9	0	0	0
2015	10	93.75	0	0
2016	8	0	0	0
2016	9	0	0	0
2016	10	0	0	0
2017	8	0	0	0
2017	9	23	0	0
2017	10	277.75	0	0
2018	8	93.5	0	0
2018	9	288.25	68	5
2018	10	0	3	0
2019	8	85.25	0	0
2019	9	457.5	135	17
2019	10	22.25	176	12
2020	8	0	0	0
2020	9	0	0	0
2020	10	736.5	0	0

Source: Purdy and Kubo (2021). Note: 2019 collection of salmon included individuals collected by beach seining near Wallace Weir in addition to the Wallace Weir trap.

Temperature Effects

As discussed in Chapter 6, *Surface Water Quality*, the effect of Alternatives 1A, 1B, 2, and 3 on water temperatures at the Sites Reservoir release site in the Sacramento River would be relatively small with the releases generally tending to cause a slight reduction in water temperature (Tables 6-12a through 6-12d). Temperature-related effects of Alternatives 1A, 1B, 2, and 3 on fall-run/late fall-run Chinook salmon at the release site would be minimal.

All changes in water temperature in the Yolo Bypass due to Sites Reservoir releases via the CBD would be zero or negative for Alternatives 1A, 1B, 2, and 3 (Table CBD_temp). These lower water temperatures are expected to have a negligible, and possibly marginally beneficial, effect on adult fall-run and late fall-run Chinook salmon in the Yolo Bypass and would have no lethal effects on juvenile late fall-run Chinook salmon. Lower temperatures could reduce the growth of juveniles somewhat due to reduced metabolism. However, the small reduction in water

Commented [C100]: Please, see CDFW's chapter 6 comments, regarding temperature effects in the Yolo Bypass.

Commented [C101]: Assuming that Sites' deliveries lower water temperatures, if these temperatures occur in the limited upper area of the bypass, they are unlikely to provide any benefit. The flows provided by the project have the potential to attract fish into the Yolo Bypass, where they are not supposed to be, and where they may experience elevated temperatures and other conditions that reduce their chances of survival. This is especially the case in critically dry years, when conditions in the Yolo Bypass are particularly bad, but when the project would still potentially be delivering sufficient volumes of water to attract fish.

temperatures is expected to occur in a limited area of the Yolo Bypass before it equilibrates with atmospheric temperatures. As a result, temperature effects in the Yolo Bypass due to Sites Reservoir releases under Alternatives 1A, 1B, 2, and 3 would be minimal at a population level for fall-run/late fall-run Chinook salmon.

As discussed in Impact Fish-2, temperature changes under Alternatives 1A, 1B, 2, and 3 due to Sites Reservoir releases in the Sacramento River below the Yolo Bypass, and the effects to fall-run/late fall-run Chinook salmon, would be minimal due to the small proportion of Sacramento River water in this reach coming off the Yolo Bypass.

Feather River

Far-Field Effects

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Feather River LFC below the Fish Barrier Dam and in the HFC at Gridley Bridge indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of fall-run Chinook salmon (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-16-1a to 6C-16-4c, Tables6C-18-1a to 6C-18-4c; Figures 6C-16-1 to 6C-16-18, Figures 6C-18-1 to 6C-18-18). At both locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±1°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at both locations.

Results of the analysis of exceedance above water temperature index values for fall-run Chinook salmon in the Feather River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X and summarized in Table 11-temp6. For each life stage and at both locations evaluated, there were no month and water year type combinations in which both: (1) the percent of months that exceeded the index values was more than 5% greater under the alternative than under the NAA, and (2) the exceedance per month was more than 0.5°F greater under the alternative than under the NAA. Results of the exceedance analysis for Alt 2 and Alt 3 are similar to Alt 1 with no month and water year type combinations in which both criteria were met for any life stage at both locations.

Table 11-temp6. Number of month and water year type combinations that satisfy both criteria for being biologically meaningful in the water temperature index value analysis, Spring-run Chinook salmon, Feather River[1,2,3]

Location	Spawning and Egg Incubation	Juvenile Rearing and Migration	Adult Immigration	Adult Holding
Low Flow Channel Below Fish Barrier Dam	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0
High Flow Channel Below Thermalito Afterbay outlet	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0

[1] These include: (1) the difference in frequency of exceedance between NAA and the alternative was greater than 5%, and (2) the difference in average monthly exceedance between NAA and the alternative was greater than 0.5°F.
[2] Index values for each life stage are located in Appendix 11B, Fisheries Impact Assessment Methods, Table 11.##.
[3] Full results presented in Appendix 11D, Fisheries Water Temperature Assessment, Table X through Table X

The probability that each alternative would meet water temperature targets to support anadromous fish, including fall-run Chinook salmon, in the Feather River included the Settlement Agreement for Licensing of the Oroville Facilities (DWR 2006, pp. A-18 to A-24) was described in Impact FISH-3 above.

Redd Scour and Entrainment

Frequency of scouring flows was not estimated for the Feather River because information on minimum flows required to mobilize sediments is not available for the Feather River.

Redd Dewatering

No redd dewatering field data similar to that used for the Sacramento River or American River (see Appendix 11K) are available for salmon or steelhead in the Feather River. The reduction in flow from the spawning to the dewatering flow was used directly as a proxy for redd dewatering. Redd dewatering was evaluated only for the High Flow Channel (HFC) of the river (downstream of Thermalito Afterbay Outlet) because none of the Project alternatives affects flow in the Low Flow Channel (LFC). The spawning and dewatering flows downstream of the Thermalito Afterbay outlet for each month of fall-run spawning, as estimated by CALSIM II, were used to compute the reduction in flow under Alternatives 1–3 and the NAA. Larger reductions are assumed to increase the percent of redds dewatered and to have a potentially negative effect on the species' populations. The use of monthly time-step flow estimates like those obtained from CALSIM II modeling likely underestimates redd dewatering rates. This potential bias is expected to equally affect the NAA and Alternatives.

The results for the Feather River fall-run spawning and incubation period (October through February) show large reductions in Feather River flow for Alternatives 1–3 following October through November spawning (Table 11N-18). These reductions potentially result in high levels of redd dewatering for fall-run spawning in the HFC. The reductions are especially large in October, when the majority of the mean reductions under Alternatives 1–3 are more than 200 cfs greater than those under the NAA. The greatest reductions are in Dry Water Years. These results indicate that Alternatives 1–3 would potentially increase fall-run redd dewatering in the Feather River. However, most spawning of Feather River salmonids occurs in the LFC (Figure 11N-1), so the expected increased redd dewatering in the HFC is not expected to affect the Feather River fall-run population. Late fall–run do not spawn in the Feather River.

Habitat Availability

Spawning Habitat Weighted Usable Area

Spring-run and fall-run are often difficult to distinguish in the Feather River, so a single WUA curve was developed for both runs (Payne and Allen 2004) (Figure 11K-7). The curve was used to compute spawning WUA with flows specific to the months of spawning and incubation for the run analyzed. To evaluate the effects of Alternatives 1–3 on fall-run spawning habitat in the Feather River, the spawning WUA was estimated under Alternatives 1–3 and the NAA for CALSIM II flows below Thermalito Afterbay during October through December, the Feather River fall-run spawning and incubation period. Differences in spawning WUA between Alternatives 1–3 and the NAA were examined using the grand mean spawning WUA for each month of the spawning period under each water year type and all water year types combined (Table 11K-18 and Table 11K-19). In the tables of results, means that differed by >5% were highlighted in red for reductions or green for increases to flag the largest differences.

The only differences >5% between Alternatives 1–3 and the NAA means were 6% to 7% reductions in October of Below Normal Water Years under Alternatives 1A, 1B, and 2, but not under Alternative 3. These results suggest that Alternatives 1–3 have mostly minor effects on fall-run spawning WUA in the Feather River.

Rearing Habitat Weighted Usable Area

No valid rearing habitat WUA curves are available for the Feather River (see Appendix 11K, *Methods*).

Juvenile Stranding

No formal method for analyzing juvenile stranding analysis has been developed for the Feather River.

American River

Far-Field Effects

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the American River below Nimbus Dam and Watt Avenue indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of fall-run Chinook salmon (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-13-1a to 6C-13-4c, Tables 6C-14-1a to 6C-14-4c; Figures 6C-13-1 to 6C-13-18, Figures 6C-14-1 to 6C-14-18). At both locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±0.5°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at both locations.

Results of the analysis of exceedance above water temperature index values for fall-run Chinook salmon in the American River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X and summarized in Table 11-temp7. For each life stage and at both locations evaluated, there were no month and water year type combinations in which both: (1) the percent of days that exceeded the index values was more than 5% greater under the alternative than under the NAA, and (2) the exceedance per day was more than 0.5°F greater under the alternative than under the NAA. Results of the exceedance analysis for Alt 2 and Alt 3 are similar to Alt 1 with no month and water year type combinations in which both criteria were met for any life stage at both locations.

Table 11-temp7. Number of month and water year type combinations that satisfy both criteria for being biologically meaningful in the water temperature index value analysis, Fall-run Chinook salmon, American River[1,2,3]

Location	Spawning and Egg Incubation	Juvenile Rearing and Emigration	Adult Immigration	Adult Holding
Hazel Ave.	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0
Watt Ave.	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0

[1] Criteria include: (1) the difference in frequency of exceedance between NAA and the alternative was greater than 5%, and (2) the difference in average daily exceedance between NAA and the alternative was greater than 0.5°F.
[2] Index values for each life stage are located in Appendix 11B, *Fisheries Impact Assessment Methods*, Table 11.##.
[3] Full results presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X

Redd Scour and Entombment

Loss of redds to scouring or entombment occurs when flows are high enough to mobilize sediments, destroying redds and their incubating eggs and alevins, or entombing the redds when sediments are redeposited. A flow of 40,000 cfs was selected as the scour flow threshold for the Sacramento River based on estimates in the literature (Table 11N-10).

Only CALSIM II monthly flow estimates were available for estimating flows in the American River under Alternatives 1–3 and the NAA. Redd scour can occur at a very small temporal scale (minutes to hours). This limitation was addressed using historical American River gauge data to determine the minimum monthly flow for which at least one daily flow of the month exceeded 40,000 cfs (Appendix 11N, Section 2, *Methods*). The minimum monthly flow was 19,530 cfs, so this flow was used as the threshold scouring flow with CALSIM II data in American River at Nimbus Dam (Figure 11N-2).

The results indicate that there are very few months in the 82-year CALSIM II record for the American River with flow greater than the redd scour or entombment threshold of 19,350 cfs (Table 11N-26). There are only two months with such flows under the NAA and Alternatives 1 and 2, and there are three such months for Alternative 3. These results indicate that Alternatives 1–3 would have little or no effect on redd scour or entombment for fall-run in the American River.

Redd Dewatering

The redd dewatering analysis for the lower American River uses relationships between flow, river stage, and redd depth distribution developed by Bratovich et al. (2017). CALSIM II flow estimates at the Nimbus Dam location were used to compute stage at the spawning and dewatering flows, and the redd depth frequency distribution was queried to determine the percentage of the redds that occur between those two stages and would be dewatered. The analyses were conducted for the months of fall-run spawning and incubation. The analysis compared CALSIM II flow estimates below Nimbus Dam for each spawning month with the minimum flow during the three months following the spawning month to estimate the percentage of redds dewatered. The use of monthly time-step flow estimates like those obtained from CALSIM II modeling likely underestimates redd dewatering rates. This potential bias is expected to affect all Project scenarios equally. The means of the redd dewatering estimates under the NAA and Alternatives 1–3 are compared using absolute differences rather than relative differences (percent change) because many of the values for percentages of redds dewatered are small. Expressing changes of small values as percent changes may result in very large values that may be misleading.

The results (Table 11N-20) show increases in redd dewatering under all the alternatives for eggs spawned in October of Dry and/or Critically Dry Water Years and November of all water year types except Wet Water Years. The largest increases are in November, including increases of 5% and 6% for Critically Dry and Above Normal Water Years, respectively, under Alternative 3. Alternatives 1–3 are predicted to moderately increase fall-run redd dewatering in the American River.

Habitat Availability

Spawning Habitat Weighted Usable Area

The WUA curve used for fall-run Chinook salmon spawning habitat in the American River (Figure 11K-9) was produced using data obtained from Bratovich et al. (2107), which provides composite spawning WUA tables for fall-run and steelhead downstream of Nimbus Dam.

To evaluate the effects of Alternatives 1–3 on fall-run spawning habitat in the American River, fall-run spawning WUA was estimated for CALSIM II flows at Nimbus Dam under the NAA and Alternatives 1–3 during the October through February spawning and incubation period using the composite fall-run spawning WUA curve (Figure 11K-9).

Differences in fall-run spawning WUA between Alternatives 1–3 and the NAA were examined using the grand mean spawning WUA for each month of the spawning period under each water year type and all water year types combined (Table 11K-21). In the tables of results, means that differed by >5% were highlighted in red for reductions or green for increases to flag the largest differences. The only difference in means >5% was a 7% reduction under Alternative 3 for November of Above Normal Water Years. These results indicate that Alternatives 1–3 would have only minor effects on fall-run spawning WUA in the American River.

Rearing Habitat Weighted Usable Area

Rearing habitat WUA curves are not available for the American River (see Appendix 11K, *Methods*).

Juvenile Stranding

A formal method for analyzing juvenile stranding analysis has not been developed for the American River.

Delta

Juvenile Through-Delta Survival

The potential for negative effects to juvenile Chinook salmon through-Delta survival, as assessed by the spreadsheet implementation of the through-Delta survival function formulated by Perry et al. (2018; see further discussion for winter-run Chinook salmon), found that during the main period of juvenile fall-run Chinook salmon occurrence in the Delta (i.e., January–May; see Table 11A-6 in Appendix 11A), there was little difference (0–2%) in mean through-Delta survival between Alternatives 1–3 and the NAA (see Table perry1 in winter-run analysis). Likewise, for juvenile late fall–run Chinook salmon, there was little difference between alternatives during the main period of occurrence (i.e., November–May; see Table 11A-7 in Appendix 11A).

As described for winter-run Chinook salmon, note that the spreadsheet implementation of the Perry et al. (2018) model does not account for the variability in coefficient estimates (Figure 6 of Perry et al. 2018), which would likely give appreciable overlap of estimates in through-Delta survival between the NAA and the alternative scenarios, particularly in relation to the relatively small differences between scenarios.

Juvenile Rearing Habitat

As discussed in more detail for winter-run Chinook salmon, available information from previous analyses of analogous flow-related impacts suggests that the alternatives would not significantly change rearing habitat for juvenile fall-run/late fall–run Chinook salmon.

South Delta Entrainment

There would be little difference in indicators of entrainment risk (south Delta exports and Old and Middle River flows) during winter/spring between the NAA and Alternatives 1–3 (see Appendix 5B3: Tables 5B3-6-1a through 5B3-6-4c; Figures 5B3-6-1 through 5B3-6-18; and Appendix 5B4: Tables 5B4-1-1a through 5B4-1-4c; Figures 5B4-1-1 through 5B4-1-18), and existing restrictive criteria from the NMFS (2019) SWP/CVP BiOp and CDFW (2020) SWP ITP focused on listed Chinook also would serve to limit entrainment risk for fall-run/late fall–run Chinook under all alternatives. South Delta export of water released from Sites Reservoir would have relatively little overlap with fall-run/late fall–run Chinook salmon. This is illustrated by the results of the salvage-density analysis (see description in Appendix 11Q for which there generally were minimal differences between NAA and the alternatives (Table fr_banks; Table fr_jones; Table lfr_banks; Table lfr_jones).

Table fr_banks. Entrainment Loss of Juvenile Fall-Run Chinook Salmon At SWP Banks Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	22,229	22,181 (0%)	22,181 (0%)	22,180 (0%)	21,860 (-2%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	4,012	4,006 (0%)	4,000 (0%)	4,008 (0%)	3,903 (-3%)
Dry	3,295	3,322 (1%)	3,270 (-1%)	3,322 (1%)	3,394 (3%)
Critically Dry	2,748	2,798 (2%)	2,801 (2%)	2,797 (2%)	2,798 (2%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any Above Normal Water Years, hence that row of the table is noted as 'NA'.

Table fr_jones. Entrainment Loss of Juvenile Fall-Run Chinook Salmon At CVP Jones Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	9,060	9,061 (0%)	9,061 (0%)	9,061 (0%)	9,055 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	2,715	2,699 (-1%)	2,723 (0%)	2,699 (-1%)	2,767 (2%)
Dry	3,906	3,871 (-1%)	3,900 (0%)	3,871 (-1%)	3,958 (1%)
Critically Dry	149	149 (0%)	149 (0%)	149 (0%)	150 (1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any Above Normal Water Years, hence that row of the table is noted as 'NA'.

Table lfr_banks. Entrainment Loss of Juvenile Late Fall-Run Chinook Salmon At SWP Banks Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	1,704	1,703 (0%)	1,712 (1%)	1,703 (0%)	1,712 (1%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	470	466 (-1%)	467 (-1%)	466 (-1%)	469 (0%)
Dry	1,028	1,041 (1%)	914 (-11%)	1,042 (1%)	1,170 (14%)
Critically Dry	962	989 (3%)	995 (3%)	985 (2%)	986 (3%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any Above Normal Water Years, hence that row of the table is noted as 'NA'.

Table lfr_jones. Entrainment Loss of Juvenile Late Fall-Run Chinook Salmon At CVP Jones Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	288	288 (0%)	288 (0%)	288 (0%)	288 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	75	76 (0%)	75 (0%)	76 (1%)	75 (0%)
Dry	94	98 (4%)	92 (-2%)	98 (4%)	95 (0%)
Critically Dry	29	28 (-2%)	29 (-1%)	29 (-1%)	28 (-2%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any Above Normal Water Years, hence that row of the table is noted as 'NA'.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

In-Delta and upstream operational impacts of Alternatives 1-3 on fall-/late fall-run Chinook salmon would be negligible. Impacts associated with operations of Alternatives 1–3 would be less than significant.

[Note to Reviewers: This conclusion is preliminary and is dependent on an upcoming side-channel analysis]

NEPA Conclusion for Alternatives 1, 2, and 3

Operational effects on fall-/late fall-run Chinook salmon under Alternative 1, 2, or 3 would be the same as described above for CEQA. Operation of Alternative 1, 2, or 3 would not result in adverse effects on winter-run Chinook salmon.

[Note to Reviewers: This conclusion is preliminary and is dependent on an upcoming side-channel analysis]

Impact FISH-5: Operations Effects on Central Valley Steelhead

Alternatives 1, 2, and 3

Effects of Alternatives 1, 2, and 3

Potential exposure of steelhead to the effects of Alternatives 1, 2, and 3 is dependent on the species' spatiotemporal distribution. As described for winter-run Chinook salmon, several sources of information provide important context, as documented in the SacPAS summary in Appendix 11A. The main patterns include:

- Red Bluff Diversion Dam rotary screw traps (Figure SH_RBRST, Appendix 11A): Passage begins in early January to late June and finishes in December. The first half (50%) passes by late May to mid-August. The main portion (90%) begins to pass in late February to around the first of August and finishes passing from mid-August to early October.
- Tisdale Weir rotary screw traps (Figure SH_TWRST, Appendix 11A): Passage begins in early January to late February and finishes from mid-February to the end of December. The first half (50%) passes by early January to early April. The main portion (90%) begins to pass in early January to mid-March and finishes passing from mid-February to mid-December.
- Knights Landing rotary screw traps (Figure SH_KLRST, Appendix 11A): Passage begins in early January to mid-February and finishes from early April to late December. The first half (50%) passes by mid-February to late April. The main portion (90%) begins to pass from mid-January to mid-March and finishes passing from mid-February to late December.
- Sacramento beach seines (Figure SH_Seines, Appendix 11A): Occurrence begins from early January to the first of March and finishes from mid-February to late December. The first half (50%) occurs by early January to early June. The main portion (90%) begins to occur in early January to the first of March and finishes from early February to mid-December.
- Sacramento trawls (Sherwood Harbor) (Figure SH_Sherwood, Appendix 11A): Occurrence begins around the first of January to early February and finishes from early March to mid-December (first to last). The first half (50%) occurs by late January to mid-April. The main portion (90%) begins to occur in mid-January to early-January and finishes from mid-February to the end of December.
- Chipps Island trawls (Figure SH_Chipps, Appendix 11A): Occurrence begins in early January to mid-February and finishes from mid-May to late December. The first half (50%) occurs by early March to mid-April. The main portion (90%) begins to occur in mid-January to late February and finishes from early March to mid-May.

- Salvage (unclipped) (Figure SH_salvage_unclipped, Appendix 11A): Salvage begins in late August to the first of February and finishes from early May to around the first of August. The first half (50%) is salvaged by the first of February to mid-May. The main portion (90%) begins to be salvaged by the first of January to mid-March and finishes from early April to mid-June.
- Salvage (clipped) (Figure SH_salvage_clipped, Appendix 11A): Salvage begins in mid-December to mid-February and finishes from mid-February to mid-July. The first half (50%) of salvage occurs by late January to late March. The main portion (90%) begins to be salvaged from early January to early March and finishes by early February to mid-June.

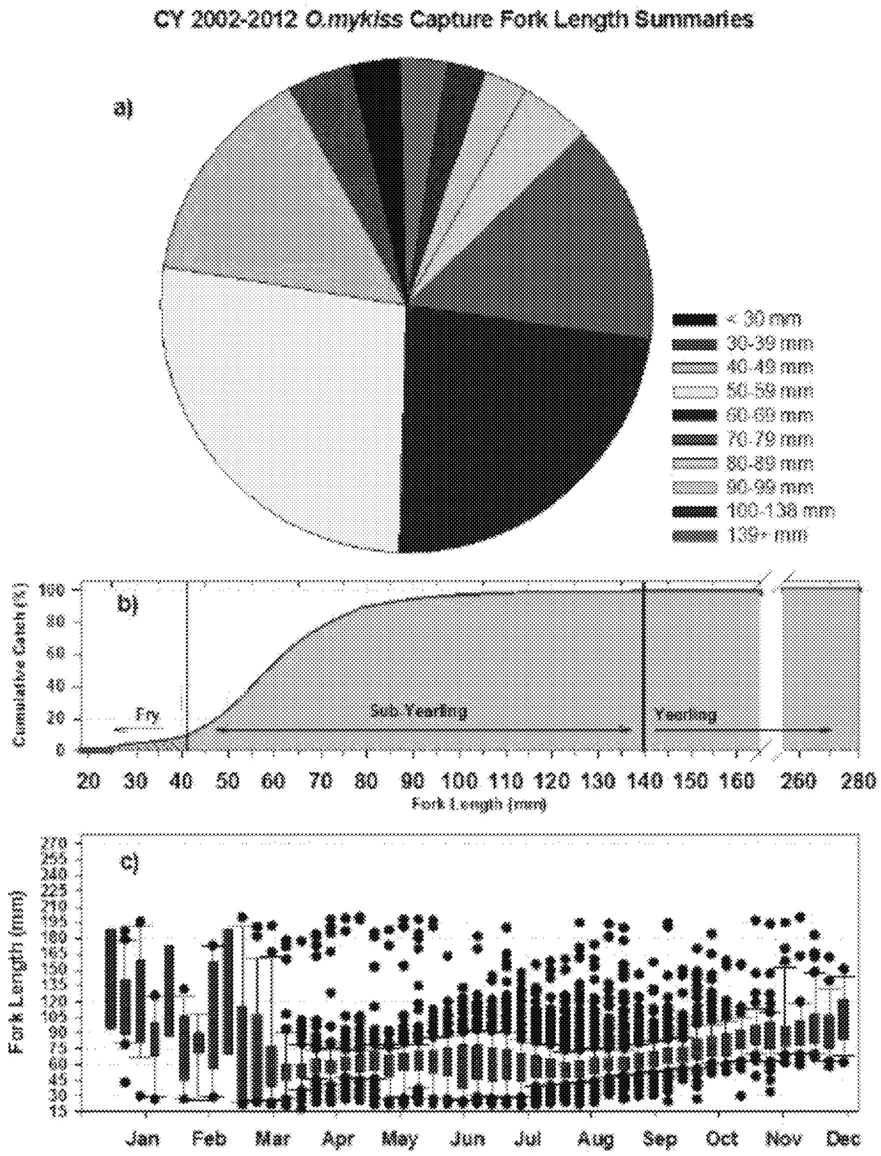
Sacramento River

Near-Field Effects

Steelhead would have the potential for similar types of near-field effects to those previously discussed for winter-run Chinook salmon (i.e., entrainment; impingement and screen contact; predation; stranding behind screens; and attraction to reservoir discharge). Only steelhead originating upstream of the Red Bluff and Hamilton City intakes would have the potential for near-field effects of the intakes as they pass them as juveniles or adults. Little is known of population sizes by tributary, although there are a number of tributaries upstream of the intakes that include steelhead (NMFS 2014a: 48). As generally discussed in Appendix 11A and described by NMFS (2016: 20), some of the main steelhead populations for which adult abundance has been estimated occur upstream of the Red Bluff and Hamilton City intakes (i.e., Coleman National Fish Hatchery and Clear Creek), whereas other key populations occur downstream of the intakes (American River, Nimbus Hatchery, Feather River Hatchery, and Mokelumne River Hatchery); only the former would have the potential to be exposed to near-field effects.

Rotary screw trap sampling at Red Bluff found around 3.5% of steelhead/rainbow trout sampled were less than 30-mm FL, with the smallest individuals occurring during March-July (Figure length_SH). The earliest occurring individuals would have the potential to be entrained in greater numbers under Alternatives 1–3 than under the NAA (Tables RB% and HC%), but entrainment potential would be limited as the species tends to undergo downstream migration as larger juveniles (yearlings or older; see Appendix 11A). This larger size would tend to considerably limit the potential for negative near-field effects to juveniles based on greater swimming ability than juvenile Chinook salmon; as noted for Chinook salmon, the Red Bluff and Hamilton City fish screens are designed to protective standards for Chinook salmon fry.

As with fall-run Chinook salmon in particular, the timing of migrating adult steelhead returning to tributaries upstream of the Sacramento River reservoir release location is such that relatively high numbers of individuals would pass this area during appreciable reservoir release flows to the river, for example during September (see Table Sites_SR in Chapter 5). As described for winter-run Chinook salmon, adult steelhead could be attracted to the reservoir discharge flow to the Sacramento River under Alternative 2 and leap out of the river, but the apron and weir designed to exclude anadromous fish would eliminate stranding risk.



Source: Poytress et al. (2014: 86). Note: CY = calendar year.

Figure length_SH. Steelhead Fork Length (a) Capture Proportions, (b) Cumulative Capture Size Curve, and (c) Average Weekly Median Boxplots, As Sampled at Red Bluff Diversion Dam Rotary Screw Traps, July 2002–June 2013.

Far-Field Effects

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Sacramento River below Keswick, at Balls Ferry, at Bend Bridge, below RBDD, and at Butte City indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of steelhead (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-5-1a to 6C-5-4c, Tables 6C-7-1a to 6C-7-4c, Tables 6C-9-1a to 6C-9-4c, Tables 6C-10-1a to 6C-10-4c , Tables 6C-12-1a to 6C-12-4c; Figures 6C-5-1 to 6C-5-18, Figures 6C-7-1 to 6C-7-18, Figures 6C-9-1 to 6C-9-1, Figures 6C-10-1 to 6C-10-18, Figures 6C-12-1 to 6C-12-18). At all locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±0.5°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at all locations.

Results of the analysis of exceedance above water temperature index values for steelhead in the Sacramento River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X and summarized in Table 11-temp8. For each life stage and at all locations evaluated, there were no month and water year type combinations in which both: (1) the percent of days that exceeded the index values was more than 5% greater under the alternative than under the NAA, and (2) the exceedance per day was more than 0.5°F greater under the alternative than under the NAA. Results of the exceedance analysis for Alt 2 are similar to Alt 1 with no month and water year type combinations in which both criteria were met for any life stage at all locations. Results of the exceedance analysis for Alt 3 are similar to Alt 1 with two exceptions. There were two month and water year type combinations in which both criteria met in a beneficial way (the percent of days that exceeded the index values was more than 5% lower under Alt 3 than under the NAA, and the exceedance per day was more than 0.5°F lower under Alt 3 than under the NAA): (1) August of critical water years at Balls Ferry and below RBDD, which overlaps with the adult holding life stage; and (2) September of Critically Dry Water Years below Clear Creek, which would overlap with the juvenile rearing life stage.

Table 11-temp8. Number of month and water year type combinations that satisfy both criteria for being biologically meaningful in the water temperature index value analysis, steelhead, Sacramento River[1,2,3]

Location	Spawning and Egg Incubation	Kelt Emigration	Juvenile Rearing	Smolt Emigration	Smoltification	Adult Immigration	Adult Holding
Below Keswick	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0
Below Clear Creek	Alt 1A, 1B, 2, 3 – 0	N/A	Alt 1A, 1B, 2 – 0 Alt 3 – 1 beneficial (63°F mean daily, September, critical years)	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	N/A	N/A
Balls Ferry	Alt 1A, 1B, 2, 3 – 0	N/A	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	N/A	Alt 1A, 1B, 2 – 0 Alt 3 – 1 beneficial (August, critical years)
Bend Bridge	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	N/A
Below Red Bluff Diversion Dam	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2 – 0 Alt 3 – 1 beneficial (August, critical years)

[1] Criteria include: (1) the difference in frequency of exceedance between NAA and the alternative was greater than 5%, and (2) the difference in average daily exceedance between NAA and the alternative was greater than 0.5°F.
[2] Index values for each life stage are located in Appendix 11B, *Fisheries Impact Assessment Methods*, Table 11.##.
[3] Full results presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X

Redd Scour Entombment

Loss of redds to scouring and entombment occurs when flows are high enough to mobilize sediments, destroying redds and their incubating eggs and alevins, or entombing the redds when sediments are redeposited. A flow of 40,000 cfs was selected as the scour flow threshold for the Sacramento River based on estimates in the literature (Table 11N-10).

The probability of redd scour and entombment was estimated for steelhead by computing the percentage of days with flows exceeding 40,000 cfs in the USRDOM 82-year daily flow record (29,952 days in total) at four locations between Keswick Dam and the RBDD during the months of steelhead spawning and incubation. Because the steelhead spawning and incubation period includes the wettest months of the year, steelhead redds have the highest probabilities of experiencing scouring flows (Table 11N-22 through Table 11N-25). Alternatives 1–3 have very little effect on the frequency of redd scouring and entombment and almost all differences result from a reduction in the probability of scouring flows. Steelhead has a relatively high percentage of days with scouring flows (about 7%) under the NAA, and Alternatives 1–3 have about 6% of days with scouring flows. The results indicate that Alternatives 1–3 would have little effect on redd scour and entombment for steelhead in the Sacramento River.

Redd Dewatering

The percentage of redds in the Sacramento River lost to dewatering was estimated using tables in USFWS (2006) that relate spawning and dewatering flows to percent reductions in species-specific spawning habitat WUA (see Appendix 11-N). USRDOM flow data, which has a daily time-step, are available for three locations in this river section: Keswick Dam (RM 302), the Sacramento River at Clear Creek (RM 289), and the Sacramento River at Battle Creek (RM 271). A single relationship for flows was developed for the entire river section, but the flows used to estimate redd dewatering in the current analysis were those that best matched the longitudinal distribution of the redds of the different salmon runs in the river as estimated from aerial redd surveys conducted by CDFW from 2003 through 2019. The spawning distribution of steelhead is uncertain, but most spawning is assumed to occur between Keswick Dam and Battle Creek where most salmon spawning occurs and where temperature conditions are most suitable. Flows for the Sacramento River at Clear Creek, which is near the center of this reach, were used to analyze steelhead redd dewatering.

Results are presented using the grand mean percentages of redds dewatered for each month of spawning, November through January, and each water year type and all water year types combined. The complete spawning and egg/alevin incubation periods are provided in the results (Table 11N-17) because changes in Project-related flow any time during these periods can affect the redd dewatering results. The means of the redd dewatering estimates under the NAA and Alternatives 1–3 are compared using absolute differences rather than relative differences (percent change) because many of the values for percentages of redds dewatered are small. Expressing changes of small values as percent changes may result in very large values that may be misleading.

The results for steelhead redd dewatering show moderate (>2%) reductions in redd dewatering for eggs spawned in November of above normal years under all four alternatives, and in December of Above Normal Water Years for Alternatives 1A and 2 (Table 11N-17). All increases in steelhead redd dewatering are less than 2%. Alternatives 1–3 are expected to have minor benefits on steelhead redd dewatering for eggs spawned in November and December.

Habitat Availability

The suitability of physical habitat for salmonid spawning is largely a function of the availability of clean, coarse gravel for constructing redds, favorable depths, and suitable flow velocities. The suitability of physical habitat for salmonid rearing is largely a function of water depth, flow velocity, and the availability and type of cover. Instream flow potentially affects all these habitat characteristics and often affects the availability of suitable habitat. Habitat suitability for spawning and rearing were analyzed using weighted usable area (WUA) curves developed by USFWS and others from results of field studies and hydraulic modeling (see Appendix 11K).

Spawning Habitat Weighted Usable Area

Spawning habitat WUA for steelhead in the Sacramento River was determined USFWS (2003a, 2006) in the same manner that it was determined for winter-run, fall-run and late fall–run, except that HSC previously determined for steelhead in the American River (USFWS 2003b) were used in developing the Sacramento River steelhead WUA curves (see Appendix 11K, Section 2, *Methods*). The spawning distribution of steelhead is uncertain, but most spawning is assumed to occur in the upper three segments (Segments 6, 5, and 4), where most salmon spawning occurs and where temperature conditions are most suitable.

To evaluate the effects of Alternatives 1–3 on steelhead spawning habitat, steelhead spawning WUA was estimated for CALSIM II flows during the November through April spawning and incubation period under Alternatives 1–3 and the NAA in the same three segments of the Sacramento River that were used for winter-run, spring-run and late fall–run.

There are few notable differences in steelhead mean spawning WUA between Alternative 1–3 and the NAA in any of the river segments. In fact, each segment has only one change >5%: a reduction in spawning WUA of 6% to 10% under Alternative 3 for February of Above Normal Water Years. These results indicate that Alternatives 1–3 would have minor effects on steelhead spawning WUA in the Sacramento River.

Rearing Habitat Weighted Usable Area

Rearing habitat WUA for steelhead was not estimated directly by U.S. Fish and Wildlife Service (2005b), but was modeled using the rearing WUA curves obtained for late fall–run Chinook salmon, in the same three Sacramento River segments that were used for the winter-run, fall-run and late fall–run spawning and rearing habitat WUA studies (USFWS 2003a, 2005b). The validity of using the late fall–run Chinook salmon WUA curves to characterize Central Valley steelhead rearing habitat is uncertain. For this analysis, fry are defined as fish less than 60 mm, and juveniles are young fish (young-of-year) greater than 60 mm.

To estimate changes in rearing WUA that would result from Alternatives 1–3, the late fall–run fry and juvenile WUA curves developed for each of the three river segments was used with mean monthly CALSIM II flow estimates for corresponding river segments under Alternatives 1–3 and the NAA during the rearing periods for steelhead fry (February through May) and juveniles (year-round) in the Sacramento River (Table 11A-8 in Appendix 11A).

Most of the means of Alternatives 1–3 for steelhead fry rearing WUA in all three segments differ from those of the NAA by less than 5% and all means that differ by >5% constitute increases in WUA in comparison to the NAA. In Segments 6 and 5, means increased >5% under Alternatives 1–3 in May of Critically Dry Water Years (Table 11K-47 and Table 11K-48). In Segment 4, none of the differences were >5% (Table 11K-49). These results indicate that Alternatives 1–3 would have only minor effects or moderate benefits to steelhead fry rearing habitat, depending on month and water year type.

Steelhead juvenile rearing WUA is similar or up to 7% higher under Alternatives 1–3 than under the NAA in Segments 6 and 5 (Table 11K-50 and Table 11K-52), with all increases occurring under Alternative 3. There are many more substantial differences in juvenile rearing WUA between Alternatives 1–3 and the NAA in Segment 4 (Table 11K-52). All but four of the 20 means that differ from the NAA mean >5% in Segment 4 are increases, and one of the four reductions in WUA (September of Above Normal Water Years under Alternative 3) is large (about 16%). Seven of the increases in rearing WUA are greater than 10%. The 16 large (>5%) increases in juvenile rearing WUA occur in the spring and summer months, especially in May and June (Table 11K-52). The results for steelhead juvenile rearing WUA indicate largely minor differences between Alternatives 1–3 and the NAA for Segments 6 and 5, but substantial differences for Segment 4. This segment would generally result in increased juvenile rearing habitat under Alternatives 1B and 3 during spring and summer, but some reduction in habitat during September and November of Above Normal Water Years.

Juvenile Stranding

Insert text here. The juvenile stranding estimation procedure for the Sacramento River computes the surface area of salmonid rearing habitat inundated at an initial flow that is dewatered at a subsequent minimum (stranding) flow, and then converts this area to number of stranded juveniles using estimates of habitat capacity based on field study observations (USFWS 2006). A period of three months is used for the juvenile stranding analysis in this report because the juveniles are presumed to be most vulnerable to stranding during their first three months after emerging from the redds (i.e., fry stage).

Juvenile stranding is computed using USRDOM daily flow estimates for Alternatives 1–3 and the NAA at three locations in the upper Sacramento River: Keswick Dam, Clear Creek, and Battle Creek. Separate tables for converting initial and stranding flows to number of juveniles stranded were developed for periods when the ACID Dam boards are in and when they are out (Table 11N-11 and Table 11N-12). Both tables are used for all the salmonid species and races.

The results are presented using the grand mean number of juveniles stranded for each month of emergence under each water year type and all water year types combined (Table 11N-28 through Table 11N-30). The analysis assumes that under equal flow conditions the fry and early juvenile stage of all runs and species are equally vulnerable to stranding. Tables 11N28 through 11N-30 combine results for all races and species. To determine the results for a given species or run, the estimated months for which the fry typically emerge (Table 11N-27) are consulted in the tables of results. The effects of dewatering flows are tracked by the analysis from the month of emergence through the three months (90 days) following. These periods are given in the tables. All three river locations show the greatest differences between Alternatives 1–3 and the NAA for the cohorts of fry that emerged during the months of April, May, June, and July (Table 11N-28 through Table 11N-30). May cohorts generally show the largest differences, and all the May differences are reductions in juvenile stranding, with the largest reduction, 55%, occurring at the Battle Creek location under Alternative 1B in May of Critically Dry Water Years. The largest increases in juvenile stranding occur for the April cohorts at all three locations, ranging as high as 30% in Dry Water Years under Alternatives 1A, 1B and 2 at the Keswick Dam location. The principal period of stranding vulnerability for steelhead is for cohorts emerging in February through May. April and May cohorts have greater stranding and lower stranding, respectively, under Alternatives 1–3 as compared to the NAA. Because of the greater magnitude and frequency of the large reductions in juvenile stranding in May over the large increases in April, Alternatives 1–3 are expected to have no overall adverse effect steelhead juvenile stranding (Table N11-28 through Table 11N-30).

Floodplain Inundation and Access

As described in Chapter 2 and as discussed for winter-run Chinook salmon, Fremont Weir notch protections are included in the diversion criteria to reduce changes to spill frequency and duration under Alternatives 1–3 relative to existing conditions. In particular, these criteria avoid impacts on Reclamation's ability to implement its obligations in the 2019 NMFS ROC on LTO Biological Opinion to implement the Yolo Bypass Restoration Salmonid Habitat Restoration and Fish Passage Implementation Plan and provide 17,000+ acres of inundation in the Yolo Bypass from December to April (NMFS 2019). As such, Alternatives 1–3 would have limited potential for negative effects to Yolo Bypass floodplain inundation and access for steelhead. This was confirmed with the modeling summarized in the winter-run Chinook salmon section (see also Attachments 11M-1 and 11M-2 to Appendix 11M).

Migration Flow-Survival

The main juvenile steelhead downstream migration period in the Sacramento River is October–June (see, for example, Table 11A-8 in Appendix 11A). This period coincides with pulse flow protection measures to be applied to precipitation-generated pulse flow events (see Chapter 2) for Alternatives 1–3 diversion criteria. River flow-survival relationships analogous to those for juvenile Chinook salmon (e.g., Michel et al. 2021; see also discussion for winter-run Chinook salmon) have not been established for migrating juvenile steelhead. However, assuming that flow may affect survival in a somewhat similar manner to juvenile Chinook salmon, the modeling based on Michel et al. (2021; see Appendix 11P) suggests there would be little difference between Alternatives 1–3 and the NAA for juvenile steelhead migration survival as a function of river flow.

Sites Reservoir Release Effects

Sites reservoir releases could temporally overlap with steelhead presence near the release location in the Sacramento River. Migrating adults would be present during August through March, although primarily August through October, and rearing or emigrating juveniles would be present during December through May (Appendix 11A, Attachment 1, Figure 39).

Sites Reservoir releases into the Yolo Bypass via the CBD would overlap with the adult steelhead upstream migration period during August through October, but not juvenile rearing and emigration (Appendix 11A, Table 11A-6; Figure FR_DJFMP).

As discussed in more detail above for fall-run/late fall–run Chinook salmon, Sites Reservoir releases to the CBD and thence the Toe Drain under Alternatives 1–3 during August–October could result in increased rates of adult steelhead occurrence at Wallace Weir, although this is uncertain. One marked (hatchery-origin) adult steelhead was collected in the fish trap at Wallace Weir in September 2018, whereas none were collected during trapping in 2014 (September/October), 2015 (October), 2017 (September/October), and 2020 (October) (see Table toedrain1 in the fall/late fall–run Chinook salmon analysis for details of trapping effort and data source). In 2019, a total of 13 adult steelhead, primarily hatchery-origin, were collected at Wallace Weir by trapping at the fish rescue facility and associated beach seining nearby, of which two fish (15%) died (Davis et al. 2019). Assuming this increased occurrence of steelhead at Wallace Weir is the result of the flow action, which is uncertain, then similar flow actions facilitated by reservoir releases under Alternatives 1–3 would have the potential to result in a very small DPS-level effect to steelhead: overall population numbers as indicated by monitoring of adults returning to hatcheries is in the thousands of fish (NMFS 2016: 12).

Temperature Effects

As discussed in Chapter 6, *Surface Water Quality*, the effect of Alternatives 1A, 1B, 2, and 3 on water temperatures at the Sites Reservoir release site in the Sacramento River would be relatively small with the releases generally tending to cause a slight reduction in water temperature (Tables 6-12a through 6-12d). Temperature-related effects of Alternatives 1A, 1B, 2, and 3 on steelhead at the release site would be minimal.

All changes in water temperature in the Yolo Bypass due to Sites Reservoir releases via the CBD would be zero or negative for Alternatives 1A, 1B, 2, and 3 (Table CBD_temp). These lower water temperatures are expected to have a negligible effect on adult steelhead in the Yolo Bypass and may have a marginally beneficial effect.

Commented [CC102]: It seems inappropriate to claim that lowering water temperatures in the Bypass may have a marginally beneficial effect for adult steelhead or any other adult salmonid. If salmonids are entrained in the Bypass and depending on how far into the Bypass they are (e.g. upstream of Ag crossing 4), without access to the Sacramento River they will likely perish without being able to contribute to the spawning population.

Commented [CC103R102]: It is inappropriate because the Colusa Basin Drain is not steelhead habitat and they shouldn't be in the CBD. The impact should not be measured in temperature affects but the fact that a federally listed species has been drawn into the CBD by the Sites Reservoir Release in the first place.

As discussed in Impact Fish-2, temperature changes under Alternatives 1A, 1B, 2, and 3 due to Sites Reservoir releases in the Sacramento River below the Yolo Bypass, and the effects to steelhead, would be minimal due to the small proportion of Sacramento River water in this reach coming off the Yolo Bypass.

Feather River

Far-Field Effects

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Feather River LFC below the Fish Barrier Dam and in the HFC at Gridley Bridge indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of steelhead (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-16-1a to 6C-16-4c, Tables 6C-18-1a to 6C-18-4c; Figures 6C-16-1 to 6C-16-18, Figures 6C-18-1 to 6C-18-18). At both locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±1°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at both locations.

Results of the analysis of exceedance above water temperature index values for steelhead in the Feather River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X and summarized in Table 11-temp9. For each life stage and at both locations evaluated, there were no month and water year type combinations in which both: (1) the percent of months that exceeded the index values was more than 5% greater under the alternative than under the NAA, and (2) the exceedance per month was more than 0.5°F greater under the alternative than under the NAA. Results of the exceedance analysis for Alt 2 and Alt 3 are similar to Alt 1 with no month and water year type combinations in which both criteria were met for any life stage at both locations.

Table 11-temp9. Number of month and water year type combinations that satisfy both criteria for being biologically meaningful in the water temperature index value analysis, steelhead, Feather River[1,2,3]

Location	Spawning and Egg Incubation	Kelt Emigration	Juvenile Rearing	Smolt Emigration	Smoltification	Adult Immigration	Adult Holding
Low Flow Channel Below Fish Barrier Dam	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0
High Flow Channel Below Thermalito Afterbay outlet	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0

[1] Criteria include: (1) the difference in frequency of exceedance between NAA and the alternative was greater than 5%, and (2) the difference in average monthly exceedance between NAA and the alternative was greater than 0.5°F.
[2] Index values for each life stage are located in Appendix 11B, *Fisheries Impact Assessment Methods*, Table 11.##.
[3] Full results presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X

The probability that each alternative would meet water temperature targets to support anadromous fish, including steelhead, in the Feather River included the Settlement Agreement for Licensing of the Oroville Facilities (DWR 2006, pp. A-18 to A-24) was described in Impact FISH-3 above.

Redd Scour and Entombment

Frequency of scouring flows was not estimated for the Feather River because information on minimum flows required to mobilize sediments is not available for the Feather River.

Redd Dewatering

No redd dewatering field data similar to that used for the Sacramento or American River (see Appendix 11K) are available for salmon or steelhead in the Feather River. The reduction in flow from the spawning to the dewatering flow was used directly as a proxy for redd dewatering. Redd dewatering was evaluated only for the High Flow Channel (HFC) of the river (downstream of Thermalito Afterbay Outlet) because none of the Project alternatives affects flow in the Low Flow Channel (LFC). The spawning and dewatering flows downstream of the Thermalito Afterbay outlet for each month of steelhead spawning, as estimated by CALSIM II, were used to compute the reduction in flow under Alternatives 1–3 and the NAA. Larger reductions are assumed to increase the percent of redds dewatered and to have a potentially negative effect on the species' populations. The use of monthly time-step flow estimates like those obtained from CALSIM II modeling likely underestimates redd dewatering rates. This potential bias is expected to equally affect the NAA and Alternatives 1–3.

The results for the Feather River steelhead spawning and incubation period (December through May) show little effect of Alternatives 1–3 on flow reductions and, by extension, on steelhead redd dewatering (Table 11N-19).

Habitat Availability

Spawning Habitat Weighted Usable Area

To evaluate the effects of Alternatives 1–3 on steelhead spawning habitat, steelhead spawning WUA was computed from the steelhead spawning WUA curve for the Feather River (Payne and Allen 2004) (Figure 11K-8) for CALSIM II flows below Thermalito Afterbay under Alternatives 1–3 and the NAA during the December through May Feather River steelhead spawning and incubation period.

There are no differences greater than 5% between Alternatives 1–3 and the NAA means in steelhead spawning WUA in the Feather River High Flow Channel (Table 11K-20). This result indicates that Alternatives 1–3 would have only minor effects of steelhead spawning WUA in the Feather River.

Rearing Habitat Weighted Usable Area

No valid rearing habitat WUA curves are available for the Feather River (see Appendix 11K, *Methods*).

Juvenile Stranding

No formal method for analyzing juvenile stranding analysis has been developed for the Feather River.

American River

Far-Field Effects

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the American River below Nimbus Dam and Watt Ave indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of steelhead (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-13-1a to 6C-13-4c, Tables 6C-14-1a to 6C-14-4c; Figures 6C-13-1 to 6C-13-18, Figures 6C-14-1 to 6C-14-18). At both locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±0.5°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at both locations.

Results of the analysis of exceedance above water temperature index values for steelhead in the American River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X and summarized in Table 11-temp10. For each life stage and at both locations evaluated, there were no month and water year type combinations in which both: (1) the percent of days that exceeded the index values was more than 5% greater under the alternative than under the NAA, and (2) the exceedance per day was more than 0.5°F greater under the alternative than under the NAA. Results of the exceedance analysis for Alt 2 and Alt 3 are similar to Alt 1 with no month and water year type combinations in which both criteria would be met for any life stage at both locations.

Table 11-temp10. Number of month and water year type combinations that satisfy both criteria for being biologically meaningful in the water temperature index value analysis, steelhead, American River[1,2,3]

Location	Spawning and Egg Incubation	Kelt Emigration	Juvenile Rearing	Smolt Emigration	Smoltification	Adult Immigration	Adult Holding
Hazel Ave.	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0
Watt Ave.	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0

[1] Criteria include: (1) the difference in frequency of exceedance between NAA and the alternative was greater than 5%, and (2) the difference in average daily exceedance between NAA and the alternative was greater than 0.5°F.
[2] Index values for each life stage are located in Appendix 11B, *Fisheries Impact Assessment Methods*, Table 11.##.
[3] Full results presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X

Redd Scour and Entombment

Loss of redds to scouring or entombment occurs when flows are high enough to mobilize sediments, destroying redds and their incubating eggs and alevins, or entombing the redds when sediments are redeposited. A flow of 40,000 cfs was selected as the scour flow threshold for the American River based on estimates in the literature (Table 11N-10).

Only CALSIM II monthly estimates were available for estimating flows in the American River under Alternatives 1–3 and the NAA. Redd scour can occur at a very small temporal scale (minutes to hours). This limitation was addressed using historical American River gauge data to determine the minimum monthly flow for which at least one daily flow of the month exceeded 40,000 cfs (Appendix 11N, Section 2, *Methods*). The minimum monthly flow was 19,530 cfs, so this flow was used as the threshold scouring flow with CALSIM II data in American River at Nimbus Dam (Figure 11N-2).

The results indicate that there are very few months in the 82-year CALSIM II record for the American River with flow greater than the redd scour or entombment threshold of 19,350 cfs (Table 11N-26). There are only two months with such flows under the NAA and Alternatives 1 - 2 and there are three such months for Alternative 3. These results indicate that Alternatives 1–3 would have little or no effect on redd scour or entombment for steelhead in the American River.

Redd Dewatering

The redd dewatering analysis for the lower American River uses relationships between flow, river stage, and redd depth distribution developed by Bratovich et al. (2017). CALSIM II flow estimates at the Nimbus Dam location were used to compute stage at the spawning and dewatering flows, and the redd depth frequency distribution was queried to determine the percentage of the redds that occur between those two stages and would be dewatered. The analyses were conducted for the months of steelhead spawning and incubation. Based on ranges provided in Bratovich et al. 2017, American River steelhead are estimated to have two-month incubation periods.

The analysis compared CALSIM II flow estimates below Nimbus Dam for each spawning month with the minimum flow during the two months following the spawning month to estimate the percentage of redds dewatered. The use of CALSIM II monthly time-step flow estimates likely underestimates redd dewatering rates. This potential bias is expected to affect all Project scenarios equally. The means of the redd dewatering estimates under the NAA and Alternatives 1–3 are compared using absolute differences rather than relative differences (percent change) because many of the values for percentages of redds dewatered are small. Expressing changes of small values as percent changes may result in very large values that may be misleading.

The results show little effect from the alternatives on steelhead redd dewatering (Table 11N-21). Alternatives 1–3 are expected to have little effect on steelhead redd dewatering in the American River.

Habitat Availability

Spawning Habitat Weighted Usable Area

To evaluate the effects of Alternatives 1–3 on steelhead spawning habitat in the American River, steelhead spawning WUA was estimated for CALSIM II flows at Nimbus Dam under the NAA and Alternatives 1–3 during the December through May spawning and incubation period using the steelhead composite spawning WUA curve (Bratovich et al. 2107) (Figure 11K-10).

None of the differences in steelhead mean spawning WUA between Alternatives 1–3 and the NAA are greater than 5% and most are <1% (Table 11K-22). This result indicates that Alternatives 1–3 would have little effect on steelhead spawning WUA in the American River.

Rearing Habitat Weighted Usable Area

No valid rearing habitat WUA curves are available for the American River (see Appendix 11K, *Methods*).

Juvenile Stranding

No formal method for analyzing juvenile stranding analysis has been developed for the American River.

Delta

Juvenile Through-Delta Survival

As described in Appendix 11A, the main juvenile steelhead migration period in the Delta is February–May. Through-Delta flow-survival relationships analogous to those for juvenile Chinook salmon (e.g., Perry et al. 2018; see also discussion for winter-run Chinook salmon) have not been established for migrating juvenile steelhead. However, assuming that flow may affect survival in a somewhat similar manner to juvenile Chinook salmon, the modeling based on the through-Delta survival function formulated by Perry et al. (2018) suggests there would be little difference between Alternatives 1–3 and the NAA (see Table perry1 in the winter-run analysis).

South Delta Entrainment

As discussed for other salmonids, there would be little difference in indicators of entrainment risk (south Delta exports and Old and Middle River flows) during winter/spring between the NAA and Alternatives 1–3 (see Appendix 5B3: Tables 5B3-6-1a through 5B3-6-4c; Figures 5B3-6-1 through 5B3-6-18; and Appendix 5B4: Tables 5B4-1-1a through 5B4-1-4c; Figures 5B4-1-1 through 5B4-1-18), and existing restrictive criteria from the NMFS (2019) SWP/CVP BiOp and CDFW (2020) SWP ITP would limit entrainment risk for steelhead under all alternatives. South Delta export of water released from Sites Reservoir would have limited overlap with steelhead occurrence. This is illustrated by the results of the salvage-density analysis (see description in Appendix 11Q) for which there were minimal differences between NAA and the alternatives (Table sh_banks; Table sh_jones).

Table sh_banks. Entrainment Loss of Juvenile Steelhead At SWP Banks Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	5,384	5,375 (0%)	5,376 (0%)	5,375 (0%)	5,377 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	4,479	4,426 (-1%)	4,461 (0%)	4,433 (-1%)	4,570 (2%)
Dry	2,359	2,360 (0%)	2,356 (0%)	2,360 (0%)	2,365 (0%)
Critically Dry	2,108	2,108 (0%)	2,123 (1%)	2,132 (1%)	2,096 (-1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any Above Normal Water Years, hence that row of the table is noted as 'NA'.

Table sh_jones. Entrainment Loss of Juvenile Steelhead At CVP Jones Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	320	321 (0%)	321 (0%)	321 (0%)	319 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	936	936 (0%)	939 (0%)	938 (0%)	939 (0%)
Dry	647	646 (0%)	648 (0%)	647 (0%)	650 (0%)
Critically Dry	181	182 (1%)	182 (1%)	183 (1%)	183 (1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any Above Normal Water Years, hence that row of the table is noted as 'NA'.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

In-Delta and upstream operational impacts of Alternative 1-3 on steelhead would be negligible. Impacts associated with operations of Alternatives 1–3 would be less than significant.

[Note to Reviewers: This conclusion is preliminary and is dependent on an upcoming side-channel analysis]

NEPA Conclusion for Alternatives 1, 2, and 3

Operational effects on steelhead under Alternative 1, 2, or 3 would be the same as described above for CEQA. Operation of Alternative 1, 2, or 3 would not result in adverse effects on winter-run Chinook salmon.

[Note to Reviewers: This conclusion is preliminary and is dependent on an upcoming side-channel analysis]

Impact FISH-6: Operations Effects on Green Sturgeon

Alternatives 1, 2, and 3

Effects of Alternatives 1, 2, and 3

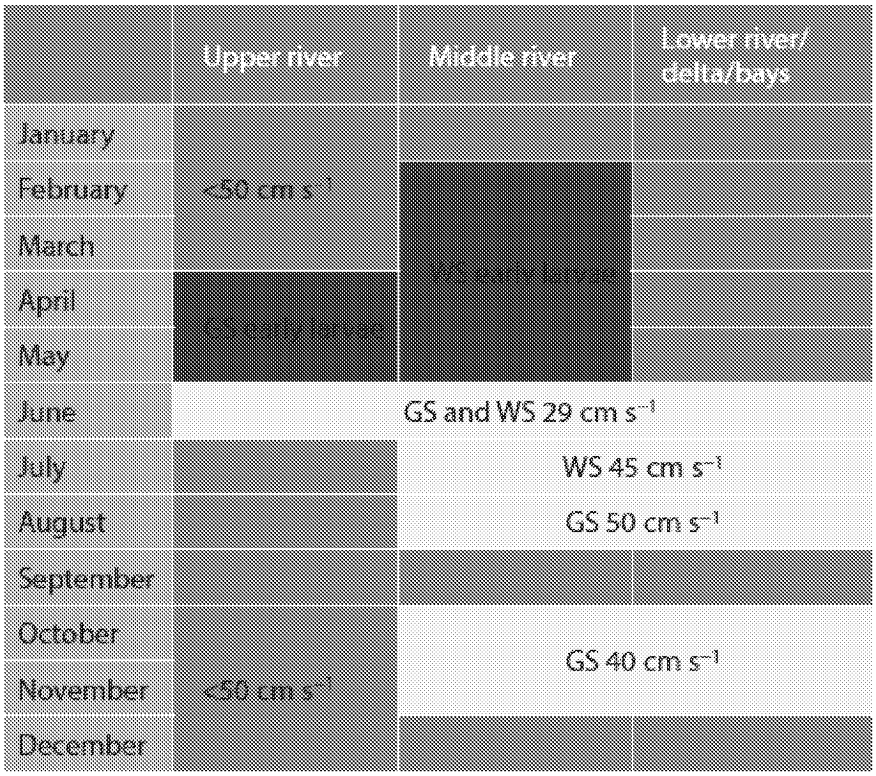
Sacramento River

Near-Field Effects

Relative to juvenile salmonids, there are no field-based investigations informing the risk from near-field effects of Alternative 1, 2, and 3 diversions at Red Bluff and Hamilton City for green sturgeon. There are, however, laboratory investigations from which risk can be inferred. Although screen criteria for green sturgeon have not been developed by NMFS or DFW, the laboratory studies of Verhille et al. (2014) provided recommendations for intake approach velocity based on flow-tolerance criteria (Figure sturg_verhille). During the primary months in which the Project diversions would operate (i.e., November–March), the flow-tolerance results of Verhille et al. (2014) suggest that approach velocity below 50 cm/s (i.e., 1.6 ft/s) would be protective (Figure sturg_verhille). The approach velocity at Red Bluff and Hamilton City would be no more than 0.33 ft/s in accordance with agency requirements, and would be expected to be protective based on the flow-tolerance relationships from Verhille et al. (2014). Verhille et al. (2014) suggested that green sturgeon larvae could be susceptible to diversions regardless of approach velocity during April and May. During April, diversions at Red Bluff under Alternatives 1–3 would generally be similar or somewhat (<100 cfs) greater than NAA, except in ~10–15% of years, when diversions would be up to ~2,000 cfs, compared to ~500 cfs under the NAA (Appendix 5B1: Figure 5B1-1-13). In May, diversions under Alternatives 1B and 3 would be up to 200 cfs less than NAA and Alternatives 1A and 2 at ~40–85% exceedance, whereas Alternatives 1–3 would have considerably greater diversions than NAA (>2,000 cfs compared to <1,000 cfs) in only a few years (Appendix 5B1: Figure 5B1-1-14). As shown in Table RB%, these diversion rates represent water-year-type means of 7–8% or less of Sacramento River flow. Similar patterns are generally evident at the Hamilton City diversion (Appendix 5B1: Figures 5B1-1-13 and 5B1-1-14), although the water-year-type mean diversion rate is greater (up to 8–9% in April; 25% or less in May; Table HC%).

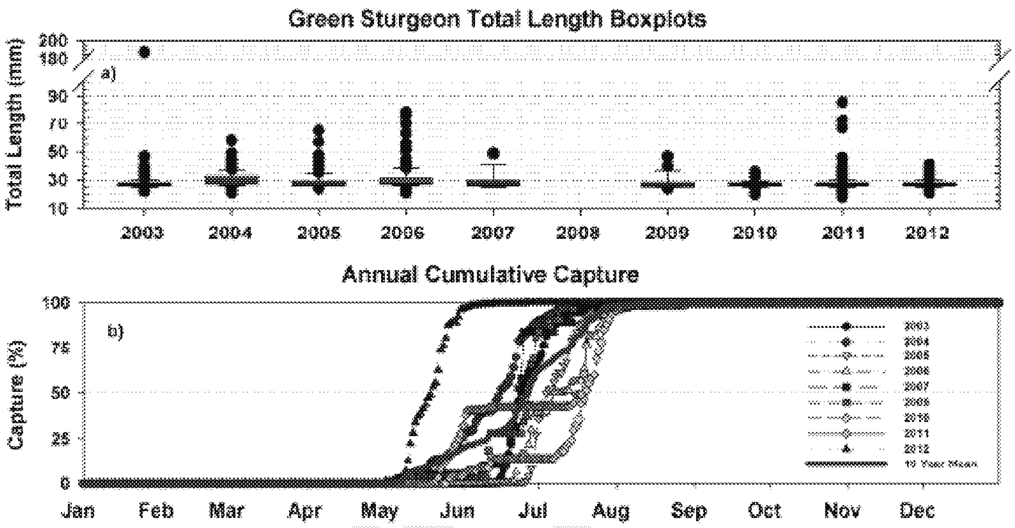
Rotary screw trap data would be available and entrainment sampling would be undertaken under Alternatives 1–3 (see Appendix 2D), allowing better assessment of potential negative effects to green sturgeon larvae and—if suggested to be necessary from this monitoring—adjustment to operations as part of the adaptive management program, which is not reflected in the modeling of operations of Alternatives 1–3. Rotary screw trap monitoring data indicate that green sturgeon larval occurrence at Red Bluff and Hamilton City generally only begins in May (Figure TCCA_GS and Table GCID_GS). Green sturgeon post larvae collected at RBDD rotary screw traps during 2002–2012 had minimum annual total lengths ranging from 18 to 25 mm (Figure TCCA_GS). The length distribution of green sturgeon in rotary screw traps does not differ from that of larval sampling nets, and indicates that this is the size at initial dispersal from egg incubation and hatching areas (Poytress et al. 2011:15). Based on these sizes, it would be expected that the 1.75-mm-opening intake screens would exclude most larval sturgeon, given that a laboratory study of screen with this size of opening found entrainment of morphologically similar pallid sturgeon at sizes below 20 mm (Mefford and Sutphin 2008). With approach velocity at Red Bluff and Hamilton City of no more than 0.33 ft/s, the two intakes would be expected to be protective of green sturgeon for the remainder of the year based on the flow-tolerance criteria suggested by Verhille et al. (2014; Figure sturg_verhille). Given that these criteria did not consider behavioral effects (e.g., avoidance of intakes) (Verhille et al. 2014), there is uncertainty in the results based solely on approach velocity. A recent review of green sturgeon biology by Heublein et al. (2017:20) noted: "Larval green sturgeon are present in areas where substantial water volumes are diverted, and, due to small size and relatively poor swimming performance of larvae, it is almost certain that entrainment effects [sic] larval survival…The RBDD [Red Bluff] and GCID [Hamilton City] facilities include modern fish screens to reduce entrainment of juvenile salmonids, but the effectiveness of screens and facility operations in reducing larval green sturgeon entrainment is poorly understood."

Entrainment of green sturgeon eggs by the Alternative 1–3 diversions could also occur during the spawning period, which occurs in April–June (Poytress et al. 2015), although such entrainment may be limited by the eggs being demersal and weakly adhesive (Wang 2006:3). In addition, the eggs may be more likely to be subject to impingement than entrainment because their diameter (generally 4.0 mm or greater; Wang 2006:3) is greater than the intake screen openings (1.75 mm). The alternatives' impingement, entrainment, and river channel monitoring program would reduce the uncertainty in the extent of near-field effects on egg and larval green sturgeon (see Appendix 2D). The primarily nocturnal migration of larval green sturgeon (Poytress et al. 2011; Figure GS_nocturn) would be assessed further during the preconstruction period, as well as following initial operations (see Appendix 2D), which would allow study and adaptive management of the optimal diel diversion periods to minimize potential effects on green sturgeon from operations of the alternatives.



Source: Verhille et al. (2014). Note: Green sections demarcate tolerable water velocities of ≥50 cm/s; red sections demarcate presence of life stages which are predicted to be intolerant of even very low water velocities; and yellow sections signify recommended water flow velocity limitations to protect present life stages. Behavioral (e.g., avoidance) considerations were not part of this analysis, and they remain an important topic for future research. Based on the text description, Red Bluff and Hamilton City diversions are in the "Upper river".

Figure sturg_verhille. Overview of Flow-Tolerance Limitations of Green (GS) and White (WS) Sturgeon Throughout the Sacramento-San Joaquin Watershed According to Location and Time of Year, Based on Critical Swimming Speed.

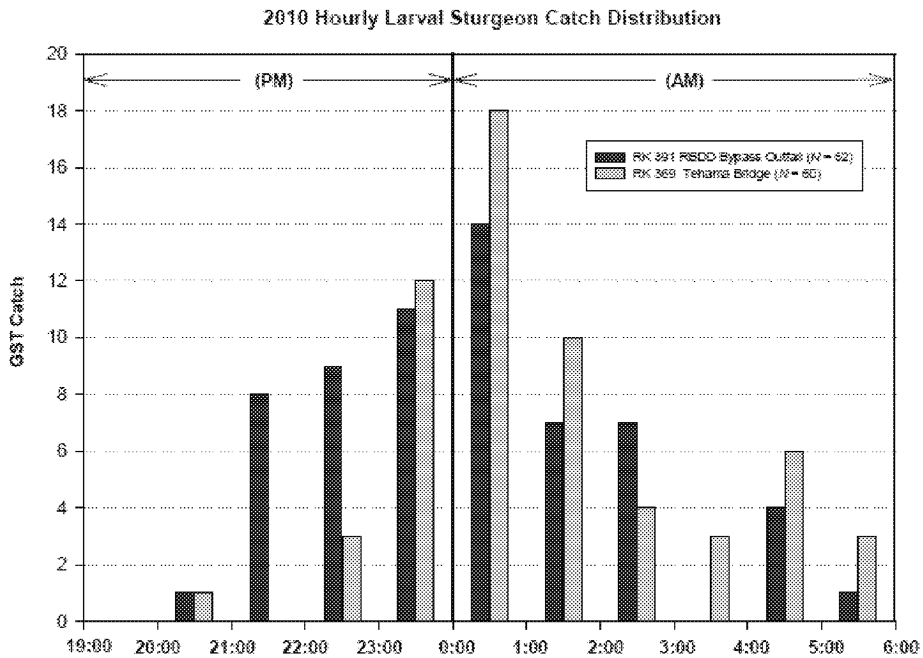


Source: Poytress et al. (2014: 99)

Figure TCCA_GS. Green Sturgeon a) Annual Total Length Capture Boxplots and b) Annual Cumulative Capture Trends with 10-Year Mean Trend Line, from Rotary Screw Trap Sampling at Red Bluff Diversion Dam, 2003-2012.

Table GCID_GS. Rotary Screw Trap Catches of Sturgeon at GCID (Source: Reclamation 2008: 11-69).

	Sturgeon in CDF&G Screw Trap at GCID														
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Average	Median	Std Dev
January	0	0	0	0	0	0	0	1	0	0	0	0	0.1	0.0	0.3
February	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
March	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
April	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
May	0	0	113	27	0	0	1	3	8	0	1	0	12.8	0.5	32.5
June	12	20	10	126	0	23	13	13	1	4	3	5	19.2	11.0	34.4
July	6	205	180	52	0	214	18	16	0	3	1	23	59.8	17.0	85.9
August	0	77	109	24	0	52	2	1	0	1	0	4	22.5	1.5	37.0
September	1	4	2	3	0	1	0	0	0	1	0	1	1.1	1.0	1.3
October	0	0	1	4	0	1	1	0	0	0	1	0	0.7	0.0	1.2
November	2	0	0	1	0	0	0	0	0	0	0	0	0.3	0.0	0.6
December	2	1	5	0	0	0	0	0	0	0	0	0	0.7	0.0	1.5
Total	23	307	420	237	0	291	35	34	9	9	6	33	117.0	33.5	151.2



Source: Poytress et al. (2011: 41).

Figure GS_nocturn. Nocturnal Distribution Pattern of Capture of Larval Green Sturgeon at Red Bluff Diversion Dam Outfall and Tehama Bridge in 2010.

Far-Field Effects

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Sacramento River at Bend Bridge, below Red Bluff Diversion Dam, and at Butte City indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of green sturgeon (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-9-1a to 6C-9-4c, Tables 6C-10-1a to 6C-10-4c, Tables 6C-12-1a to 6C-12-4c; Figures 6C-9-1 to 6C-9-18, Figures 6C-10-1 to 6C-10-18, Figures 6C-12-1 to 6C-12-18). At all locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±0.5°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at all locations.

Results of the analysis of exceedance above water temperature index values for green sturgeon in the Sacramento River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X and summarized in Table 11-temp11. For each life stage and at all locations evaluated, there were no month and water year type combinations in which both: (1) the percent of days that exceeded the index values was more than 5% greater under Alt 1A than under the NAA, and (2) the exceedance per day was more than 0.5°F greater under Alt 1A than under the NAA. For Alt 1B, there was one month and water year type combination, July of Above Normal Water Years, in which both criteria met. Results of the exceedance analysis for Alt 2 are similar to Alt 1A with no month and water year type combinations in which both criteria would be met for any life stage at all locations. Results of the exceedance analysis for Alt 3 are similar to Alt 1B in that there was one month and water year type combination, July of Above Normal Water Years, in which both criteria would be met.

Table 11-temp11. Number of month and water year type combinations that satisfy both criteria for being biologically meaningful in the water temperature index value analysis, green sturgeon, Sacramento River[1,2,3]

Location	Non-Spawning Adult Presence	Spawning and Egg Incubation	Larval to Juvenile Rearing and Emigration
Bend Bridge	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0
Below Red Bluff Diversion Dam	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0
Hamilton City	Alt 1A, 1B, 2, 3 – 0	Alt 1A – 0 Alt 1B – 1 negative (July, Above normal years) Alt 2 – 0 Alt 3 – 1 negative (July, Above normal years)	Alt 1A, 1B, 2, 3 – 0

[1] Criteria include: (1) the difference in frequency of exceedance between NAA and the alternative was greater than 5%, and (2) the difference in average daily exceedance between NAA and the alternative was greater than 0.5°F.
[2] Index values for each life stage are located in Appendix 11B, *Fisheries Impact Assessment Methods*, Table 11.##.
[3] Full results presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X

Flow Effects

Spawning and Egg Incubation

The effects of flow on green sturgeon spawning in the Sacramento River were recently studied by Wyman et al. (2018). The authors conducted analyses of habitat attribute suitabilities and weighted usable area (WUA) of green sturgeon in spawning pools and determined that the optimal flow-related habitat characteristics include:

- Depths about 25 to 30 feet.
- Flow velocity about 3.3 fps.
- Substrate of gravel or sand.

Based on measurements of depth, flow velocity and substrate in spawning pools at different Sacramento River flows, the authors determined that spawning WUA for the green sturgeon was roughly uniform from about 7,500 cfs, the lowest flow level included the study, to about 12,360 cfs. From 12,360 cfs to the highest flow included in the study, about 23,500 cfs, the WUA fell sharply. Flow velocity was found to be the most important flow-related habitat attribute for green sturgeon habitat selection, and very low flows in the Sacramento River would likely result in adverse flow velocity conditions. However, the flow level at which habitat with suitable flow velocities would be unavailable is not known.

For purposes of this effects analysis, Sacramento River flows that exceed 12,360 cfs or fall below 7,500 cfs within the green sturgeon spawning reach and during the spawning period are considered to adversely affect green sturgeon spawning habitat. Note that the lower flow threshold is not based on evidence of less suitable spawning habitat conditions at flows below 7,500 cfs, but rather on the lack of evidence that the lower flows are as suitable. Green sturgeon spawning in the Sacramento River has been observed from upstream of GCID (RM 200) (near Hamilton City) to Inks Creek (RM 265), and possibly to the confluence with Cow Creek (RM 277) (Heublein et al. 2017b). The adults spawn primarily from March through July, although they periodically spawn in late summer and fall (as late as October) (Heublein et al. 2009, 2017b, NMFS 2018b).

During March through July, CALSIM II estimates of mean monthly flows below RBDD under Alternatives 1-3 and the NAA range from about 5,400 cfs in April of critically dry water years to about 14,500 cfs in April of wet years (Table 11ST-1). Differences in flows between Alternatives 1-3 and the NAA are less than 5% in most months, but flows are 8% to 14% lower under all project alternatives in March of dry, below normal, and above normal water years, and about 8% lower for all the project alternatives in May of critically dry years (Table 11-ST1). The reductions in mean flows during March of above normal years bring the flows closer to the upper flow threshold, 12,360 cfs, for reductions in spawning WUA, but all the project alternative flows (about 15,900 cfs to 16,100 cfs) are well above the threshold. The other months and water year types with appreciable flow reductions all have flows within the range of uniform WUA, 7,500 cfs to 12,360 cfs, so no effects on spawning are expected. Differences in flow results between Alternatives 1-3 and the NAA for the Sacramento River at Bend Bridge (RM 258), near the upper limit of the green sturgeon spawning distribution in the Sacramento River, shows no flow changes between the NAA and the project alternatives outside the uniform WUA range (Table 11-ST2). At Hamilton City (RM 197), which is near lower end of the spawning distribution, reductions in mean flow during March are similar to those at RBDD, but the flow reductions in May of critically dry years result in flows under the project alternatives that are further from the low flow threshold of 7,500 cfs than the NAA flow (Table 11-ST3), which might result in a reduction in WUA. Hamilton City flows also increase under the project alternatives in July of dry and critically dry years, and above normal and below normal water years for Alternative 3. However, all these flow changes occur within the range of uniform spawning WUA.

Table 11-ST1. CALSIM II Monthly Average Flow (cfs) by Month and Water Year Type Below Red Bluff Diversion Dam for the No Action Alternative (NAA) and Alternatives 1A, 1B, 2, and 3, and Percent Differences between Them (in Parentheses).

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	ALT 3
January	Wet	29134	28109 (-3.5%)	28041 (-3.8%)	28144 (-3.4%)	28008 (-3.9%)
	Above Normal	16816	15573 (-7.4%)^	15573 (-7.4%)^	15573 (-7.4%)^	15574 (-7.4%)^
	Below Normal	9531	8946 (-6.1%)^	8931 (-6.3%)^	8945 (-6.2%)^	8932 (-6.3%)^
	Dry	6853	6509 (-5%)^	6503 (-5.1%)^	6509 (-5%)^	6501 (-5.1%)^
	Critically Dry	6476	6293 (-2.8%)	6187 (-4.5%)	6206 (-4.2%)	6132 (-5.3%)^
	All	15778	15069 (-4.5%)	15028 (-4.8%)	15067 (-4.5%)	15009 (-4.9%)
February	Wet	31811	30785 (-3.2%)	30704 (-3.5%)	30865 (-3%)	30874 (-2.9%)
	Above Normal	24627	23549 (-4.4%)	23501 (-4.6%)	23575 (-4.3%)	24136 (-2%)
	Below Normal	13259	12166 (-8.2%)^	12265 (-7.5%)^	12105 (-8.7%)^	12275 (-7.4%)^
	Dry	9027	8405 (-6.9%)^	8458 (-6.3%)^	8405 (-6.9%)^	8489 (-6%)^
	Critically Dry	6605	6385 (-3.3%)	6402 (-3.1%)	6398 (-3.1%)	6385 (-3.3%)
	All	18902	18064 (-4.4%)	18062 (-4.4%)	18084 (-4.3%)	18215 (-3.6%)
March	Wet	24953	24149 (-3.2%)	24124 (-3.3%)	24279 (-2.7%)	23906 (-4.2%)
	Above Normal	17530	16047 (-8.5%)^	16102 (-8.1%)^	16045 (-8.5%)^	15903 (-9.3%)^
	Below Normal	8863	7643 (-13.8%)^	7643 (-13.8%)^	7644 (-13.8%)^	7626 (-14%)^
	Dry	8777	7790 (-11.3%)^	7782 (-11.3%)^	7847 (-10.6%)^	7907 (-9.9%)^
	Critically Dry	6646	6375 (-4.1%)	6327 (-4.8%)	6371 (-4.1%)	6373 (-4.1%)
	All	14890	13953 (-6.3%)^	13945 (-6.3%)^	14006 (-5.9%)^	13878 (-6.8%)^
April	Wet	14501	14100 (-2.8%)	14069 (-3%)	14165 (-2.3%)	13955 (-3.8%)
	Above Normal	9517	9392 (-1.3%)	9435 (-0.9%)	9392 (-1.3%)	9437 (-0.8%)
	Below Normal	7201	7098 (-1.4%)	7101 (-1.4%)	7098 (-1.4%)	7175 (-0.4%)
	Dry	6326	6277 (-0.8%)	6196 (-2.1%)	6277 (-0.8%)	6221 (-1.7%)
	Critically Dry	5407	5414 (0.1%)	5408 (0%)	5414 (0.1%)	5266 (-2.6%)
	All	9400	9227 (-1.8%)	9205 (-2.1%)	9248 (-1.6%)	9167 (-2.5%)
May	Wet	12102	11955 (-1.2%)	11895 (-1.7%)	11954 (-1.2%)	11844 (-2.1%)
	Above Normal	10400	10347 (-0.5%)	10352 (-0.5%)	10347 (-0.5%)	10352 (-0.5%)
	Below Normal	8526	8379 (-1.7%)	8232 (-3.5%)	8380 (-1.7%)	8201 (-3.8%)
	Dry	8707	8481 (-2.6%)	8471 (-2.7%)	8480 (-2.6%)	8271 (-5%)^
	Critically Dry	8637	7952 (-7.9%)^	7920 (-8.3%)^	7942 (-8%)^	7934 (-8.1%)^
	All	9990	9761 (-2.3%)	9710 (-2.8%)	9759 (-2.3%)	9647 (-3.4%)
June	Wet	9714	9615 (-1%)	9615 (-1%)	9615 (-1%)	9575 (-1.4%)
	Above Normal	9943	9804 (-1.4%)	9491 (-4.5%)	9805 (-1.4%)	9224 (-7.2%)^

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	ALT 3
	Below Normal	10386	10207 (-1.7%)	10163 (-2.1%)	10207 (-1.7%)	9694 (-6.7%)*
	Dry	11091	10807 (-2.6%)	11008 (-0.8%)	10807 (-2.6%)	10793 (-2.7%)
	Critically Dry	9847	9884 (0.4%)	9778 (-0.7%)	9864 (0.2%)	9770 (-0.8%)
	All	10184	10045 (-1.4%)	10020 (-1.6%)	10042 (-1.4%)	9840 (-3.4%)
July	Wet	12188	12214 (0.2%)	12214 (0.2%)	12215 (0.2%)	12215 (0.2%)
	Above Normal	13514	13566 (0.4%)	13470 (-0.3%)	13569 (0.4%)	13538 (0.2%)
	Below Normal	12498	12653 (1.2%)	12618 (1%)	12658 (1.3%)	12738 (1.9%)
	Dry	11804	12020 (1.8%)	12056 (2.1%)	12025 (1.9%)	11908 (0.9%)
	Critically Dry	9836	9902 (0.7%)	9904 (0.7%)	9880 (0.4%)	9814 (-0.2%)
	All	12007	12106 (0.8%)	12094 (0.7%)	12106 (0.8%)	12079 (0.6%)
August	Wet	10586	10552 (-0.3%)	10552 (-0.3%)	10588 (0%)	10551 (-0.3%)
	Above Normal	10078	10052 (-0.3%)	10108 (0.3%)	10053 (-0.2%)	9582 (-4.9%)
	Below Normal	9136	9165 (0.3%)	9156 (0.2%)	9175 (0.4%)	9127 (-0.1%)
	Dry	8818	9077 (2.9%)	9024 (2.3%)	9079 (3%)	8846 (0.3%)
	Critically Dry	8392	8296 (-1.1%)	8462 (0.8%)	8464 (0.9%)	8278 (-1.4%)
	All	9555	9588 (0.3%)	9607 (0.5%)	9626 (0.7%)	9459 (-1%)
September	Wet	10552	10554 (0%)	10563 (0.1%)	10554 (0%)	10556 (0%)
	Above Normal	8516	8547 (0.4%)	8873 (4.2%)	8552 (0.4%)	9309 (9.3%)*
	Below Normal	5940	6023 (1.4%)	6085 (2.4%)	6021 (1.4%)	6133 (3.3%)
	Dry	5165	5404 (4.6%)	5371 (4%)	5403 (4.6%)	5347 (3.5%)
	Critically Dry	4790	5025 (4.9%)	5036 (5.1%)*	5009 (4.6%)	4970 (3.8%)
	All	7441	7547 (1.4%)	7603 (2.2%)	7545 (1.4%)	7657 (2.9%)
October	Wet	8577	8579 (0%)	8571 (-0.1%)	8579 (0%)	8578 (0%)
	Above Normal	6908	6981 (1.1%)	7059 (2.2%)	6981 (1.1%)	7467 (8.1%)*
	Below Normal	7088	7100 (0.2%)	7176 (1.2%)	7152 (0.9%)	7419 (4.7%)
	Dry	5968	6022 (0.9%)	5927 (-0.7%)	6027 (1%)	6135 (2.8%)
	Critically Dry	5996	6469 (7.9%)*	6411 (6.9%)*	6415 (7%)*	6514 (8.6%)*
	All	7128	7222 (1.3%)	7215 (1.2%)	7224 (1.3%)	7379 (3.5%)
November	Wet	9514	9152 (-3.8%)	9088 (-4.5%)	9155 (-3.8%)	9097 (-4.4%)
	Above Normal	10569	10371 (-1.9%)	10342 (-2.1%)	10374 (-1.8%)	10389 (-1.7%)
	Below Normal	8209	8276 (0.8%)	8467 (3.1%)	8199 (-0.1%)	8542 (4%)
	Dry	7306	7239 (-0.9%)	7647 (4.7%)	7181 (-1.7%)	7646 (4.7%)
	Critically Dry	6386	6353 (-0.5%)	6401 (0.2%)	6386 (0%)	6363 (-0.3%)
	All	8503	8351 (-1.8%)	8456 (-0.6%)	8332 (-2%)	8473 (-0.4%)
December	Wet	13245	13178 (-0.5%)	13174 (-0.5%)	13180 (-0.5%)	13183 (-0.5%)
	Above Normal	11720	11574 (-1.2%)	11701 (-0.2%)	11574 (-1.2%)	11780 (0.5%)
	Below Normal	13308	12989 (-2.4%)	13073 (-1.8%)	12998 (-2.3%)	13281 (-0.2%)

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	ALT 3
	Dry	13980	13853 (-0.9%)	13701 (-2%)	13860 (-0.9%)	14184 (1.5%)
	Critically Dry	6676	6113 (-8.4%)^	6189 (-7.3%)^	6197 (-7.2%)^	6198 (-7.2%)^
	All	12232	12025 (-1.7%)	12035 (-1.6%)	12041 (-1.6%)	12192 (-0.3%)

* Results for which mean flow under Alternative 1, 2, or 3 is more than 5% above mean flow under the NAA are highlighted green to flag the largest increases for reader's convenience.
^ Results for which mean flow under Alternative 1, 2, or 3 is more than 5% below mean flow under the NAA are highlighted red to flag the largest increases for reader's convenience.

Table 11-ST2. CALSIM II Monthly Average Flow (cfs) by Month and Water Year Type at Bend Bridge for the No Action Alternative (NAA) and Alternatives 1A, 1B, 2, and 3, and Percent Differences between Them (in Parentheses).

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	ALT 3
January	Wet	28508	28548 (0.1%)	28603 (0.3%)	28543 (0.1%)	28586 (0.3%)
	Above Normal	16345	16353 (0%)	16353 (0%)	16353 (0%)	16354 (0.1%)
	Below Normal	9304	9307 (0%)	9293 (-0.1%)	9305 (0%)	9294 (-0.1%)
	Dry	6713	6693 (-0.3%)	6692 (-0.3%)	6693 (-0.3%)	6691 (-0.3%)
	Critically Dry	6390	6490 (1.6%)	6384 (-0.1%)	6403 (0.2%)	6328 (-1%)
	All	15428	15453 (0.2%)	15452 (0.2%)	15438 (0.1%)	15439 (0.1%)
February	Wet	31283	31309 (0.1%)	31356 (0.2%)	31309 (0.1%)	31525 (0.8%)
	Above Normal	24171	24302 (0.5%)	24391 (0.9%)	24325 (0.6%)	25067 (3.7%)
	Below Normal	12964	12894 (-0.5%)	13047 (0.6%)	12831 (-1%)	13145 (1.4%)
	Dry	8846	8782 (-0.7%)	8841 (0%)	8782 (-0.7%)	8873 (0.3%)
	Critically Dry	6515	6448 (-1%)	6465 (-0.8%)	6460 (-0.8%)	6447 (-1%)
	All	18565	18557 (0%)	18626 (0.3%)	18551 (-0.1%)	18800 (1.3%)
March	Wet	24660	24660 (0%)	24660 (0%)	24660 (0%)	24660 (0%)
	Above Normal	17301	17331 (0.2%)	17386 (0.5%)	17330 (0.2%)	17309 (0%)
	Below Normal	8785	8785 (0%)	8785 (0%)	8786 (0%)	8784 (0%)
	Dry	8666	8603 (-0.7%)	8647 (-0.2%)	8606 (-0.7%)	8773 (1.2%)
	Critically Dry	6599	6669 (1.1%)	6623 (0.4%)	6666 (1%)	6622 (0.4%)
	All	14719	14719 (0%)	14730 (0.1%)	14720 (0%)	14747 (0.2%)
April	Wet	14483	14464 (-0.1%)	14464 (-0.1%)	14464 (-0.1%)	14465 (-0.1%)
	Above Normal	9681	9691 (0.1%)	9734 (0.6%)	9691 (0.1%)	9736 (0.6%)
	Below Normal	7386	7354 (-0.4%)	7339 (-0.6%)	7354 (-0.4%)	7415 (0.4%)
	Dry	6462	6405 (-0.9%)	6293 (-2.6%)	6405 (-0.9%)	6326 (-2.1%)
	Critically Dry	5463	5465 (0%)	5458 (-0.1%)	5465 (0%)	5323 (-2.6%)
	All	9488	9466 (-0.2%)	9444 (-0.5%)	9466 (-0.2%)	9445 (-0.5%)
May	Wet	12724	12711 (-0.1%)	12711 (-0.1%)	12711 (-0.1%)	12711 (-0.1%)
	Above Normal	11074	11011 (-0.6%)	11004 (-0.6%)	11011 (-0.6%)	11004 (-0.6%)
	Below Normal	9138	9002 (-1.5%)	8717 (-4.6%)	9002 (-1.5%)	8688 (-4.9%)

This Chapter is not yet edited. Provided for preliminary review and discussion.

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	ALT 3
	Dry	9106	8898 (-2.3%)	8790 (-3.5%)	8897 (-2.3%)	8533 (-6.3%)^
	Critically Dry	8754	8069 (-7.8%)^	8000 (-8.6%)^	8059 (-7.9%)^	8040 (-8.2%)^
	All	10495	10312 (-1.7%)	10229 (-2.5%)	10311 (-1.8%)	10173 (-3.1%)
June	Wet	10822	10768 (-0.5%)	10768 (-0.5%)	10768 (-0.5%)	10768 (-0.5%)
	Above Normal	11093	11049 (-0.4%)	10373 (-6.5%)^	11048 (-0.4%)	10103 (-8.9%)^
	Below Normal	11318	11223 (-0.8%)	11028 (-2.6%)	11223 (-0.8%)	10316 (-8.9%)^
	Dry	11720	11451 (-2.3%)	11567 (-1.3%)	11452 (-2.3%)	11224 (-4.2%)
	Critically Dry	10013	10043 (0.3%)	9930 (-0.8%)	10023 (0.1%)	9968 (-0.4%)
	All	11025	10931 (-0.9%)	10807 (-2%)	10928 (-0.9%)	10577 (-4.1%)
July	Wet	13475	13522 (0.4%)	13522 (0.4%)	13523 (0.4%)	13523 (0.4%)
	Above Normal	14827	14780 (-0.3%)	14471 (-2.4%)	14773 (-0.4%)	14115 (-4.8%)
	Below Normal	13594	13700 (0.8%)	13612 (0.1%)	13695 (0.7%)	13469 (-0.9%)
	Dry	12521	12701 (1.4%)	12783 (2.1%)	12704 (1.5%)	12501 (-0.2%)
	Critically Dry	10030	10083 (0.5%)	10068 (0.4%)	10060 (0.3%)	10037 (0.1%)
	All	12980	13053 (0.6%)	13009 (0.2%)	13049 (0.5%)	12866 (-0.9%)
August	Wet	11605	11615 (0.1%)	11616 (0.1%)	11615 (0.1%)	11615 (0.1%)
	Above Normal	11106	11073 (-0.3%)	11105 (0%)	11073 (-0.3%)	10192 (-8.2%)*
	Below Normal	9999	9969 (-0.3%)	9965 (-0.3%)	9978 (-0.2%)	9888 (-1.1%)
	Dry	9388	9607 (2.3%)	9567 (1.9%)	9609 (2.4%)	9369 (-0.2%)
	Critically Dry	8545	8426 (-1.4%)	8588 (0.5%)	8587 (0.5%)	8455 (-1%)
	All	10323	10347 (0.2%)	10366 (0.4%)	10373 (0.5%)	10156 (-1.6%)
September	Wet	10811	10813 (0%)	10822 (0.1%)	10813 (0%)	10815 (0%)
	Above Normal	8763	8790 (0.3%)	9121 (4.1%)	8797 (0.4%)	9508 (8.5%)*
	Below Normal	6115	6139 (0.4%)	6205 (1.5%)	6135 (0.3%)	6269 (2.5%)
	Dry	5304	5479 (3.3%)	5447 (2.7%)	5476 (3.2%)	5436 (2.5%)
	Critically Dry	4844	5054 (4.3%)	5065 (4.6%)	5035 (3.9%)	5028 (3.8%)
	All	7628	7706 (1%)	7763 (1.8%)	7702 (1%)	7820 (2.5%)
October	Wet	8722	8725 (0%)	8716 (-0.1%)	8725 (0%)	8725 (0%)
	Above Normal	7023	7096 (1%)	7171 (2.1%)	7096 (1%)	7561 (7.7%)*
	Below Normal	7199	7171 (-0.4%)	7249 (0.7%)	7220 (0.3%)	7490 (4.1%)
	Dry	6073	6091 (0.3%)	6005 (-1.1%)	6091 (0.3%)	6217 (2.4%)
	Critically Dry	6058	6519 (7.6%)*	6455 (6.6%)*	6461 (6.7%)*	6570 (8.5%)*
	All	7242	7320 (1.1%)	7314 (1%)	7320 (1.1%)	7478 (3.3%)
November	Wet	9466	9445 (-0.2%)	9365 (-1.1%)	9445 (-0.2%)	9374 (-1%)
	Above Normal	10518	10530 (0.1%)	10507 (-0.1%)	10528 (0.1%)	10648 (1.2%)
	Below Normal	8157	8224 (0.8%)	8413 (3.1%)	8215 (0.7%)	8557 (4.9%)
	Dry	7256	7210 (-0.6%)	7616 (5%)	7152 (-1.4%)	7616 (5%)
	Critically Dry	6376	6345 (-0.5%)	6393 (0.3%)	6378 (0%)	6354 (-0.3%)

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	ALT 3
	All	8459	8451 (-0.1%)	8551 (1.1%)	8441 (-0.2%)	8593 (1.6%)
December	Wet	13051	13022 (-0.2%)	13018 (-0.3%)	13023 (-0.2%)	13026 (-0.2%)
	Above Normal	11516	11498 (-0.2%)	11697 (1.6%)	11498 (-0.2%)	11881 (3.2%)
	Below Normal	13104	13130 (0.2%)	13214 (0.8%)	13139 (0.3%)	13458 (2.7%)
	Dry	13766	13978 (1.5%)	13812 (0.3%)	13984 (1.6%)	14300 (3.9%)
	Critically Dry	6565	6468 (-1.5%)	6544 (-0.3%)	6552 (-0.2%)	6560 (-0.1%)
	All	12043	12068 (0.2%)	12085 (0.3%)	12084 (0.3%)	12266 (1.8%)

* Results for which mean flow under Alternative 1, 2, or 3 is more than 5% above mean flow under the NAA are highlighted green to flag the largest increases for reader's convenience.
^ Results for which mean flow under Alternative 1, 2, or 3 is more than 5% below mean flow under the NAA are highlighted red to flag the largest increases for reader's convenience.

Table 11-ST3. CALSIM II Monthly Average Flow (cfs) by Month and Water Year Type at Hamilton City for the No Action Alternative (NAA) and Alternatives 1A, 1B, 2, and 3, and Percent Differences between Them (in Parentheses).

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	ALT 3
January	Wet	32780	31516 (-3.9%)	31401 (-4.2%)	31552 (-3.7%)	31368 (-4.3%)
	Above Normal	19441	17823 (-8.3%)^	17823 (-8.3%)^	17824 (-8.3%)^	17823 (-8.3%)^
	Below Normal	10879	10294 (-5.4%)^	10284 (-5.5%)^	10293 (-5.4%)^	10280 (-5.5%)^
	Dry	7652	7308 (-4.5%)	7301 (-4.6%)	7308 (-4.5%)	7300 (-4.6%)
	Critically Dry	7052	6872 (-2.5%)	6770 (-4%)	6785 (-3.8%)	6712 (-4.8%)
	All	17808	16968 (-4.7%)	16914 (-5%)^	16967 (-4.7%)	16894 (-5.1%)^
February	Wet	35503	34085 (-4%)	33940 (-4.4%)	34180 (-3.7%)	34078 (-4%)
	Above Normal	27752	26520 (-4.4%)	26451 (-4.7%)	26543 (-4.4%)	26975 (-2.8%)
	Below Normal	14992	13827 (-7.8%)^	13928 (-7.1%)^	13766 (-8.2%)^	13889 (-7.4%)^
	Dry	10418	9761 (-6.3%)^	9817 (-5.8%)^	9761 (-6.3%)^	9846 (-5.5%)^
	Critically Dry	7401	7182 (-3%)	7199 (-2.7%)	7194 (-2.8%)	7185 (-2.9%)
	All	21248	20243 (-4.7%)	20219 (-4.8%)	20268 (-4.6%)	20337 (-4.3%)
March	Wet	28021	26893 (-4%)	26851 (-4.2%)	27115 (-3.2%)	26484 (-5.5%)^
	Above Normal	20211	18149 (-10.2%)^	18204 (-9.9%)^	18173 (-10.1%)^	18006 (-10.9%)^
	Below Normal	10294	8965 (-12.9%)^	8975 (-12.8%)^	8971 (-12.9%)^	8957 (-13%)^
	Dry	10365	9232 (-10.9%)^	9211 (-11.1%)^	9295 (-10.3%)^	9333 (-10%)^
	Critically Dry	7535	7242 (-3.9%)	7196 (-4.5%)	7239 (-3.9%)	7248 (-3.8%)
	All	16978	15800 (-6.9%)^	15785 (-7%)^	15888 (-6.4%)^	15671 (-7.7%)^
April	Wet	16778	15876 (-5.4%)^	15753 (-6.1%)^	15995 (-4.7%)	15509 (-7.6%)^
	Above Normal	11140	10858 (-2.5%)	10901 (-2.1%)	10858 (-2.5%)	10902 (-2.1%)
	Below Normal	8469	8233 (-2.8%)	8237 (-2.7%)	8233 (-2.8%)	8311 (-1.9%)
	Dry	7057	7031 (-0.4%)	6946 (-1.6%)	7031 (-0.4%)	6971 (-1.2%)
	Critically Dry	5511	5541 (0.5%)	5543 (0.6%)	5541 (0.5%)	5390 (-2.2%)

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	ALT 3
	All	10752	10383 (-3.4%)	10332 (-3.9%)	10420 (-3.1%)	10251 (-4.7%)
May	Wet	12053	11789 (-2.2%)	11708 (-2.9%)	11792 (-2.2%)	11598 (-3.8%)
	Above Normal	9742	9601 (-1.4%)	9607 (-1.4%)	9601 (-1.4%)	9606 (-1.4%)
	Below Normal	7330	7180 (-2%)	7184 (-2%)	7180 (-2%)	7250 (-1.1%)
	Dry	7176	7049 (-1.8%)	7051 (-1.7%)	7049 (-1.8%)	7071 (-1.5%)
	Critically Dry	6907	6456 (-6.5%)^	6440 (-6.8%)^	6439 (-6.8%)^	6495 (-6%)^
	All	9085	8861 (-2.5%)	8835 (-2.8%)	8859 (-2.5%)	8824 (-2.9%)
June	Wet	8440	8212 (-2.7%)	8181 (-3.1%)	8215 (-2.7%)	8143 (-3.5%)
	Above Normal	8190	7982 (-2.5%)	7770 (-5.1%)^	7982 (-2.5%)	7736 (-5.5%)^
	Below Normal	8216	8047 (-2.1%)	7977 (-2.9%)	8047 (-2.1%)	7953 (-3.2%)
	Dry	8636	8647 (0.1%)	8754 (1.4%)	8608 (-0.3%)	8778 (1.6%)
	Critically Dry	7577	7628 (0.7%)	7603 (0.3%)	7595 (0.2%)	7572 (-0.1%)
	All	8282	8160 (-1.5%)	8127 (-1.9%)	8148 (-1.6%)	8107 (-2.1%)
July	Wet	9928	9914 (-0.1%)	9915 (-0.1%)	9916 (-0.1%)	9917 (-0.1%)
	Above Normal	11107	11165 (0.5%)	11158 (0.5%)	11168 (0.6%)	12101 (9%)*
	Below Normal	9933	10097 (1.7%)	10091 (1.6%)	10101 (1.7%)	10537 (6.1%)*
	Dry	9375	10133 (8.1%)*	10146 (8.2%)*	10135 (8.1%)*	10104 (7.8%)*
	Critically Dry	7630	8187 (7.3%)*	8185 (7.3%)*	8126 (6.5%)*	8063 (5.7%)*
	All	9644	9923 (2.9%)	9925 (2.9%)	9917 (2.8%)	10112 (4.9%)
August	Wet	8511	8430 (-0.9%)	8431 (-0.9%)	8467 (-0.5%)	8430 (-0.9%)
	Above Normal	8113	8087 (-0.3%)	8143 (0.4%)	8088 (-0.3%)	7875 (-2.9%)
	Below Normal	7138	7206 (0.9%)	7235 (1.4%)	7216 (1.1%)	7232 (1.3%)
	Dry	6996	7657 (9.5%)*	7623 (9%)*	7612 (8.8%)*	7350 (5.1%)*
	Critically Dry	6668	6898 (3.5%)	7066 (6%)*	6988 (4.8%)	6733 (1%)
	All	7616	7777 (2.1%)	7807 (2.5%)	7794 (2.3%)	7659 (0.6%)
September	Wet	10077	10045 (-0.3%)	10089 (0.1%)	10080 (0%)	10046 (-0.3%)
	Above Normal	8012	8044 (0.4%)	8373 (4.5%)	8049 (0.5%)	8811 (10%)
	Below Normal	5433	5565 (2.4%)	5623 (3.5%)	5570 (2.5%)	5675 (4.5%)
	Dry	4642	5030 (8.4%)*	4984 (7.4%)*	5033 (8.4%)*	4950 (6.6%)*
	Critically Dry	4292	4605 (7.3%)*	4602 (7.2%)*	4569 (6.4%)*	4551 (6%)*
	All	6942	7090 (2.1%)	7152 (3%)	7098 (2.2%)	7196 (3.7%)
October	Wet	8297	8133 (-2%)	8124 (-2.1%)	8135 (-1.9%)	8130 (-2%)
	Above Normal	6657	6730 (1.1%)	6751 (1.4%)	6730 (1.1%)	7143 (7.3%)*
	Below Normal	6930	7085 (2.2%)	7158 (3.3%)	7139 (3%)	7402 (6.8%)*
	Dry	5613	5801 (3.3%)	5707 (1.7%)	5807 (3.4%)	5903 (5.2%)*
	Critically Dry	5662	6223 (9.9%)*	6151 (8.6%)*	6184 (9.2%)*	6227 (10%)*
	All	6849	6957 (1.6%)	6939 (1.3%)	6963 (1.7%)	7094 (3.6%)
	Wet	9582	9222 (-3.8%)	9158 (-4.4%)	9226 (-3.7%)	9167 (-4.3%)

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	ALT 3
November	Above Normal	10622	10472 (-1.4%)	10434 (-1.8%)	10480 (-1.3%)	10481 (-1.3%)
	Below Normal	8266	8411 (1.7%)	8602 (4.1%)	8342 (0.9%)	8685 (5.1%)*
	Dry	7317	7353 (0.5%)	7764 (6.1%)*	7267 (-0.7%)	7721 (5.5%)*
	Critically Dry	6125	6143 (0.3%)	6173 (0.8%)	6165 (0.7%)	6144 (0.3%)
	All	8506	8406 (-1.2%)	8507 (0%)	8380 (-1.5%)	8517 (0.1%)
December	Wet	14455	14392 (-0.4%)	14389 (-0.5%)	14394 (-0.4%)	14397 (-0.4%)
	Above Normal	13021	12895 (-1%)	13023 (0%)	12895 (-1%)	13008 (-0.1%)
	Below Normal	14669	14263 (-2.8%)	14346 (-2.2%)	14271 (-2.7%)	14554 (-0.8%)
	Dry	15624	15413 (-1.4%)	15262 (-2.3%)	15422 (-1.3%)	15738 (0.7%)
	Critically Dry	7368	6826 (-7.4%)^	6902 (-6.3%)^	6908 (-6.3%)^	6912 (-6.2%)^
	All	13501	13268 (-1.7%)	13278 (-1.7%)	13284 (-1.6%)	13420 (-0.6%)

* Results for which mean flow under Alternative 1, 2, or 3 is more than 5% above mean flow under the NAA are highlighted green to flag the largest increases for reader's convenience.
^ Results for which mean flow under Alternative 1, 2, or 3 is more than 5% below mean flow under the NAA are highlighted red to flag the largest increases for reader's convenience.

During the August through October period, when green sturgeon spawning occurs in occasional years, all the mean flows under Alternatives 1-3 and the NAA at all three locations are below the 12,360 cfs threshold for reduced spawning WUA, and many are below the 7,500 cfs lower threshold (Table 11-ST1, Table 11-ST2, Table 11-ST3). Almost all flow changes during these months, especially at Hamilton City, consist of increases in flow, and many of these increases bring the flows closer to or above the lower flow threshold for uniform spawning WUA, which may result in greater spawning WUA for green sturgeon. The increases in mean flows primarily occur only in the drier water year types, except under Alternative 3, when they also occur often in wetter water years.

Changes in mean flow under Alternatives 1-3 within the green sturgeon spawning reach during the spawning months are expected to result in potential reductions in spawning WUA at the Hamilton City location during May of critically dry years. Changes in mean flow under Alternatives 1-3 are expected to result in potential increases in spawning WUA at Hamilton City during March and April and August through October, at RBDD during March and October, and at Bend Bridge during October of critically dry years. Taken together, these changes indicate that Alternatives 1-3 would have no adverse effects on green sturgeon spawning habitat in the Sacramento River.

Larval and Juvenile Rearing and Emigration

According to field observations, green sturgeon larvae begin to disperse from hatching areas about 18 days post hatch (dph), and dispersion is complete about 35 dph (Poytress et al. 2011, cited in Heublein et al. 2017b). The green sturgeon spawning period is from March through July, so the larval period is considered to be April through September. The downstream distribution of green sturgeon larvae in the Sacramento River is uncertain, but is estimated to extend to the

Colusa area, at RM 157 (Heublein et al. 2017b). The upstream limit is the Cow Creek confluence.

The green sturgeon juvenile stage begins when metamorphosis of the larva is complete, typically about 45 dph and at about 75 mm in length (Heublein et al 2017b). It is likely that juveniles rear near spawning habitat for a few months or more before migrating to the Delta (Heublein et al. 2017b). The juveniles rear in the Sacramento River from about May through December (NMFS 2017 *CWF BiOp, Appendix B*). During most of this period, the juveniles are likely to be found anywhere from the upstream spawning habitat near the Cow Creek confluence to the Delta.

The effects of flow on green sturgeon larvae and juveniles are poorly understood. There appears to be a positive relationship between annual outflow and abundance in rotary screw traps at RBDD of green sturgeon larvae and juveniles (Heublein et al. 2017b). This relationship may result from flows transporting larvae to areas with greater food availability, dispersing larvae over a wider area, and/or enhancing nutrient availability to the Sacramento River and Delta/Estuary.

CALSIM II modeling results for the Sacramento River at Bend Bridge, below RBDD and at Hamilton City indicate that mean monthly flows during the April through September period of larval rearing are generally similar between the NAA and Alternatives 1-3 except for moderately lower mean flows in May of critically dry years and, under Alternative 3, in June of above normal and below normal water years (Table 11-ST1, Table 11-ST2, Table 11-ST3). Flows are moderately higher in July through September, depending on the location. The same pattern of flow differences between the NAA and Alternatives 1-3 is evident in the Sacramento River at Wilkins Slough (RM 117), about 30 river miles downstream of Colusa, the presumed downstream limit of the green sturgeon larval distribution (Table 11-ST4). The July through September increases in flow have the potential to benefit green sturgeon larvae because, as discussed above, there appears to be a positive relationship between annual outflow and abundance of green sturgeon larvae and juveniles, but this conclusion is highly uncertain.

Table 11-ST4. CALSIM II Monthly Average Flow (cfs) by Month and Water Year Type at Wilkins Slough for the No Action Alternative (NAA) and Alternatives 1A, 1B, 2, and 3, and Percent Differences between Them (in Parentheses).

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	ALT 3
January	Wet	20933	20623 (-1.5%)	20571 (-1.7%)	20675 (-1.2%)	20565 (-1.8%)
	Above Normal	18310	17795 (-2.8%)	17800 (-2.8%)	17795 (-2.8%)	17804 (-2.8%)
	Below Normal	12261	11863 (-3.2%)	11853 (-3.3%)	11860 (-3.3%)	11851 (-3.3%)
	Dry	8576	8338 (-2.8%)	8322 (-3%)	8337 (-2.8%)	8319 (-3%)
	Critically Dry	8126	7963 (-2%)	7862 (-3.3%)	7873 (-3.1%)	7804 (-4%)
	All	14482	14164 (-2.2%)	14128 (-2.4%)	14167 (-2.2%)	14118 (-2.5%)
February	Wet	21863	21609 (-1.2%)	21590 (-1.2%)	21616 (-1.1%)	21595 (-1.2%)
	Above Normal	20692	20325 (-1.8%)	20363 (-1.6%)	20334 (-1.7%)	20532 (-0.8%)
	Below Normal	15211	14593 (-4.1%)	14642 (-3.7%)	14546 (-4.4%)	14691 (-3.4%)

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	ALT 3
	Dry	11930	11543 (-3.2%)	11575 (-3%)	11544 (-3.2%)	11608 (-2.7%)
	Critically Dry	8394	8213 (-2.2%)	8238 (-1.9%)	8232 (-1.9%)	8232 (-1.9%)
	All	16404	16053 (-2.1%)	16072 (-2%)	16052 (-2.2%)	16113 (-1.8%)
March	Wet	19607	19124 (-2.5%)	19108 (-2.5%)	19209 (-2%)	18953 (-3.3%)
	Above Normal	18867	17759 (-5.9%)^	17795 (-5.7%)^	17777 (-5.8%)^	17680 (-6.3%)^
	Below Normal	11773	10562 (-10.3%)^	10570 (-10.2%)^	10568 (-10.2%)^	10557 (-10.3%)^
	Dry	11798	10914 (-7.5%)^	10905 (-7.6%)^	10977 (-7%)^	11010 (-6.7%)^
	Critically Dry	8727	8448 (-3.2%)	8398 (-3.8%)	8442 (-3.3%)	8452 (-3.1%)
	All	14855	14098 (-5.1%)^	14090 (-5.1%)^	14141 (-4.8%)	14053 (-5.4%)^
April	Wet	16301	15790 (-3.1%)	15768 (-3.3%)	15872 (-2.6%)	15734 (-3.5%)
	Above Normal	12447	12357 (-0.7%)	12399 (-0.4%)	12356 (-0.7%)	12406 (-0.3%)
	Below Normal	9510	9406 (-1.1%)	9409 (-1.1%)	9405 (-1.1%)	9476 (-0.4%)
	Dry	7476	7470 (-0.1%)	7387 (-1.2%)	7468 (-0.1%)	7410 (-0.9%)
	Critically Dry	5560	5570 (0.2%)	5575 (0.3%)	5570 (0.2%)	5423 (-2.5%)
	All	11068	10876 (-1.7%)	10858 (-1.9%)	10901 (-1.5%)	10843 (-2%)
May	Wet	10572	10373 (-1.9%)	10293 (-2.6%)	10375 (-1.9%)	10183 (-3.7%)
	Above Normal	8265	8105 (-1.9%)	8110 (-1.9%)	8105 (-1.9%)	8109 (-1.9%)
	Below Normal	5473	5303 (-3.1%)	5308 (-3%)	5303 (-3.1%)	5372 (-1.8%)
	Dry	4619	4478 (-3%)	4484 (-2.9%)	4478 (-3%)	4505 (-2.5%)
	Critically Dry	4378	3906 (-10.8%)^	3890 (-11.1%)^	3888 (-11.2%)^	3955 (-9.7%)^
	All	7151	6935 (-3%)	6910 (-3.4%)	6933 (-3%)	6900 (-3.5%)
June	Wet	6786	6555 (-3.4%)	6526 (-3.8%)	6560 (-3.3%)	6488 (-4.4%)
	Above Normal	5884	5671 (-3.6%)	5460 (-7.2%)^	5671 (-3.6%)	5426 (-7.8%)^
	Below Normal	5540	5366 (-3.1%)	5296 (-4.4%)	5366 (-3.1%)	5270 (-4.9%)
	Dry	5618	5629 (0.2%)	5733 (2%)	5591 (-0.5%)	5759 (2.5%)
	Critically Dry	4755	4830 (1.6%)	4805 (1.1%)	4798 (0.9%)	4768 (0.3%)
	All	5887	5767 (-2.1%)	5734 (-2.6%)	5755 (-2.2%)	5713 (-3%)
July	Wet	7085	7074 (-0.2%)	7075 (-0.1%)	7077 (-0.1%)	7077 (-0.1%)
	Above Normal	7918	7975 (0.7%)	7979 (0.8%)	7978 (0.8%)	8925 (12.7%)*
	Below Normal	6685	6849 (2.4%)	6847 (2.4%)	6853 (2.5%)	7295 (9.1%)*
	Dry	6299	7052 (11.9%)*	7060 (12.1%)*	7055 (12%)*	7018 (11.4%)*
	Critically Dry	4761	5306 (11.4%)*	5305 (11.4%)*	5247 (10.2%)*	5185 (8.9%)*
	All	6626	6904 (4.2%)	6906 (4.2%)	6898 (4.1%)	7095 (7.1%)
August	Wet	6077	5988 (-1.5%)	5987 (-1.5%)	6025 (-0.8%)	5985 (-1.5%)
	Above Normal	5841	5807 (-0.6%)	5859 (0.3%)	5807 (-0.6%)	5559 (-4.8%)
	Below Normal	4703	4755 (1.1%)	4784 (1.7%)	4765 (1.3%)	4764 (1.3%)

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	ALT 3
	Dry	4736	5360 (13.2%)*	5326 (12.5%)*	5315 (12.2%)*	5059 (6.8%)*
	Critically Dry	4847	5049 (4.2%)	5216 (7.6%)*	5141 (6.1%)*	4889 (0.9%)
	All	5334	5476 (2.7%)	5505 (3.2%)	5493 (3%)	5350 (0.3%)
September	Wet	10096	10066 (-0.3%)	10110 (0.1%)	10100 (0%)	10066 (-0.3%)
	Above Normal	7906	7938 (0.4%)	8263 (4.5%)	7944 (0.5%)	8729 (10.4%)*
	Below Normal	5294	5423 (2.4%)	5480 (3.5%)	5428 (2.5%)	5541 (4.6%)
	Dry	4445	4821 (8.5%)*	4778 (7.5%)*	4826 (8.6%)*	4754 (6.9%)*
	Critically Dry	4000	4314 (7.9%)*	4302 (7.6%)*	4272 (6.8%)*	4266 (6.7%)*
	All	6823	6969 (2.1%)	7029 (3%)	6976 (2.2%)	7083 (3.8%)
October	Wet	7961	7797 (-2.1%)	7787 (-2.2%)	7799 (-2%)	7795 (-2.1%)
	Above Normal	6351	6420 (1.1%)	6434 (1.3%)	6420 (1.1%)	6806 (7.2%)*
	Below Normal	6644	6793 (2.2%)	6863 (3.3%)	6846 (3%)	7105 (6.9%)*
	Dry	5092	5284 (3.8%)	5192 (2%)	5287 (3.8%)	5382 (5.7%)*
	Critically Dry	5102	5659 (10.9%)*	5591 (9.6%)*	5629 (10.3%)*	5661 (11%)*
	All	6452	6560 (1.7%)	6540 (1.4%)	6566 (1.8%)	6690 (3.7%)
November	Wet	9018	8684 (-3.7%)	8621 (-4.4%)	8688 (-3.7%)	8629 (-4.3%)
	Above Normal	8768	8749 (-0.2%)	8679 (-1%)	8754 (-0.2%)	8643 (-1.4%)
	Below Normal	8090	8232 (1.8%)	8400 (3.8%)	8161 (0.9%)	8481 (4.8%)
	Dry	6567	6620 (0.8%)	7010 (6.7%)*	6533 (-0.5%)	6953 (5.9%)*
	Critically Dry	5450	5453 (0.1%)	5488 (0.7%)	5476 (0.5%)	5451 (0%)
	All	7763	7690 (-0.9%)	7780 (0.2%)	7665 (-1.3%)	7773 (0.1%)
December	Wet	12477	12421 (-0.4%)	12428 (-0.4%)	12423 (-0.4%)	12437 (-0.3%)
	Above Normal	12576	12442 (-1.1%)	12610 (0.3%)	12442 (-1.1%)	12714 (1.1%)
	Below Normal	13002	12916 (-0.7%)	12972 (-0.2%)	12925 (-0.6%)	13114 (0.9%)
	Dry	11959	11966 (0.1%)	11870 (-0.7%)	11974 (0.1%)	12141 (1.5%)
	Critically Dry	8000	7495 (-6.3%)^	7569 (-5.4%)^	7574 (-5.3%)^	7580 (-5.3%)^
	All	11812	11688 (-1.1%)	11714 (-0.8%)	11703 (-0.9%)	11817 (0%)

* Results for which mean flow under Alternative 1, 2, or 3 is more than 5% above mean flow under the NAA are highlighted green to flag the largest increases for reader's convenience.
^ Results for which mean flow under Alternative 1, 2, or 3 is more than 5% below mean flow under the NAA are highlighted red to flag the largest increases for reader's convenience.

During the May through December period of juvenile green sturgeon rearing in the Sacramento River, CALSIM II results for the Sacramento River at Bend Bridge, below RBDD, and at Hamilton City and Wilkins Slough are generally similar between the NAA and Alternatives 1-3, with exceptions including moderately lower flows under the project alternatives in May and December of critically dry years and higher flows in July through October in drier water years, especially at the more downstream sites (Table 11-ST3 and Table 11-ST4). The results under Alternative 3 also show increases in flow in other year types at these locations.

Adult Migration and Holding

Green sturgeon adults enter the Sacramento River from the Delta as early as February and ultimately make their way upstream to spawn in deep pools from the GCID oxbow (near Hamilton City) to the Cow Creek confluence (Heublein et al. 2017b). Elevated flows during the late winter and early spring months may provide an important cue for spawning green sturgeon adults to initiate their upstream migrations (Heublein et al. 2009; NMFS 2018b). Very low flows potentially create difficult upstream passage conditions (NMFS 2018b). Green sturgeon spawn in most years from March through July, but spawn in occasional years as late as October. After spawning, the adults hold in the river for varying amounts of time, but typically emigrate back to the San Francisco Estuary and the ocean from about October through December (Heublein et al. 2017b).

Differences in mean monthly flows during the March through December portion of the green sturgeon period of adult immigration, spawning and holding were described above in the sections on spawning and larval and juvenile rearing and emigration. Mean flows for these months are generally similar between the NAA and Alternatives 1-3 at all locations, with some reductions in the spring months and increases in the summer and fall (Table 11-ST1 through Table 11-ST4). Mean flows during February are generally lower under Alternatives 1-3 in dry and below normal water years below RBDD and at Hamilton City. Most of the larger flow reductions (>5%) occur within a range of mean flows (~6,000 cfs to ~20,000 cfs) not expected to substantially affect upstream passage of migrating green sturgeon. However, mean flows at Wilkins Slough in May of critically dry years are expected to drop from about 4,400 cfs under the NAA to about 3,900 cfs under the project alternatives.

To evaluate the frequency of low flows at Wilkins Slough that would potentially affect upstream passage of sturgeon, the frequency of monthly flows less than 3,250 cfs during the February through June immigration period was determined from CALSIM II outputs (see Appendix 11-N). The CALSIM II record shows no months with flows less than 3,250 cfs for the NAA, while it shows about 1% to 1.5% such months for the project alternatives (Table 11N-33). These results indicate that the project alternatives would have a somewhat greater likelihood of having flows potentially low enough to create adverse passage conditions, but a frequency of 1% to 1.5% for such flows is unlikely to have an appreciable effect on the sturgeon population. Especially low flows would potentially result in some delay in upstream migration, but the adults would likely continue their migration and spawning after flow subsequently increased.

Commented [C104]: What is the minimum flow requirement is it 5,000 cfs?

Sites Reservoir Release Effects

Sites reservoir releases could temporally overlap with green sturgeon presence near the release location in the Sacramento River. Migrating adults would be present primarily during February through April and rearing or emigrating juveniles could be present year-round (Appendix 11A, Table 11A-10).

Sites Reservoir releases into the Yolo Bypass via the CBD would not overlap with the adult green sturgeon migration period, but would coincide with the juvenile rearing and emigration from August through October (Appendix 11A, Table 11A-10). No green sturgeon were collected during rescue efforts at Wallace Weir in 2014–2020 (Purdy and Kubo 2021).

Temperature Effects

As discussed in Chapter 6, *Surface Water Quality*, the effect of Alternatives 1A, 1B, 2, and 3 on water temperatures at the Sites Reservoir release site in the Sacramento River would be relatively small with the releases generally tending to cause a slight reduction in water temperature (Tables 6-12a through 6-12d). Temperature-related effects of Alternatives 1A, 1B, 2, and 3 on green sturgeon at the release site would be minimal.

All changes in water temperature in the Yolo Bypass due to Sites Reservoir releases via the CBD would be zero or negative for Alternatives 1A, 1B, 2, and 3 (Table CBD_temp). These lower water temperatures are not expected to have a lethal effect on juvenile green sturgeon in the Yolo Bypass. Lower temperatures could reduce the growth of juvenile green sturgeon somewhat due to reduced metabolism. However, the small reduction in water temperatures is expected to occur in a limited area of the Yolo Bypass before it equilibrates with atmospheric temperatures. As a result, temperature effects under Alternatives 1A, 1B, 2, and 3 in the Yolo Bypass due to Sites Reservoir releases would be minimal at a population level for green sturgeon.

As discussed in Impact Fish-2, temperature changes for Alternatives 1A, 1B, 2, and 3 due to Sites Reservoir releases in the Sacramento River below the Yolo Bypass, and effects to green sturgeon, would be minimal due to the small proportion of Sacramento River water in this reach coming off the Yolo Bypass.

Feather River

Far-Field Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between Alternatives 1–3 and the NAA in the Feather River LFC below the Fish Barrier Dam and in the HFC at Gridley Bridge indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of green sturgeon (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-16-1a to 6C-16-4c, Tables 6C-18-1a to 6C-18-4c; Figures 6C-16-1 to 6C-16-18, Figures 6C-18-1 to 6C-18-18). At all locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within

±1°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at all locations.

Results of the analysis of exceedance above water temperature index values for green sturgeon in the Feather River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X and summarized in Table 11-temp12. For each life stage and at each location evaluated, there were no month and water year type combinations in which both: (1) the percent of months that exceeded the index values was more than 5% greater under Alt 1A than under the NAA, and (2) the exceedance per month was more than 0.5°F greater under Alt 1A than under the NAA. For Alt 1B, there was one month and water year type combination, June of Dry Water Years in the HFC below Thermalito Afterbay outlet, in which both criteria would be met. Results of the exceedance analysis for Alt 2 and Alt 3 are similar to Alt 1A with no month and water year type combinations in which both criteria were met for any life stage at all locations.

Table 11-temp12. Number of month and water year type combinations that satisfy both criteria for being biologically meaningful in the water temperature index value analysis, green sturgeon, Feather River[1,2,3]

Location	Non-Spawning Adult Presence	Spawning and Egg Incubation	Larval to Juvenile Rearing and Emigration
Low Flow Channel Below Fish Barrier Dam	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0
High Flow Channel Below Thermalito Afterbay outlet	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A – 0 Alt 1B – 1 negative (June, Dry years) Alt 2, 3 – 0
Gridley	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0	Alt 1A, 1B, 2, 3 – 0

[1] Criteria include: (1) the difference in frequency of exceedance between NAA and the alternative was greater than 5%, and (2) the difference in average monthly exceedance between NAA and the alternative was greater than 0.5°F.
[2] Index values for each life stage are located in Appendix 11B, *Fisheries Impact Assessment Methods*, Table 11.##.
[3] Full results presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X

Flow Effects

Spawning and Egg Incubation

Green sturgeon irregularly spawn in the Feather River. Spawning was documented in 2011 at the Thermalito Afterbay outlet and in 2017 below the Fish Barrier Dam (NMFS 2018b, Seesholtz et al. 2015). In both 2011 and 2017, water temperature was substantially cooler than average, likely due to the above average flow that occurred in the spring (Heublein et al. 2017b). Green sturgeon may spawn in the Feather River only during wet, high flow years (Heublein et al. 2017b, Seesholtz et al. 2015). In most years, water temperatures downstream of the Thermalito Afterbay outlet are too warm for normal egg incubation by late May (Heublein 2017b). When green sturgeon spawn in the Feather River, spawning occurs only in spring and early summer (Heublein et al. 2017b, Seesholtz et al. 2015); water temperatures in the river are generally too warm for a late summer and fall spawning period such as that documented for Sacramento River green sturgeon (NMFS 2018b).

Feather River flow upstream of the Thermalito Afterbay outlet (the Low Flow Channel) under Alternatives 1-3 would be identical to that under the NAA. However, downstream of the Afterbay outlet (the High Flow Channel), the flows differ between the alternatives. Feather River mean monthly flow under Alternatives 1-3 is similar to or lower than flow under the NAA during the late spring and early summer, when most green sturgeon spawning and egg incubation likely occurs (Table 11-ST5). Flow reductions under the project alternatives are especially large during June of drier water years, including 11% to 19% reductions in dry and critically dry water years. These reductions in flow would not necessarily degrade spawning habitat because, as described in the previous section on Sacramento River green sturgeon, high flow levels can result in unsuitably high flow velocities (Wyman et al. 2018). The optimal flow range for spawning habitat in the Feather River is not known. Because green sturgeon spawn in deep pools (Wyman et al. 2018), their eggs and embryos are protected from direct effects of flow reduction such as dewatering. Furthermore, Feather River spawning likely occurs only in wetter years, such as 2011 and 2017, so green sturgeon eggs are likely not present during the drier years in June when flow reductions under the project alternatives are greatest. Differences in the CALSIM II mean monthly flows during wet water years are relatively small (Table 11-ST5). Consequently, Alternatives 1-3 are not expected to have any substantial effect with regard to flow on spawning and egg incubation of green sturgeon in the Feather River.

Table 11-ST5. CALSIM II Monthly Average Flow (cfs) by Month and Water Year Type in the Feather River at Thermalito Afterbay Outlet for the No Action Alternative (NAA) and Alternatives 1A, 1B, 2, and 3, and Percent Differences between Them (in Parentheses).

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	ALT 3
January	Wet	9851	9818 (-0.3%)	9818 (-0.3%)	9818 (-0.3%)	9849 (0%)
	Above Normal	2444	2444 (0%)	2444 (0%)	2444 (0%)	2496 (2.1%)
	Below Normal	1475	1474 (-0.1%)	1482 (0.5%)	1474 (-0.1%)	1480 (0.3%)
	Dry	1397	1401 (0.3%)	1401 (0.3%)	1401 (0.3%)	1401 (0.3%)
	Critically Dry	1185	1195 (0.9%)	1186 (0.1%)	1186 (0%)	1185 (0%)
	All	4213	4205 (-0.2%)	4205 (-0.2%)	4203 (-0.2%)	4222 (0.2%)
February	Wet	10480	10545 (0.6%)	10470 (-0.1%)	10548 (0.6%)	10519 (0.4%)
	Above Normal	4517	4496 (-0.5%)	4538 (0.5%)	4504 (-0.3%)	4585 (1.5%)
	Below Normal	2647	2646 (0%)	2652 (0.2%)	2646 (0%)	2651 (0.2%)
	Dry	1534	1534 (0%)	1534 (0%)	1534 (0%)	1534 (0%)
	Critically Dry	1371	1371 (0%)	1371 (0%)	1371 (0%)	1371 (0%)
	All	4973	4991 (0.4%)	4974 (0%)	4993 (0.4%)	4996 (0.5%)
March	Wet	12293	12279 (-0.1%)	12279 (-0.1%)	12279 (-0.1%)	12290 (0%)

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	ALT 3
	Above Normal	5180	5152 (-0.5%)	5152 (-0.5%)	5153 (-0.5%)	5124 (-1.1%)
	Below Normal	1797	1797 (0%)	1797 (0%)	1797 (0%)	1797 (0%)
	Dry	1458	1456 (-0.1%)	1457 (-0.1%)	1456 (-0.1%)	1458 (0%)
	Critically Dry	1567	1568 (0%)	1564 (-0.2%)	1568 (0%)	1563 (-0.2%)
	All	5512	5503 (-0.2%)	5503 (-0.2%)	5503 (-0.2%)	5502 (-0.2%)
April	Wet	6570	6570 (0%)	6568 (0%)	6570 (0%)	6570 (0%)
	Above Normal	1897	1885 (-0.6%)	1885 (-0.6%)	1885 (-0.6%)	1885 (-0.6%)
	Below Normal	1147	1150 (0.2%)	1145 (-0.1%)	1150 (0.2%)	1146 (0%)
	Dry	1153	1171 (1.5%)	1170 (1.4%)	1171 (1.5%)	1166 (1.1%)
	Critically Dry	1155	1153 (-0.2%)	1152 (-0.3%)	1152 (-0.2%)	1161 (0.5%)
	All	2979	2981 (0.1%)	2979 (0%)	2981 (0.1%)	2981 (0.1%)
May	Wet	7547	7548 (0%)	7548 (0%)	7548 (0%)	7548 (0%)
	Above Normal	3358	3357 (0%)	3355 (-0.1%)	3356 (-0.1%)	3354 (-0.1%)
	Below Normal	1536	1551 (1%)	1550 (0.9%)	1556 (1.3%)	1541 (0.3%)
	Dry	1969	1947 (-1.1%)	1907 (-3.1%)	1947 (-1.1%)	1865 (-5.3%)^
	Critically Dry	1966	1976 (0.5%)	1977 (0.6%)	1976 (0.5%)	1962 (-0.2%)
	All	3866	3866 (0%)	3857 (-0.2%)	3867 (0%)	3844 (-0.6%)
June	Wet	5068	5048 (-0.4%)	5048 (-0.4%)	5048 (-0.4%)	5048 (-0.4%)
	Above Normal	3104	3074 (-1%)	3081 (-0.7%)	3074 (-1%)	3098 (-0.2%)
	Below Normal	2759	2594 (-6%)^	2601 (-5.8%)^	2595 (-6%)^	2609 (-5.4%)^
	Dry	4510	3692 (-18.1%)^	3645 (-19.2%)^	3771 (-16.4%)^	3893 (-13.7%)^
	Critically Dry	3765	3242 (-13.9%)^	3250 (-13.7%)^	3286 (-12.7%)^	3360 (-10.8%)^
	All	4073	3778 (-7.2%)^	3771 (-7.4%)^	3802 (-6.7%)^	3846 (-5.6%)^
July	Wet	5735	5711 (-0.4%)	5713 (-0.4%)	5713 (-0.4%)	5713 (-0.4%)
	Above Normal	7984	8002 (0.2%)	7989 (0.1%)	7998 (0.2%)	7758 (-2.8%)
	Below Normal	8670	8357 (-3.6%)	8380 (-3.4%)	8366 (-3.5%)	8408 (-3%)
	Dry	6927	6427 (-7.2%)^	6503 (-6.1%)^	6429 (-7.2%)^	6709 (-3.1%)
	Critically Dry	3818	3648 (-4.5%)	3672 (-3.8%)	3662 (-4.1%)	3723 (-2.5%)
	All	6546	6353 (-2.9%)	6376 (-2.6%)	6357 (-2.9%)	6400 (-2.2%)
August	Wet	4385	4395 (0.2%)	4401 (0.4%)	4394 (0.2%)	4385 (0%)
	Above Normal	6821	6819 (0%)	6861 (0.6%)	6819 (0%)	6831 (0.2%)
	Below Normal	7478	7528 (0.7%)	7523 (0.6%)	7487 (0.1%)	7570 (1.2%)
	Dry	1912	2161 (13%)*	2226 (16.4%)*	2172 (13.6%)*	2187 (14.4%)*
	Critically Dry	2217	2470 (11.4%)*	2425 (9.3%)*	2452 (10.6%)*	2491 (12.3%)*
	All	4409	4512 (2.3%)	4527 (2.7%)	4505 (2.2%)	4527 (2.7%)
September	Wet	6466	6469 (0%)	6463 (0%)	6456 (-0.2%)	6427 (-0.6%)
	Above Normal	7654	7656 (0%)	7595 (-0.8%)	7656 (0%)	7552 (-1.3%)
	Below Normal	2389	2405 (0.7%)	2524 (5.7%)*	2406 (0.7%)	2451 (2.6%)

Commented [C105]: Significant impact potential when disentangled from average flows.

Month	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	ALT 3
	Dry	1009	1076 (6.7%)	1090 (8%)	1104 (9.4%)	1106 (9.7%)
	Critically Dry	1321	1516 (14.8%)	1557 (17.8%)	1551 (17.4%)	1509 (14.2%)
	All	3993	4040 (1.2%)	4059 (1.6%)	4047 (1.4%)	4025 (0.8%)
October	Wet	3753	3820 (1.8%)	3817 (1.7%)	3821 (1.8%)	3845 (2.5%)
	Above Normal	3613	3598 (-0.4%)	3660 (1.3%)	3600 (-0.4%)	3643 (0.8%)
	Below Normal	1991	2348 (18%)*	2290 (15.1%)*	2344 (17.8%)*	2152 (8.1%)*
	Dry	1287	1891 (46.9%)*	1886 (46.5%)*	1797 (39.6%)*	1712 (33%)*
	Critically Dry	1126	1460 (29.7%)*	1427 (26.7%)*	1388 (23.2%)*	1209 (7.3%)*
	All	2506	2767 (10.4%)*	2760 (10.1%)*	2736 (9.2%)*	2672 (6.6%)*
November	Wet	2898	2902 (0.2%)	2902 (0.2%)	2902 (0.2%)	2902 (0.2%)
	Above Normal	2113	2113 (0%)	2084 (-1.4%)	2113 (0%)	2062 (-2.4%)
	Below Normal	1629	1756 (7.8%)*	1756 (7.8%)*	1758 (7.9%)*	1745 (7.2%)*
	Dry	1260	1501 (19.2%)*	1423 (13%)*	1440 (14.3%)*	1363 (8.2%)*
	Critically Dry	954	1024 (7.3%)*	1022 (7.1%)*	1016 (6.5%)*	1019 (6.8%)*
	All	1922	2009 (4.5%)	1987 (3.4%)	1994 (3.7%)	1968 (2.4%)
December	Wet	4827	4859 (0.7%)	4858 (0.6%)	4867 (0.8%)	4845 (0.4%)
	Above Normal	2867	2821 (-1.6%)	2819 (-1.7%)	2821 (-1.6%)	2920 (1.8%)
	Below Normal	1966	1958 (-0.4%)	1957 (-0.5%)	1980 (0.7%)	1957 (-0.5%)
	Dry	1981	2020 (2%)	2025 (2.2%)	2020 (2%)	2018 (1.9%)
	Critically Dry	1654	1653 (0%)	1654 (0%)	1654 (0%)	1654 (0%)
	All	2962	2973 (0.4%)	2973 (0.4%)	2979 (0.6%)	2982 (0.7%)

* Results for which mean flow under Alternative 1, 2, or 3 is more than 5% above mean flow under the NAA are highlighted green to flag the largest increases for reader's convenience.
^ Results for which mean flow under Alternative 1, 2, or 3 is more than 5% below mean flow under the NAA are highlighted red to flag the largest increases for reader's convenience.

Larval and Juvenile Rearing and Emigration

Very little information is available on the distribution and timing of green sturgeon larvae or juveniles in the Feather River (NMFS 2018b, Heublein 2017b). Assuming that life stage development times and behaviors for green sturgeon larvae and juveniles in the Feather River are like those in the Sacramento River, the larvae occur in the Feather River from early spring to early autumn and are distributed from the Fish Barrier Dam to the confluence with the Sacramento River, while Feather River juveniles are present from May through December and from the Fish Barrier Dam to the Delta.

Mean flows in the High Flow Channel of the Feather River are substantially lower under Alternatives 1-3 than under the NAA during June, as described above, and are much higher during August through November of drier years, including 23% to 50% higher during October of dry and critically dry years under Alternatives 1A, 1B and 2 (Table 11-ST6). The October flow increases are also higher under Alternative 3, but somewhat less so. As noted for green sturgeon in the Sacramento River, higher flows may improve conditions for emigrating green sturgeon larvae and juveniles (Heublein et al. 2017b), but this is uncertain.

Adult Migration and Holding

Green sturgeon adults have been found throughout the Feather River downstream of the Fish Barrier Dam (NMFS 2018b, Heublein 2017b). However, information on the timing of adult migrations and the duration of the holding period in the Feather River is lacking so it is assumed to be the same as that for the Sacramento River: immigration from February through June and holding from March through December. CALSIM II results for Feather River mean monthly flows below the Thermalito Afterbay outlet show little difference in flow between the project alternatives and the NAA from February to May, reductions in flow under the project alternatives during June and July, and large increases in flow during late summer and fall (Table 11-ST5). All the larger differences in flow occur during below normal, dry, and critically dry years.

The flow reductions in June have the potential to result in passage barriers to upstream migrating green sturgeon. Currently, a boulder weir at the Sunset Pumps in the Feather River at Live Oak is the principal passage obstruction in the Feather River (NMFS 2018b; Seesholtz pers. comm). This weir creates a partial barrier to the only confirmed spawning location of green sturgeon in the Feather River (Seesholtz et al. 2015). USFWS (2016) indicates that the boulder weir is a barrier to upstream passage of green sturgeon when Feather River flow is less than 6,000 cfs. Although some passage at lower flows may occur, the potential effect of Feather River flow reductions under the project alternatives was assessed by enumerating from CALSIM II outputs the frequency of flow lower than 6,000 cfs during the February through June immigration period (Appendix N). The results indicate that a high percentage of the monthly flows under the NAA and Alternatives 1-3 are below the 6,000 cfs threshold for passage at the Sunset Pumps, including 78% of flows under the NAA and about 62% of lows under the project alternatives (Table 11N-34). These high percentages suggest that a Sunset Pumps passage barrier may contribute to the lack of spawning by green sturgeon in the Feather River during all but the wettest years. In any case, the results indicate that Alternatives 1-3 provide slightly improved flow conditions for upstream passage with regard to low flows. The increased flows under the project alternatives during late summer and fall may improve habitat and passage conditions for adults emigrating from the river after spawning.

Commented [C106]: Sites needs to look at the BO for the new FERC license which requires pulse flows to deal with passage issues. This should be your baseline for evaluating this impact.

Delta

South Delta Entrainment

In contrast to salmonids, for which most south Delta entrainment at the SWP and CVP export facilities occurs in winter/spring, a period of the year when there would be little difference between Alternatives 1–3 and the NAA, green sturgeon entrainment can occur in most months of the year, reflecting the year-round presence of juveniles in the Delta. However, salvage of green sturgeon has been very low in recent years, and entrainment is regarded as a threat of low importance to the population in the NMFS green sturgeon recovery plan (NMFS 2018b: 26). The salvage-density analysis (see description in Appendix 11Q) was used to assess the potential for differences in south Delta entrainment between alternatives. The method weights south Delta exports at SWP (Banks) and CVP (Jones) export facilities by historical salvage per unit volume (i.e., salvage density) of juvenile green sturgeon. The results of the analysis suggest that there would be very little difference in south Delta entrainment between NAA and Alternatives 1–3 at either export facility (Table gs_banks; Table gs_jones).

Table gs_banks. Salvage of Juvenile Green Sturgeon At SWP Banks Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	1	1 (-1%)	1 (-1%)	1 (-1%)	1 (1%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	2	2 (0%)	2 (0%)	2 (0%)	2 (0%)
Dry	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Critically Dry	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any Above Normal Water Years, hence that row of the table is noted as 'NA'.

Table gs_jones. Salvage of Juvenile Green Sturgeon At CVP Jones Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	7	7 (0%)	7 (0%)	7 (0%)	7 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Dry	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Critically Dry	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any Above Normal Water Years, hence that row of the table is noted as 'NA'.

Delta Outflow Effects

The NMFS green sturgeon recovery plan suggested that larval abundance and distribution may be influenced by spring and summer outflow and recruitment may be highest in wet years, making water flow an important habitat parameter (NMFS 2018b: 12). As noted by NMFS (2018b: 12), there are correlations between white sturgeon and Delta outflow, which have previously been used to infer potential effects on green sturgeon (ICF International 2016: 5-197 to 5-205). As discussed below for white sturgeon, the results of regression analyses for this impact analysis suggest that any potential effects of the alternatives on Delta outflow and white sturgeon year-class strength would be limited, primarily because the largest recruitment occurs in wetter years (Fish 2010) when there are smaller differences between the alternatives and NAA scenarios. This suggests potential Delta outflow effects of the alternatives on green sturgeon may also be limited.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

Differences in flow results between Alternatives 1-3 and the NAA for the Sacramento River at Bend Bridge, near the upper limit of the green sturgeon spawning distribution in the Sacramento River, shows no changes between the NAA and the project alternatives. In reference to Sacramento River green sturgeon spawning habitat, differences in mean flow between Alternatives 1-3 are negligeable. Similarly, for green sturgeon larvae rearing habitat in the Sacramento River, differences in mean monthly flows between Alternatives 1-3 are minimal and may in certain situations have potential benefits.

Modeled results indicate that Alternatives 1-3 would have a greater likelihood of having flows potentially low enough to create adverse passage conditions in the Sacramento River. This could potentially result in some delays in upstream migration; however, it is likely adults would hold and continue their migration and spawning after flow subsequently increased.

Modeled results indicate that Alternatives 1-3 are not expected to have any substantial effect with regard to flow on spawning and egg incubation of green sturgeon in the Feather River. Additionally, for the Feather River, modeling results indicate that Alternatives 1-3 provide slightly improved Feather River flow conditions for upstream and downstream passage. In-Delta and upstream operations and their impacts associated with Alternatives 1-3 on green sturgeon would be negligible on green sturgeon and their spawning habitat. Per the above discussion related to green sturgeon, impacts associated with operations of Alternative 1–3 on green sturgeon would be less than significant.

NEPA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

Per the above impact analysis and the below discussion related to green sturgeon, impacts associated with operations of Alternative 1–3 would not be adverse on green sturgeon in the Sacramento River and Feather River. Differences in flow results between Alternatives 1-3 and the NAA for the Sacramento River at Bend Bridge, near the upper limit of the green sturgeon spawning distribution in the Sacramento River, shows no changes between the NAA and the project alternatives. In reference to Sacramento River green sturgeon spawning habitat, differences in mean flow between Alternatives 1-3 are negligeable. Similarly, for green sturgeon larvae rearing habitat in the Sacramento River, differences in mean monthly flows between Alternatives 1-3 are minimal and may in certain situations have potential benefits.

Modeled results indicate that Alternatives 1-3 would have a greater likelihood of having flows potentially low enough to create adverse passage conditions in the Sacramento River. This could potentially result in some delays in upstream migration; however, it is likely adults would hold and continue their migration and spawning after flow subsequently increased.

Modeled results indicate that Alternatives 1-3 are not expected to have any substantial effect with regard to flow on spawning and egg incubation of green sturgeon in the Feather River. Additionally, for the Feather River, modeling results indicate that Alternatives 1-3 provide slightly improved Feather River flow conditions for upstream and downstream passage. In-Delta and upstream operations and their impacts associated with Alternatives 1-3 on green sturgeon would be negligible on green sturgeon and their spawning habitat.

Impact FISH-7: Operations Effects on White Sturgeon

Alternatives 1, 2, and 3

Effects of Alternatives 1, 2, and 3

Sacramento River

Near-Field Effects

White sturgeon spawning, and early life stages potentially vulnerable to entrainment and other near-field effects occurs downstream of the Red Bluff and Hamilton City intakes, as described in Appendix 11A and as reflected in the overview of flow tolerance limitations by location (see Figure sturg_verhille in the analysis for green sturgeon). Near-field effects associated with the Red Bluff and Hamilton City intakes are not expected to occur as a result of operations of the alternatives.

Far-Field Effects

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Sacramento River at Butte City indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of white sturgeon (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-12-1a to 6C-12-4c; Figures 6C-12-1 to 6C-12-18). Mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±0.5°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1.

Results of the analysis of exceedance above water temperature index values for white sturgeon in the Sacramento River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. For each life stage in each month and water year type at all locations analyzed, the difference in percent of days exceeding each index value between the NAA and Alt 1A and between the NAA and Alt 1B would be <5%, with some few isolated exceptions. For spawning and egg incubation, the percent of days exceeding the 61°F index value under both Alt 1A and Alt 1B in May of Critically Dry Water Years would be 5.1% greater than the percent of months under the NAA. Also, for juvenile rearing and emigration, the percent of days exceeding the 66°F index value under Alt 1B in June of Above Normal Water Years would be 6.1% greater than the percent of days under the NAA and the percent of months exceeding the 66°F index value under Alt 1A and Alt 1B in August of Critically Dry Water Years would be 5.1% and 7.0% lower, respectively, than the percent of days under the NAA.

Results of the analysis of exceedance for Alt 2 would be nearly identical to Alt 1A.

Results for Alt 3 would be similar to Alt 1A with some additional differences in exceedance above 5%. For spawning and egg incubation, the percent of days exceeding the 61°F index value under Alt 3 in May of Below Normal and Critically Dry Water Years would be 5.8% and 6.2% greater, respectively, than the percent of days under the NAA. For juvenile rearing and emigration, the percent of days exceeding the 66°F index value under Alt 3 in June of Above Normal and Below Normal Water Years would be 11.1% and 7.9% greater, respectively, than the percent of days under the NAA. Further, the percent of days exceeding the 66°F index value under Alt 3 in July of Above Normal Water Years would be 6.2% greater than the percent of days under the NAA.

Flow Effects

Spawning and Egg Incubation

White sturgeon spawn in deep water in the middle and lower Sacramento River from Verona (RM 80) to just upstream of Colusa (RM 146) from late February to early June, but primarily during March and April (Moyle et al. 2015; Heublein et al. 2017b). The adults typically return to the Delta soon after spawning.

During the March and April spawning and egg incubation period of white sturgeon, CALSIM II estimates of mean monthly flows at Wilkins Slough (RM ~117) under the NAA and Alternatives 1-3 range from about 5,500 cfs for April of critically dry water years to about 19,000 cfs for March of wet water years (Table 11-ST4). Differences in flows, which almost all constitute flow reductions under the project alternatives, range up to 10% for March of below normal years. Assuming that the relationship between flow and spawning weighted usable area (WUA) for white sturgeon in the Sacramento River is similar to that described above in the section on green sturgeon, the flow reductions in March of above normal water years would increase spawning WUA of white sturgeon, while the reductions in March of below normal and dry years would have no effect. It is concluded that Alternatives 1-3 would have no flow effect on white sturgeon spawning or egg incubation.

Larval and Juvenile Rearing and Emigration

During the white sturgeon juvenile emigration period, approximately April to July, CALSIM II results at Wilkins Slough indicate that flows would decrease 10% to 11% in May of critically dry years and increase 9% to 12% in July of dry and critically dry years (Table 11-ST4). Under Alternative 3, July flow would also increase in below normal and above normal years (up to 13%). The July increases in flow have the potential to benefit white sturgeon larvae because there appears to be a positive relationship between annual outflow during late winter through July and the abundance of age 0 and yearling white sturgeon (Fish 2010).

Adult Upstream Migration and Holding

White Sturgeon adults initiate their upstream spawning migrations during late winter and early spring, probably in response to elevated flows (Fish 2010). CALSIM II flows at Wilkins Slough for the December through February immigration period are largely similar between Alternatives 1-3 and the NAA, except during December of critically dry years, when reductions of up to 6% are expected for the project alternatives (Table 11-ST4). Reduced flows have potentially adverse effects on white sturgeon immigration, because they may reduce flow cues that may initiate migrations (Fish 2010), and because very low flows can result in passage barriers. However, all CALSIM II mean flows at Wilkins Slough for the white sturgeon immigration period, are between about 7,500 and 22,000 cfs, which are suitable for migration.

The white sturgeon holding period extends from about January through April. This period includes large flow reductions under the all the project alternatives during March (Table 11-ST4). However, all mean flows under the NAA and the project alternatives throughout the holding period exceed 7,500 cfs, which is likely to be adequate for conditions in the deep-water habitat in which the adults hold. Alternatives 1-3 would have no flow effects on white sturgeon immigration or holding.

Sites Reservoir Release Effects

Sites Reservoir releases could temporally overlap with white sturgeon presence near the release location in the Sacramento River. Migrating adults would be present primarily during December through February and rearing or emigrating juveniles would be present primarily during approximately April through July.

Sites Reservoir releases in the Yolo Bypass via the CBD would not coincide with the upstream migration period of adult white sturgeon or the juvenile rearing and emigration period... No white sturgeon were collected during rescue efforts at Wallace Weir in 2014–2020 (Purdy and Kubo 2021).

Temperature Effects

As discussed in Chapter 6, *Surface Water Quality*, the effect of Alternatives 1A, 1B, 2, and 3 on water temperatures at the Sites Reservoir release site in the Sacramento River would be relatively small with the releases generally tending to cause a slight reduction in water temperature (Tables 6-12a through 6-12d). Temperature-related effects of Alternatives 1A, 1B, 2, and 3 on white sturgeon at the release site would be minimal.

There would be no temperature-related effects of Sites Reservoir releases in the Yolo Bypass via the CBD and in the Sacramento River below the Yolo Bypass under Alternatives 1A, 1B, 2, and

3 because no white sturgeon would be present in these locations during August through October when the Yolo Bypass would receive Sites Reservoir releases.

Feather River

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between Alternatives 1–3 and the NAA in the Feather River LFC below the Fish Barrier Dam and in the HFC at Gridley indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of green sturgeon (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-16-1a to 6C-16-4c, Tables 6C-18-1a to 6C-18-4c; Figures 6C-16-1 to 6C-16-18, Figures 6C-18-1 to 6C-18-18). At all locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±0.7°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at all locations.

Results of the analysis of exceedance above water temperature index values for white sturgeon in the Feather River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. In the LFC below the Fish Barrier Dam, there would be no differences in exceedance of water temperature indices for any life stage between Alt 1A and Alt 1B compared to the NAA in any month or water year type. In the HFC, for each life stage in each month and water year type, the difference in percent of days exceeding each index value between the NAA and Alt 1A and between the NAA and Alt 1B would be <5%, with some isolated exceptions. Below Thermalito Afterbay in April of Critically Dry Water Years and May of Dry Water Years, there would be 8.3% and 5.6% reductions, respectively, in exceedance above the spawning and egg incubation index value of 61°F under both Alt 1A and Alt 1B compared to the NAA. Below Thermalito Afterbay in June of Above Normal Water Years, there would be a 9.1% reduction in exceedance above the juvenile rearing and emigration index value of 66°F under Alt 1A compared to the NAA. Also below Thermalito Afterbay in June and September of Critically Dry Water Years, there would be 8.3% increases in exceedance above the juvenile rearing and emigration index value of 66°F under both Alt 1A and Alt 1B compared to the NAA. There would also be a 5.6% increase in exceedance above the 66°F juvenile rearing and emigration index value below Thermalito Afterbay in June of Dry Water Years under Alt 1B relative to the NAA. At the mouth of the Feather River, there would be no differences in exceedances of water temperature indices for any life stage between Alt 1A and Alt 1B compared to the NAA in any month or water year type.

Results of the water temperature exceedance analysis for white sturgeon for Alt 2 are identical to those for Alt 1A with two exceptions. First, in June of Above Normal Water Years, there would be a 5.6% increase in exceedance of the 66°F juvenile rearing and emigration index value below Thermalito Afterbay relative to the NAA. Second, in September of Critically Dry Water Years, the exceedance above the 66°F juvenile rearing and emigration index value would be 16.7% greater under Alt 2 relative to the NAA.

Results of the water temperature exceedance analysis for white sturgeon for Alt 3 are predominantly identical to those for Alt 1A with three exceptions. First, below Thermalito Aferbay in May of Critically Dry Water Years, the exceedance above the 61°F spawning and egg incubation index value would be the same (8.3%) under both Alt 3 and the NAA. Second, below Thermalito Aferbay in June of Above Normal Water Years, there would be no difference between Alt 3 and the NAA in the exceedance above the 66°F juvenile rearing and emigration incubation index value. Third, at the Feather River mouth, the exceedance above the 66°F juvenile rearing and emigration incubation index value under Alt 3 would be 9.1% greater than under the NAA.

Delta

South Delta Entrainment

As with green sturgeon, the salvage-density analysis (see description in Appendix 11Q) was used to assess the potential for differences in south Delta entrainment of juvenile white sturgeon between alternatives. The results of the analysis suggest that there would be very little difference in south Delta entrainment between NAA and Alternatives 1–3 at either export facility (Table gs_banks; Table gs_jones). Although the mean salvage under Alternative 2 in dry years was 9% greater than under the NAA (Table gs_jones), this relative difference should be placed in the context of the very low observed historical salvage in recent years, indicating that any increase in entrainment would remain very small in population-level terms.

Table ws_banks. Salvage of Juvenile White Sturgeon At SWP Banks Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	19	19 (0%)	19 (0%)	19 (0%)	19 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	11	11 (2%)	11 (2%)	11 (2%)	11 (3%)
Dry	5	5 (0%)	5 (0%)	5 (0%)	5 (0%)
Critically Dry	4	4 (1%)	4 (1%)	4 (0%)	4 (0%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any Above Normal Water Years, hence that row of the table is noted as 'NA'.

Table ws_jones. Salvage of Juvenile White Sturgeon At CVP Jones Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	85	84 (0%)	85 (0%)	84 (0%)	84 (0%)
Above Normal	NA	NA	NA	NA	NA

Below Normal	16	16 (0%)	16 (1%)	16 (0%)	17 (6%)
Dry	2	2 (1%)	2 (9%)	2 (0%)	2 (8%)
Critically Dry	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any Above Normal Water Years, hence that row of the table is noted as 'NA'.

Delta Outflow Effects

Statistically significant positive correlations between white sturgeon year-class strength and Delta outflow have been found for November–February and March–July outflow averaging periods (Fish 2010). Other similar analyses were found that also examined the April-May outflow (ICF International 2016: 5-197 to 5-205). The mechanisms for these correlations are uncertain and could reflect upstream or in-Delta impacts. Appreciable amounts of variation are left unexplained by the relationships (i.e., r^2 of ~70%), with differences possibly reflecting hydrological conditions as opposed to operational differences in outflow. A regression-based approach predicting white sturgeon year-class strength as a function of April–May and March–July averaging periods was undertaken (see Appendix 11L). The results of the analysis indicated that there would be little difference in white sturgeon year-class strength between Alternatives 1–3 and the NAA based on April–May Delta outflow differences (Table ws_aprmay), whereas the relative difference would be larger in drier (Below Normal and Dry Water Years) years based on March–July Delta outflow differences (Table ws_marjul). Overall, these results suggest that any potential effects of the alternatives on Delta outflow and white sturgeon year-class strength would be limited, primarily because the largest recruitment occurs in wetter years (Fish 2010) when there are smaller differences between the Alternatives 1–3 and NAA scenarios.

Table ws_aprmay. Year-Class Strength of White Sturgeon Based on April–May Regression with Delta Outflow.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	148	146 (-2%)	145 (-2%)	146 (-1%)	145 (-2%)
Above Normal	70	69 (-1%)	69 (-1%)	69 (-1%)	69 (-1%)
Below Normal	32	31 (-2%)	31 (-2%)	31 (-2%)	31 (-2%)
Dry	7	7 (-1%)	7 (-1%)	7 (-1%)	7 (-1%)
Critically Dry	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty.

Table ws_marjul. Year-Class Strength of White Sturgeon Based on March–July Regression with Delta Outflow.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	121	118 (-2%)	118 (-2%)	119 (-2%)	118 (-3%)
Above Normal	55	53 (-4%)	53 (-4%)	53 (-4%)	53 (-4%)

Below Normal	9	8 (-10%)	8 (-10%)	8 (-10%)	8 (-9%)
Dry	2	2 (-22%)	2 (-22%)	2 (-21%)	2 (-16%)
Critically Dry	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

If it is assumed that the relationship between flow and spawning WUA for white sturgeon is similar to that of green sturgeon in the Sacramento River, differences in WUA for Alternatives 1-3 would have no effect to white sturgeon. White sturgeon juveniles emigrate April to July. Modeling results indicate that flows at Wilkins Slough would decrease 10% to 11% in May of critically dry years and increase 9% to 12% in July of dry and critically dry years. Under Alternative 3, July flow would also increase in below normal and above normal years (up to 13%). Similar to green sturgeon there is some correlative evidence that appears to show a positive relationship between annual outflow during late winter through July and the abundance of age 0 and yearling white sturgeon, which may mean there is a potential benefit to white sturgeon larvae from flow increases in July.

Upstream spawning migrations by white sturgeon adults are generally during late winter and early spring and may coincide with higher flows. Modeled flows at Wilkins Slough for December through February are similar between Alternatives 1-3 and the NAA, except during December of critically dry years, when reductions of up to 6% are expected for the project alternatives. Reduced flows may reduce flow cues for adult migration potentially causing adverse effects on white sturgeon immigration and because very low flows can result in passage barriers. However, all modeled mean flows at Wilkins Slough for the white sturgeon immigration period, are between about 7,500 and 22,000 cfs, which are suitable for migration. White sturgeon holding period extends from about January through April in deep water habitat. All modeled mean flows under the NAA and the project alternatives during the holding period exceed 7,500 cfs, which is likely to be adequate for white sturgeon holding conditions.

Commented [C107]: Significant impact in critical years. The impact is likely to be more extreme than the long term average in many years.

Per the above discussion related to white sturgeon, impacts associated with operations of Alternative 1–3 on white sturgeon adult immigration and holding, and on spawning and egg incubation would be less than significant.

NEPA Conclusion for Alternatives 1, 2, and 3

Per the above analysis and below discussion related to white sturgeon, impacts associated with operations of Alternative 1–3 would not be adverse on white sturgeon adult immigration and holding, and on spawning and egg incubation. If it is assumed that the relationship between flow and spawning WUA for white sturgeon is similar to that of green sturgeon in the Sacramento River, differences in WUA for Alternatives 1-3 would have no effect to white sturgeon. White sturgeon juveniles emigrate April to July. Modeling results indicate that flows at Wilkins Slough would decrease 10% to 11% in May of critically dry years and increase 9% to 12% in July of dry and critically dry years. Under Alternative 3, July flow would also increase in below normal and above normal years (up to 13%). Similar to green sturgeon there is some correlative evidence that appears to show a positive relationship between annual outflow during late winter through July and the abundance of age 0 and yearling white sturgeon, which may mean there is a potential benefit to white sturgeon larvae from flow increases in July.

Upstream spawning migrations by white sturgeon adults are generally during late winter and early spring and may coincide with higher flows. Modeled flows at Wilkins Slough for the December through February are similar between Alternatives 1-3 and the NAA, except during December of critically dry years, when reductions of up to 6% are expected for the project alternatives. Reduced flows they may reduce flow cues for adult migration potentially causing adverse effects on white sturgeon immigration and because very low flows can result in passage barriers. However, all modeled mean flows at Wilkins Slough for the white sturgeon immigration period, are between about 7,500 and 22,000 cfs, which are suitable for migration. White sturgeon holding period extends from about January through April in deep water habitat. All modeled mean flows under the NAA and the project alternatives during the holding period exceed 7,500 cfs, which is likely to be adequate for white sturgeon holding conditions.

Impact FISH-8: Operations Effects on Delta Smelt

Alternatives 1, 2, and 3

<u>*Effects of Alternatives 1, 2, and 3*</u>

As described in Appendix 11A, delta smelt primarily occur within the Delta and Suisun Bay/Marsh, so this impact analysis is focused on these areas.

<u>**Effects from Reservoir Releases to CBD/Yolo Bypass**</u>

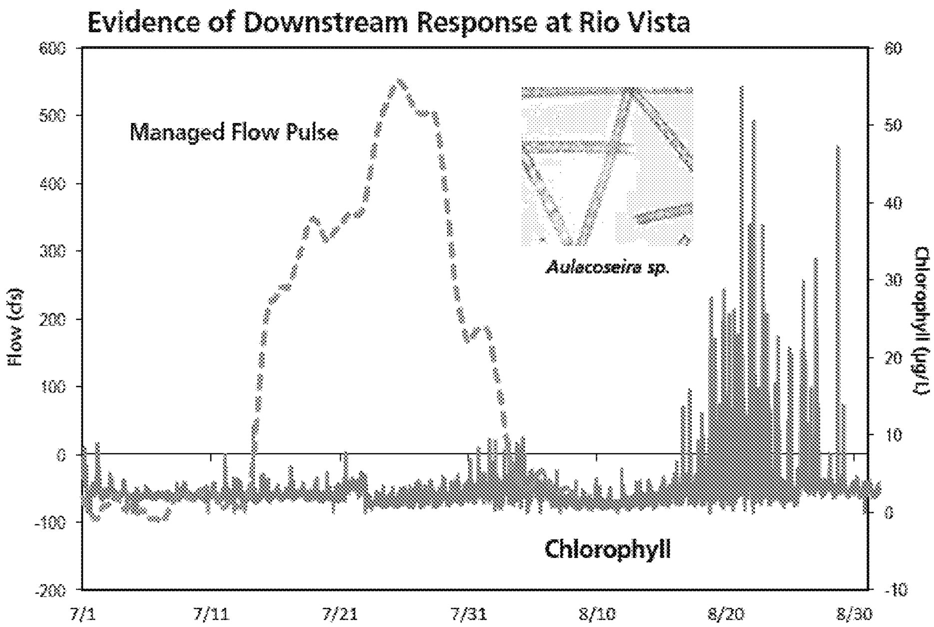
Food availability is a key habitat attribute hypothesized to be important for juvenile delta smelt (IEP MAST 2015: 88). Alternatives 1–3 include summer/fall releases of water from Sites Reservoir into the CBD and thence the Yolo Bypass, in order to enhance foodweb productivity in the north Delta for delta smelt. Thus Alternatives 1–3 would increase flow through Yolo Bypass in August from ~50 cfs in nearly 90% of years under NAA to ~400–450 cfs in 60–70% of years under Alternatives 1–3; in September from ~50–60 cfs in 80% of years under NAA to ~300–350 cfs more under Alternatives 1–3 in 40% of years; and in October from <100 cfs in most years to ~400 cfs or more in 30–40% of years under Alternatives 1–3 (Appendix 5B3: Tables 5B3-3-1a through 5B3-3-4c).

An average of 23% of delta smelt surviving to adulthood are resident in the Cache Slough Complex/Sacramento Deepwater Ship Channel region throughout their lives, whereas the remainder either migrate to the low salinity zone or are resident there (Bush 2017). The portion of the population resident in the north Delta would be most likely to benefit from the summer/fall north Delta food subsidy from CBD, in particular those occurring in the Yolo Bypass Toe Drain (Mahardja et al. 2019). A pilot implementation of this action in 2016 found that primary

Commented [C108]: To date there is no evidence that Delta Smelt are benefiting from the summer/fall north Delta food subsidy.

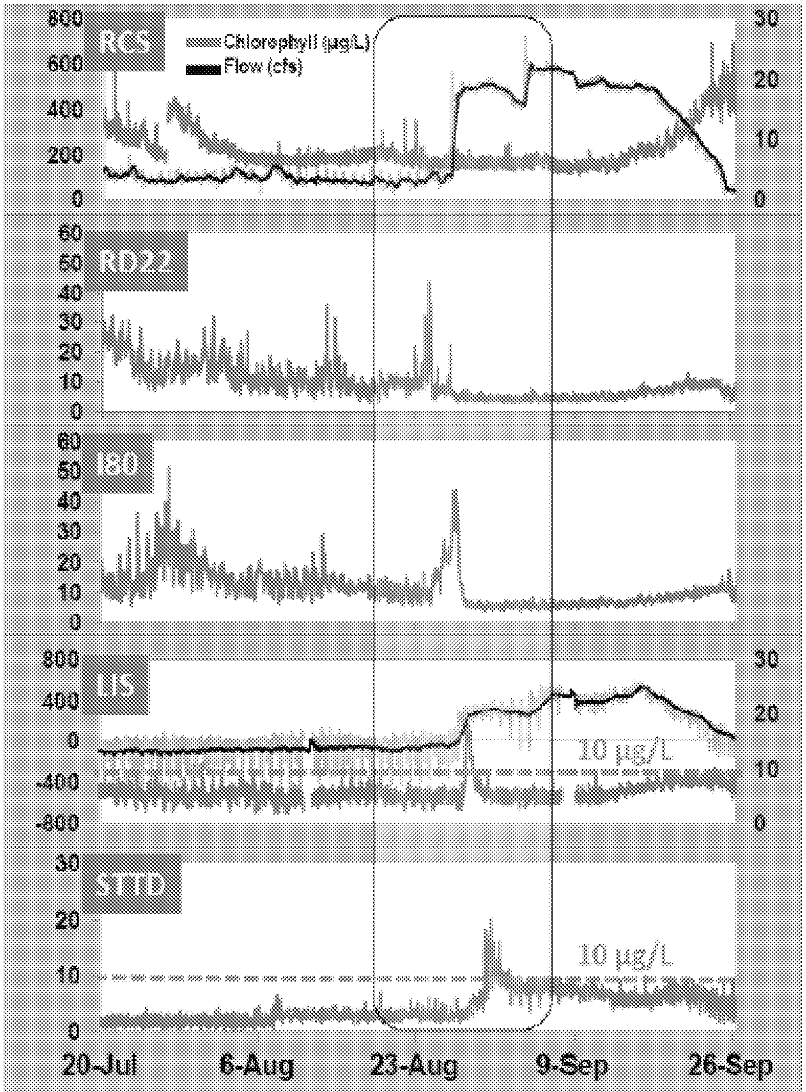
production in the north Delta increased as a result of the action (Figure CBD1; as had been observed by Frantzich et al. [2018] in previous years with flow pulses). This increased primary production resulted in enhanced zooplankton growth and egg production (California Natural Resources Agency 2017). Reclamation (2018: 2) suggested that a chlorophyll concentration of 10 µg/l of chlorophyll, as achieved in 2016 for a number of days during the action (Figure CBD1), could support relatively high zooplankton production (Mueller-Solger et al. 2002) without adversely affecting water quality (e.g., dissolved oxygen concentration). Analyses are underway to determine the potential effectiveness of a 2018 pilot implementation of the action, but preliminary information suggests that chlorophyll concentration above 10 µg/l was limited in duration in the Yolo Bypass (Figure CBD2) and there was no increase at Rio Vista (Figure CBD3).

Commented [CC109]: Subsequent north Delta food web actions did not result in an increase in zooplankton. Provide more support for the food web benefit.



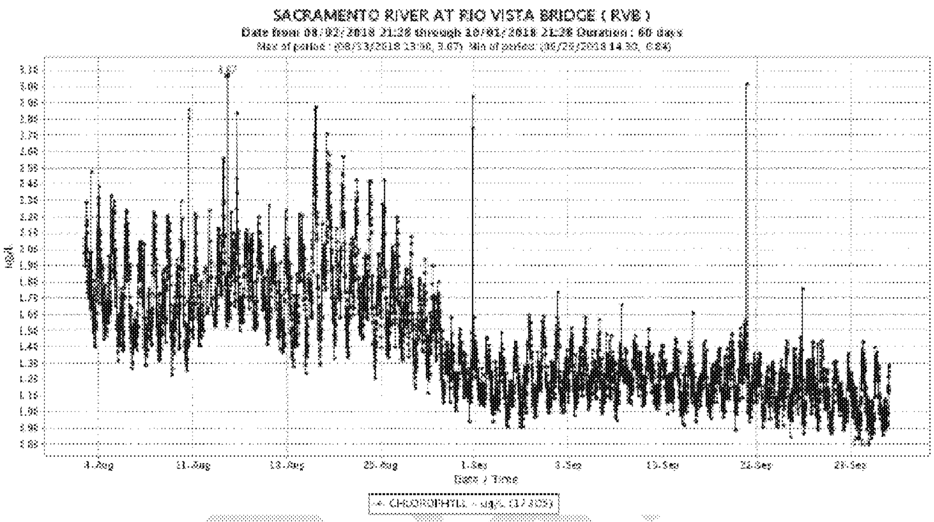
Source: California Natural Resources Agency (2017).

Figure CBD1. Managed Flow Pulse in the Yolo Bypass Toe Drain at Lisbon Weir and Chlorophyll Concentration at Rio Vista During 2016 Pilot North Delta Food Subsidy From Colusa Basin Drain Action.



Source: NCWA (2018). Note: Yellow box indicates flow pulse into Yolo Bypass from Colusa Basin Drain.

Figure CBD2. Managed Flow Pulse in the Yolo Bypass Toe Drain at Lisbon Weir and Chlorophyll Concentration from North (RCS) to South (STTD) in the Yolo Bypass During 2018 Pilot North Delta Food Subsidy From Colusa Basin Drain Action.



Source: California Data Exchange Center, http://cdec.water.ca.gov/jspplot/jspPlotServlet.jsp?sensor_no=17305&end=10%2F01%2F2018+21%3A28&geom=huge&interval=60&cookies=cdec01, accessed January 2, 2019.

Figure CBD3. Chlorophyll Concentration at Rio Vista Before, During, and After 2018 Pilot North Delta Food Subsidies Action.

Analyses of the effectiveness of the 2019 pilot implementation of the action are being undertaken. Preliminary results showed caged delta smelt in the Yolo Bypass did not survive because of a heat wave in late August, whereas survival during the after-action period was significantly higher, although this was likely due to seasonal effects and not the flow action alone (Davis et al. 2019). Primary productivity, as measured by chlorophyll fluorescence, was moved downstream during the action, with an increase at the downstream-most monitoring station in the Yolo Bypass Toe Drain from <3 μg/L to up to ~7.5 μg/L for a short period, before returning to levels <3 μg/L after the action (Maguire et al. 2020).

In addition to potential positive effects from food web materials moving downstream, Alternatives 1–3 have the potential to affect water quality, including pesticides, water temperature, and dissolved oxygen. Pesticide concentrations in the Yolo Bypass and Cache Slough Complex were analyzed during augmented pulse flows in July 2016 and September 2018 and also in 2017 during ambient conditions (Orlando et al. 2020). Water samples were taken from the Yolo Bypass and Cache Slough Complex before, during, and after the pulse flows to determine if pesticide concentrations increased. Flows in July 2016 were from the Sacramento River into the CBD and the Yolo Bypass Toe Drain. Augmented flows in 2018 were from agricultural tailwater, mainly from rice field discharge water. Results from the three years of study concluded that the 2016 pulse of Sacramento River water reduced pesticide concentration at the upstream end of the Yolo Bypass, but may have moved some pesticide downstream to the lower part of the Yolo Bypass near Lisbon Weir. However, in Cache Slough near Ryer Island, where flow is much higher due to influence of the Sacramento River, there was no apparent pesticide signature. There was more of a pesticide signature at the downstream end of the Yolo Bypass during 2018, as the flow pulse was composed of agricultural drainage water. However, there was no change in pesticide concentrations evident in Cache Slough at Ryer Island. In 2017, pesticide concentrations remained the same and lessened in the early fall (Orlando et al. 2020: 93–99). Pulse flows from Sites reservoir will generally have low to no concentration of pesticides and would not contaminate the Sacramento River and would dilute the relatively high pesticide concentrations in CBD. Delta smelt are not likely to be affected by an increase in pesticides under Alternatives 1–3 (see discussion on pesticides in Chapter 6, *Surface Water Quality*).

Entrainment

Adults

Adult delta smelt can be entrained into the south Delta export facilities during dispersal prior to spawning, with this dispersal typically occurring during December–March in response to increases in precipitation, flow, and turbidity (Grimaldo et al. 2009; Sommer et al. 2011). Alternatives 1–3 do not include any changes to the criteria such as Old and Middle River flows from the USFWS (2019) SWP/CVP Biological Opinion and CDFW (2020) SWP ITP, which limit export pumping to minimize the risk of adult delta smelt south Delta entrainment. The CalSim modeling for the alternatives suggested that December–March Old and Middle River flows generally would be very similar under Alternatives 1–3 and the NAA (Appendix 5B3: Figures 5B3-6-9 through 5B3-6-12) which, combined with the same real-time criteria to minimize risk as currently implemented (USFWS 2019, CDFW 2020), suggests there would be little difference in entrainment risk for adult delta smelt between the NAA and Alternatives 1–3.

Larvae/Early Juveniles

South Delta entrainment of larval/early juvenile delta smelt generally occurs in March–June, with the risk of entrainment limited through criteria related to factors such as Old and Middle River flows (USFWS 2019, CDFW 2020). Alternatives 1–3 do not include any changes to these criteria. As described in the IEP MAST (2015: 88) conceptual model, larval/early juvenile entrainment risk is a function of exports and spring hydrology, with USFWS (2008: 220) demonstrating that entrainment risk increases as Old and Middle River flows decrease and become more negative (reflecting an increasing hydrodynamic influence of the south Delta export facilities) and X2 increases (reflecting less Delta outflow and a greater portion of delta smelt occurring farther upstream in the Delta). CALSIM II modeling suggests little difference in Old and Middle River flows between the NAA and Alternatives 1–3 during March–June

(Appendix 5B3: Figures 5B3-6-12 through 5B3-6-15). Diversions to Sites Reservoir during March–June would result in some reductions in Delta outflow and increases in X2, primarily in March (see Table DSM2-X2 in Chapter 6). Given the real-time nature of entrainment risk management that currently exists under the USFWS (2019) SWP/CVP biological opinion and CDFW (2020) SWP ITP, which would not be changed under the alternatives, there would be little difference in south Delta entrainment risk between the NAA and Alternatives 1–3. Although there would be somewhat greater pumping at the Barker Slough Pumping Plant under Alternatives 1–3, this would be a relatively small increase (10–20 cfs or less) and would occur during July–August (Appendix 5B4: Tables 5B-4-6-1a through 5B-4-6-4c; Figures 5B4-6-1 through 5B-4-6-18), by which time delta smelt juveniles would be large enough to be excluded from entrainment by the Barker Slough Pumping Plant fish screens.

Flow-Related Effects

Spring (March–May) X2 correlates with the density of the delta smelt zooplankton prey *Eurytemora affinis* (Kimmerer 2002; Greenwood 2018), suggesting a potential positive effect of Delta outflow on this prey species, and thereby affecting individual delta smelt growth and survival per the IEP MAST conceptual model (IEP MAST 2015: 88). The CALSIM II and DSM2 modeling indicates that Alternatives 1–3 would have lower Delta outflow and somewhat greater X2 in March, with little difference in April–May (see Table 5B3-5-1a–c, Table 5B3-5-2a–c, Table 5B3-5-3a–c, and Table 5B3-5-4a–c in Appendix 5B; Table DSM2-X2 in Chapter 6). For this impact analysis, the negative relationship between *E. affinis* density and X2 developed by Greenwood (2018) was applied (see Appendix 11F). The results of the analysis suggest that spring food density for delta smelt under Alternatives 1–3 would only be minimally negatively affected (Table eaffinis1). Note that there is appreciable uncertainty in the predictions of *E. affinis* density as a function of X2, with 95% prediction intervals generally spanning two to three orders of magnitude (see Tables 11F-1 through 11F-5 in Appendix 11F).

Table eaffinis1. Density of Adult *Eurytemora affinis* Based on March–May Regression with X2.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	177	176 (0%)	176 (0%)	176 (0%)	176 (0%)
Above Normal	153	152 (-1%)	152 (-1%)	152 (-1%)	152 (-1%)
Below Normal	121	120 (-1%)	120 (-1%)	120 (-1%)	120 (-1%)
Dry	96	96 (-1%)	96 (-1%)	96 (-1%)	96 (-1%)
Critically Dry	73	72 (-1%)	72 (-1%)	72 (-1%)	72 (-1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty.

The IEP MAST conceptual model (2015) suggests that the probability of egg/larval Delta Smelt surviving to the juvenile life stage is influenced by predation risk, which may involve different factors such as turbidity, water temperature, and predators (silversides). Operations have limited potential to affect water temperature in the Delta (Wagner et al. 2011), and turbidity during spring would be expected to be similar under the NAA and Alternatives 1–3 (see also examination of *Upstream Sediment Entrainment* discussed below). The main potential factor being influenced by Alternatives 1–3 would be predators (silversides), for which Mahardja et al. (2016) showed that summer (June–September) Delta inflow and spring (March–May) South Delta exports had the strongest correlations with silverside cohort strength (both relationships were negative). Mahardja et al. (2016: 12) cautioned that the relationships are not meant to imply causality, given that the mechanisms could not be identified, and that further investigation is merited. Nonetheless, should the relationships be found to be causative, examination of CALSIM-modeled inflow and south Delta exports for Alternatives 1–3 allows inference of potential effects on delta smelt predation. The CALSIM modeling results indicate that June–September inflow under Alternatives 1–3 would be similar to NAA in Wet, Above Normal, and Below Normal Water Years, or slightly greater (6–7%) in Dry and Critically Dry Water Years (Table inflowss1). March–May south Delta exports (Table exportss1) would be little different (0–1%) between all alternatives (Table exportss1). Taken together, these results suggest that there would be little difference in silverside predation of delta smelt between alternatives and if there were any difference, predation would be expected to be less under Alternatives 1–3 compared to NAA because of slightly greater June–September inflow under Alternatives 1–3.

Table inflowss1. Mean June–September Delta Inflow (Cubic Feet per Second) by Alternative and Water Year Type.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	27,110	27,157 (0%)	27,155 (0%)	27,183 (0%)	27,125 (0%)
Above Normal	22,593	22,690 (0%)	22,692 (0%)	22,695 (0%)	22,797 (1%)
Below Normal	18,415	18,762 (2%)	18,777 (2%)	18,773 (2%)	18,798 (2%)
Dry	14,149	15,135 (7%)	15,151 (7%)	15,106 (7%)	15,024 (6%)
Critically Dry	10,268	11,037 (7%)	11,030 (7%)	10,954 (7%)	10,929 (6%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Delta inflow is calculated as sum of flows: Sacramento River at Freeport (CalSim channel C169); Yolo Bypass (CalSim channel C157); Mokelumne River (CalSim channel C504); and San Joaquin River at Vernalis (CalSim channel C639).

Table exportss1. Mean March–May South Delta Exports (Cubic Feet Per Second) by Alternative and Water Year Type.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	7,173	7,167 (0%)	7,161 (0%)	7,166 (0%)	7,130 (-1%)
Above Normal	5,196	5,194 (0%)	5,216 (0%)	5,197 (0%)	5,216 (0%)
Below Normal	4,578	4,568 (0%)	4,561 (0%)	4,567 (0%)	4,562 (0%)
Dry	3,378	3,366 (0%)	3,378 (0%)	3,366 (0%)	3,400 (1%)
Critically Dry	2,644	2,660 (1%)	2,667 (1%)	2,677 (1%)	2,662 (1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA.

The IEP MAST (2015) conceptual model describes food availability and quality as key components of the June through September transition probability of juvenile Delta Smelt to subadulthood through growth and survival of individuals. Delta outflow is positively correlated with the subsidy of the delta smelt zooplankton prey *Pseudodiaptomus forbesi* to the low salinity zone from the freshwater Delta during July–September (Kimmerer et al. 2018). During these months, Delta outflow under Alternatives 1–3 would be similar or somewhat greater than under the NAA, indicating that the subsidy of *P. forbesi* would not be expected to be negatively affected by differences in outflow as a result of the alternatives (Table outflowjulsep1).

Table outflowjulsep1. Mean July–September Delta Outflow (Cubic Feet Per Second) by Alternative and Water Year Type.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	10,502	10,658 (1%)	10,663 (2%)	10,690 (2%)	10,650 (1%)
Above Normal	9,187	9,402 (2%)	9,378 (2%)	9,408 (2%)	9,419 (3%)
Below Normal	5,035	5,401 (7%)	5,423 (8%)	5,424 (8%)	5,433 (8%)
Dry	3,976	4,280 (8%)	4,267 (7%)	4,267 (7%)	4,202 (6%)
Critically Dry	3,501	3,571 (2%)	3,583 (2%)	3,570 (2%)	3,526 (1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA.

South Delta exports may entrain *P. forbesi* (USFWS 2008: 228; Kimmerer et al. 2019), and density of *P. forbesi* on the San Joaquin River side of the Delta is relatively high (Kimmerer et al. 2018), so modeled flows in the lower San Joaquin River (QWEST) may provide an indicator of *P. forbesi* downstream subsidy potential to the low salinity zone (DWR 2020: 4-149). There is uncertainty in this mechanism and the magnitude of QWEST flow differences that may be of consequence. Based on the assumption that net positive QWEST provides an indicator of potential downstream subsidy to the low salinity zone (DWR 2020: 4-149), CalSim modeling showed that Alternatives 1–3 had a lower frequency of positive flows in July (~15% of years compared to ~20% of years under the NAA), August (~6% of years compared to ~10% under the NAA), and September (~7–9% of years compared to ~10% under the NAA). Given the few years with positive QWEST under any scenario and uncertainty in the extent to which these modeled differences would be of consequence because of the high rate of grazing in the low salinity zone (Kimmerer et al. 2019), as well as the distribution of an appreciable portion of delta smelt upstream of the low salinity zone, i.e., an average of 23% (range 2%–47%) during 2005–2014 (Bush 2017), the differences between scenarios would likely be small. Coupled with the overall increase in June–September Delta outflow under Alternatives 1–3 previously discussed above, the differences in subadult delta smelt food availability between Alternatives 1–3 and the NAA are likely to be limited.

As discussed in the ROC LTO BA (Reclamation 2019: 5-385 to 5-386), various factors have the potential to affect harmful algal blooms (in particular *Microcystis*) that could affect delta smelt or its prey. Among these factors, RBI (2017) focused on maximum absolute daily velocity as an indicator of turbulent mixing potential, which could disrupt *Microcystis* blooms. The ROC LTO analysis compared a proposed action operations scenario to a without action scenario with no exports and no south Delta temporary barriers, and generally found little difference in *Microcystis* bloom potential between the two because of generally similar maximum absolute daily velocity (Reclamation 2019: 5-385 to 5-390). Where differences arose, it was as a result of the south Delta temporary barriers being in place in the proposed action but not being in place in the without action scenario. Given that Alternatives 1–3 and the NAA would all include baseline conditions with the south Delta temporary barriers present, there would be little difference expected in terms of harmful algal bloom potential between the alternatives and NAA.

The IEP MAST (2015: 88) delta smelt conceptual model also includes predation risk as an important habitat attribute affecting juvenile survival from June to September (see also ROC LTO BA, Reclamation 2019: 5-390 to 5-391). The operations-related that could influence predation risk would not be expected to differ greatly Alternatives 1–3 and the NAA: turbidity as a function of sediment (see *Upstream Sediment Entrainment* section analysis below), striped bass abundance (based on general similarity in fall X2; see analysis below), and water temperature (which is driven mainly by air temperature and is only slightly affected by freshwater inflow; Wagner et al. 2011).

The IEP MAST (2015: 89) delta smelt conceptual model posits that size and location of the low salinity zone is a habitat attribute that could affect subadult delta smelt survival. The summer-fall delta smelt habitat action from the USFWS (2019) SWP/CVP BiOp and CDFW (2020) ITP would be undertaken under all alternatives, so differences in the size and location of the low salinity zone would be limited to differences caused by reservoir releases under Alternatives 1–3. DSM2 X2 modeling shows that X2 generally would be similar or somewhat farther downstream under Alternatives 1–3 compared to the NAA (see Table DSM2-X2 in Chapter 6), indicating that Alternatives 1–3 would not reduce low salinity zone habitat for delta smelt relative to the NAA based on the negative relationship with X2 (Feyrer et al. 2011). Note that there is debate regarding the importance of low salinity zone habitat to delta smelt (e.g., Manly et al. 2015; Feyrer et al. 2015; Murphy and Weiland 2019). The IEP MAST (2015: 89) conceptual model also posits that food availability affects subadult delta smelt survival, which was discussed above for the early fall period during which there was concluded to be little potential effect of Alternatives 1–3 relative to the NAA. The IEP MAST (2015: 89) conceptual model also posits turbidity as an important factor affecting subadult delta smelt predation risk, which is discussed below in the next section as a result of upstream sediment entrainment caused by Alternative 1–3 operations.

Upstream Sediment Entrainment

The IEP MAST (2015) conceptual model identifies predation risk as a habitat attribute affecting delta smelt. Flows interact with erodible sediment supply to affect turbidity. In general, greater turbidity is thought to lower the risk of predation on delta smelt. Large amounts of sediment enter the Delta from winter and spring storm runoff, with resuspension by tidal and wind action. A conceptual model of sedimentation in the Delta includes a submodel for river supply, which notes that dams and reservoirs have contributed to decreased sediment supply to the Delta

(Schoellhamer et al. 2012: their Figure 4). However, a recent analysis examining future climate scenarios predicted significant increases in large flow events and sediment transport over the next century, which may increase turbidity (Stern et al. 2020). As described in Chapter 7, only construction, maintenance, and operation activities on the Sacramento River—not the effects of Sites Reservoir in capturing sediment from its small upstream tributaries—would have the potential to affect the fluvial geomorphology of the Sacramento River.

Previous modeling conducted for the 2017 DEIR/S Alternatives A and C, which are conservatively higher but generally representative of the amount and pattern of water diversion under Alternatives 1–3, suggested that around 100,000-160,000 tons of sediment could be entrained annually at the three Project intakes combined, compared to around 40,000-50,000 tons under existing conditions (Huang and Greimann [2011] Table 2-6: 21; as presented in DEIR/S, Appendix 8A). As described in the 2017 DEIR/S (pages 8-20 and 8-27), the entrained sediment load would represent approximately ≤5% of Sacramento River sediment that otherwise could move downstream to the Delta, compared to around 3% under baseline conditions. As further described in the 2017 DEIR/S (pages 8-20 and 8-27), because water and sediment would both be diverted, the concentration of the sediment in the water would remain unchanged, so the turbidity of the water would be expected to remain the same at the time the water is being diverted (i.e., principally in the winter/spring).

The slightly reduced (≤5%) sediment load to the Delta under Alternatives 1–3 may have only slight effects on turbidity as a result of the reduction in sediment for resuspension at other times of the year, but there is some uncertainty in this conclusion. This uncertainty would be addressed through the sediment monitoring, modeling, and reintroduction commitment described in Appendix 2D, in order to inform whether adaptive management measures such as sediment reintroduction are warranted based on estimated effects to turbidity.

Available estimates of sediment removal by the south Delta export facilities are low, i.e., ~2% of sediment entering the Delta at Freeport in 1999–2002 (Wright and Schoellhamer 2005). This suggests that south Delta exports in association with the alternatives would remove only a small percentage of sediment entering the Delta. Given the limited expected difference in suspended sediment entering the Delta under Alternatives 1–3 relative to the NAA, as well as the small percentage of sediment that would be expected to be removed by the south Delta export facilities and the similarity in south Delta exports between the alternatives and the NAA during the high flow period of the year when most sediment is delivered to the Delta (see *South Delta Entrainment* section above), the potential negative effect of Alternatives 1–3 on turbidity would be expected to be low. As previously noted above, uncertainty in the conclusion would be addressed through the sediment monitoring, modeling and reintroduction commitment described in Appendix 2D.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

Operations impacts of Alternatives 1–3 on delta smelt would be less than significant, as indicated by small differences assessed for flow-related zooplankton prey and other flow-related habitat attributes during spring and summer; south Delta exports of Sites water not occurring during times of the year when delta smelt are susceptible to entrainment; a commitment for sediment monitoring, modeling and reintroduction through adaptive management if necessary; and potential positive effects from summer/fall Sites reservoir releases to move food web materials into the lower Yolo Bypass and Cache Slough Complex.

NEPA Conclusion for Alternatives 1, 2, and 3

Operations impacts of Alternatives 1–3 on delta smelt would not be adverse, as indicated by small differences assessed for flow-related zooplankton prey and other flow-related habitat attributes during spring and summer; south Delta exports of Sites water not occurring during times of the year when delta smelt are susceptible to entrainment; a commitment for sediment monitoring, modeling and reintroduction through adaptive management if necessary; and potential positive effects from summer/fall Sites reservoir releases to move food web materials into the lower Yolo Bypass and Cache Slough Complex.

Impact FISH-9: Operations Effects on Longfin Smelt

Alternatives 1, 2, and 3

Effects of Alternatives 1, 2, and 3

As described in Appendix 11A, of the geographic areas potentially affected by Alternatives 1–3, longfin smelt occur within the Delta and Suisun Bay/Marsh.

Effects from Reservoir Releases to CBD/Yolo Bypass

Longfin smelt would not be affected by summer/fall flow releases from the CBD because the species occurs well downstream of the Delta at this point in its life cycle (see Appendix 11A; Merz et al. 2013).

Entrainment

Commented [CC110]: This analysis does not take into account the correlation between larval and juvenile Longfin Smelt distribution and X2. Higher X2 shifts the distribution of young Longfin Smelt upstream putting them at higher risk of entrainment into the pumps or retention in poor habitat in the south and central Delta. Spawning distribution is also shifted upstream under drier conditions. I suggest considering the cumulative effects of reduced Delta outflow through the entire season.

Key hydrodynamic variables influencing longfin smelt entrainment risk at the south Delta export facilities include Old and Middle River flow (Grimaldo et al. 2009) and flow in the lower San Joaquin River near Jersey Point (QWEST) (California Department of Fish and Game 2009). During the main winter-spring months of potential adult, larval, and juvenile longfin smelt entrainment risk (i.e., December through May), CalSim modeling indicates little difference in Old and Middle River flows between the NAA and Alternatives 1–3 (Appendix 5B3: Figures 5B3-6-9 through 5B3-6-14). There was also little difference in QWEST between Alternatives 1–3 and NAA for the key larval entrainment months of January through March (Tables QWESTjan, QWESTfeb, and QWESTmar). This, together with the fact that south Delta entrainment risk for longfin smelt would continue to be limited based on the California Department of Fish and Wildlife (2020) SWP ITP under the NAA and Alternatives 1–3, suggests that the effect from Alternatives 1–3 on longfin smelt south Delta entrainment risk would be similar to the NAA. As discussed for delta smelt, differences in Barker Slough Pumping Plant diversions would occur during July–August and would be relatively small (10–20 cfs); the timing of these differences would not result in a change in entrainment risk to longfin smelt because the species is downstream of the Delta at this time of year.

Table QWESTjan. Mean January QWEST (Cubic Feet Per Second) by Alternative and Water Year Type.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	14,095	14,032	14,028	14,038	14,039
Above Normal	6,205	6,082	6,094	6,082	6,098
Below Normal	1,614	1,548	1,551	1,551	1,557
Dry	-643	-678	-674	-678	-635
Critically Dry	-933	-1,063	-967	-961	-905

Table QWESTfeb. Mean February QWEST (Cubic Feet Per Second) by Alternative and Water Year Type.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	15,900	15,850	15,841	15,852	15,848
Above Normal	9,100	9,065	9,057	9,066	9,048
Below Normal	5,400	5,392	5,405	5,387	5,395
Dry	1,140	1,089	1,087	1,069	1,075
Critically Dry	-496	-512	-517	-513	-555

Table QWESTmar. Mean March QWEST (Cubic Feet Per Second) by Alternative and Water Year Type.

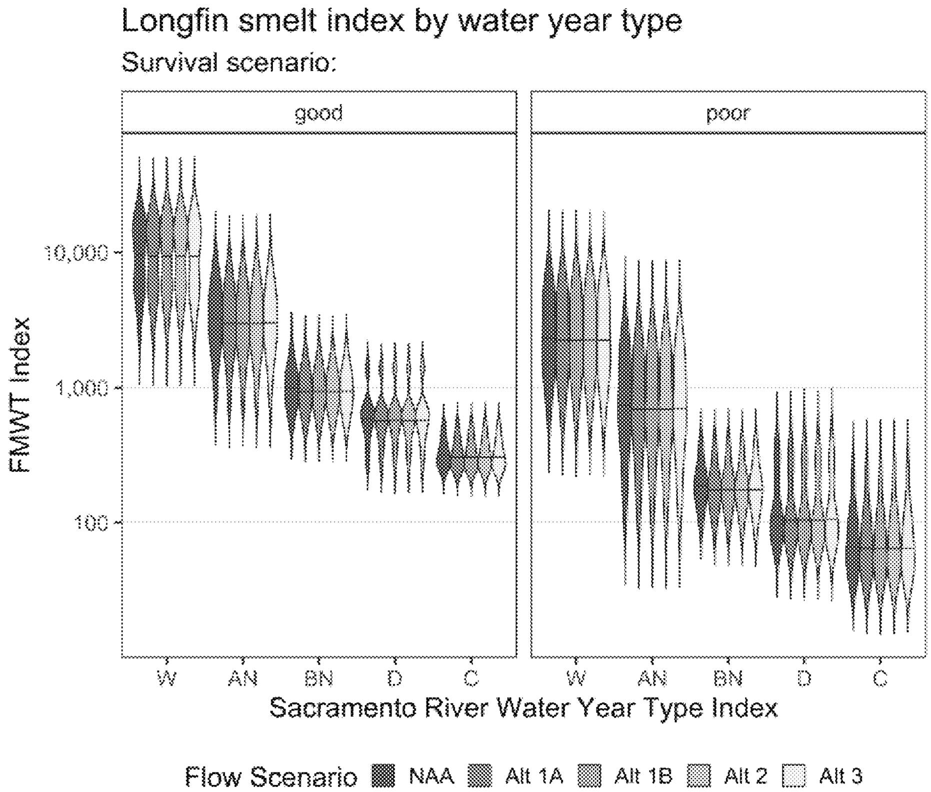
Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	16,719	16,644	16,658	16,665	16,639
Above Normal	9,791	9,605	9,611	9,607	9,583
Below Normal	4,082	3,921	3,922	3,922	3,919
Dry	2,090	1,944	1,942	1,953	1,963
Critically Dry	5	-59	-93	-116	-36

Flow-Related Effects

Winter-spring diversions for Alternatives 1–3 would reduce Delta inflow and Delta outflow (see Appendix 5B3: Tables 5B3-5-1a to 5B3-5-4c and Figures 5B3-5-1 to 5B3-5-18). The analysis of potential negative effects to the smelt zooplankton prey *Eurytemora affinis* previously discussed for delta smelt showed minimal potential negative effects as a result of Alternatives 1–3 (see Table eaffinis1). As discussed in Appendix 11A, there is a positive correlation between juvenile longfin smelt abundance in the fall and the preceding winter-spring Delta outflow (also often represented as a negative correlation with X2). DWR (2020: 4-177–4-178) presents further discussion of this relationship. The model described by Nobriga and Rosenfield (2016) was used to compare Alternatives 1–3 to the NAA, using Delta outflow outputs from CalSim; additional detail on the method is provided in Appendix 11F.

Results of the Nobriga and Rosenfield (2016) model showed considerable overlap between scenarios in longfin smelt fall midwater abundance indices, with values under Alternatives 1–3 generally being slightly lower than NAA (Figure nr_violin; Table nr_good and nr_poor). As with other recent analyses using this model (DWR [2020: 4-178–4-179]), it should be noted that the variability in the modeling predictions of longfin smelt fall midwater trawl abundance index for a given operational scenario is high relative to the differences between scenarios (Figure nr_series). This variability reflects the uncertainty in model parameter estimates, which results in uncertainty in the extent to which operations-related differences in Delta outflow could affect longfin smelt: differences related to operations may be relatively small compared to differences created by hydrological conditions (e.g., wetter vs. drier years) (DWR 2020: 4-178). Nevertheless, the results of the analysis suggest the potential for a small negative effect to longfin smelt.

Commented [CC111]: Given this high variability, a more robust assessment of the flow related impacts to Longfin Smelt may be appropriate.



Note: FMWT Index = longfin smelt fall midwater trawl index. Horizontal line indicates median. See Appendix 11F for clarification of good vs. poor survival scenarios.

Figure nr_violin. Violin Plots of Longfin Smelt Fall Midwater Trawl Index by Water Year Type from Nobriga and Rosenfield (2016) Model.

Table nrgood. Mean Longfin Smelt Fall Midwater Trawl Index by Water Year Type from Nobriga and Rosenfield (2016) Model, Based on Good Juvenile Survival Scenario.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	10,625	10,476 (-2%)	10,427 (-2%)	10,455 (-2%)	10,429 (-2%)
Above Normal	3,644	3,445 (-6%)	3,445 (-6%)	3,443 (-6%)	3,460 (-5%)
Below Normal	1,055	1,010 (-4%)	1,015 (-4%)	1,009 (-5%)	1,016 (-4%)

Dry	646	628 (-3%)	633 (-2%)	627 (-3%)	634 (-2%)
Critically Dry	334	328 (-2%)	329 (-2%)	329 (-2%)	328 (-2%)

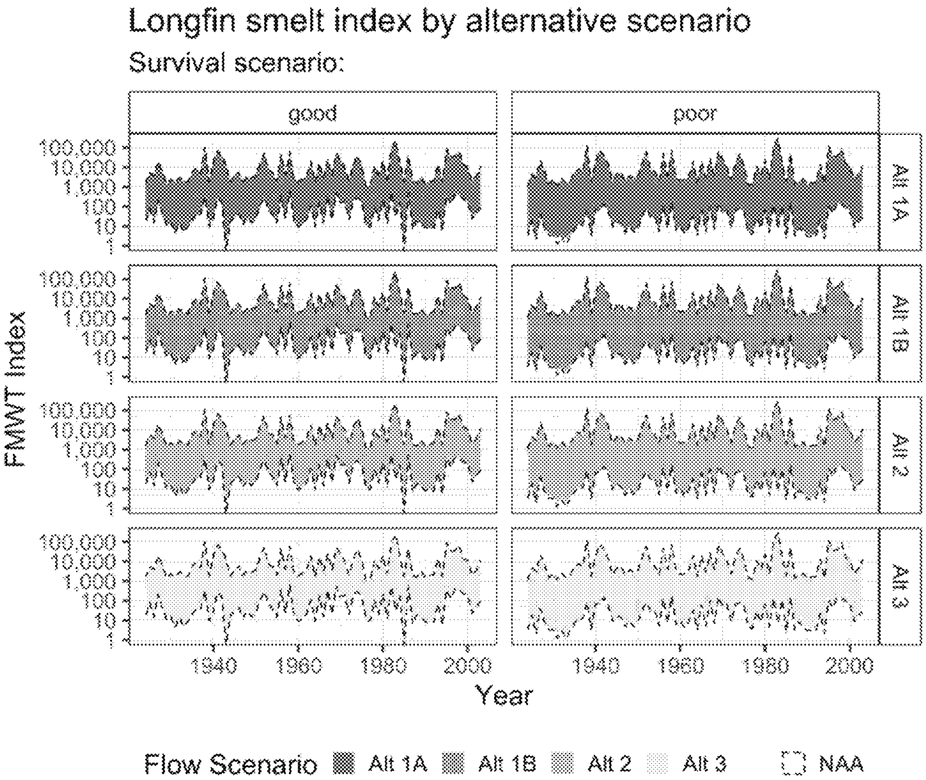
Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty. Details regarding the method, including juvenile survival, are provided in Appendix 11F.

Commented [CC112]: This does not appear to be a realistic prediction of the FMWT Longfin Smelt index for a critically dry year. Even the poor survival scenario in the next table seems to be an overestimate. This analysis should account for the continued decline in the population rather than averaging over the entire model run.

Table nrpoor. Mean Longfin Smelt Fall Midwater Trawl Index by Water Year Type from Nobriga and Rosenfield (2016) Model, Based on Poor Juvenile Survival Scenario.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	2,948	2,849 (-3%)	2,847 (-4%)	2,854 (-3%)	2,843 (-4%)
Above Normal	962	907 (-6%)	906 (-6%)	908 (-6%)	911 (-6%)
Below Normal	203	193 (-5%)	193 (-5%)	193 (-5%)	193 (-5%)
Dry	153	147 (-4%)	148 (-3%)	147 (-4%)	149 (-3%)
Critically Dry	84	82 (-2%)	82 (-2%)	82 (-2%)	82 (-2%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty. Details regarding the method, including juvenile survival, are provided in Appendix 11F.



Note: FMWT Index = longfin smelt fall midwater trawl index. Each chart compares the named alternative (color shades) to the NAA (broken lines). See Appendix 11F for clarification of good vs. poor survival scenarios.

Figure nr_series. 95% Confidence Intervals of Longfin Smelt Fall Midwater Trawl Index by Water Year Type from Nobriga and Rosenfield (2016) Model.

A second modeling approach was used to assess potential effects of Alternatives 1–3 as a reflection of differences in winter-spring Delta outflow. This modeling approach is considered because it was recently included in the SWP ITP effects analysis by DWR (2020) at CDFW's behest (see discussion by DWR 2020: Appendix E, Attachment 2: E2-1). The same method was employed herein[7], which produces an estimate of longfin smelt fall midwater trawl index as a

[7] The method has been previously referred to as the "Kimmerer regression", reflecting previous similar analyses, e.g., Kimmerer (2002) and Kimmerer et al. (2009); see DWR (2020, Appendix E, Attachment 2, p.E2-1). The method is described in Appendix 11F.

function of mean January–June X2. The results of the analysis showed that mean fall midwater trawl index under Alternatives 1–3 was similar or slightly lower than the NAA (Table lfsabundance1), reflecting somewhat lower Delta outflow and higher X2 during January–June. As with the analysis based on Nobriga and Rosenfield (2016) described above, differences between scenarios were considerably greater than the variability in the estimates for a given scenario as a result of uncertainty in the model's parameters (see Tables 11F-7 through 11F-11 in Appendix 11F), but again suggested the potential for a small negative effect.

Table lfsabundance1. Mean Longfin Smelt Fall Midwater Trawl Index Based on January–June X2.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	591	586 (-1%)	585 (-1%)	586 (-1%)	586 (-1%)
Above Normal	360	351 (-3%)	351 (-3%)	351 (-3%)	351 (-3%)
Below Normal	158	152 (-4%)	152 (-4%)	152 (-4%)	152 (-4%)
Dry	72	70 (-3%)	70 (-3%)	70 (-3%)	70 (-2%)
Critically Dry	24	22 (-4%)	23 (-4%)	23 (-4%)	22 (-4%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty. In addition to January–June X2, the predictive model assumed a coefficient representing the Pelagic Organism Decline period (see DWR 2020, Appendix E, Attachment 2; see method description in Appendix F).

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

The analyses of potential impacts of Alternatives 1–3 on longfin smelt suggested that entrainment risk under the alternatives would be similar to entrainment risk under the NAA. The analyses of flow-related effects (differences in Delta outflow/X2) suggested the potential for small negative effects under the alternatives, albeit with uncertainty given the appreciably greater variability of longfin smelt abundance index estimates for a given alternative relative to the difference from NAA. As identified in Section 11.4 *Methods of Analysis*, operations resulting from the alternatives would be consistent with all applicable regulations to limit the potential for negative effects to fish and aquatic resources, including the existing spring outflow measures required by the California Department of Fish and Wildlife (2020) ITP. Mitigation would be required for the small, uncertain negative outflow-related effect in consideration of longfin smelt's CESA-listed status; as such, Alternatives 1–3 provide tidal habitat restoration mitigation as described below. Tidal habitat would expand the diversity, quantity, and quality of longfin smelt rearing and refuge habitat consistent with recent tidal habitat mitigation required for outflow impacts to the species (California Department of Fish and Wildlife 2020: 112). As shown by multiple recent tidal habitat restoration projects in the Delta[8], there are potential feasible opportunities for tidal habitat restoration directly applicable to longfin smelt. Alternative

[8] See, for example, the California EcoRestore program's summary of recent projects (https://water.ca.gov/Programs/All-Programs/EcoRestore).

1–3 operational impacts would be less than significant with mitigation incorporated for longfin smelt.

Mitigation Measure FISH-9.1: Tidal Habitat Restoration for Longfin Smelt

Tidal habitat restoration mitigation for longfin smelt was calculated based on the same method recently applied by DWR (2019d: 5-5). The method is described in more detail in Appendix 11F, *Smelt Analysis*. The mitigation requirement for each alternative varies between 11 and 15 acres (Table lfs_mit).

Table lfs_mit. Tidal Habitat Restoration Mitigation for Longfin Smelt (Acres).

Alt 1A	Alt 1B	Alt 2	Alt 3
11	13	11	15

NEPA Conclusion for Alternatives 1, 2, and 3

Alternatives 1–3 would not be adverse to longfin smelt because entrainment risk would be similar to the NAA and tidal habitat restoration is required to mitigate potential negative flow-related effects, as described further above in the CEQA significance determination.

Impact FISH-10: Operations Effects on Lampreys

Alternatives 1, 2, and 3

Effects of Alternatives 1, 2, and 3

Sacramento River

Near-Field Effects

Lamprey ammocoetes, smaller than 40–50-mm total length could be entrained by the Red Bluff and Hamilton City intakes if passing close during operational periods. The probability of entrainment will be reduced to almost zero at 60-mm total length (Rose and Mesa 2012). It is not known what proportion of lamprey populations occur upstream of the intakes. Larger migrating juvenile lamprey (macrophthalmia, around 120-mm total length) would not be at risk of entrainment because of their size. Impingement risk for lamprey macrophthalmia would be very low given the intakes' fish screens are designed to be protective of Chinook salmon fry and have approach velocity of 0.33 ft/s (Moser et al. 2015). Given the tendency for elevated river flows/precipitation events to coincide with Pacific lamprey macrophthalmia migrating in very high numbers (Goodman et al. 2015) or ammocoetes being flushed from burrows (Rose and Mesa 2012), potential near-field effects from diversions would be limited under all alternatives by inclusion of pulse flow protection measures to be applied to precipitation-generated pulse flow events from October through May (see Chapter 2). As described in Appendix 11A, river lamprey downstream migration may occur in spring/summer, during which time there would be little difference between NAA and the alternatives in terms of diversions. As discussed for winter-run Chinook salmon, there may be some small level of risk to juvenile lamprey from stranding behind the fish screens during very high flow events, but such events would be rare and would not differ between the alternatives and existing conditions in their frequency. There is a lack of information regarding potential near-field effects related to predation of lamprey in the vicinity of the screens, although given that the main period of migration/movement is associated with high flow events or during periods when diversions would not greatly differ between NAA and the alternatives (see discussion above), predation risk may be limited and will not differ between NAA and the alternatives. With respect to attraction of adult lamprey to reservoir releases to the Sacramento River and risk of stranding under Alternative 2, this risk would be minimized by the combination of the 60-foot-long apron and weir, as described further for winter-run Chinook salmon.

Far-Field Effects

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Sacramento River below Keswick Dam and below Red Bluff Diversion Dam indicates that water temperatures would be similar among alternatives during the period of presence of each life stage of Pacific and river lamprey (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-5-1a to 6C-5-4c, Tables 6C-10-1a to 6C-10-4c; Figures 6C-5-1 to 6C-5-18, Figures 6C-10-1 to 6C-10-18). At both locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±0.5°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1.

Results of the analysis of exceedance above water temperature index values or occurrence outside index ranges for lamprey in the Sacramento River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X. At both locations for both lamprey species and both life stages in each month and water year type, the difference in percent of days outside each index range or exceeding each index value between the NAA and Alt 1A and between the NAA and Alt 1B would be <5%, with one exception. Below Keswick Dam, the percent of days outside of the 50°F to 64°F river lamprey spawning and egg incubation index range under Alt 1B in July of above normal water years would be 5.4% lower than the percent of days under the NAA.

Results of the analysis of exceedance for Alt 2 would be nearly identical to Alt 1A.

Results for Alt 3 would be similar to Alt 1A with some additional differences in the percent of days outside the 50°F to 64°F index range for river lamprey spawning and egg incubation below Keswick Dam. The percent of days outside the index range under Alt 3 in June and July of above normal water years and June of below normal years would be 5.8%, 12.1%, and 9.1% lower, respectively, than the percent of days under the NAA.

Flow Effects

Spawning Habitat

Flow-related impacts on spawning habitat of Pacific lamprey and river lamprey were evaluated by estimating effects of flow alterations on redd dewatering risk. Pacific lamprey eggs take about 19 days to incubate (Moyle et al. 2015), during which they must remain covered by water. Incubation times for river lamprey are unknown but assumed to be similar. Rapid reductions in flow can dewater redds leading to mortality. Redds are often found in low gradient stream reaches, in gravel, and at the tailouts of pools and riffles (USFWS 2012). These areas are vulnerable to dewatering when flows drop suddenly,.

A dewatering risk analysis was conducted for redd dewatering in the Sacramento River at Keswick and Red Bluff. Pacific lamprey spawn between January and August and river lamprey spawn between February and June (citation needed), so flow reductions during those months have the potential to dewater redds, which could result in egg and embryo mortality. Dewatering risk to redds was estimated using CALSIM II outputs, as the number of spawning-period months followed in the next month by a reduction in flow of greater than 50%. The dewatering risk is expressed as number of months with such flow reductions summed over the 82 years of the CALSIM II record. Small-scale spawning location suitability characteristics (e.g., depth, velocity, substrate) of Pacific and river lamprey are not adequately understood to employ a more formal analysis such as a weighted usable area analysis. A month-over-month flow reduction of at least 50% was chosen as a best professional estimate of flow conditions under which redd dewatering would occur, but it is not an empirically derived estimate of redd dewatering events. As such, there is uncertainty that these values represent actual redd dewatering events, and results should be treated as estimates of expected month to month flow fluctuations during egg incubation periods. The redd dewatering results are expressed as the percentage of months with elevated dewatering risk, and percent differences, for Alternatives 1–3 and the NAA.

The results for both lamprey species at the two the Sacramento River locations analyzed indicate that Alternatives 1-3 would have little effect on the frequency of months predicted to experience a month-over-month reduction in flow of greater than 50% (Table 11-?1 and Table 11-?2). Alternatives 1–3 are not expected to affect redd dewatering risk of Pacific Lamprey or river lamprey in the Sacramento River.

Table 11-?1. Percentage of Pacific Lamprey Spawning Months with >50% Flow Reduction in the Next Month, Used as a Proxy for Redd Dewatering Risk[a] for Locations in the Sacramento River, and Percent Differences (in parentheses) between the No Action Alternative (NAA) and Alternatives 1–3 (Alt 1A, Alt 1B, Alt 2, and Alt 3).

Location	NAA	Alt 1A vs. NAA	Alt 1B vs. NAA	Alt 2 vs. NAA	Alt 3 vs. NAA
Sacramento River at Keswick	9.6	9 (-6.3%)	9.3 (-3.2%)	9.1 (-4.8%)	9.3 (-3.2%)
Sacramento River at Red Bluff	9.9	9.8 (-1.5%)	9.6 (-3.1%)	9.8 (-1.5%)	9.8 (-1.5%)

[a] Positive value for percent differences (in parentheses) indicates a higher risk of redd dewatering under Alternative 1–

3 vs. the NAA and negative values indicate a lower risk.

Table 11-?2. Percentage of River Lamprey Spawning Months with >50% Flow Reduction in the Next Month, Used as a Proxy for Redd Dewatering Risk[a] for Locations in the Sacramento River, and Percent Differences (in parentheses) between the No Action Alternative (NAA) and Alternatives 1–3 (Alt 1A, Alt 1B, Alt 2, and Alt 3).

Location	NAA	Alt 1A vs. NAA	Alt 1B vs. NAA	Alt 2 vs. NAA	Alt 3 vs. NAA
Sacramento River at Keswick	10.0	10 (0%)	10.2 (2.4%)	10 (0%)	10.2 (2.4%)
Sacramento River at Red Bluff	11.4	11.7 (2.1%)	11.7 (2.1%)	11.7 (2.1%)	11.9 (4.3%)

[a] Positive value for percent differences (in parentheses) indicates a higher risk of redd dewatering under Alternative 1–3 vs. the NAA and negative values indicate a lower risk.

Rearing Habitat

Flow-related impacts to Pacific and river lamprey rearing habitat were evaluated by estimating dewatering of ammocoete rearing habitat resulting from changes in river stage as estimated from project-related changes in flow. An ammocoete is the filter-feeding larval stage of the lamprey. It remains relatively immobile in the sediment at the same location for several years (Moyle et al. 2015), after which it migrates downstream. During the rearing period there is potential for dewatering of ammocoete rearing habitat, also referred to as ammocoete stranding, from rapid reductions in flow, leading to mortality (USFWS 2012). Suitable habitat for ammocoetes is often at stream margins in areas of low velocity with fine substrate, which are the first areas dewatered when stream flows drop. Ammocoetes do not segregate themselves by age so a single event can affect multiple year classes, significantly impacting a local lamprey population (UFWS 2012).

Rearing habitat dewatering risks were analyzed for ammocoetes under Alternatives 1-3 and the NAA in the Sacramento River at Keswick, Bend Bridge and Hamilton City. Data from weighted usable area (WUA) studies in the Tualatin River Basin in Oregon indicate that Pacific lamprey ammocoete rearing habitat is primarily located from near surface to about 8 feet deep (David Evans and Associated, Inc. et al. 2007). For this analysis, the ammocoetes are assumed to have a uniform depth distribution over this range. River lamprey ammocoetes are assumed to have a similar depth distribution. Using flow vs. river stage tables for established gauges at the three river locations listed above (Department of Water Resources California Data Exchange Center: https://cdec.water.ca.gov/rtables/), changes in river stage were determined from the CALSIM II monthly flow records for Alternatives 1-3 and the NAA. A cohort of ammocoetes was assumed to begin every month during the spawning period (January through August for Pacific lamprey and February through June for river lamprey) and spend 7 years rearing upstream. Eggs hatch in about 19 days and ammocoetes quickly disperse to rearing habitat (Moyle et al. 2015), so initiation of an ammocoete cohort was assumed to occur each month of spawning over the 82-

year CALSIM II record. At each river location, the stage of the river, estimated from the CALSIM II flow and the stage vs. flow table for that river location, was tracked for each cohort from the month of spawning through seven years of ammocoete rearing. The greatest reduction in stage from the month of spawning during the following 7-year period was used to determine, from the depth distribution of ammocoete habitats, the percentage of the ammocoete cohort stranded. For instance, a stage reduction of 4 feet was estimated to result in the stranding of 50 percent of the cohort and a stage reduction of 8 feet was estimated to result in a 100 percent stranding. This procedure assumes that the ammocoetes do not change location during their rearing period, which is not necessarily the case (USFWS 2012), but any error associated with this assumption is likely to be roughly equal for all the alternatives, including the NAA.

The results of the stranding analysis are expressed as the mean percentage of ammocoetes stranded in each month and water year type under Alternatives 1–3 and the NAA, and the differences in the percentages between Alternatives 1–3 and the NAA. For convenience in finding the largest differences between Alternatives 1-3 and the NAA in the results tables (Table 11?-3 through Table 11?-5), differences larger than 5% are highlighted. Greater than 5% reductions in percentage of ammocoetes stranded are highlighted green and greater than 5% increases are highlighted red. Each table gives results for both lamprey species, with specific results for a species corresponding to the spawning months for that species (referred to as "Initial Month of Cohort" in the tables): January through August for Pacific Lamprey and February through June for river lamprey.

The results show a range of about 0% to 90% in ammocoete stranding for the Sacramento River at Keswick Dam, 1% to 68% for the river at Bend Bridge, and 10% to 63% for the river at Hamilton City (Table 11?-3 through Table 11?-5). There was little difference among alternatives in the maximum stranding at any of the three locations. Difference in mean ammocoete stranding between Alternatives 1-3 and the NAA are minor. For the Keswick Dam and Bend Bridge locations, most of the largest differences (>5%) occur in May and June, which are within the cohort initiation periods of both lamprey species (Table 11?-3 and Table 11?-4). These differences all consist of reductions in stranding, and all are less than 8%. The largest increases in stranding at both locations occurs in September of above normal years under Alternative 3 and is less than about 7%. For the Hamilton City location, all the largest differences are less than 8% reductions in standing and all occur in February and March, which are also within the cohort initiation periods of both species (Table 11?-5). These results indicate that Alternatives 1-3 would have no appreciable effect on dewatering risk of the ammocoete rearing habitat of Pacific lamprey or river lamprey in the Sacramento River.

Table 11?-3. Percent of Pacific and River Lamprey Ammocoetes Stranded During 7-Year Rearing Period in the Sacramento River at Keswick Dam and Differences in the Percentages for the No Action Alternative (NAA) and Alternatives 1–3 (Alt 1A, Alt 1B, Alt 2, and Alt 3). January through August Results Pertain to Pacific Lamprey and the February through June Results Pertain to River Lamprey.

Initial Month of Cohort	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
January	Wet	60.2	60 (-0.2)	60 (-0.2)	60 (-0.2)	60 (-0.2)
	Above Normal	28.1	28.1 (0)	28.1 (0)	28.1 (0)	28.1 (0)
	Below Normal	12.9	13.1 (0.2)	12.9 (0)	13.1 (0.2)	12.8 (-0.1)
	Dry	0.3	0 (-0.3)	0 (-0.3)	0 (-0.3)	0 (-0.3)
	Critically Dry	5.2	6.1 (0.9)	5.1 (-0.1)	5.3 (0.1)	4.6 (-0.6)
	All	26.2	26.3 (0)	26.1 (-0.1)	26.1 (-0.1)	26 (-0.2)
February	Wet	60.9	61 (0.1)	61 (0.1)	61 (0.1)	61 (0.1)
	Above Normal	51.7	52.6 (0.9)	53.6 (1.9)	52.7 (1)	55.9 (4.2)
	Below Normal	32.0	32.2 (0.2)	32.9 (0.9)	31.4 (-0.6)	34.7 (2.7)
	Dry	4.1	3.4 (-0.7)	3.7 (-0.4)	3.4 (-0.7)	4.3 (0.1)
	Critically Dry	3.6	2.8 (-0.8)	3 (-0.6)	3 (-0.6)	2.8 (-0.8)
	All	33.8	33.7 (-0.1)	34.1 (0.3)	33.6 (-0.2)	34.8 (1)
March	Wet	59.3	59.3 (0)	59.3 (0)	59.3 (0)	59.3 (0)
	Above Normal	48.0	48.2 (0.2)	48.6 (0.6)	48.2 (0.2)	48.6 (0.6)
	Below Normal	13.0	13 (0)	13 (0)	13 (0)	13 (0)
	Dry	10.2	9.4 (-0.7)	9.9 (-0.3)	9.4 (-0.7)	10.8 (0.6)
	Critically Dry	9.7	10 (0.3)	9.6 (-0.1)	9.9 (0.2)	9.5 (-0.2)
	All	31.7	31.6 (-0.1)	31.7 (0)	31.6 (-0.1)	31.9 (0.2)
April	Wet	41.0	40.8 (-0.2)	40.8 (-0.2)	40.8 (-0.2)	40.8 (-0.2)
	Above Normal	15.5	15.6 (0.1)	16.1 (0.6)	15.6 (0.1)	16.1 (0.6)
	Below Normal	9.4	9.4 (0)	9.1 (-0.3)	9.4 (0)	9.7 (0.4)
	Dry	10.5	9.7 (-0.8)	8.5 (-1.9)	9.7 (-0.8)	8.4 (-2.1)
	Critically Dry	11.0	10.9 (-0.1)	10.8 (-0.2)	10.9 (-0.1)	9.2 (-1.9)
	All	20.8	20.6 (-0.2)	20.3 (-0.5)	20.6 (-0.2)	20.2 (-0.6)
May	Wet	54.4	54.2 (-0.2)	54.2 (-0.2)	54.2 (-0.2)	54.2 (-0.2)
	Above Normal	44.4	43.7 (-0.6)	43.6 (-0.7)	43.7 (-0.6)	43.6 (-0.7)
	Below Normal	46.0	44.6 (-1.4)	42 (-4)	44.6 (-1.4)	41.7 (-4.3)
	Dry	40.7	38.8 (-1.9)	38.5 (-2.2)	38.8 (-1.9)	36.7 (-3.9)
	Critically Dry	47.4	40.9 (-6.4)*	40.3 (-7)*	40.9 (-6.4)*	40.4 (-6.9)*
	All	47.5	45.7 (-1.8)	45.1 (-2.4)	45.7 (-1.8)	44.7 (-2.8)
June	Wet	50.4	49.9 (-0.5)	49.9 (-0.5)	49.9 (-0.5)	49.9 (-0.5)
	Above Normal	56.7	56.7 (0)	52.1 (-4.6)	56.7 (0)	50.4 (-6.3)*

Initial Month of Cohort	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
	Below Normal	69.9	69 (-1)	67.6 (-2.4)	69 (-1)	62.1 (-7.9)*
	Dry	65.1	62.8 (-2.3)	63.7 (-1.4)	62.8 (-2.3)	62.3 (-2.8)
	Critically Dry	61.5	61.8 (0.3)	61 (-0.5)	61.6 (0.1)	61.3 (-0.2)
	All	59.5	58.7 (-0.8)	57.9 (-1.6)	58.7 (-0.8)	56.4 (-3.1)
July	Wet	75.7	76.1 (0.4)	76.1 (0.4)	76.2 (0.4)	76.1 (0.4)
	Above Normal	84.8	84.5 (-0.3)	81.6 (-3.2)	84.3 (-0.4)	79.7 (-5.1)*
	Below Normal	89.5	90.1 (0.6)	89.4 (-0.1)	90.1 (0.5)	88.7 (-0.8)
	Dry	74.9	75.9 (1)	76.5 (1.6)	75.9 (1)	74.3 (-0.6)
	Critically Dry	65.0	65.3 (0.3)	65.2 (0.2)	65.1 (0.1)	65.3 (0.3)
	All	77.6	78 (0.5)	77.6 (0.1)	78 (0.4)	76.8 (-0.8)
August	Wet	68.6	68.8 (0.1)	68.8 (0.1)	68.8 (0.1)	68.8 (0.1)
	Above Normal	67.4	67.1 (-0.4)	67.5 (0.1)	67.1 (-0.4)	61 (-6.4)*
	Below Normal	66.0	65.6 (-0.4)	65.7 (-0.3)	65.8 (-0.2)	64.8 (-1.2)
	Dry	53.9	55.7 (1.8)	55.5 (1.6)	55.8 (1.9)	53.5 (-0.4)
	Critically Dry	52.9	51.6 (-1.3)	53 (0.2)	53.1 (0.3)	53.1 (0.2)
	All	62.4	62.5 (0.1)	62.8 (0.4)	62.8 (0.4)	61.3 (-1.1)
September	Wet	61.3	61.3 (0)	61.3 (0)	61.3 (0)	61.3 (0)
	Above Normal	46.9	47.2 (0.2)	50.7 (3.7)	47.4 (0.4)	[redacted]
	Below Normal	29.0	29.1 (0.2)	29.8 (0.8)	29 (0.1)	30.6 (1.6)
	Dry	16.8	18.7 (1.9)	18.4 (1.5)	18.7 (1.8)	17.8 (0.9)
	Critically Dry	14.9	17.3 (2.4)	17.4 (2.5)	17 (2.1)	17.2 (2.3)
	All	37.0	37.8 (0.8)	38.4 (1.4)	37.8 (0.8)	38.7 (1.7)
October	Wet	41.3	41.4 (0)	41.3 (0)	41.4 (0)	41.4 (0)
	Above Normal	27.8	28.7 (0.9)	29.3 (1.6)	28.7 (0.9)	32.6 (4.8)
	Below Normal	30.9	30.6 (-0.2)	31.4 (0.5)	31.1 (0.2)	34 (3.1)
	Dry	18.8	19.3 (0.5)	18.6 (-0.2)	19.3 (0.5)	20.4 (1.7)
	Critically Dry	25.1	29.8 (4.7)	29.2 (4.1)	29.1 (4)	29.4 (4.3)
	All	30.2	31.2 (0.9)	31.1 (0.8)	31.1 (0.9)	32.5 (2.2)
November	Wet	32.8	32.6 (-0.2)	31.8 (-1)	32.6 (-0.2)	31.8 (-0.9)
	Above Normal	36.7	36.8 (0.1)	35.8 (-0.9)	36.8 (0.1)	36.4 (-0.3)
	Below Normal	29.0	29.7 (0.6)	31.6 (2.6)	29.7 (0.6)	32.5 (3.5)
	Dry	18.0	17.8 (-0.3)	21.8 (3.7)	17.1 (-1)	21.4 (3.4)
	Critically Dry	19.1	18.8 (-0.3)	19.3 (0.2)	19 (-0.1)	18.9 (-0.2)
	All	27.5	27.4 (0)	28.3 (0.9)	27.3 (-0.2)	28.4 (1)
December	Wet	30.8	30.5 (-0.2)	30.6 (-0.2)	30.5 (-0.2)	30.8 (0)
	Above Normal	26.9	26.8 (-0.1)	28.7 (1.8)	26.8 (-0.1)	30.6 (3.7)
	Below Normal	39.0	39.1 (0.1)	40 (1)	39.2 (0.2)	42 (3)

Initial Month of Cohort	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
	Dry	24.2	25.1 (1)	23.4 (-0.8)	25.1 (1)	25.9 (1.8)
	Critically Dry	4.1	2.8 (-1.3)	3.6 (-0.5)	3.7 (-0.4)	3.9 (-0.2)
	All	26.3	26.2 (-0.1)	26.4 (0.1)	26.4 (0.1)	27.7 (1.4)

* Results for which ammocoetes stranded under Alternative 1, 2, or 3 is more than 5% below ammocoetes stranded under the NAA are highlighted green.
^ Results for which ammocoetes stranded under Alternative 1, 2, or 3 is more than 5% above ammocoetes stranded under the NAA are highlighted red.

Table 11?-4. Percent of Pacific and River Lamprey Ammocoetes Stranded During 7-Year Rearing Period in the Sacramento River at Bend Bridge and Differences in the Percentages for the No Action Alternative (NAA) and Alternatives 1–3 (Alt 1A, Alt 1B, Alt 2, and Alt 3). January through August Results Pertain to Pacific Lamprey and the February through June Results Pertain to River Lamprey.

Initial Month of Cohort	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
January	Wet	68.4	68.4 (0)	68.4 (0)	68.4 (0)	68.5 (0.1)
	Above Normal	50.4	50.5 (0.1)	50.6 (0.2)	50.5 (0.1)	50.7 (0.3)
	Below Normal	28.0	28.1 (0.1)	28.1 (0.1)	28 (0)	28.1 (0.1)
	Dry	6.2	6.5 (0.3)	6.6 (0.4)	6.5 (0.3)	6.9 (0.7)
	Critically Dry	9.2	9.8 (0.6)	8.9 (-0.2)	9 (-0.1)	8.9 (-0.2)
	All	36.5	36.7 (0.2)	36.6 (0.1)	36.6 (0.1)	36.7 (0.2)
February	Wet	66.7	66.7 (0.1)	66.8 (0.1)	66.7 (0.1)	67 (0.3)
	Above Normal	62.8	63.5 (0.7)	64.4 (1.6)	63.6 (0.8)	64.5 (1.7)
	Below Normal	46.0	46.1 (0.2)	46.7 (0.7)	45.5 (-0.5)	48.2 (2.2)
	Dry	22.1	21.9 (-0.1)	22.4 (0.3)	21.9 (-0.1)	22.9 (0.8)
	Critically Dry	10.1	9.4 (-0.7)	9.5 (-0.6)	9.4 (-0.7)	9.5 (-0.6)
	All	44.5	44.5 (0)	44.9 (0.4)	44.4 (-0.1)	45.3 (0.8)
March	Wet	63.0	63 (0)	63.1 (0.1)	63 (0)	63.2 (0.2)
	Above Normal	57.1	57.4 (0.2)	57.9 (0.7)	57.4 (0.2)	57.6 (0.4)
	Below Normal	24.6	24.6 (0)	24.7 (0.1)	24.6 (0)	24.8 (0.2)
	Dry	22.3	22.1 (-0.1)	22.4 (0.1)	22.1 (-0.1)	23.6 (1.3)
	Critically Dry	10.4	11.1 (0.7)	10.5 (0.1)	11 (0.6)	10.8 (0.4)
	All	38.9	39.1 (0.1)	39.1 (0.2)	39 (0.1)	39.4 (0.5)
April	Wet	48.9	48.8 (-0.1)	48.9 (0)	48.8 (-0.1)	49.1 (0.2)
	Above Normal	24.1	24.3 (0.2)	24.7 (0.6)	24.3 (0.2)	24.9 (0.8)
	Below Normal	15.6	15.4 (-0.3)	15.4 (-0.3)	15.4 (-0.3)	16 (0.4)
	Dry	8.4	8.5 (0.1)	7.7 (-0.7)	8.5 (0.1)	8.3 (-0.1)
	Critically Dry	3.7	3.7 (0)	3.7 (0)	3.7 (0)	3.6 (-0.1)

Initial Month of Cohort	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
	All	24.1	24 (0)	24 (-0.1)	24 (0)	24.3 (0.2)
May	Wet	43.9	43.8 (-0.1)	44 (0.1)	43.8 (-0.1)	44.2 (0.4)
	Above Normal	29.1	28.8 (-0.3)	29.1 (-0.1)	28.8 (-0.3)	29.3 (0.1)
	Below Normal	26.0	25 (-1)	23.1 (-2.9)	25 (-1)	22.8 (-3.2)
	Dry	22.2	21.1 (-1.2)	21.1 (-1.2)	21.1 (-1.2)	19.2 (-3)
	Critically Dry	23.8	18.7 (-5.2)*	18.2 (-5.7)*	18.5 (-5.4)*	18.9 (-4.9)
	All	31.0	29.7 (-1.2)	29.4 (-1.6)	29.7 (-1.3)	29.2 (-1.8)
June	Wet	31.3	30.9 (-0.4)	31 (-0.3)	30.9 (-0.4)	31.3 (0)
	Above Normal	34.1	34.2 (0.1)	30.1 (-4)	34 (-0.1)	28.7 (-5.4)*
	Below Normal	41.8	40.9 (-0.9)	39.6 (-2.2)	41 (-0.8)	34.5 (-7.3)*
	Dry	39.2	37.4 (-1.8)	38.3 (-0.8)	37.4 (-1.8)	36.6 (-2.5)
	Critically Dry	32.8	33 (0.2)	32.3 (-0.5)	32.9 (0.1)	32.9 (0.1)
	All	35.4	34.8 (-0.6)	34.1 (-1.3)	34.8 (-0.7)	32.9 (-2.6)
July	Wet	49.2	49.8 (0.6)	50 (0.8)	49.8 (0.6)	50.2 (1)
	Above Normal	59.0	58.7 (-0.3)	56.7 (-2.3)	58.5 (-0.4)	54.1 (-4.9)
	Below Normal	57.8	58.4 (0.6)	57.9 (0.1)	58.4 (0.6)	56.8 (-1)
	Dry	45.1	46.4 (1.3)	46.8 (1.7)	46.3 (1.2)	45.2 (0.1)
	Critically Dry	33.1	33.4 (0.3)	33.2 (0.1)	33.2 (0.1)	33.3 (0.2)
	All	48.7	49.3 (0.6)	49.1 (0.4)	49.2 (0.5)	48.3 (-0.5)
August	Wet	39.5	39.6 (0.2)	39.8 (0.3)	39.6 (0.2)	40 (0.6)
	Above Normal	37.0	36.9 (-0.1)	37.6 (0.6)	36.9 (-0.1)	32.1 (-4.9)
	Below Normal	32.5	32.3 (-0.3)	32.3 (-0.2)	32.3 (-0.3)	31.6 (-0.9)
	Dry	25.3	27.3 (2)	26.9 (1.6)	27.3 (2)	25.6 (0.2)
	Critically Dry	22.1	21.1 (-1)	22.4 (0.3)	22.5 (0.4)	21.5 (-0.6)
	All	32.2	32.5 (0.3)	32.8 (0.6)	32.7 (0.5)	31.5 (-0.7)
September	Wet	34.2	34.3 (0.1)	34.6 (0.4)	34.3 (0.1)	34.8 (0.6)
	Above Normal	20.6	20.8 (0.2)	23.2 (2.6)	20.7 (0.1)	[redacted]
	Below Normal	7.2	7.4 (0.2)	7.4 (0.2)	7.4 (0.2)	7.7 (0.5)
	Dry	2.8	3.9 (1.1)	3.7 (1)	3.8 (1)	3.6 (0.8)
	Critically Dry	1.1	2 (0.9)	2.1 (1)	1.9 (0.8)	2.6 (1.4)
	All	15.8	16.3 (0.5)	16.7 (0.9)	16.2 (0.4)	17.2 (1.4)
October	Wet	20.7	20.8 (0.1)	20.9 (0.2)	20.8 (0.1)	21.3 (0.6)
	Above Normal	10.4	10.9 (0.5)	11.7 (1.3)	10.9 (0.5)	13.8 (3.4)
	Below Normal	13.7	13.4 (-0.3)	13.9 (0.2)	13.7 (0)	15.4 (1.7)
	Dry	5.2	5.8 (0.6)	5.8 (0.6)	5.9 (0.7)	6.6 (1.4)
	Critically Dry	6.8	9.2 (2.4)	8.8 (2)	8.8 (2)	9.4 (2.6)
	All	12.5	13.1 (0.5)	13.3 (0.7)	13.1 (0.5)	14.2 (1.7)

Initial Month of Cohort	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
November	Wet	23.4	23.3 (-0.1)	23 (-0.4)	23.3 (-0.1)	23.4 (0)
	Above Normal	24.6	24.7 (0.1)	24.2 (-0.4)	24.7 (0.1)	24.6 (0)
	Below Normal	19.9	20.3 (0.4)	21.9 (2)	20.3 (0.4)	23 (3.1)
	Dry	12.9	12.8 (-0.1)	14.9 (2)	12.7 (-0.2)	14.5 (1.6)
	Critically Dry	8.5	7.7 (-0.8)	8.1 (-0.4)	8.1 (-0.4)	8.6 (0.1)
	All	18.5	18.4 (-0.1)	19 (0.5)	18.4 (-0.1)	19.4 (0.9)
December	Wet	30.1	29.9 (-0.1)	30.2 (0.1)	29.9 (-0.1)	30.5 (0.4)
	Above Normal	35.2	35.4 (0.1)	36.4 (1.2)	35.4 (0.1)	37.6 (2.4)
	Below Normal	40.6	40.9 (0.3)	41.5 (0.9)	40.9 (0.3)	43.3 (2.6)
	Dry	27.2	28.1 (0.9)	26.7 (-0.5)	28.1 (0.9)	28.8 (1.5)
	Critically Dry	9.8	9.7 (-0.1)	10 (0.2)	9.9 (0.1)	10.1 (0.3)
	All	29.0	29.2 (0.2)	29.3 (0.3)	29.3 (0.2)	30.3 (1.3)

* Results for which ammocoetes stranded under Alternative 1, 2, or 3 is more than 5% below ammocoetes stranded under the NAA are highlighted green.

^ Results for which ammocoetes stranded under Alternative 1, 2, or 3 is more than 5% above ammocoetes stranded under the NAA are highlighted red.

Table 11?-5. Percent of Pacific and River Lamprey Ammocoetes Stranded During 7-Year Rearing Period in the Sacramento River at Hamilton City and Differences in the Percentages for the No Action Alternative (NAA) and Alternatives 1–3 (Alt 1A, Alt 1B, Alt 2, and Alt 3). January through August Results Pertain to Pacific Lamprey and the February through June Results Pertain to River Lamprey.

Initial Month of Cohort	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
January	Wet	63.1	60.6 (-2.5)	60 (-3.1)	60.8 (-2.3)	60.4 (-2.8)
	Above Normal	44.4	39.9 (-4.5)	39.6 (-4.8)	39.9 (-4.5)	39.8 (-4.6)
	Below Normal	28.6	24.9 (-3.8)	24.1 (-4.6)	24.9 (-3.8)	24.4 (-4.2)
	Dry	12.2	10.5 (-1.7)	10.3 (-2)	10.5 (-1.7)	10.3 (-1.9)
	Critically Dry	15.1	13.2 (-1.9)	12.6 (-2.6)	12.7 (-2.5)	13 (-2.2)
	All	36.3	33.5 (-2.8)	33 (-3.3)	33.5 (-2.8)	33.3 (-3)
February	Wet	63.2	60.7 (-2.5)	60.3 (-2.8)	60.7 (-2.5)	60.8 (-2.4)
	Above Normal	58.3	55.6 (-2.6)	55.3 (-3)	55.6 (-2.6)	56.1 (-2.2)
	Below Normal	41.7	36.8 (-5)	36.2 (-5.6)*	36.5 (-5.2)*	36.4 (-5.3)*
	Dry	24.0	20.8 (-3.2)	20.6 (-3.5)	20.8 (-3.2)	20.9 (-3.1)
	Critically Dry	16.8	14.7 (-2.1)	14.8 (-2)	14.7 (-2.1)	15.3 (-1.5)
	All	43.4	40.4 (-3)	40.1 (-3.3)	40.4 (-3.1)	40.5 (-2.9)
March	Wet	56.8	53.7 (-3.1)	53.3 (-3.5)	54.3 (-2.5)	52.4 (-4.4)

Initial Month of Cohort	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
	Above Normal	50.2	43.5 (-6.7)*	43.3 (-6.9)*	43.6 (-6.6)*	42.9 (-7.3)*
	Below Normal	26.5	19.8 (-6.7)*	18.9 (-7.5)*	19.9 (-6.6)*	19.2 (-7.3)*
	Dry	24.4	19.5 (-4.9)	19.4 (-5)*	19.7 (-4.7)	19.7 (-4.7)
	Critically Dry	17.5	15.3 (-2.2)	15.1 (-2.4)	15.3 (-2.2)	15.8 (-1.7)
	All	37.8	33.3 (-4.5)	32.9 (-4.9)	33.6 (-4.2)	32.8 (-5)
April	Wet	42.0	39 (-3)	38.5 (-3.5)	39.4 (-2.6)	38.4 (-3.6)
	Above Normal	23.0	21.3 (-1.7)	21.2 (-1.9)	21.3 (-1.7)	21.4 (-1.7)
	Below Normal	18.9	16.9 (-2)	16.1 (-2.8)	16.9 (-2)	16.7 (-2.2)
	Dry	13.3	12.2 (-1.1)	11.5 (-1.8)	12.2 (-1.1)	11.7 (-1.6)
	Critically Dry	8.0	7 (-1)	7 (-1)	7 (-1)	6.9 (-1.1)
	All	24.0	22.1 (-1.9)	21.6 (-2.4)	22.2 (-1.8)	21.7 (-2.3)
May	Wet	27.4	25.9 (-1.5)	25.4 (-2)	25.9 (-1.4)	25.5 (-1.9)
	Above Normal	18.4	17.1 (-1.3)	16.8 (-1.6)	17.1 (-1.3)	17 (-1.3)
	Below Normal	14.9	12.8 (-2.2)	12 (-3)	12.8 (-2.2)	12.9 (-2.1)
	Dry	13.1	11.6 (-1.5)	11.4 (-1.7)	11.6 (-1.5)	11.4 (-1.7)
	Critically Dry	15.2	12.2 (-3.1)	11.8 (-3.4)	12.1 (-3.2)	12.6 (-2.7)
	All	19.0	17.2 (-1.8)	16.8 (-2.2)	17.2 (-1.8)	17.1 (-1.9)
June	Wet	15.4	13.5 (-1.9)	13.1 (-2.3)	13.5 (-1.9)	13.4 (-2)
	Above Normal	16.2	14.7 (-1.5)	13.8 (-2.4)	14.7 (-1.5)	13.9 (-2.3)
	Below Normal	19.0	16.8 (-2.2)	15.6 (-3.4)	16.8 (-2.2)	15.9 (-3.1)
	Dry	18.9	17.7 (-1.2)	17.7 (-1.2)	17.6 (-1.3)	18.2 (-0.7)
	Critically Dry	17.8	17 (-0.8)	16.9 (-0.9)	16.8 (-1)	17 (-0.8)
	All	17.2	15.7 (-1.6)	15.2 (-2.1)	15.6 (-1.6)	15.5 (-1.8)
July	Wet	21.8	21 (-0.9)	20.7 (-1.2)	21 (-0.9)	21.2 (-0.6)
	Above Normal	27.1	26.6 (-0.6)	26.2 (-0.9)	26.5 (-0.7)	28.9 (1.7)
	Below Normal	25.9	25 (-0.9)	24.4 (-1.5)	25.1 (-0.8)	26.2 (0.2)
	Dry	22.2	23.5 (1.3)	23.2 (1)	23.5 (1.3)	23 (0.8)
	Critically Dry	18.1	19.3 (1.3)	19.3 (1.3)	19.1 (1.1)	19.2 (1.2)
	All	22.8	22.7 (0)	22.4 (-0.4)	22.7 (-0.1)	23.2 (0.4)
August	Wet	17.8	16.7 (-1.1)	16.4 (-1.4)	16.8 (-1)	16.9 (-0.9)
	Above Normal	17.3	16.3 (-1)	16.4 (-0.9)	16.3 (-1)	15.9 (-1.5)
	Below Normal	14.5	13.6 (-0.9)	12.7 (-1.8)	13.7 (-0.8)	13.1 (-1.4)
	Dry	13.6	14.6 (1)	14.3 (0.7)	14.4 (0.8)	13.5 (-0.1)
	Critically Dry	13.8	13.3 (-0.6)	14.2 (0.4)	13.9 (0.1)	13.4 (-0.4)
	All	15.6	15.1 (-0.5)	15 (-0.7)	15.2 (-0.4)	14.8 (-0.8)
September	Wet	23.0	22 (-0.9)	21.9 (-1)	22.2 (-0.8)	22.3 (-0.7)
	Above Normal	16.2	15.2 (-1)	16.8 (0.7)	15.5 (-0.7)	18.7 (2.5)

Initial Month of Cohort	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
	Below Normal	6.2	5 (-1.1)	4.4 (-1.8)	5 (-1.1)	5.4 (-0.8)
	Dry	1.9	2.7 (0.8)	1.8 (-0.1)	2.7 (0.8)	2 (0.1)
	Critically Dry	1.0	2.3 (1.3)	2.3 (1.3)	1.9 (0.9)	2.6 (1.5)
	All	11.2	10.9 (-0.3)	10.8 (-0.4)	11 (-0.2)	11.4 (0.2)
October	Wet	16.4	15 (-1.3)	14.7 (-1.7)	15 (-1.3)	15.4 (-1)
	Above Normal	11.6	10.6 (-1.1)	10.2 (-1.5)	10.6 (-1.1)	12 (0.4)
	Below Normal	12.6	11.5 (-1.1)	11.3 (-1.3)	11.8 (-0.8)	12.9 (0.3)
	Dry	5.9	6 (0.1)	5.1 (-0.8)	5.9 (0)	6.4 (0.5)
	Critically Dry	8.4	10.1 (1.7)	9.9 (1.5)	10 (1.6)	10 (1.6)
	All	11.6	11 (-0.5)	10.6 (-0.9)	11.1 (-0.5)	11.7 (0.1)
November	Wet	19.4	17.4 (-2)	17 (-2.4)	17.4 (-2)	17.6 (-1.8)
	Above Normal	23.6	22.7 (-0.9)	21.9 (-1.7)	22.7 (-0.9)	21.5 (-2.1)
	Below Normal	17.8	17.3 (-0.4)	17.6 (-0.2)	17.2 (-0.5)	18.2 (0.5)
	Dry	12.8	12.4 (-0.4)	13.9 (1.1)	12.1 (-0.8)	13.7 (0.9)
	Critically Dry	9.9	9.8 (-0.1)	10 (0.1)	9.8 (-0.1)	9.7 (-0.2)
	All	16.9	15.9 (-1)	16.1 (-0.8)	15.9 (-1)	16.3 (-0.6)
December	Wet	28.3	27.2 (-1.1)	26.8 (-1.5)	27.2 (-1.1)	27.5 (-0.9)
	Above Normal	33.3	31.7 (-1.6)	31.6 (-1.7)	31.7 (-1.6)	32.1 (-1.2)
	Below Normal	37.8	35.2 (-2.6)	34.8 (-3)	35.2 (-2.6)	35.9 (-1.9)
	Dry	29.2	28.3 (-0.9)	27.4 (-1.8)	28.2 (-1)	28.5 (-0.6)
	Critically Dry	15.8	12.6 (-3.1)	12.9 (-2.8)	12.9 (-2.8)	13.1 (-2.7)
	All	29.0	27.3 (-1.7)	27 (-2.1)	27.4 (-1.6)	27.7 (-1.3)

Feather River

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Feather River LFC below the Fish Barrier Dam and in the HFC at Gridley Bridge and the mouth indicates that water temperatures would be predominantly similar among alternatives during the period of presence of both life stages of Pacific and river lamprey (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-16-1a to 6C-16-4c, Tables 6C-18-1a to 6C-18-4c, Tables 6C-19-1a to 6C-19-4c; Figures 6C-16-1 to 6C-16-18, Figures 6C-18-1 to 6C-18-18, Figures 6C-19-1 to 6C-19-18). At all locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±1°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at all locations.

Results of the analysis of exceedance above water temperature index values or occurrence outside index ranges for Pacific and river lampreys in the Feather River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water*

Temperature Assessment, Table X through Table X. In the LFC below the fish dam, there would be no differences in exceedance of water temperature indices for any life stage of both lampreys between Alt 1A and Alt 1B compared to the NAA in any month or water year type. In the HFC, for each life stage in each month and water year type for both lampreys, the difference in percent of days exceeding each index value between the NAA and Alt 1A and between the NAA and Alt 1B would be <5%, with some isolated exceptions. Below Thermalito Afterbay in June of dry years, there would be a 5.6% reduction in water temperatures outside the spawning and egg incubation index range of 50°F to 64°F for both lampreys under both Alt 1A and Alt 1B compared to the NAA. Below Thermalito Afterbay in July of critical water years and August of dry years, there would be 8.3% and 5.6% reductions, respectively, in exceedance above the ammocoete rearing and emigration index value of 72°F for both lampreys under Alt 1A and Alt 1B compared to the NAA. At the Feather River mouth in July of below normal and dry water years, there would be 7.1% and 5.6% increases, respectively, in exceedance above the 72°F ammocoete rearing and emigration index value for both lampreys under Alt 1A and Alt 1B compared to the NAA. Also, at the Feather River mouth in September of critical water years, there would be 8.3% increases in exceedance above the juvenile rearing and emigration index value of 72°F under Alt 1A compared to the NAA.

Results of the water temperature exceedance analysis for Pacific and river lamprey for Alt 2 are identical to those for Alt 1A.

Results of the water temperature exceedance analysis for Pacific and river lamprey for Alt 3 are similar to those for Alt 1A with some exceptions. In the LFC below the fish dam during February of dry water years, there would be 5.6% fewer months under Alt 3 relative to the NAA in which water temperature fall outside the 50°F to 64°F index range for river lamprey spawning and egg incubation. Below Thermalito Afterbay Outlet during May of dry water years, there would be 5.6% more months under Alt 3 relative to the NAA in which water temperature fall outside the 50°F to 64°F index range for river lamprey spawning and egg incubation. At the Feather River mouth during both June and August of dry water years, there would be 5.6% fewer months in which water temperature exceeds the 72°F ammocoete rearing and emigration index value for both Pacific and river lamprey. Below Thermalito Afterbay Outlet during July of below normal water years, there would be 9.1% more months in which water temperatures would exceed the 72°F ammocoete rearing and emigration index value. Further, unlike Alt 1A, below Thermalito Afterbay Outlet during September of critical water years, there would be no difference between Alt 3 and the NAA in exceedance of the 72°F ammocoete rearing and emigration index value for both Pacific and river lamprey.

Flow Effects

Spawning Habitat

Spawning habitat for Pacific and river lamprey was evaluated for the Feather River by analyzing redd dewatering risk as described above for the Sacramento River. CALSIM II flow outputs for the Feather River at the Thermalito Afterbay outlet were used to compare the redd dewatering risks between Alternatives 1-3 and the NAA. The results for both lamprey species showed no differences between the project alternatives and the NAA or minor reductions under the project alternatives in the percentage of months with elevated dewatering risk (Table 11-?6).

Table 11-?6. Percentage of Pacific and River Lamprey Spawning Months with >50% Flow Reduction in the Next Month, Used as a Proxy for Redd Dewatering Risk[a] in the Feather at Thermalito Afterbay, and Percent Differences (in parentheses) between the No Action Alternative (NAA) and Alternatives 1–3 (Alt 1A, Alt 1B, Alt 2, and Alt 3).

Location	NAA	Alt 1A vs. NAA	Alt 1B vs. NAA	Alt 2 vs. NAA	Alt 3 vs. NAA
Pacific Lamprey	22.63	15.4 (-6.5%)	15.4 (-6.5%)	15.5 (-5.6%)	15.4 (-6.5%)
River Lamprey	13.1	13.1 (0%)	12.9 (-1.9%)	13.1 (0%)	12.9 (-1.9%)

[a] Positive value for percent differences (in parentheses) indicates a higher risk of redd dewatering under Alternative 1 – 3 vs. the NAA and negative values indicate a lower risk.

Rearing Habitat

Rearing habitat for Pacific and river lamprey was evaluated for the Feather River by analyzing ammocoete habitat dewatering risk as described above for the Sacramento River. CALSIM II flow outputs for the Feather River at the Thermalito Afterbay outlet were used to compare the dewatering risks between Alternatives 1-3 and the NAA. No river stage vs. flow table was found for the Feather River at the Thermalito Afterbay outlet, with the closest location being the Gridley gauge about 7 miles downstream. However, there are no major diversions or inflows on the Feather River between the Thermalito Afterbay outlet and the Gridley gauge locations, so the CALSIM II flow estimates for the Thermalito Afterbay outlet are expected to provide a reasonable approximation of flows at the Gridley gauge. The CALSIM II flows at Thermalito were used with the river stage vs flow table for Gridley to estimate changes in river stage attributable to the alternatives.

The results show a range of about 4% to 82% in ammocoete stranding for the Feather River, with little difference among alternatives in the maximum stranding (Table 11?-7). There are only minor difference in mean ammocoete stranding between Alternatives 1-3 and the NAA. The largest differences were 6% increases in ammocoete stranding in October of dry water years under Alternatives 1A and 1B. October is outside of the cohort initiation periods of both lamprey species. Alternatives 1-3 are expected to have little effect on dewatering risk of ammocoete rearing habitat for Pacific and river lamprey in the Feather River.

Table 11?-7. Percent of Pacific and River Lamprey Ammocoetes Stranded During 7-Year Rearing Period in the Feather River at Gridley Gauge and Differences in the Percentages for the No Action Alternative (NAA) and Alternatives 1–3 (Alt 1A, Alt 1B, Alt 2, and Alt 3). January through August Results Pertain to Pacific Lamprey and the February through June Results Pertain to River Lamprey.

Initial Month of Cohort	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
January	Wet	66.7	66.6 (-0.1)	66.6 (-0.1)	66.6 (-0.1)	66.7 (0)
	Above Normal	49.1	48.6 (-0.5)	48.6 (-0.5)	48.7 (-0.4)	49 (0)
	Below Normal	32.9	32.6 (-0.3)	32.7 (-0.2)	32.6 (-0.3)	32.8 (-0.1)
	Dry	23.2	23.3 (0.1)	23.3 (0.1)	23.3 (0.1)	23.2 (0)
	Critically Dry	24.1	24.1 (0)	24.1 (0)	24.1 (0)	24.4 (0.3)
	All	42.6	42.4 (-0.1)	42.4 (-0.1)	42.4 (-0.1)	42.6 (0)
February	Wet	82.3	82.3 (0)	82.3 (0)	82.3 (0)	82.3 (0)
	Above Normal	43.9	43.3 (-0.6)	43.3 (-0.6)	43.4 (-0.5)	43.7 (-0.2)
	Below Normal	48.9	48.6 (-0.3)	48.6 (-0.3)	48.6 (-0.3)	48.8 (-0.1)
	Dry	26.0	25.9 (-0.1)	25.9 (-0.1)	25.9 (-0.1)	25.8 (-0.1)
	Critically Dry	21.1	21.1 (0)	21.1 (0)	21.2 (0.1)	21.4 (0.3)
	All	49.6	49.5 (-0.2)	49.5 (-0.2)	49.5 (-0.1)	49.6 (0)
March	Wet	79.0	79 (0)	79 (0)	79 (0)	79 (0)
	Above Normal	67.2	66.5 (-0.6)	66.5 (-0.6)	66.6 (-0.5)	66.7 (-0.4)
	Below Normal	43.0	42.6 (-0.3)	42.6 (-0.3)	42.6 (-0.3)	42.9 (-0.1)
	Dry	28.0	27.9 (-0.1)	27.9 (-0.1)	27.9 (-0.1)	27.8 (-0.2)
	Critically Dry	19.6	19.6 (0)	19.5 (-0.1)	19.7 (0.1)	19.8 (0.2)
	All	51.2	51 (-0.2)	51 (-0.2)	51.1 (-0.2)	51.1 (-0.1)
April	Wet	67.9	67.9 (0)	67.9 (0)	67.9 (0)	67.9 (0)
	Above Normal	48.5	47.7 (-0.7)	47.7 (-0.7)	47.8 (-0.6)	48 (-0.4)
	Below Normal	35.2	34.8 (-0.4)	34.8 (-0.4)	34.8 (-0.4)	35.1 (-0.1)
	Dry	26.4	26.5 (0.1)	26.5 (0.1)	26.5 (0.1)	26.4 (-0.1)
	Critically Dry	23.6	23.5 (-0.1)	23.5 (-0.1)	23.6 (0)	23.8 (0.2)
	All	43.9	43.7 (-0.2)	43.7 (-0.2)	43.7 (-0.1)	43.8 (-0.1)
May	Wet	68.8	68.8 (0.1)	68.8 (0.1)	68.8 (0.1)	68.8 (0)
	Above Normal	39.5	38.8 (-0.7)	38.8 (-0.7)	38.9 (-0.6)	39.2 (-0.3)
	Below Normal	35.3	34.9 (-0.4)	34.9 (-0.4)	34.9 (-0.4)	35.2 (-0.1)
	Dry	26.8	26.4 (-0.4)	26.1 (-0.7)	26.4 (-0.4)	25.5 (-1.3)
	Critically Dry	17.9	18.1 (0.2)	18.1 (0.2)	18.2 (0.3)	18.3 (0.4)
	All	42.1	41.9 (-0.2)	41.9 (-0.3)	42 (-0.2)	41.8 (-0.3)
June	Wet	55.6	55.4 (-0.2)	55.4 (-0.2)	55.4 (-0.2)	55.3 (-0.3)
	Above Normal	35.9	34.9 (-1)	34.9 (-1)	35 (-0.9)	35.5 (-0.4)

Initial Month of Cohort	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
	Below Normal	32.8	31.2 (-1.6)	31.2 (-1.6)	31.2 (-1.6)	31.4 (-1.3)
	Dry	34.3	29.5 (-4.8)	29.1 (-5.2)*	30 (-4.3)	30.3 (-4)
	Critically Dry	29.2	24.7 (-4.6)	24.7 (-4.6)	25.2 (-4)	25.7 (-3.5)
	All	40.3	38.1 (-2.2)	38 (-2.3)	38.3 (-2)	38.5 (-1.8)
July	Wet	44.1	43.7 (-0.4)	43.7 (-0.4)	43.7 (-0.4)	43.7 (-0.4)
	Above Normal	50.8	50.2 (-0.6)	50.1 (-0.7)	50.2 (-0.6)	49.5 (-1.2)
	Below Normal	56.8	54.6 (-2.2)	54.7 (-2.1)	54.6 (-2.2)	55.3 (-1.5)
	Dry	42.5	39.4 (-3.1)	39.8 (-2.8)	39.4 (-3.1)	41 (-1.6)
	Critically Dry	25.2	23.9 (-1.2)	24.1 (-1.1)	24.2 (-1)	24.8 (-0.4)
	All	44.0	42.6 (-1.5)	42.7 (-1.4)	42.6 (-1.4)	43.1 (-1)
August	Wet	34.3	34.3 (0)	34.3 (-0.1)	34.3 (-0.1)	34.2 (-0.1)
	Above Normal	44.1	43.6 (-0.6)	43.9 (-0.2)	43.7 (-0.5)	44 (-0.1)
	Below Normal	50.7	50.7 (0)	50.6 (-0.1)	50.4 (-0.2)	51 (0.3)
	Dry	11.1	12.8 (1.7)	13.4 (2.3)	12.9 (1.8)	13.1 (1.9)
	Critically Dry	13.8	16.3 (2.5)	16 (2.2)	16.3 (2.5)	16.7 (2.9)
	All	30.3	31 (0.7)	31.1 (0.8)	30.9 (0.6)	31.1 (0.8)
September	Wet	50.5	50.4 (-0.1)	50.4 (-0.1)	50.4 (-0.1)	50.1 (-0.4)
	Above Normal	56.7	56.2 (-0.6)	55.8 (-0.9)	56.3 (-0.4)	55.7 (-1)
	Below Normal	26.3	26.2 (-0.1)	27.1 (0.8)	26.2 (-0.1)	26.7 (0.4)
	Dry	16.9	17.4 (0.6)	17.4 (0.6)	17.6 (0.8)	17.6 (0.8)
	Critically Dry	9.9	11.9 (2.1)	12.3 (2.4)	12.4 (2.5)	12.7 (2.8)
	All	33.7	34 (0.3)	34.1 (0.4)	34.1 (0.4)	34.1 (0.4)
October	Wet	26.7	27.2 (0.5)	27.2 (0.5)	27.2 (0.5)	27.3 (0.6)
	Above Normal	27.8	27.2 (-0.6)	27.7 (-0.1)	27.3 (-0.5)	27.8 (0)
	Below Normal	17.7	20.6 (2.9)	20 (2.3)	20.5 (2.8)	19.5 (1.9)
	Dry	8.0	[redacted]	[redacted]	12.9 (4.8)	12.4 (4.4)
	Critically Dry	4.8	8.2 (3.4)	7.8 (3)	7.4 (2.6)	5.9 (1)
	All	18.0	20.3 (2.3)	20.2 (2.2)	20 (2)	19.6 (1.6)
November	Wet	18.3	18.3 (0)	18.3 (0)	18.3 (0)	18.3 (0)
	Above Normal	18.6	18.1 (-0.5)	17.7 (-0.8)	18.2 (-0.4)	17.7 (-0.8)
	Below Normal	16.4	17.2 (0.8)	17.2 (0.8)	17.3 (0.9)	17.5 (1.1)
	Dry	10.8	12.2 (1.4)	12.1 (1.3)	12 (1.2)	11.1 (0.3)
	Critically Dry	4.1	4.7 (0.6)	4.8 (0.7)	4.8 (0.7)	4.8 (0.7)
	All	14.3	14.8 (0.5)	14.7 (0.4)	14.8 (0.5)	14.5 (0.2)
December	Wet	33.7	33.8 (0.2)	33.8 (0.2)	33.9 (0.2)	33.8 (0.1)
	Above Normal	24.4	23.5 (-0.8)	23.5 (-0.8)	23.7 (-0.7)	24.4 (0)
	Below Normal	30.9	30.5 (-0.4)	30.5 (-0.4)	30.5 (-0.4)	30.8 (-0.1)

Initial Month of Cohort	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
	Dry	16.2	16.4 (0.1)	16.4 (0.2)	16.4 (0.1)	16.3 (0.1)
	Critically Dry	8.3	7.6 (-0.6)	7.6 (-0.6)	7.7 (-0.5)	7.9 (-0.3)
	All	24.3	24.1 (-0.2)	24.1 (-0.2)	24.1 (-0.2)	24.3 (0)

American River

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the American River below Nimbus Dam, at Watt Ave, and at the mouth indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of the two lamprey species (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-13-1a to 6C-13-4c, Tables 6C-14-1a to 6C-14-4c, Tables 6C-15-1a to 6C-15-4c; Figures 6C-13-1 to 6C-13-18, Figures 6C-14-1 to 6C-14-18, Figures 6C-15-1 to 6C-15-18). At all locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±0.5°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at all locations.

Results of the analysis of exceedance above water temperature index values or occurrence outside index ranges for Pacific and river lampreys in the American River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment*, Table X through Table X. Below Nimbus Dam and at Watt Ave, there would be no differences in exceedance of water temperature indices for any life stage of both lampreys between Alt 1A and Alt 1B compared to the NAA in any month or water year type. At the confluence, for each life stage in each month and water year type for both lampreys, the difference in percent of days exceeding each index value between the NAA and Alt 1A and between the NAA and Alt 1B would be <5%, with one exception. In July of dry water years, there would be 5.4% and 5.7% more exceedances above the 71.6°F index value for ammocete rearing and emigration of both lampreys under Alt 1A and 1B, respectively, compared to the NAA.

Results of the water temperature exceedance analysis for Pacific and river lamprey for Alt 2 are very similar to those for Alt 1A.

Results of the water temperature exceedance analysis for Pacific and river lamprey for Alt 3 are similar to those for Alt 1A with two exceptions. At Watt Ave in July of critical water years, there would be 5.1% fewer days on which water temperatures exceed the 71.6°F index value for ammocete rearing and emigration of both lampreys under Alt 3 relateive to the NAA. At the American River mouth in July of dry water years, there would be 9.7% more days on which water temperatures exceed the 71.6°F index value for ammocete rearing and emigration of both lampreys under Alt 3 relative to the NAA.

Flow Effects

Spawning Habitat

Spawning habitat effects for Pacific and river lamprey were evaluated for the American River by analyzing redd dewatering risk as described above for the Sacramento River. CALSIM II flow outputs for the American River at Nimbus Dam and the H Street Bridge were used to compare the American River redd dewatering risks between Alternatives 1-3 and the NAA.

The results for Pacific lamprey of the potential redd dewatering risks primarily show small reductions in frequency of month-over-month >50% reductions in flow during spawning months under Alternatives 1-3 at both river locations (Table 11-?8). The results for river lamprey primarily show minor increases in frequency of month-over-month >50% reductions in flow under Alternatives 1A, 1B, and 2 at both river locations (Table 11?-9). The results for river lamprey under Alternative 3 show larger increases in the frequency at both locations, including an increase of 2 percent of months (12.5% difference) in the American River at the H Street. A two percent increase in spawning months with a potentially elevated redd dewatering risk at one location is unlikely to affect the river lamprey population. Alternatives 1–3 are not expected to affect redd dewatering risk of Pacific or river lamprey in the American River.

Table 11-?8. Percentage of Pacific Lamprey Spawning Months with >50% Flow Reduction in the Next Month, Used as a Proxy for Redd Dewatering Risk[a] for Locations in the American River, and Percent Differences (in parentheses) between the No Action Alternative (NAA) and Alternatives 1–3 (Alt 1A, Alt 1B, Alt 2, and Alt 3).

Location	NAA	Alt 1A vs. NAA	Alt 1B vs. NAA	Alt 2 vs. NAA	Alt 3 vs. NAA
American River at Nimbus Dam	13.9	13.7 (-1.1%)	14 (1.1%)	13.7 (-1.1%)	13.4 (-3.3%)
American River at H Street	15.9	14.9 (-5.8%)	15.4 (-2.9%)	14.9 (-5.8%)	15.5 (-1.9%)

[a] Positive value for percent differences (in parentheses) indicates a higher risk of redd dewatering under Alternative 1–3 vs. the NAA and negative values indicate a lower risk.

Table 11-?9. Percentage of River Lamprey Spawning Months with >50% Flow Reduction in the Next Month, Used as a Proxy for Redd Dewatering Risk[a] for Locations in the American River, and Percent Differences (in parentheses) between the No Action Alternative (NAA) and Alternatives 1–3 (Alt 1A, Alt 1B, Alt 2, and Alt 3).

Location	NAA	Alt 1A vs. NAA	Alt 1B vs. NAA	Alt 2 vs. NAA	Alt 3 vs. NAA
American River at Nimbus Dam	12.6	12.9 (1.9%)	13.3 (5.8%)	12.9 (1.9%)	13.6 (7.7%)
American River at H Street	15.5	15.3 (-1.6%)	15.8 (1.6%)	15.5 (0%)	17.5 (12.5%)

[a] Positive value for percent differences (in parentheses) indicates a higher risk of redd dewatering under Alternative 1–3 vs. the NAA and negative values indicate a lower risk.

Rearing Habitat

Rearing habitat effects for Pacific and river lamprey were evaluated for the American River by analyzing ammocoete habitat dewatering risk as described above for the Sacramento River. CALSIM II flow outputs for the American River at Nimbus Dam were used to compare the ammocoete stranding risks between Alternatives 1-3 and the NAA. The river stage vs. flow relationships used for the American River analysis were obtained from the salmonid redd dewatering study (Bratovich et al. 2017) that was used to develop the procedures for estimating effects of Alternatives 1-3 on redd dewatering of fall-run Chinook salmon and steelhead in the American River (see Appendix 11K).

The results show a range of about 0% to 52% in ammocoete stranding for the American River, with little difference among alternatives in the maximum stranding (Table 11?-9). There are only minor difference in mean stranding between Alternatives 1-3 and the NAA. The largest difference was a 5% reduction in July of below normal water years. None of the differences was greater than 5%. Alternatives 1-3 are expected to have little effect on dewatering risk of ammocoete rearing habitat for Pacific and river lamprey in the American River.

Table 11?-9. Percent of Pacific and River Lamprey Ammocoetes Stranded During 7-Year Rearing Period in the American River at Nimbus Dam and Differences in the Percentages for the No Action Alternative (NAA) and Alternatives 1–3 (Alt 1A, Alt 1B, Alt 2, and Alt 3). January through August Results Pertain to Pacific Lamprey and the February through June Results Pertain to River Lamprey.

Initial Month of Cohort	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
January	Wet	48.5	48.2 (-0.3)	48.3 (-0.2)	48.2 (-0.4)	48.7 (0.1)
	Above Normal	32.2	31.9 (-0.3)	31.9 (-0.3)	31.9 (-0.3)	32.3 (0.1)
	Below Normal	17.4	17.6 (0.2)	17.5 (0.1)	17.9 (0.5)	17.6 (0.2)
	Dry	9.8	9.3 (-0.5)	9.1 (-0.7)	9.2 (-0.6)	10.3 (0.5)
	Critically Dry	10.0	9.5 (-0.5)	8.9 (-1.1)	9.4 (-0.6)	9.2 (-0.7)
	All	26.7	26.4 (-0.3)	26.3 (-0.4)	26.4 (-0.3)	26.8 (0.1)
February	Wet	51.5	51.4 (-0.2)	51.3 (-0.3)	51.3 (-0.2)	51.3 (-0.2)
	Above Normal	40.3	40 (-0.3)	39.7 (-0.6)	40 (-0.3)	39.8 (-0.4)
	Below Normal	33.3	33.3 (-0.1)	33.3 (-0.1)	33.3 (0)	33.1 (-0.2)
	Dry	15.8	15.9 (0.1)	15.8 (0)	15.9 (0.1)	16.3 (0.5)
	Critically Dry	13.4	11.8 (-1.6)	12.7 (-0.7)	12.9 (-0.5)	10.5 (-2.9)
	All	33.4	33 (-0.3)	33.1 (-0.3)	33.2 (-0.1)	32.9 (-0.5)
March	Wet	37.6	37.5 (-0.2)	37.4 (-0.3)	37.4 (-0.2)	37.4 (-0.2)
	Above Normal	33.3	33 (-0.3)	32.7 (-0.6)	33 (-0.3)	32.8 (-0.4)
	Below Normal	16.0	15.9 (-0.1)	15.7 (-0.3)	15.9 (-0.1)	15.8 (-0.2)
	Dry	14.8	14.1 (-0.7)	13.7 (-1)	14 (-0.7)	14.3 (-0.5)
	Critically Dry	7.4	7.9 (0.6)	7.2 (-0.1)	7.4 (0.1)	7.1 (-0.2)

Initial Month of Cohort	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
	All	23.8	23.7 (-0.2)	23.4 (-0.5)	23.6 (-0.3)	23.5 (-0.3)
April	Wet	37.9	37.8 (-0.2)	37.8 (-0.1)	37.8 (-0.1)	37.8 (-0.1)
	Above Normal	26.2	26 (-0.2)	25.7 (-0.6)	26 (-0.3)	25.8 (-0.4)
	Below Normal	20.3	20 (-0.2)	19.9 (-0.3)	20.1 (-0.2)	19.7 (-0.5)
	Dry	10.3	10 (-0.3)	9.4 (-0.9)	9.8 (-0.5)	10.2 (-0.1)
	Critically Dry	9.9	9.3 (-0.6)	8.8 (-1.1)	9.2 (-0.7)	9.9 (0)
	All	23.0	22.8 (-0.3)	22.5 (-0.6)	22.7 (-0.3)	22.8 (-0.2)
May	Wet	46.7	46.5 (-0.2)	46.5 (-0.2)	46.5 (-0.2)	46.5 (-0.2)
	Above Normal	33.7	33.4 (-0.3)	33.1 (-0.6)	33.4 (-0.3)	33.2 (-0.5)
	Below Normal	29.6	29.4 (-0.1)	29.2 (-0.3)	29.5 (-0.1)	29.4 (-0.2)
	Dry	16.5	16.6 (0.2)	15.9 (-0.6)	16.4 (0)	15.3 (-1.1)
	Critically Dry	9.1	8.6 (-0.5)	8.3 (-0.8)	8.8 (-0.3)	7.7 (-1.3)
	All	29.7	29.6 (-0.2)	29.3 (-0.4)	29.6 (-0.2)	29.1 (-0.6)
June	Wet	35.8	35.7 (-0.1)	35.7 (-0.1)	35.6 (-0.2)	35.6 (-0.2)
	Above Normal	24.8	23.9 (-0.9)	23.2 (-1.5)	23.9 (-0.9)	23.3 (-1.5)
	Below Normal	20.4	20.4 (0)	20 (-0.4)	20.5 (0.1)	19.8 (-0.6)
	Dry	16.9	16.6 (-0.3)	16.8 (-0.1)	16.4 (-0.5)	15.3 (-1.6)
	Critically Dry	7.9	7.2 (-0.8)	7.3 (-0.7)	7.3 (-0.7)	7.4 (-0.6)
	All	23.3	23 (-0.3)	22.9 (-0.5)	23 (-0.4)	22.5 (-0.8)
July	Wet	26.8	26.4 (-0.4)	26.4 (-0.4)	26.4 (-0.4)	26.4 (-0.4)
	Above Normal	30.7	30.5 (-0.2)	30.1 (-0.7)	30.5 (-0.3)	27.2 (-3.5)
	Below Normal	33.7	33.6 (-0.1)	32.7 (-1)	33.4 (-0.3)	29.1 (-4.6)
	Dry	18.2	17.8 (-0.5)	17.8 (-0.4)	17.6 (-0.6)	17.1 (-1.2)
	Critically Dry	11.0	10.6 (-0.4)	10 (-1.1)	10.4 (-0.6)	10.3 (-0.7)
	All	24.3	23.9 (-0.3)	23.6 (-0.6)	23.8 (-0.5)	22.5 (-1.8)
August	Wet	25.7	25.6 (-0.1)	25.6 (-0.1)	25.5 (-0.2)	25.5 (-0.2)
	Above Normal	22.3	22.7 (0.4)	20.9 (-1.3)	22.7 (0.4)	22 (-0.3)
	Below Normal	17.3	17.2 (-0.1)	16.9 (-0.4)	17.4 (0)	16.9 (-0.4)
	Dry	16.0	15.1 (-0.9)	15 (-1)	15 (-1.1)	15.7 (-0.3)
	Critically Dry	10.1	10.7 (0.6)	9 (-1.1)	9 (-1.1)	11.3 (1.2)
	All	19.3	19.2 (-0.1)	18.6 (-0.7)	18.9 (-0.4)	19.3 (-0.1)
September	Wet	18.1	17.9 (-0.1)	17.8 (-0.3)	17.9 (-0.2)	17.9 (-0.2)
	Above Normal	23.0	22.8 (-0.2)	21 (-1.9)	22.8 (-0.2)	19.6 (-3.4)
	Below Normal	19.4	19.1 (-0.3)	19.1 (-0.3)	19.1 (-0.3)	18.9 (-0.5)
	Dry	12.4	12.3 (-0.2)	12 (-0.5)	12.1 (-0.4)	12.1 (-0.4)
	Critically Dry	5.5	5.4 (-0.1)	5.3 (-0.2)	5.3 (-0.2)	5.3 (-0.2)
	All	15.8	15.7 (-0.2)	15.3 (-0.5)	15.6 (-0.2)	15.1 (-0.7)

Initial Month of Cohort	Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
October	Wet	14.4	14.2 (-0.2)	14.2 (-0.1)	14.2 (-0.2)	14.2 (-0.2)
	Above Normal	14.1	13.8 (-0.3)	13.4 (-0.7)	13.9 (-0.2)	13.5 (-0.7)
	Below Normal	11.4	11.3 (-0.1)	10.8 (-0.6)	11.5 (0)	11.2 (-0.2)
	Dry	6.4	6.4 (0)	7.3 (0.9)	6.2 (-0.2)	8.1 (1.7)
	Critically Dry	3.7	4.6 (0.9)	4.6 (0.9)	4.6 (0.9)	3 (-0.7)
	All	10.5	10.5 (0)	10.6 (0.1)	10.5 (0)	10.6 (0.1)
November	Wet	30.3	30.6 (0.3)	30.3 (0)	30.5 (0.2)	30.5 (0.3)
	Above Normal	22.2	22.1 (-0.2)	22.8 (0.6)	22.4 (0.2)	24.1 (1.9)
	Below Normal	20.8	21 (0.2)	20.7 (-0.1)	21.1 (0.3)	22.1 (1.3)
	Dry	11.1	12.5 (1.4)	11 (-0.2)	12.3 (1.2)	11.5 (0.3)
	Critically Dry	1.3	0.5 (-0.8)	1.2 (-0.1)	1.2 (-0.1)	2.9 (1.6)
	All	19.0	19.3 (0.3)	19.1 (0)	19.4 (0.4)	19.9 (0.9)
December	Wet	26.8	26.5 (-0.2)	26.6 (-0.2)	26.3 (-0.4)	26.5 (-0.3)
	Above Normal	26.1	25.8 (-0.4)	25.5 (-0.7)	25.9 (-0.3)	26.2 (0.1)
	Below Normal	29.0	28.8 (-0.2)	28.8 (-0.2)	28.9 (-0.1)	29.8 (0.8)
	Dry	23.5	24 (0.5)	24 (0.5)	23.7 (0.2)	24.3 (0.8)
	Critically Dry	1.2	2.3 (1.1)	2.2 (1)	1.9 (0.7)	0.3 (-0.9)
	All	22.6	22.7 (0.1)	22.7 (0.1)	22.5 (-0.1)	22.7 (0.1)

<u>**Delta**</u>

Entrainment

Both Pacific and river lamprey are entrained at the south Delta export facilities. Concerns exist over the relatively low salvage efficiency of these facilities for the lamprey species (Goodman et al. 2017). Potential differences in entrainment risk between Alternatives 1–3 and the NAA were assessed with the salvage-density method (see Appendix 11Q) for each species as well as for lamprey not identified to species (indicated as 'unknown' in the historical salvage database). The differences between Alternatives 1–3 and the NAA were minor (Tables pl_banks; pl_jones; rl_banks; rl_jones; uk_banks; uk_jones), indicating entrainment risk under the alternatives would be similar to existing conditions.

Table pl_banks. Salvage of Pacific Lamprey At SWP Banks Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Dry	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Critically Dry	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

Table pl_jones. Salvage of Pacific Lamprey At CVP Jones Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	77	77 (0%)	77 (0%)	77 (0%)	76 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	765	766 (0%)	767 (0%)	766 (0%)	767 (0%)
Dry	20	21 (2%)	21 (5%)	21 (2%)	22 (6%)
Critically Dry	371	369 (0%)	370 (0%)	370 (0%)	373 (1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

Table rl_banks. Salvage of River Lamprey At SWP Banks Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Dry	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Critically Dry	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

Table rl_jones. Salvage of River Lamprey At CVP Jones Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	1	1 (0%)	1 (0%)	1 (0%)	1 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	5	5 (0%)	5 (0%)	5 (0%)	5 (-1%)
Dry	0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Critically Dry	5	5 (2%)	5 (2%)	5 (2%)	5 (3%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

Table uk_banks. Salvage of Unknown Species of Lamprey At SWP Banks Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	892	891 (0%)	892 (0%)	891 (0%)	891 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	162	161 (-1%)	162 (0%)	161 (-1%)	163 (0%)
Dry	57	58 (1%)	55 (-3%)	58 (1%)	60 (5%)
Critically Dry	50	50 (1%)	51 (2%)	50 (2%)	50 (1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

Table uk_jones. Salvage of Unknown Species of Lamprey At CVP Jones Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	7,116	7,116 (0%)	7,114 (0%)	7,115 (0%)	7,099 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	1,675	1,675 (0%)	1,674 (0%)	1,675 (0%)	1,669 (0%)
Dry	1,548	1,601 (3%)	1,519 (-2%)	1,601 (3%)	1,558 (1%)
Critically Dry	39	40 (2%)	39 (1%)	39 (1%)	39 (0%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

The results indicate for Pacific lamprey and river lamprey show that Alternatives 1-3 are not expected to affect redd dewatering risk in the Sacramento, Feather, or the American river. Results also indicate that Alternatives 1-3 would have no appreciable to little effect on dewatering risk of the ammocoete rearing habitat of Pacific lamprey or river lamprey in the Sacramento, Feather, or American river. For these reasons, impacts associated with operations of Alternative 1–3 on Pacific lamprey or river lamprey would be less than significant.

NEPA Conclusion for Alternatives 1, 2, and 3

The results indicate for Pacific lamprey and river lamprey show that Alternatives 1-3 are not expected to affect redd dewatering risk in the Sacramento, Feather, or the American river. Results also indicate that Alternatives 1-3 would have no appreciable to little effect on dewatering risk of the ammocoete rearing habitat of Pacific lamprey or river lamprey in the

Sacramento, Feather, or American river. For these reasons, impacts associated with operations of Alternative 1–3 would not be adverse on Pacific lamprey or river lamprey.

Impact FISH-11: Operations Effects on Native Minnows (Sacramento Splittail, Sacramento Hitch, Hardhead, and Central California Roach)

Alternatives 1, 2, and 3

Effects of Alternatives 1, 2, and 3

Sacramento River

Near-Field Effects

Early life stages of native minnows occurring at the Red Bluff and Hamilton City intakes would be susceptible to risk of near-field effects such as entrainment at greater levels than existing conditions if present during the main winter-early spring period of Alternative 1–3 diversions to Sites Reservoir. As discussed in Appendix 11A, Sacramento splittail spawning occurs primarily in areas downstream of the two intakes, so the potential for negative near-field effects would be very limited. Sacramento hitch spawning may occur during March–June, with juveniles occurring at stream margins before exiting shallow water after two months at about 50-mm fork length (Moyle et al. 2015; see also Appendix 11A). As such, the risk of near-field effects under Alternatives 1–3 generally would be similar to the NAA because there would be little difference in diversions during the May–August time period when juveniles would be most likely to exit shallow water rearing habitat (see Tables RB% and HC% in the winter-run Chinook salmon analysis). Hardhead spawning is mainly in April and May and as with other native minnows the young generally occur at stream margins before moving into deeper habitats at larger size (see Appendix 11A). Similar to Sacramento hitch, this timing means that potential exposure of juveniles to the Red Bluff and Hamilton City intakes would occur when there would be little difference in diversions between Alternatives 1–3 and the NAA. Central California roach tend to occur in small streams or in backwaters with dense riparian cover along the mainstem rivers (see Appendix 11A). This distribution would tend to limit potential for negative near-field effects, although Moyle et al. (2015) noted that larval drift may be significant form of dispersal during some years, with the late spring timing and apparent short drift period possibly being adaptations to reduce risk of drifting downstream to unsuitable habitats such as the Central Valley floor. This lack of systematic, broad-scale migration past the Red Bluff and Hamilton intakes and the late spring timing would limit the potential for greater near-field effects to Central California roach under Alternatives 1–3 given the general similarity of diversions to the NAA during this time period (see Tables RB% and HC% in the winter-run Chinook salmon analysis).

Funks and Stone Corral Creeks

Funks and Stone Corral Creeks will be modified downstream of the proposed dams. On Stone Corral Creek, the reach of interest is from the downstream face of the Sites Dam to just above the GCID Main Canal (7.7 miles); on Funks Creek, it is from the downstream face of Golden

Gate Dam to the upper end of Funks Reservoir (1.8 miles). While these reaches have been modified by cattle grazing and minor diversions, they still have available fish habitat and both native and nonnative fish have been observed in each drainage. (*cite to: California Fish and Game Code 5937 and Funks and Stone Corral Creeks Memo, once finalized)*.

Stone Corral Creek would receive bypass flows from the reservoir from an outlet on the Sites Dam and Funks Creek would receive augmented flow from the Funks pipelines to its reaches immediately upstream of Funks Reservoir. Associated with the project are field studies. These would be initiated once access is obtained and before final designs for Sites and Golden Gate Dams are completed. The Authority would use information from these field studies, along with currently available information, to prepare an Operations Plan for Funks and Stone Corral Creeks. The Operations Plan would identify the approach for releases, including release schedule and volumes, a monitoring plan, and an adaptive management plan to maintain fish in good condition consistent with California Fish and Game Code Section 5937. Additional information on Funks and Stone Corral Creeks can be found in section 7.4 of the Fluvial Geomorphology Chapter.

Far-Field Effects

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Sacramento River below Keswick Dam, below Red Bluff Diversion Dam, Hamilton City, and Butte City indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of native minnows: Sacramento splittail, Sacramento hitch, and hardhead (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-5-1a to 6C-5-4c, Tables 6C-10-1a to 6C-10-4c, Tables 6C-11-1a to 6C-11-4c, Tables 6C-12-1a to 6C-12-4c; Figures 6C-5-1 to 6C-5-18, Figures 6C-10-1 to 6C-10-18, Figures 6C-11-1 to 6C-11-18, Figures 6C-12-1 to 6C-12-18). At al sites, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±0.5°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1.

Results of the analysis of occurrence outside the 45°F to 75°F spawning index range for Sacramento splittail in the Sacramento River at Hamilton City from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. The percent of months outside the index range would be similar between the NAA and all alternatives.

Results of the analysis of occurrence of water temperatures outside index range of Sacramento hitch spawning in the Sacramento River below Red Bluff Diversion Dam and at Butte City from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. Below Red Bluff Diversion Dam, the percent of days outside the index range would be similar between Alt 1A and Alt 11B compared to the NAA with some exceptions. In May and June of below normal years and May of critical years, the occurrence outside the index range under Alt 1B would be 6.2%, 7.2%, and 5.4% lower than under the NAA. In addition, the occurrence of water temperatures outside the index range under Alt 1B in July of dry years would be 5.9% greater than under the NAA. At Butte City, the percent of months outside the index range would be similar between Alt 1A and Alt 11B compared to the NAA for all months of occurrence and water years types. Results of Alt 2 would be similar to Alt 1A except for a 5.9% reduction in the occurrence outside the index range in May of critical years. Alt 3 results would be similar to Alt 1A except for some larger reductions in the occurrence of water temperatures outside the index range during June and July (6.2% to 11.4%) relative to the NAA.

Results of the analysis of occurrence outside index ranges for hardhead in the Sacramento River below Keswick Dam and below Red Bluff Diversion Dam from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. At Keswick, the percent of days outside the index range would be similar between Alt 1A and Alt 11B compared to the NAA. Below Red Bluff Diversion Dam, the percent of days outside the index range would be similar between Alt 1A and Alt 11B compared to the NAA with some exceptions. For the 59°F to 64°F spawning range, there would be an 8.3% reduction in occurrence outside the index range under Alt 1A compared to the NAA in May of critical water years. In addition, for May of below normal, May of critical, and June of above normal water years, there would be 5.1%, 8.6%, and 12.8% reductions, respectively, in occurence of water temperatures outside the range under Alt 1B compared to the NAA. Results for Alt 2 would be similar to Alt 1A. Results for Alt 3 would be similar to Alt 1B.

Floodplain Inundation

Floodplain inundation is an important aspect of the life history of Sacramento splittail as spawning and early rearing habitat (see Appendix 11A). As described in Chapter 2 and as discussed for winter-run Chinook salmon, Fremont Weir notch protections are included in the diversion criteria to reduce changes to spill frequency and duration under Alternatives 1–3 relative to existing conditions. In particular, these criteria avoid impacts on Reclamation's ability to implement its obligations in the 2019 NMFS ROC on LTO Biological Opinion to implement the Yolo Bypass Restoration Salmonid Habitat Restoration and Fish Passage Implementation Plan and provide 17,000+ acres of inundation in the Yolo Bypass from December to April (NMFS 2019). As such, Alternatives 1–3 would have limited potential for negative effects to Yolo Bypass floodplain inundation and access for Sacramento splittail. This was confirmed with the modeling summarized in the winter-run Chinook salmon section (see also Attachments 11M-1 and 11M-2 to Appendix 11M).

Feather River

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Feather River LFC below the Fish Barrier Dam and in the HFC at Gridley Bridge and at the mouth indicates that water temperatures would be predominantly similar among alternatives during the periods of presence of native minnows: Sacramento splittail, Sacramento hitch, and hardhead (Appendix 6C, *River*

Temperature Modeling (HEC5Q and Reclamation Temperature Model) Tables 6C-16-1a to 6C-16-4c, Tables 6C-18-1a to 6C-18-4c, Tables 6C-19-1a to 6C-19-4c; Figures 6C-16-1 to 6C-16-18, Figures 6C-18-1 to 6C-18-18, Figures 6C-19-1 to 6C-19-18). At all locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±1°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at all locations.

Results of the analysis of occurrence outside the 45°F to 75°F spawning index range for Sacramento splittail at the mouth of the Feather River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. The percent of months outside the index range would be similar between the NAA and all alternatives.

Results of the analysis of occurrence of water temperatures outside index range of Sacramento hitch spawning in the Feather River LFC below the fish dam and in the HFC below Thermalito Afterbay outlet from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. In the LFC below the fish dam, the percent of months with water temperatures outside the index range would be similar between Alt 1A and Alt 1B compared to the NAA with one exception. In June of critical water years, there would be 8.3% fewer months under Alt 1A and Alt 1B relative to the NAA in which water temperatures would be outside the index range. Below Thermaltio Afterbay Outlet, the percent of months with water temperatures outside the index range would be similar between Alt 1A and Alt 11B compared to the NAA. Results for Alt 2 are similar to Alt 1. Results for Alt 3 are similar to Alt 1 with one exception. In June of dry water years below the fish dam, there would be 5.6% more months under Alt 3 relative to the NAA in which water temperatures are outside the index range.

Results of the analysis of occurrence outside index ranges for hardhead in the Feather River LFC below the fish dam and in the HFC below Thermalito Afterbay outlet and at the mouth from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. In the LFC below the fish dam, the percent of months with water temperatures outside the index range would be similar between Alt 1A and Alt 1B compared to the NAA. Below Thermalito Afterbay, the percent of months with water temperatures outside the index range would be similar between Alt 1A and Alt 1B compared to the NAA with two exceptions. In May of dry years, there would be 5.6% fewer months under Alt 1A and Alt 1B relative to the NAA in which water temperatures are outside the index range. In June of dry years, there would be 5.6% more months under Alt 1A and Alt 1B relative to the NAA in which water temperatures are outside the index range. At the Feather River mouth he percent of months with water temperatures outside the index range would be similar between Alt 1A and Alt 1B compared to the NAA. Results for Alt 2 would be similar to Alt 1. Results for Alt 3 would be similar to Alt 1 with one exception. Below Thermaltio Afterbay, there would be no 5.6% reduction in occurrence of water temerpatures outside the index range under Alt 3 in May of dry water years that there would be under Alt 1.

American River

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the American River below Nimbus Dam, at Watt Ave, and at the mouth indicates that water temperatures would be predominantly similar among alternatives during the period of presence of native minnows: Sacramento splittail, Sacramento hitch, and hardhead (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-13-1a to 6C-13-4c, Tables 6C-14-1a to 6C-14-4c, Tables 6C-15-1a to 6C-15-4c; Figures 6C-13-1 to 6C-13-18, Figures 6C-14-1 to 6C-14-18, Figures 6C-15-1 to 6C-15-18). At all locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±0.5°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at all locations.

Results of the analysis of occurrence outside the 45°F to 75°F spawning index range for Sacramento splittail at the mouth of the American River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. The percent of days outside the index range would be similar between the NAA and all alternatives.

Results of the analysis of occurrence of water temperatures outside the spawning index range of Sacramento hitch spawning in the American River below Nimbus Dam and at Watt Ave from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. At both locations, the percent of days outside the index range would be similar between the NAA and all alternatives.

Results of the analysis of occurrence outside index ranges for hardhead in the American River at Watt Ave from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. The percent of days with water temperatures outside the index range would be similar between Alt 1A and Alt 1B compared to the NAA. Results for Alt 2 would be similar to Alt 1. Results for Alt 3 would be similar to Alt 1 with few exceptions. For juvenile and adult presence, the occurrence of water temperatures outside the index range for Alt 3 would be 5.6% lower than the NAA in May of critical water years and 7.4% higher than the NAA in September of below normal water years. For hardhead spawning, the occurrence of water temperatures outside the index range for Alt 3 would be 5.3% higher than the NAA in April of critical water years.

Delta

Within the Delta, Alternatives 1–3 have the potential to affect native minnows by increasing south Delta exports during summer/fall relative to existing conditions. Very few hitch, Central California roach, or hardhead have been salvaged historically and so increases in exports during summer/fall under the alternatives would not result in appreciable additional salvage; as described in Appendix 11A, these species occur mostly upstream of the Delta. For Sacramento splittail, the salvage-density method (see description in Appendix 11Q) suggested entrainment risk under Alternatives 1–3 generally would be similar to NAA, with some potential for small increases in drier years (Table sp_banks and sp_jones) as the species temporally overlaps the period with greater exports under the alternatives. Such differences would not give population-level consequences because the main driver of splittail population dynamics is floodplain habitat availability and entrainment is not an important driver (Sommer et al. 1997).

Table sp_banks. Salvage of Sacramento Splittail At SWP Banks Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	658,975	657,362 (0%)	657,212 (0%)	657,300 (0%)	642,001 (-3%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	5,986	6,040 (1%)	6,032 (1%)	6,032 (1%)	6,003 (0%)
Dry	608	617 (1%)	615 (1%)	617 (1%)	616 (1%)
Critically Dry	467	481 (3%)	483 (3%)	484 (4%)	474 (2%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

Table sp_jones. Salvage of Sacramento Splittail At CVP Jones Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	7,328,200	7,330,136 (0%)	7,330,973 (0%)	7,330,175 (0%)	7,330,091 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	70,806	70,704 (0%)	71,442 (1%)	70,716 (0%)	72,928 (3%)
Dry	1,320	1,351 (2%)	1,386 (5%)	1,352 (2%)	1,400 (6%)
Critically Dry	13	13 (3%)	13 (1%)	13 (1%)	13 (0%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

Operations of Alternative 1, 2, or 3, would provide bypass flows to Stone Corral and Funks Creeks. These flows would be refined through studies required under Project Commitments. These flows would support processes in these channels that support the fish (including native minnows) assemblage below the dams. Per the discussion above, native minnow spawning is not anticipated to be negatively impacted due to operations of the Red Bluff and Hamilton City intakes for Alternatives 1-3. Mean monthly temperatures by water year types between the alternatives and the NAA in the Sacramento, Feather, and American rivers would be similar during the presence of each life stage of native minnows. Alternatives 1–3 would have limited potential for negative effects to Yolo Bypass floodplain inundation and access for Sacramento splittail. Within the Delta, few hitch, Central California roach, or hardhead have been salvaged historically and so increases in exports during summer/fall under the alternatives would not result in appreciable additional salvage. For the reasons analyzed and discussed above, operations impacts of Alternatives 1–3 on native minnows would be less than significant.

NEPA Conclusion for Alternatives 1, 2, and 3

Operations impacts of Alternatives 1–3 on native minnows would not be adverse. Operations of Alternative 1, 2, or 3, would provide bypass flows to Stone Corral and Funks Creeks. These flows would be refined through studies required under Project Commitments. These flows would support processes in these channels that support the fish (including native minnows) assemblage below the dams. Per the discussion above, native minnow spawning is not anticipated to be negatively impacted due to operations of the Red Bluff and Hamilton City intakes for Alternatives 1-3. Mean monthly temperatures by water year types between the alternatives and the NAA in the Sacramento, Feather, and American rivers would be similar during the presence of each life stage of native minnows. Alternatives 1–3 would have limited potential for negative effects to Yolo Bypass floodplain inundation and access for Sacramento splittail. Within the Delta, few hitch, Central California roach, or hardhead have been salvaged historically and so increases in exports during summer/fall under the alternatives would not result in appreciable additional salvage.

Impact FISH-12: Operations Effects on Starry Flounder and Northern Anchovy

Alternatives 1, 2, and 3

Effects of Alternatives 1, 2, and 3

Within the Delta, Alternatives 1–3 have the potential to affect starry flounder by increasing south Delta exports during summer/fall relative to existing conditions. Starry flounder are entrained in relatively small numbers at the south Delta export facilities. The salvage-density method (see description in Appendix 11Q) suggested entrainment risk under Alternatives 1–3 could increase in drier years (Table sf_banks and sf_jones) as the species temporally overlaps the period with greater exports under the alternatives. Given the small numbers of starry flounder salvaged under existing conditions, any increase in salvage would remain a small number of fish, particularly relative to the overall range of the species along the Pacific coast (see Appendix 11A).

Table sf_banks. Salvage of Starry Flounder At SWP Banks Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	66	66 (0%)	66 (0%)	66 (0%)	66 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	126	126 (-1%)	126 (-1%)	126 (-1%)	124 (-2%)
Dry	20	22 (10%)	22 (10%)	22 (9%)	21 (8%)
Critically Dry	14	15 (13%)	15 (13%)	15 (12%)	15 (11%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

Table sf_jones. Salvage of Starry Flounder At CVP Jones Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	15	15 (0%)	15 (0%)	15 (0%)	15 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	25	25 (0%)	25 (1%)	25 (0%)	26 (2%)
Dry	14	14 (0%)	15 (3%)	14 (0%)	15 (5%)
Critically Dry	8	9 (4%)	8 (0%)	8 (0%)	8 (-2%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

Kimmerer et al. (2009) found a statistically significant negative relationship between annual mean March–June X2 (an index of Delta outflow) and annual mean starry flounder bay otter trawl abundance indices, which they suggested could be related to an increase in residual circulation in the San Francisco Estuary with increasing Delta outflow; if such an increase translates to more rapid or more complete entrainment of starry flounder early life stages into the estuary, or more rapid transport to their rearing grounds, then presumably, survival from hatching to settlement would be higher under high-flow conditions (Kimmerer et al. 2009: 385). Note that this relationship only pertains to starry flounder within the Bay-Delta and does not consider the very broad range of the species along the Pacific coast (see Appendix 11A). A comparison of modeled bay otter trawl indices for Alternatives 1–3 compared to NAA as a function of modeled X2 was undertaken using the regression coefficients presented by Kimmerer et al. (2009: their Table 2; see also Appendix 11Q). This indicated that there would be very little difference in abundance indices expected between Alternatives 1–3 and NAA as a function of X2 (Table sf_kim).

Table sf_kim. Starry Flounder Bay Otter Trawl Index, Averaged by Water Year Type, as a Function of Mean March–June X2.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	201	200 (0%)	200 (0%)	200 (0%)	200 (-1%)
Above Normal	155	153 (-1%)	153 (-1%)	153 (-1%)	153 (-1%)
Below Normal	104	101 (-2%)	101 (-2%)	101 (-2%)	102 (-2%)
Dry	71	71 (-1%)	71 (-1%)	71 (-1%)	71 (-1%)
Critically Dry	42	41 (-1%)	41 (-1%)	41 (-1%)	41 (-1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty.

Northern anchovy generally occur well downstream of the Delta. Any potential changes in salinity as a result of Alternatives 1–3 would be small relative to the salinity tolerance of northern anchovy (Baxter et al. 1999). Kimmerer et al. (2009) showed for northern anchovy that neither indices of abundance nor indices of habitat extent were related to X2, which is an index of Delta outflow and its effects. This, coupled with the small differences in salinity between Alternatives 1–3 and the NAA, indicates that the alternatives would have minimal effects on northern anchovy.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

Operations impacts of Alternatives 1–3 on starry flounder and northern anchovy would be less than significant, as indicated by the very small differences compared to existing conditions in bay otter trawl abundance for starry flounder as a function of mean March–June X2, limited entrainment risk, and small effects to salinity relative to northern anchovy salinity tolerance.

NEPA Conclusion for Alternatives 1, 2, and 3

Operations impacts of Alternatives 1–3 on California bay shrimp would not be adverse, as indicated by the very small differences compared to existing conditions in bay otter trawl abundance for starry flounder as a function of mean March–June X2, limited entrainment risk, and small effects to salinity relative to northern anchovy salinity tolerance.

Impact FISH-13: Operations Effects on Striped Bass

Alternatives 1, 2, and 3

Effects of Alternatives 1, 2, and 3

Sacramento River

Near-Field Effects

As described in Appendix 11A, striped bass spawning occurs in the Sacramento River from Colusa to Sacramento, which is downstream of the Red Bluff and Hamilton City intakes. Thus smaller life stages potentially vulnerable to entrainment or other near-field effects would not occur at the intakes.

Far-Field Effects

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Sacramento River at Butte City indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of striped bass (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-12-1a to 6C-12-4c; Figures 6C-12-1 to 6C-12-18). Mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±1°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1.

Results of the analysis of occurrence outside index ranges for striped bass in the Sacramento River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. The percent of months with water temperatures outside each index range under Alt 1A and Alt 1B would be similar to those under the NAA with some exceptions. For spawning, embryo incubation and initial rearing in April of dry water years, there would be 16.7% and 11.1% fewer months with water temperatures outside the index range under Alt 1A and Alt 1B, respectively, compared to the NAA. In June of dry water years, there would be 5.6% more months with water temperatures outside the index range under both Alt 1A than under the NAA. For larvae, fry, and juvenile rearing and emigration, in April of critical water years and September of below normal water years, there would be would be 8.3% and 7.1% more months, respectively, with water temperatures outside the index range under Alt 1A and Alt 1B relative to the NAA. There would also be 16.7% fewer months with water temperatures outside the index range under Alt 1A and Alt 1B relative to the NAA in May of critical water years. There would be four additional month and water year type combinations with >5% differences between Alt 1B and the NAA in the percent of months with water temperatures outside the index range, two of which have higher occurrences outside the index range under Alt 1B relative to the NAA and two that have lower occurrences outside the index range under Alt 1B relative to the NAA.

Results of the analysis of exceedance for Alt 2 are nearly identical to Alt 1A.

Results for Alt 3 are similar to Alt 1B with some additional differences in the percent of days outside the 61°F to71°F index range for larvae, fry, and juvenile rearing and emigration, including a 36.4% increase in occurrence outside the index range under Alt 3 relative to the NAA. The percent of days outside the range under Alt 3 in June and July of above normal water years and June of below normal years would be 5.8%, 12.1%, and 9.1% lower, respectively, than the percent of days under the NAA.

Flow Effects

Striped bass spawn in the Sacramento River primarily between about Verona (RM 78) and Wilkins Slough (RM 121) during April through June (Moyle 2002). No spawning occurs until water temperature reaches 57°F (Moyle 2002). The eggs are free-floating and negatively buoyant and hatch in about two days after spawning (at 66°F) as they drift downstream. Low flows can result in eggs settling on the bottom, which they cannot survive for long. The larvae may inhabit shallow, open water of the lower river from April to mid-June and then are carried by flows to the Delta and Suisun Bay (Stevens et al. 1987; Moyle 2002). Juvenile striped bass generally do not occur in the Sacramento River upstream of the Delta. Adult striped bass are found in the upper Sacramento River at RBDD and upstream, primarily from late spring through early fall, where they forage heavily on juvenile salmon and other fish (Tucker et al. 1998). Striped bass also spawn in the Feather and American Rivers, but little is known about their spawning behavior in these rivers.

High flows in April through June benefit striped bass eggs because they help prevent them from settling to the river bottom. High flows likely also accelerate transport of striped bass larvae to their nursery habitats in the Delta and Suisun Bay (Moyle 2002). CALSIM II flow results for Wilkins Slough indicate that mean monthly flow during April through June under Alternatives 1-3 would be generally similar to flow under the NAA, except for substantially lower (10% - 11%) flows during May of critically dry years (Table 11-ST4). These reductions result in mean flows of about 3,900 cfs under all the project alternatives cfs. The reductions would potentially result in less favorable conditions for transport of striped bass eggs downstream, but this is uncertain because the actual level of flow in the river that negatively affects egg transport is not known. Substantial increases in flow occur in July through October of drier water years under all the project alternatives, and also under Alternative 3 in July and October of above normal and below normal water years. Adult striped bass may reside throughout the Sacramento River in summer and early fall (Tucker et al. 1998).

The CalSim II flow results indicate that Alternatives 1-3 would result in reductions in Sacramento River flow near Wilkins Slough during May of critically dry years that could adversely affect survival of striped bass eggs drifting downstream from spawning locations. However, it is considered unlikely that this potential effect would impact the striped bass population for the following two reasons:

1. The CALSIM flow for the project alternatives in May of critically dry years was 10% or more below the NAA a total of six months for each alternative, which constitutes 2.4% of all months (April – June) of the spawning period in the CALSIM record. Note that any reductions in the other months and water year types would likely have less effect because May of critically dry years has the lowest flows (Table 11-ST4).
2. Analyses of the effects of X2 on juvenile striped bass indices of abundance in the Delta indicate that the striped bass indices under Alternatives 1-3 differed little from those under the NAA (see Delta section below). This result indicates that effects of X2, and indirectly Delta outflow, on striped bass abundance were little different between Alternatives 1-3 and the NAA. Delta outflow combines flow from many sources that affect the striped bass population, and provides a good indication of overall flow effects of the project alternatives on the striped bass population as a whole.

Feather River

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Feather River HFC at Gridley Bridge and at the mouth indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of striped bass (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-18-1a to 6C-18-4c, Tables 6C-19-1a to 6C-19-4c; Figures 6C-18-1 to 6C-18-18, Figures 6C-19-1 to

6C-19-18). At both locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±1°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at all locations.

Results of the analysis of occurrence outside the water temperature index ranges for striped bass below Thermalito Afterbay outlet and at the mouth of the Feather River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. At both locations, the percent of months outside the 59°F to 68°F spawning, egg incubation, and initial rearing index range would be similar between the NAA and Alt 1A and Alt 1B, except below Thermalito Afterbay during May of dry years (5.6% lower under Alt 1A and Alt 1B) and in June of below normal, dry, and critical water years, in which occurrences of water temperatures outside the index range would be 7.1%, 16.7%, and 8.3% higher, respectively, under both Alt 1A and Alt 1B than the NAA. At both locations, the percent of months outside the 61°F to 71°F larvae, fry, and juvenile rearing and emigration index range would be largely similar between the NAA and Alt 1A and Alt 1B, with some exceptions ranging from 8.3% lower to 16.7% higher occurrence outside the index range under Alt 1A and Alt 1B relative to the NAA. Results for Alt 2 and Alt 3 would be similar to those for Alt 1.

<u>**American River**</u>

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the American River below Nimbus Dam, Watt Ave, and at the mouth indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of striped bass (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-13-1a to 6C-13-4c, Tables 6C-14-1a to 6C-14-4c, Tables 6C-15-1a to 6C-15-4c; Figures 6C-13-1 to 6C-13-18, Figures 6C-14-1 to 6C-14-18, Figures 6C-15-1 to 6C-15-18). At all locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±0.5°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at all locations.

Results of the analysis of occurrence outside the water temperature index ranges for striped bass at Watt Ave and at the mouth of the American River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. At both locations, the percent of months outside the 59°F to 68°F spawning, egg incubation, and initial rearing index range would be similar between the NAA and Alt 1A and Alt 1B. Results for Alt 2 and 3 would be similar to Alt 1, except for a 5.3% increase under Alt 3 relative to the NAA in the occurrence of water temperatures outside the index range in April of critical water years. At both locations, the percent of months outside the 61°F to 71°F larvae, fry, and juvenile rearing and emigration index range would be largely similar between the NAA and Alt 1A and Alt 1B, except for a 6.7% and 5.9% increase in occurrence of water temperatures outside the index range under Alt 1A and Alt 1B, respectively, relative to the NAA in August of critical water years. Results for Alt 2 and Alt 3 would be similar to those for Alt 1, except for a 6.2% and 9.9% increase in occurrence of water temperatures outside the index range in July of below normal and critical water years, respectively under Alt 3 relative to the NAA.

Delta

Entrainment

As described in Appendix 11A, striped bass are vulnerable to entrainment at the south Delta export facilities. The spawning and egg/larval downstream movement of striped bass occurs in spring, during which time south Delta exports that could result in entrainment risk would be similar between Alternatives 1–3 and the NAA (Appendix 5B4: Tables 5B4-1-1a through 5B4-1-4c; Figures 5B4-1-1 through 5B4-1-18). Juvenile striped bass entrainment and salvage occurs throughout the year, including the summer/fall time period when south Delta exports would differ most between Alternatives 1–3 and the NAA. The salvage-density method (see description in Appendix 11Q) gave somewhat greater estimated salvage under the alternatives, particularly in critically dry years at SWP (Tables stb_banks and stb_jones). As noted in Appendix 11A, available studies suggest that even considerable levels of historical estimated population-level entrainment (33–99% of the population) did not give discernible population-level effects. This indicates that the differences in entrainment risk suggested by the salvage-density method would not be expected to give differing population-level effects between Alternatives 1–3 and the NAA.

Table stb_banks. Salvage of Striped Bass At SWP Banks Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	318,601	318,704 (0%)	318,900 (0%)	318,727 (0%)	319,155 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	345,914	353,760 (2%)	353,056 (2%)	353,692 (2%)	351,485 (2%)
Dry	123,629	129,708 (5%)	125,253 (1%)	129,311 (5%)	131,977 (7%)
Critically Dry	80,930	88,660 (10%)	88,883 (10%)	88,217 (9%)	86,578 (7%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

Table stb_jones. Salvage of Striped Bass At CVP Jones Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	64,418	64,266 (0%)	64,270 (0%)	64,265 (0%)	64,232 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	95,340	97,066 (2%)	99,169 (4%)	97,111 (2%)	99,941 (5%)
Dry	165,044	168,690 (2%)	172,639 (5%)	168,744 (2%)	174,456 (6%)

Critically Dry	56,926	56,923 (0%)	56,801 (0%)	56,896 (0%)	57,251 (1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

Flow-Related Effects

Kimmerer et al. (2009) found several statistically significant negative relationships between annual mean April–June X2 and various indices of striped bass juvenile abundance or survival. Application of these relationships to Alternatives 1–3 and the NAA indicated minimal differences between the alternatives and NAA (Tables stb_TNS_surv, stb_FMWT, stb_BMWT, stb_BOT). This reflects limited differences in mean X2 between Alternatives 1–3 and the NAA during this time period.

Juvenile striped bass abundance indices are also negatively related to fall (September–December) X2 (Mac Nally et al. 2010). Under Alternatives 1–3, mean fall X2 would be similar or somewhat lower than NAA (Table X2_STB), so there would not be negative effects to striped bass from the alternatives relative to existing conditions as a result of differences in fall X2.

Table stb_TNS_surv. Striped Bass Summer Townet Survival Index, Averaged by Water Year Type, as a Function of Mean April–June X2.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	209	208 (0%)	208 (0%)	208 (0%)	208 (0%)
Above Normal	159	158 (-1%)	158 (-1%)	158 (-1%)	158 (-1%)
Below Normal	116	115 (-1%)	115 (-1%)	115 (-1%)	115 (-1%)
Dry	82	82 (0%)	82 (0%)	82 (0%)	82 (0%)
Critically Dry	54	54 (0%)	54 (-1%)	54 (0%)	54 (-1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty.

Table stb_TNS. Striped Bass Summer Townet Abundance Index, Averaged by Water Year Type, as a Function of Mean April–June X2.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	1.5	1.5 (0%)	1.5 (0%)	1.5 (0%)	1.5 (0%)
Above Normal	1.2	1.2 (-1%)	1.2 (-1%)	1.2 (-1%)	1.2 (-1%)
Below Normal	1.0	1.0 (-1%)	1.0 (-1%)	1.0 (-1%)	1.0 (-1%)
Dry	0.8	0.8 (0%)	0.8 (0%)	0.8 (0%)	0.8 (0%)
Critically Dry	0.5	0.5 (0%)	0.5 (0%)	0.5 (0%)	0.5 (0%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty.

Table stb_FMWT. Striped Bass Fall Midwater Trawl Abundance Index, Averaged by Water Year Type, as a Function of Mean April–June X2.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	346	345 (0%)	345 (0%)	345 (0%)	345 (0%)
Above Normal	308	307 (0%)	307 (0%)	307 (0%)	307 (0%)
Below Normal	268	267 (0%)	267 (0%)	267 (0%)	267 (0%)
Dry	231	231 (0%)	231 (0%)	231 (0%)	230 (0%)
Critically Dry	192	192 (0%)	192 (0%)	192 (0%)	192 (0%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty.

Table stb_BMWT. Striped Bass Bay Midwater Trawl Abundance Index, Averaged by Water Year Type, as a Function of Mean April–June X2.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	1,827	1,820 (0%)	1,820 (0%)	1,821 (0%)	1,820 (0%)
Above Normal	1,360	1,348 (-1%)	1,348 (-1%)	1,347 (-1%)	1,348 (-1%)
Below Normal	972	961 (-1%)	961 (-1%)	961 (-1%)	963 (-1%)
Dry	666	664 (0%)	663 (0%)	664 (0%)	662 (-1%)
Critically Dry	422	420 (0%)	420 (-1%)	420 (-1%)	419 (-1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty.

Table stb_BOT. Striped Bass Bay Otter Trawl Abundance Index, Averaged by Water Year Type, as a Function of Mean April–June X2.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	3,246	3,238 (0%)	3,238 (0%)	3,238 (0%)	3,238 (0%)
Above Normal	2,736	2,721 (-1%)	2,722 (-1%)	2,721 (-1%)	2,722 (-1%)
Below Normal	2,238	2,223 (-1%)	2,224 (-1%)	2,223 (-1%)	2,225 (-1%)
Dry	1,796	1,794 (0%)	1,793 (0%)	1,794 (0%)	1,791 (0%)
Critically Dry	1,375	1,371 (0%)	1,370 (0%)	1,370 (0%)	1,369 (0%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty.

Table X2_STB. Mean Fall (September–December) X2, Averaged by Water Year Type.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	78.0	77.9	77.9	77.9	77.9
Above Normal	79.9	79.7	79.7	79.7	79.6
Below Normal	84.8	84.5	84.3	84.4	84.1
Dry	87.9	87.2	87.2	87.3	87.4

Critically Dry	91.5	90.9	90.9	91.0	91.1

The SWRCB Bay-Delta water quality control plan includes an April–May electrical conductivity objective for the San Joaquin River between Jersey Point and Prisoners Point for striped bass spawning water quality. DSM2-QUAL modeling for Alternatives 1–3 indicates that compliance with this objective would be the same as under the NAA.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

Striped bass spawning occurs in the Sacramento River from Colusa to Sacramento, which is downstream of the Red Bluff and Hamilton City intakes. Smaller life stages potentially vulnerable to entrainment or other near-field effects would not occur at the intakes.

Temperatures by water year type between Alternatives 1-3 and the NAA in the Sacramento, Feather, and American river indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of striped bass.

While CalSim II flow results indicate that Alternatives 1-3 would result in reductions in Sacramento River flow near Wilkins Slough during May of critically dry years, it is considered unlikely that this potential effect would impact the striped bass population. The analysis indicates limited differences in mean X2 between Alternatives 1–3, and the mean fall X2 would be similar or somewhat lower than NAA. Thus, there would not be negative effects to striped bass from the alternatives relative to existing conditions as a result of differences in fall X2.

Additionally, any differences in entrainment risk suggested by the salvage-density method would not be expected to give differing population-level effects between Alternatives 1–3 and the NAA.

Based on the above analysis, operation impacts of Alternatives 1-3 on striped bass would be less than significant.

NEPA Conclusion for Alternatives 1, 2, and 3

Striped bass spawning occurs in the Sacramento River from Colusa to Sacramento, which is downstream of the Red Bluff and Hamilton City intakes, and therefore smaller life stages potentially vulnerable to entrainment or other near-field effects would not occur at the intakes.

Temperatures by water year type between Alternatives 1-3 and the NAA in the Sacramento, Feather, and American river indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of striped bass.

While CalSim II flow results indicate that Alternatives 1-3 would result in reductions in Sacramento River flow near Wilkins Slough during May of critically dry years, it is considered unlikely that this potential effect would impact the striped bass population. The analysis indicates limited differences in mean X2 between Alternatives 1–3, and the mean fall X2 would be similar or somewhat lower than NAA. Thus, there would not be negative effects to striped bass from the alternatives relative to existing conditions as a result of differences in fall X2.

Additionally, any differences in entrainment risk suggested by the salvage-density method would not be expected to give differing population-level effects between Alternatives 1–3 and the NAA.

Based on the above analysis, operation impacts of Alternatives 1-3 would not be adverse to striped bass.

Impact FISH-14: Operations Effects on American Shad

Alternatives 1, 2, and 3

Effects of Alternatives 1, 2, and 3

Sacramento River

Near-Field Effects

As described in Appendix 11A, the main spawning areas for American shad are the Sacramento, Feather, American, and Yuba Rivers. Based on the nursery areas of juveniles (Stevens et al. 1987), spawning in the Sacramento River seems to be primarily from Colusa downstream and downstream of the Red Bluff and Hamilton City intakes. As such, the smaller American shad life stages potentially vulnerable to entrainment or other near-field effects would not be expected to occur at the intakes in substantial numbers, and given that the main spawning period is May–July, there would be little difference in diversion between Alternatives 1–3 and the NAA (see Tables RB% and HC% in the winter-run Chinook salmon analysis).

Far-Field Effects

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Sacramento River below Red Bluff Diversion Dam and Butte City indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of American shad (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-10-1a to 6C-10-4c, Tables 6C-12-1a to 6C-12-4c; Figures 6C-10-1 to 6C-10-18, Figures 6C-12-1 to 6C-12-18. At both sites, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±1°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1.

Results of the analysis of occurrence outside index ranges for striped bass in the Sacramento River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in

Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. For the 59°F to 68°F spawning, embryo incubation, and initial rearing life stages, the percent of days below Red Bluff Diversion Dam and months at Butte City with water temperatures outside each index range under Alt 1A and Alt 1B would be similar to those under the NAA with some exceptions that showed up to 8.3% reductions in the occurrence of water temperatures outside the index range under Alt 1A and Alt 1B. For the 63°F to 77°F larvae, fry, and juvenile rearing and emigration life stages, there would be minimal differences between Alt 1A and Alt 1B compared to the NAA below Red Bluff Diversion Dam. At Butte City, occurrence of water temperatures outside the index range would be predominantly similar between Alt 1A and Alt 1B compared to the NAA, with some exceptions ranging from 11.1% more and 11.1% fewer occurrences under Alt 1A and Alt 1B compared to the NAA. Alt 2 and Alt 3 results would be similar to those under Alt 1.

Flow Effects

American shad migrate upstream in the Sacramento River starting in March, and typically spawn from April to June. They also spawn in the lower Feather river and, to a lesser degree, in the American River (see Appendix 1A). Shad eggs settle to the river bottom or drift downstream from spawning areas and hatch in about 2.5 days at 77°F to about 8.5 days at 59°F (Marschall et al. 2020). Larval shad are planktonic for about 4 weeks, after which they metamorphose to actively swimming juveniles. Juveniles spend the next several months in fresh water In the Sacramento River, summer rearing habitat occurs in the main river from Colusa to the north Delta (Stevens et al. 1987). As the season progresses, juvenile shad move downstream and enter salt water primarily during September through November (Moyle 2002). In general, variations in river discharge and temperature during early larval development are considered important regulators of year-class strength and recruitment of American shad (Hinrichsen et al. 2013; Marschall et al. 2020). Adequate flow is needed to disperse eggs and larvae, exposing them to a range of habitat conditions (Marschall et al. 2020). Although the importance of various potential mechanisms is unknown, the abundance of juvenile American shad in the Sacramento–San Joaquin Delta has been shown to be positively correlated with freshwater inflow during the April through June spawning and nursery periods (Stevens et al. 1987, Kimmerer 2002b, Kimmerer et al. 2009).

During the spawning and larval rearing period (April through June), CALSIM II modeling results at Wilkins Slough indicate that mean monthly flow during April through June under Alternatives 1-3 would be generally similar to flow under the NAA, except for substantially lower (10% - 11%) flows during May of critically dry years (Table 11-ST4). These reductions result in mean flows of about 3,900 cfs under all the project alternatives. The reductions would potentially result in less favorable conditions for transport of American shad eggs and larvae downstream, but this effect is uncertain because the actual level of flow in the river that negatively affects egg and larval transport is not known. Large reductions (>10%) in flow also occur in the Feather River at the Thermalito Afterbay in June of dry and critically dry years (Table 11-ST5). Substantial increases in flow occur in July through October of drier water years at Wilkins Slough under all the project alternatives, and also under Alternative 3 in July and

October of above normal and below normal water years (Table 11-ST4). The importance of river flows for juvenile shad in July through October is unknown.

The CALSIM II flow results indicate that Alternatives 1-3 would result in reductions in Sacramento River flow near Wilkins Slough during May of critically dry years that could adversely affect survival of American shad eggs and larvae drifting downstream from spawning locations. However, it is considered unlikely that this potential effect would impact the American shad population for the following two reasons:

1. The CALSIM flow for the project alternatives in May of critically dry years was 10% or more below the NAA a total of six months for each alternative, which constitutes 2.4% of all months (April – June) of the spawning period in the CALSIM record. Note that any reductions in the other months and water year types would likely have less effect because May of critically dry years has the lowest flows (Table 11-ST4).
2. Analyses of the effects of X2 on juvenile American shad indices of abundance in the Delta indicate that the American shad indices under Alternatives 1-3 differed little from those under the NAA (see Delta section below). X2 which is strongly related to Delta outflow. This result indicates that effects of X2, and indirectly of Delta outflow, on American shad abundance were little different between Alternatives 1-3 and the NAA. Delta outflow combines flow from a number of sources that affect the American shad population, and therefore provide a good indication of overall flow effects of the project alternatives on the American population as a whole.

Feather River

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Feather River HFC at Gridley Bridge and at the mouth indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of American shad (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-18-1a to 6C-18-4c, Tables 6C-19-1a to 6C-19-4c; Figures 6C-18-1 to 6C-18-18, Figures 6C-19-1 to 6C-19-18). At all locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±1°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at all locations.

Results of the analysis of occurrence outside the water temperature index ranges for American shad below Thermalito Afterbay outlet and at the mouth of the Feather River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. At both locations, the percent of months outside the 60°F to 70°F spawning, egg incubation, and initial rearing index range would be similar between the NAA and Alt 1A and Alt 1B, except below Thermalito Afterbay outlet during June of dry years when the occurrence of water temperatures outside the range would be 5.6% lower under Alt 1A and Alt 1B relative to the NAA. At both locations, the percent of months outside the 63°F to 77°F larvae, fry, and juvenile rearing and emigration index range would be similar between the NAA and Alt 1A and Alt 1B with some exceptions. Below Thermalito Afterbay outlet during September of below normal and critical water years, there would be 7.1% and 8.3% fewer months, respectively, in which water temperatures are outside the index range. At the mouth of the Feather River in July of below normal water years and in October of below normal, dry, and critical water years, there would be between 5.6% and 8.3% more months in which water temperatures are outside the index range. Results for Alt 2 and Alt 3 would be predominantly similar to those of Alt 1.

American River

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the American River below Nimbus Dam, at Watt Ave, and at the mouth indicates that water temperatures would be predominantly similar among alternatives during the period of presence of American shad (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-13-1a to 6C-13-4c, Tables 6C-14-1a to 6C-14-4c, Tables 6C-15-1a to 6C-15-4c; Figures 6C-13-1 to 6C-13-18, Figures 6C-14-1 to 6C-14-18, Figures 6C-15-1 to 6C-15-18). At all locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±0.5°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at all locations.

Results of the analysis of occurrence outside the water temperature index ranges for American shad at Watt Ave and at the mouth of the American River from Appendix 11B, *Fisheries Impact Assessment Methods*, Table X are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. At both locations, the percent of months outside the two index ranges would be similar between the NAA and Alt 1A and Alt 1B. Results for Alt 2 would be similar to those of Alt 1. Results of Alt 3 would be predominantly similar to those of Alt 1, except that water temperatures in October of above normal and dry water years would be outside the 63°F to 77°F larvae, fry, and juvenile rearing and emigration index range 6.7% and 6.3% more often, respectively, under Alt 3 relative to the NAA.

Delta

Entrainment

Some of the highest densities of American shad observed historically in south Delta export facility salvage samples have occurred during July and August, so application of the salvage-density method (see Appendix 11Q) suggested the potential for greater salvage under Alternatives 1–3 than the NAA at the SWP facility (Table as_banks) as a result of greater exports under the alternatives during this time period; there was little difference in salvage at the CVP facility (Table as_jones). Although it has been suggested that declines observed in American shad populations since the 1970s were related to diversions in the Delta as well as upstream (see Appendix 11A), there has not been a population-level examination of the influence of south Delta exports on the population, and statistical analyses have focused instead on the influence of Delta outflow/X2 (see *Flow-Related Effects* below). Despite the salvage-density method suggesting the potential for greater entrainment as a result of greater summer exports under the alternatives, the overall density of American shad in the south Delta is very low relative to other areas occupied by the species, including the north Delta, Sacramento River from Colusa to Sacramento, and Feather River below the Yuba River (Stevens et al. 1987). This suggests that increased entrainment potential under Alternatives 1–3 relative to the NAA would not have population-level consequences.

Table as_banks. Salvage of American Shad At SWP Banks Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	319,408	319,894 (0%)	320,164 (0%)	319,903 (0%)	319,859 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	268,019	280,016 (4%)	279,259 (4%)	280,128 (5%)	278,651 (4%)
Dry	123,754	144,661 (17%)	138,533 (12%)	143,478 (16%)	146,264 (18%)
Critically Dry	84,072	102,310 (22%)	102,314 (22%)	100,487 (20%)	98,856 (18%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

Table as_jones. Salvage of American Shad At CVP Jones Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	254,487	253,790 (0%)	253,826 (0%)	253,791 (0%)	253,805 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	61,744	62,251 (1%)	63,313 (3%)	62,193 (1%)	63,831 (3%)
Dry	73,192	74,410 (2%)	74,386 (2%)	74,370 (2%)	74,993 (2%)
Critically Dry	3,654	3,605 (-1%)	3,579 (-2%)	3,578 (-2%)	3,595 (-2%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

Flow-Related Effects

Kimmerer et al. (2009) found statistically significant negative relationships between annual mean February–May X2 and indices of American shad juvenile abundance from fall midwater trawl and Bay midwater trawl sampling. Application of these relationships to Alternatives 1–3 and the NAA indicated minimal differences between the alternatives and NAA (Tables as_FMWT, as_BMWT; see methods description in Appendix 11Q). This reflects limited differences in mean X2 between Alternatives 1–3 and the NAA during this time period.

Table as_FMWT. American Shad Fall Midwater Trawl Abundance Index, Averaged by Water Year Type, as a Function of Mean February–May X2.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	2,992	2,988 (0%)	2,988 (0%)	2,988 (0%)	2,988 (0%)
Above Normal	2,793	2,779 (0%)	2,781 (0%)	2,780 (0%)	2,780 (0%)
Below Normal	2,341	2,318 (-1%)	2,319 (-1%)	2,319 (-1%)	2,320 (-1%)
Dry	1,945	1,930 (-1%)	1,930 (-1%)	1,930 (-1%)	1,933 (-1%)
Critically Dry	1,522	1,510 (-1%)	1,511 (-1%)	1,512 (-1%)	1,509 (-1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty.

Table as_BMWT. American Shad Bay Midwater Trawl Abundance Index, Averaged by Water Year Type, as a Function of Mean February–May X2.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	7,650 (0%)	7,649 (0%)	7,650 (0%)	7,650 (0%)	7,650 (0%)
Above Normal	6,919 (-1%)	6,922 (-1%)	6,919 (-1%)	6,922 (-1%)	6,919 (-1%)
Below Normal	5,387 (-1%)	5,390 (-1%)	5,388 (-1%)	5,392 (-1%)	5,387 (-1%)
Dry	4,188 (-1%)	4,190 (-1%)	4,191 (-1%)	4,198 (-1%)	4,188 (-1%)
Critically Dry	2,976 (-1%)	2,980 (-1%)	2,981 (-1%)	2,975 (-1%)	2,976 (-1%)

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

American shad spawning in the Sacramento River is downstream of the Red Bluff and Hamilton City intakes. Exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Sacramento, Feather, and American rivers indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of American shad. It is unlikely that flow associated with Alternatives 1-3 in comparison to the NAA will have any potential effect on American shad. Any increased entrainment potential under Alternatives 1–3 relative to the NAA would not have population-level consequences. Related to flow, the data indicates that relationships to Alternatives 1–3 and the NAA indicated minimal differences between the alternatives and NAA. Based on the above reasons and the analysis provided, the operational impacts of Alternatives 1-3 on American shad would be less than significant.

NEPA Conclusion for Alternatives 1, 2, and 3

Alternatives 1–3 would not be adverse to American shad due to the above analysis and the below description. American shad spawning in the Sacramento River is downstream of the Red Bluff and Hamilton City intakes. Exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Sacramento, Feather, and American rivers indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of American shad. It is unlikely that flow associated with Alternatives 1-3 in comparison to the NAA will have any potential effect on American shad. Any increased entrainment potential under Alternatives 1–3 relative to the NAA would not have population-level consequences. Related to flow, the data indicates that relationships to Alternatives 1–3 and the NAA indicated minimal differences between the alternatives and NAA.

Impact FISH-15: Operations Effects on Threadfin Shad

Alternatives 1, 2, and 3

Effects of Alternatives 1, 2, and 3

Increases in south Delta exports during the summer under Alternatives 1–3 have the potential to increase threadfin shad entrainment at the south Delta export facilities. This is illustrated by the results of the salvage-density method (see description in Appendix 11Q), which showed appreciable increases in SWP exports weighted by historical salvage density during dry and critically dry years (Table ts_banks), in contrast to little difference in CVP exports (Table ts_jones). To examine this potential increase in entrainment in more detail, consideration was given to the differences in entrainment risk in the main region of the Delta occupied by threadfin shad, i.e., the San Joaquin River in the southeast Delta (Feyrer et al. 2009). As described further in Appendix 11Q, relationships between proportional entrainment of particles and E:I ratio developed from particle tracking modeling by Kimmerer and Nobriga (2008) were used to assess differences in entrainment risk during the months of June–November for particles released in the San Joaquin River at Medford Island, Potato Slough, and Stockton. This found that there was little difference in particle proportional entrainment between Alternatives 1–3 and the NAA except in July of critically dry years, for which the mean proportion of particles entrained under Alternatives 1–3 was 22–24% greater than under the NAA (see results tabulation in Appendix 11Q). The extent to which this difference represents a potential increase in actual entrainment risk is uncertain because passive particles may not be representative of threadfin shad. The population-level importance of changes in exports has only been examined for spring and fall, with some evidence supporting exports as having a negative effect on population trends (Mac Nally et al. 2010; Thomson et al. 2010). Thomson et al. (2010: 1444) suggested that threadfin shad may be especially vulnerable to exports throughout the year because they occupy freshwater throughout the year (see also species account in Appendix 11A), but noted that proportional loss estimates have not been made for the species.

Table ts_banks. Salvage of Threadfin Shad At SWP Banks Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	452,291	453,275 (0%)	453,349 (0%)	453,318 (0%)	452,758 (0%)
Above Normal	NA	NA	NA	NA	NA

Below Normal	1,479,053	1,520,622 (3%)	1,516,341 (3%)	1,519,489 (3%)	1,513,641 (2%)
Dry	1,123,194	1,395,991 (24%)	1,392,101 (24%)	1,389,354 (24%)	1,364,519 (21%)
Critically Dry	338,243	603,439 (78%)	603,352 (78%)	585,542 (73%)	567,530 (68%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

Table ts_jones. Salvage of Threadfin Shad At CVP Jones Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	795,167	793,477 (0%)	793,588 (0%)	793,485 (0%)	793,464 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	899,886	895,840 (0%)	913,027 (1%)	895,629 (0%)	917,177 (2%)
Dry	2,650,871	2,676,015 (1%)	2,740,758 (3%)	2,677,292 (1%)	2,821,131 (6%)
Critically Dry	221,610	211,056 (-5%)	210,852 (-5%)	210,716 (-5%)	221,252 (0%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

The entrainment analyses indicate the potential for appreciably greater south Delta entrainment of threadfin shad in July of critically dry years under Alternatives 1–3 compared to the NAA. However, greater summer entrainment appears unlikely to have population-level consequences because abundance in the fall (when most of the commercial harvest in the Delta occurs; Feyrer et al. 2009) is poorly related to abundance in summer, potentially as a result of factors such as toxicity of Microcystis blooms (Acuña et al. 2012a, 2020) being more important (Feyrer et al. 2009; Baxter et al. 2010). The lack of relationship between summer and fall abundance of threadfin shad indicates that the impact would be less than significant.

NEPA Conclusion for Alternatives 1, 2, and 3

Alternatives 1–3 would not be adverse to threadfin shad because as described above in the CEQA significance determination, the primary impact of potentially greater summer entrainment would be unlikely to lead to lower population levels later in the year.

Impact FISH-16: Operations Effects on Black Bass (Largemouth Bass, Smallmouth Bass, and Spotted Bass)

Alternatives 1, 2, and 3

Effects of Alternatives 1, 2, and 3

Sacramento River

Near-Field Effects

Although black bass would be susceptible to near-field effects such as entrainment or impingement at the Red Bluff and Hamilton City intakes, population-level effects would be expected to be minimal because the smallest life stages would tend to occur during spring/early summer (see Appendix 11A) when there would be little difference in diversions between Alternatives 1–3 and the NAA (see Tables RB% and HC% in the winter-run Chinook salmon analysis). In addition, the species are widespread in the Central Valley (and in particular in the Delta) without specific migratory patterns that would cause them to systematically move past the intakes (in contrast to anadromous fish, for example).

Far-Field Effects

Temperature Effects

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Sacramento River below Keswick and below Red Bluff Diversion Dam indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of largemouth bass (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-5-1a to 6C-5-4c, Tables 6C-10-1a to 6C-10-4c; Figures 6C-5-1 to 6C-5-18, Figures 6C-10-1 to 6C-10-1). At both sites, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±0.5°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1.

Results of the analysis of occurrence outside the 54°F to 75°F spawning index range for largemouth bass in the Sacramento River (Appendix 11B, *Fisheries Impact Assessment Methods*, Table X) are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. At both locations, the percent of days with water temperatures outside each index range under Alt 1A and Alt 1B would be similar to those under the NAA. The results for Alt 2 would be similar to those for Alt 1. The results for Alt 3 would be similar to those for Alt 1, except for a 10.6% increase under Alt 3 relative to the NAA in the percent of days with temperatures outside the index range in June of critical water years.

Flow Effects

The Sacramento, Feather, and American Rivers upstream of the Delta generally provide poor habitat conditions for largemouth bass because of large seasonal flow fluctuations, relatively cold water, and lack of suitable nesting and rearing habitat. Largemouth bass populations upstream of the Delta are largely dependent on off stream habitats, including reservoirs, floodplain ponds and sloughs, and irrigation canals that provide suitable conditions for spawning and rearing during the late spring and summer months. Smallmouth bass are better adapted to the more rapid flows and cooler water temperatures of the rivers upstream of the Delta, but they generally prefer smaller, higher elevations rivers and streams (Moyle 202). Spotted Bass inhabit streams and reservoirs and prefer moderate-size, clear, low-gradient sections of rivers and reservoirs. They prefer pool habitat and slower, more turbid water than smallmouth bass, but faster water than largemouth bass (Moyle 2002).

Commented [CC113]: The data sets suggest otherwise.

Commented [CC114]: The data sets do not agree. and angler reports for smallmouth bass are very good in the Feather and Sacramento Rivers.

Commented [CC115R114]: CDFW recommends that this section be revised to accurately reflect data and that the data are expanded to include Feather and Sacramento River datasets.

All three black bass species spawn and rear in the spring and summer (Moyle 20002). The males construct and guard nest depressions. In streams, nesting and reproduction can be disrupted by flow reductions that lead to nest dewatering or elevated flows that wash embryos and fry out of nests or lower water temperatures excessively (Graham and Orth 1986; Lukas and Orth 1995). Because the largemouth bass life cycle upstream of the Delta is generally not directly affected by the mainstem rivers upstream of the Delta, changes in the Sacramento, Feather and American River flows related to the project are expected to have minimal effects of the largemouth bass population. Smallmouth and spotted bass may make more use of the mainstem rivers upstream of the Delta, but smallmouth in particular are more often found in somewhat higher elevation and smaller rivers and streams (Moyle 2002). All three black bass species are highly adaptable, as evidenced by their rapid colonization of habitats throughout California, so it is highly unlikely that the relatively small differences in flow between Alternatives 1-3 and the NAA (Table 11ST-1 through Table 11ST-5) would have more than minimal effects on the black bass populations of the rivers upstream of the Delta.

Commented [CC116]: These non native species are prolific in rivers mentioned. Project actions will directly benefit non natives.

Feather River

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Feather River HFC at Gridley Bridge and at the mouth indicates that water temperatures would be predominantly similar among alternatives during the spawning period of presence of each life stage of largemouth bass (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-18-1a to 6C-18-4c, Tables 6C-19-1a to 6C-19-4c; Figures 6C-18-1 to 6C-18-18, Figures 6C-19-1 to 6C-19-18). At both locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±1°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at all locations.

Results of the analysis of occurrence outside the 54°F to 75°F spawning index range for largemouth bass below Thermalito Afterbay outlet and at the mouth of the Feather River (Appendix 11B, *Fisheries Impact Assessment Methods*, Table X) are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. At both locations, the percent of months outside the spawning index range would be similar between the NAA and Alt 1A and Alt 1B, except below Thermalito Afterbay outlet during April of dry years when the occurrence of water temperatures outside the range would be 5.6% lower under Alt 1A and Alt 1B relative to the NAA and in June of dry years when the occurrence of water temperatures outside the range would be 5.6% higher under Alt 1A and Alt 1B relative to the NAA. Results for Alt 2 and Alt 3 would be similar to those of Alt 1 at all locations.

American River

Visual observation of exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the American River at Watt Ave indicates that water temperatures would be predominantly similar among alternatives during the period of presence of largemouth bass (Appendix 6C, *River Temperature Modeling (HEC5Q and Reclamation Temperature Model)*, Tables 6C-14-1a to 6C-14-4c; Figures 6C-14-1 to 6C-14-18). At all locations, mean monthly water temperatures for all months within all water year types under Alt 1A and Alt 1B were within ±0.5°F of the NAA. Water temperature modeling results for Alt 2 and Alt 3 were similar to those of Alt 1 at all locations.

Results of the analysis of occurrence outside the 54°F to 75°F spawning index range for largemouth bass in the American River at Watt Ave (Appendix 11B, *Fisheries Impact Assessment Methods*, Table X) are presented in Appendix 11D, *Fisheries Water Temperature Assessment,* Table X through Table X. The percent of months outside the spawning index range would be similar between the NAA and Alt 1A and Alt 1B. Results for Alt 2 and Alt 3 would be similar to those of Alt 1.

Delta

Differences in south Delta export patterns between Alternatives 1–3 and the NAA could change south Delta entrainment risk for black bass. Historical salvage data show very few smallmouth or spotted bass are entrained, whereas largemouth bass are entrained in relatively high numbers. The seasonality of largemouth bass salvage at the south Delta export facilities results in highest salvage occurring during May–July, which overlaps the time period during which exports would be greater under the alternatives, in particular at the SWP facility in drier years as illustrated by the salvage-density method (Table lmb_banks; Table lmb_jones; see Appendix 11Q for description of salvage-density method). However, the salvage-density method is solely a calculation of differences in south Delta exports between alternatives weighted by historical density of observed fish in salvage and is not a prediction of actual salvage expected. Analyses by Grimaldo et al. (2009) did not find a significant relationship between largemouth bass salvage and Old and Middle River flows, an important indicator of entrainment risk for other species such as delta smelt and longfin smelt. Grimaldo et al. (2009) suggested that the littoral (nearshore) habitat occupied by the species probably provides a buffer from entrainment. As such, the differences in entrainment risk suggested by the salvage-density method are likely to be much less. This, coupled with the widespread occurrence of largemouth bass (e.g., Conrad et al. 2016; Mahardja et al. 2017), indicates population-level effects from changes in entrainment risk as a result of Alternatives 1–3 would be small.

Table lmb_banks. Salvage of Largemouth Bass At SWP Banks Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	19,290	19,296 (0%)	19,295 (0%)	19,297 (0%)	19,297 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	16,275	16,395 (1%)	16,369 (1%)	16,388 (1%)	16,231 (0%)
Dry	7,726	9,063 (17%)	9,031 (17%)	9,001 (16%)	8,876 (15%)
Critically Dry	3,035	4,287 (41%)	4,272 (41%)	4,203 (38%)	4,048 (33%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

Table lmb_jones. Salvage of Largemouth Bass At CVP Jones Pumping Plant, Averaged by Water Year Type, Based on the Salvage-Density Method.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	50,849	50,762 (0%)	50,767 (0%)	50,762 (0%)	50,750 (0%)
Above Normal	NA	NA	NA	NA	NA
Below Normal	62,921	64,281 (2%)	65,871 (5%)	64,296 (2%)	66,532 (6%)
Dry	67,570	68,850 (2%)	70,358 (4%)	68,881 (2%)	71,138 (5%)
Critically Dry	39,913	39,988 (0%)	39,862 (0%)	39,903 (0%)	40,218 (1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. The analysis was based on historical salvage data during 2009–2019 which did not include any above normal water years, hence that row of the table is noted as 'NA'.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

Black bass are anticipated to have minimal population-level effects related to entrainments at the Red Bluff and Hamilton City intakes. Exceedance plots and differences in modeled mean monthly temperatures by water year type between alternatives and the NAA in the Sacramento, Feather, and American rivers indicates that water temperatures would be predominantly similar among alternatives during the period of presence of each life stage of Black bass. All three black bass species are adaptable, so it is highly unlikely that the relatively small differences in flow between Alternatives 1-3 and the NAA would have more than minimal effects on the black bass populations of the rivers upstream of the Delta. Population-level effects from changes in entrainment risk as a result of Alternatives 1–3 would be small. Based on the above reasons and the analysis provided, the operational impacts of Alternatives 1-3 on Black bass would be less than significant.

NEPA Conclusion for Alternatives 1, 2, and 3

Alternatives 1–3 would not be adverse to Black bass due to the description above in the CEQA significance determination, and the provided analysis in Impact FISH-16.

Impact FISH-17: Operations Effects on California Bay Shrimp

Alternatives 1, 2, and 3

Effects of Alternatives 1, 2, and 3

Kimmerer et al. (2009) found a statistically significant negative relationship between annual mean April–June X2 and the bay shrimp Bay otter trawl abundance index. Application of this relationship to Alternatives 1–3 and the NAA indicated minimal differences between the alternatives and NAA (Table bs_BOT; see methods description in Appendix 11Q). This reflects limited differences in mean X2 between Alternatives 1–3 and the NAA during this time period.

Table bs_BOT. California Bay Shrimp Bay Otter Trawl Abundance Index, Averaged by Water Year Type, as a Function of Mean April–June X2.

Water Year Type	NAA	Alt 1A	Alt 1B	Alt 2	Alt 3
Wet	365	364 (0%)	364 (0%)	364 (0%)	364 (0%)
Above Normal	328	325 (-1%)	325 (-1%)	325 (-1%)	325 (-1%)
Below Normal	246	242 (-2%)	242 (-1%)	242 (-1%)	242 (-1%)
Dry	191	189 (-1%)	189 (-1%)	189 (-1%)	189 (-1%)
Critically Dry	128	127 (-1%)	127 (-1%)	127 (-1%)	127 (-1%)

Note: Percentage values in parentheses indicate differences of alternatives compared to NAA. Table only includes annual mean responses and does not consider model uncertainty.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

Operations impacts of Alternatives 1–3 on California bay shrimp would be less than significant, as indicated by the very small differences in bay otter trawl abundance as a function of mean April–June X2.

NEPA Conclusion for Alternatives 1, 2, and 3

Operations impacts of Alternatives 1–3 on California bay shrimp would not be adverse, as indicated by the very small differences in bay otter trawl abundance as a function of mean April–June X2.

Impact FISH-18: Operations Effects on Reservoir Species

Reservoir cold-water fish species are not State or federal special-status species but are evaluated for their recreational importance. Populations of some of these species are artificially augmented or sustained through periodic fish stocking programs.

A detailed description of the methods and results of this analysis, including a summary of changes in aquatic habitat conditions for cold-water and warm-water fish species in Sites, Oroville, Folsom, and San Luis reservoirs and Shasta Lake resulting from implementation of each alternative relative to the NAA, is presented in Appendix 11E, *Reservoir Fish Species Analysis*.

Because there would be negligible differences among alternatives in the operations of Trinity Reservoir, New Melones Reservoir, and Millerton Lake, there would be negligible differences in reservoir storage volumes and water surface elevations among alternatives. The evaluations of negligible impacts for these reservoirs are not presented.

No Project

The conditions in the No Project scenario, or NAA, are identical to the Existing Conditions at Shasta Lake, Oroville Reservoir, Folsom Reservoir, San Luis Reservoir, Trinity Reservoir, New Melones Reservoir, and Millerton Lake. As such, there are no impacts to cold-water and warm-water reservoir species due to the lack of changes to reservoir storage and surface water elevation.

Significance Determination

Because conditions in the No Project scenario, or NAA, are identical to the Existing Conditions at Shasta Reservoir, Oroville Reservoir, Folsom Reservoir, San Luis Reservoir, Trinity Reservoir, New Melones Reservoir, and Millerton Lake, there would be no impact.

Alternative 1, 2, and 3

Effects of Alternative 1, 2, and 3

As described in Appendix 11E, *Reservoir Fish Species Analysis*, Alternatives 1–3 would provide a benefit to cold-water and warm-water reservoir species relative to the NAA in Sites Reservoir because Sites Reservoir, and the new habitat it would create, would not exist under the NAA (Table 11E-1).

Storage volume in Shasta and Folsom Lakes, and Oroville reservoir under Alternatives 1–3 would generally be similar to or greater than storage under the NAA (Appendix 11E, *Reservoir Fish Species Analysis*, Table 11E-2, Table 11E-3, Table 11E-4). Shasta Lake storage would be consistently >5% higher under Alternative 3 in critical years between July and September, representing a beneficial effect on cold-water reservoir species. Folsom Reservoir storage would be greater under Alternative 3 between July through November in above normal, below normal, and dry water years, representing a beneficial effect to cold-water reservoir species. Negligible differences between each alternative and the NAA in the operations of Trinity, New Melones, and Millerton reservoir would have no impact on cold-water fish habitat.

Reservoir warm-water fish species habitat conditions in Shasta Lake, Oroville Reservoir, Folsom Lake, and San Luis Reservoir generally would be similar or more suitable under Alternatives 1-2, relative to the NAA. This is based on modeling results indicating minor differences in the frequency of monthly water surface elevation reductions of six feet or more during the evaluation period (Appendix 11E, *Reservoir Fish Species Analysis*, Tables 11E-5, Tables 11E-5, Tables 11E-6, Tables 11E-7, Tables 11E-8, Tables 11E-9, Tables 11E-10, Tables 11E-11, Tables 11E-12, Tables 11E-13). Negligible changes among alternatives in the operations of Trinity Reservoir, New Melones Reservoir, and Millerton Reservoir would result in no impact to warm-water fish habitat.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

The analyses of potential impacts of Alternatives 1–3 on reservoir cold-water fish species in Sites Reservoir suggested that construction of the reservoir would be beneficial through the creation of new habitat. Construction of Sites Reservoir under Alternatives 1–3 would create new habitat for reservoir warm-water fish species.

The analyses of potential impacts of Alternatives 1–3 on reservoir species in CVP and SWP reservoirs suggested that changes in the Sites Reservoir storage and water surface elevation would be similar to changes in the CVP and SWP reservoirs.

For these reasons, Alternatives 1, 2, and 3 would have a beneficial impact to warm-water and cold-water reservoir species.

NEPA Conclusion for Alternatives 1, 2, and 3

The analyses of potential impacts of Alternatives 1–3 on reservoir cold-water fish species in Sites Reservoir suggested that construction of the reservoir would be beneficial through the creation of new habitat. Construction of Sites Reservoir under Alternatives 1–3 would create new habitat for reservoir warm-water fish species.

The analyses of potential impacts of Alternatives 1–3 on reservoir species in CVP and SWP reservoirs suggested that changes in the Sites Reservoir storage and water surface elevation would be similar to changes in the CVP and SWP reservoirs.

For these reasons, Alternatives 1, 2 and 3 would have a beneficial effect to warm-water and cold-water reservoir species.

Impact FISH-19: Operations Effects on Southern Resident Killer Whale

Alternatives 1, 2, and 3

Effects of Alternatives 1, 2, and 3

Southern Resident killer whales (*Orcinus orca*) are found in coastal waters off the shore of British Columbia, Washington, and Oregon in summer and fall (NMFS 2008). During winter, killer whales are sometimes found off the central California coast, but more frequently off the Washington coast (Hilborn et al., 2012). The 2005 NMFS endangered listing (Federal Register

2005) for the Southern Resident killer whale distinct population segment lists several factors that may be limiting the recovery of killer whales (including the quantity and quality of prey).

Operations of the Sites Project would not directly affect ocean conditions; however, operations have the potential to affect killer whales indirectly by influencing the number of Chinook salmon that enter the Pacific Ocean and become available as a food supply. This potential impact was evaluated qualitatively based on the potential impacts to Chinook salmon, particularly any changes in production. Alternatives 1–3 have the potential to affect Southern Resident Killer Whale by impacting the number of Chinook salmon produced in the Central Valley entering the Pacific Ocean, which are an important component of the killer whale diet. The Independent Science Panel reported that Southern Resident killer whales depend on Chinook salmon as a critical food resource (Hilborn et al. 2012). Hanson et al. (2010) analyzed tissues from predation events and feces to confirm that Chinook salmon were the most frequent prey item for killer whales in two regions of the whale's summer range off the coast of British Columbia and Washington state, representing more than 90 percent of the diet in July and August. Samples indicated that when Southern Resident killer whales are in inland waters from May to September, they consume Chinook salmon stocks that originate from regions including the Fraser River, Puget Sound, the Central British Columbia Coast, West and East Vancouver Island, and Central Valley California (Hanson et al. 2010). Available fish harvest data and killer whale diet and contaminants analyses suggest that Central Valley Chinook salmon make up a significant portion of the total abundance of Chinook salmon available to killer whale throughout their range in most, if not all, years (NMFS 2019).

Significant changes in food availability for killer whales have occurred over the past 150 years, largely because of human impacts on prey species. Salmon abundance has been reduced over the entire range of the Southern Resident killer whales, from British Columbia to California. The Recovery Plan for Southern Resident killer whales (NMFS 2008) indicates that wild salmon have declined primarily because of degraded aquatic ecosystems, overharvesting, and production of fish in hatcheries. The recovery plan supports restoration efforts to rebuild depleted salmon populations and other prey to ensure an adequate food base for Southern Resident killer whales. Central Valley streams produce Chinook salmon that contribute to the diet of Southern Resident killer whales. The number of Central Valley salmon that annually enter the ocean and survive to a size susceptible to predation by killer whales is not known. However, estimates of total Chinook salmon production produced by the Comprehensive Assessment and Monitoring Program, administered by USFWS and Reclamation, provide an approximation of the size of the ocean population of Central Valley Chinook salmon potentially available to killer whales.

Data on the abundance and composition of Central Valley Chinook salmon indicates that approximately 75 percent of all Central Valley-origin Chinook salmon available for consumption by Southern Resident killer whales are produced by Central Valley fall-run Chinook salmon hatcheries (Palmer-Zwhalen and Kormos, 2012). Most Central Valley hatchery fall-run Chinook salmon are released directly into San Francisco Bay, and thus bypass potential impacts from project operations. Even where there might be a nexus with CVP and SWP operations. The purpose of Central Valley fall-run Chinook salmon hatchery programs is to produce large numbers of fish independent of freshwater conditions.

Since fall-run Chinook salmon hatcheries came on-line more than forty years ago, the only period of exceptionally low returns was principally attributed to unusual ocean conditions (Lindley et al., 2007). Ocean commercial and recreational fisheries annually harvest hundreds of thousands of Chinook salmon. The Northwest Region of NMFS (NMFS, 2009) used a model that estimates prey reduction associated with the salmon fishery and which considers the metabolic requirements of killer whales and the remaining levels of prey availability. Their analysis concluded that the salmon fishery was not likely to result in jeopardy for Southern Resident killer whales.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

Given conclusions and discussions from NMFS (2009, 2019), and that at least 75 percent of fall-run Chinook salmon available for Southern Resident killer whales are produced by Central Valley hatcheries, it is likely that Central Valley fall-run Chinook salmon as a prey base for killer whales would not be appreciably affected by the operations of Alternatives 1-3. The potential impacts on Southern Resident Killer Whale are considered less than significant.

NEPA Conclusion for Alternatives 1, 2, and 3

Given conclusions and discussions from NMFS (2009, 2019), and the fact that at least 75 percent of fall-run Chinook salmon available for Southern Resident killer whales are produced by Central Valley hatcheries, it is likely that Central Valley fall-run Chinook salmon as a prey base for killer whales would not be appreciably affected by the operations of Alternatives 1-3. The potential operational impacts would not be adverse on Southern Resident Killer Whale.

Impact FISH-20: Maintenance Effects on Fish and Aquatic Biological Resources

The assessment of impacts from maintenance activities was based on a qualitative evaluation for the facilities included under Alternatives 1, 2, and 3 and focuses on maintenance activities that are near waterways and can affect fish. Electrical transmission connections and lines, substations, distribution lines, dam monitoring equipment, and administration and other buildings are not included in the assessment since these facilities are located away from waterways and will not affect fish and aquatic resources.

No Project

Under the No Project Alternative, the maintenance activities for the new dams, associated facilities, conveyance pipelines, and new roadways and bridges would not be implemented. However, there are several facilities that are in operation that have maintenance activities and would continue under the No Project alternative.

GCID typically dewaters its Main Canal for up to 6 weeks each year between early January and late February for maintenance activities. The existing RBPP and the Hamilton City Pump Station would also be in operation under the No Project alternative. The RBPP and GCID have established operations and maintenance plans that would be followed and are permitted.

Significance Determination

Under the No Project Alternative, no new Project facilities would be constructed, thus there would be no new maintenance activities. Considering that established maintenance activities are already permitted, and there would be no additional new facilities, the No Project Alternative would have no impact on special-status fish or aquatic resources from maintenance activities.

Alternatives 1, 2, and 3

Maintenance activities for all facilities, including recreational areas, would include debris removal, vegetation control, rodent control, erosion control and protection, routine inspections (dams, tunnels, pipelines, PGPs, I/O Works, fencing, signs, and gates), painting, cleaning, repairs, and other routine tasks to maintain the facilities in accordance with design standards after construction and commissioning. Routine visual inspection of the facilities would be conducted to monitor performance and prevent mechanical and structural failures. The Authority would implement operations and maintenance BMPs that are described in Section 2.5.4, *Project Commitments and Best Management Practices Common to All Alternatives*.

Effects of Alternatives 1, 2, and 3

Sediment Disturbance

Maintenance activities associated with the Project alternatives have the potential to cause erosion, sediment, and soil disturbance. These activities result in sediment transport and delivery to streams. Sediment input to streams could temporarily increase water column turbidity and sedimentation rates above ambient levels and potentially alter fish physiology, behavior, and habitat conditions.

Maintenance activities that have the potential to result in erosion and sediment transport and delivery to streams include: (1) debris removal at fish screens, (2) vegetation removal in and around the reservoirs; (3) erosion control in and around new pipeline inlets/outlets and dams; and (4) road and bridge maintenance. Under Alternative 2, sediment- and turbidity-producing activities would include maintenance of the Dunnigan Pipeline where it connects to the Sacramento River, which may include vegetation removal or other maintenance activities. Maintenance activities that occur in or immediately adjacent to stream channels (e.g., vegetation removal, road and bridge work) or during the wet season have the greatest potential to disturb stream sediments or cause erosion and contribute sediment to waterways. Maintenance activities near the Sacramento River can affect special-status fish species such as Chinook salmon, steelhead, green sturgeon, Pacific lamprey, and others as listed in Table 11-2. Maintenance activities in and around the reservoirs could affect black bass species (Table 11-2).

As discussed under *Impact FISH-1, Construction Effects on Fish and Aquatic Biological Resources,* elevated levels of suspended sediments have the potential to result in physiological, behavioral, and habitat effects on fish. The severity of these effects depends on the sediment concentration, duration of exposure, proximity of the action to the waterbody, and timing of the disturbance relative to the occurrence of the species and sensitive life stages. Short-term increases in turbidity and suspended sediment may disrupt normal behavior patterns of fish, potentially affecting foraging, rearing, and migration. The level of disturbance may also cause juvenile fish to abandon protective habitat or reduce their ability to detect predators, potentially increasing their vulnerability to predators (e.g., piscivorous birds and fish). Chronic exposure to high turbidity and suspended sediment may affect fish growth and survival by impairing respiratory function, reducing tolerance to disease and contaminants, and causing physiological stress (Waters 1995). Deposition of excessive fine sediment on the stream bottom could eliminate habitat for aquatic insects; reduce density, biomass, number, and diversity of aquatic insects and vegetation; reduce the quality and quantity of spawning habitat; and block the interchange of surface and subsurface waters.

The maintenance footprint for the alternatives includes areas with known and potentially contaminated sediments (e.g., metals, hydrocarbons such as oil and grease, organochlorine pesticides, and PCBs), indicating the potential for release and dispersal of these contaminants if these sediments are disturbed during maintenance activities. Fish and aquatic species could be directly exposed to elevated levels of contaminants if they are in immediate proximity to construction activities that disturb contaminated sediments. Bed disturbance could also result in indirect effects on fish and aquatic species. Toxins in river channel sediments can enter the food chain via benthic organisms. If contaminated sediments are disturbed and become suspended in the water column, they also become available directly to pelagic organisms, including fish species and planktonic food sources of fish species. Thus, maintenance-related disturbance of contaminated bottom sediments creates another potential pathway to the food chain, and the potential bioaccumulation of these toxins in various fish species. The bioaccumulation of toxins can lead to lethal effects, as well as sublethal effects (e.g., effects on behavior, digestion, and immune system; Connon et al. 2011, p.290). The toxins in contaminated sediments are adhered to the sediment and as described above for turbidity, elevated suspended sediment because of maintenance activity for the alternatives would be spatially limited to a small portion of channel width and not extend far downstream, dissipating within hours of maintenance activities ceasing.

The Project is subject to a maintenance-related stormwater permit and dewatering requirements of the federal Clean Water Act and National Pollutant Discharge Elimination System program. The Project operators would obtain required permits through the Central Valley Regional Water Quality Control Board before any ground-disturbing construction activity occurs. As required by the Construction General Permit, a Stormwater Pollution Protection Plan (SWPPP) would be prepared and implemented before and throughout the construction period. The SWPPP would identify BMPs to prevent and minimize the introduction of contaminants into surface waters (see Section 2.5.4, *Project Commitments and Best Management Practices Common to all Alternatives*). The Project would also limit maintenance activities to potential in-water work windows established by CDFW, NMFS, and USFWS. As a result, there would be no changes to surface water quality from maintenance activities that would result in increased or contaminated stormwater runoff or violations of water quality standards that would negatively affect fish populations and habitat.

Water Quality Effects

Maintenance activities for the Alternatives could result in accidental spills of contaminants, including cement, oil, fuel, hydraulic fluids, paint, and other maintenance-related materials, resulting in localized water quality degradation. This could in turn result in adverse effects on fish and aquatic species, through direct injury and mortality (e.g., damage to gill tissue, causing asphyxiation) or delayed effects on growth and survival (e.g., increased stress or reduced feeding), depending on nature and extent of the spill and the contaminants involved.

The greatest potential for an adverse water quality impact is associated with an accidental spill from maintenance activities occurring in or near surface waters. Maintenance of pumps include cleaning and lubricating with oil products and heavy equipment use near waterways which could release fuel or hydraulic fluid. Special-status fish species located in waterways near pumps include Chinook salmon, steelhead, green sturgeon and others (Table 11-2). Implementation of measures listed in Section 2.5.4, *Project Commitments and Best Management Practices Common to all Alternatives* includes *Spill Prevention and Hazardous Materials Management/Accidental Spill Prevention, Containment, and Countermeasure Plans and Response Measures* to contain any accidental spills that may occur.

Reduced Prey Availability

Maintenance for the Alternatives has the potential to reduce prey availability for fish and aquatic species through disturbance of aquatic habitat. Prey species may be affected by debris or other vegetation removal (i.e., reducing habitat structures for prey in or above water during clearing). The potential effects would be limited in extent relative to the overall area of habitat available to fish and aquatic species in the affected waterways.

CEQA Significance Determination and Mitigation Measures for Alternatives 1, 2, and 3

Alternatives 1, 2, and 3 are less than significant because maintenance BMPs (see Section 2.5.4) include measures to ensure sedimentation and contaminant releases are controlled by minimizing soil disturbance, SWPPP and BMPs, Spill Prevention and Hazardous Material Management/Accidental Spill Prevention, Containment, and Countermeasure Plans and Response Measures, and comply with requirement of RWQCB Order 5-00-175.

NEPA Conclusion for Alternatives 1, 2, and 3

Alternatives 1, 2 and 3 are not an adverse effect on fish and aquatic species because implementation of Project Commitments and BMPs (Section 2.5.4) will ensure sedimentation and contaminant releases are minimal.

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Appendix 11A

Aquatic Species Life Histories

This document has not yet been reviewed by the Authority or Reclamation and does not represent the agencies input, positions, or policies. All content is subject to change.

Appendix 11A Aquatic Species Life Histories

The species descriptions in this appendix were generally adapted from recent documents such as the Department of Water Resources (DWR) (2019) Incidental Take Permit (ITP) Application for Long-Term Operation of the State Water Project (SWP) and its associated Final Environmental Impact Report (EIR) (California Department of Water Resources 2020), the Biological Assessment (BA) and associated Final Environmental Impact Statement (EIS) for the Reinitiation of Consultation on the Coordinated Long-Term Operations of the Central Valley Project (CVP) and SWP (Reclamation 2019), and the California WaterFix BA (ICF International 2016a) and ITP Application (ICF International 2016b). Updates to some descriptions have been provided to reflect newer information.

11A.1 Species Descriptions

A species' listing status may only apply to a distinct population segment (DPS) or evolutionarily significant unit (ESU). The designation of a DPS is dependent on the discreteness of a population with respect to the remainder of the species to which it belongs and its significance to the species. An ESU represents a population of a species that is substantially reproductively isolated from other populations and contributes an important evolutionary legacy of the species.

11A.1.1. Delta Smelt

11A.1.1.1. Legal Status

Delta smelt (*Hypomesus transpacificus*) was listed as a threatened species under the California Endangered Species Act (CESA) in 1993. An emergency petition was filed in February 2007 with the California Fish and Game Commission to elevate the status of delta smelt from threatened to endangered under CESA (The Bay Institute et al. 2007). On March 4, 2009, the California Fish and Game Commission elevated the status of delta smelt to endangered under CESA. A 12-month finding on a petition to reclassify the delta smelt as an endangered species was completed on April 7, 2010. After reviewing all available scientific and commercial information, the U.S. Fish and Wildlife Service (USFWS) determined that reclassifying the delta smelt from threatened to endangered was warranted but was precluded by other higher priority listing actions (U.S. Fish and Wildlife Service 2010).

11A.1.1.2. Life History and General Ecology

Delta smelt are endemic to the San Francisco Estuary and Sacramento–San Joaquin Delta (Delta) where the species primarily occupies open-water habitats in Suisun Bay, Suisun Marsh, and the Delta. On occasion, delta smelt distribution can extend up the Sacramento River to about Garcia Bend in the Pocket-Greenhaven neighborhood of Sacramento, up the San Joaquin River from Antioch to areas near Stockton, up the lower Mokelumne River system, and west throughout the Napa River and San Francisco Bay. Delta smelt is primarily an annual species, completing its life cycle in 1 year, which typically occurs from April to the following April. In captivity, delta

Commented [CC1]: I suggest removing San Francisco Bay from this description or specifying that Delta Smelt have rarely been detected in San Francisco Bay and that the furthest downstream detection was near Berkeley. See Merz 2011, Spatial perspective for delta smelt: a summary of contemporary survey data. California Fish and Game 97(4):164-189; Table 11A-1 below also show 0% frequency of occurrence in San Francisco Bay.

smelt can survive to spawn at 2 years of age (Lindberg et al. 2013), but age-2 delta smelt are now rare in the wild (Bennett 2005; Damon et al. 2016).

Delta smelt complete their entire life cycle within the low-salinity zone of the Upper San Francisco Estuary, in the tidal freshwater region of the Cache Slough Complex or move between the two regions of fresh water and low salinity (Bennett 2005; Sommer and Mejia 2013; Hobbs et al. 2019).[1] Komoroske et al. (2016) found that delta smelt can acclimate to salinities greater than 6 parts-per-thousand (ppt) in the laboratory, but observations of delta smelt presence in waters having salinities exceeding 6 ppt in the wild are comparatively rare (92% of fish caught are at salinity < 6 ppt; Komoroske et al. 2016). This could be because the osmoregulatory costs at such high salinities are too high to support growth and survival (Komoroske et al. 2016), or the discrepancy between field observations and laboratory observations may be evidence that delta smelt's distribution in the wild is due to a factor or factors other than salinity per se (U.S. Fish and Wildlife Service 2019:122).

Commented [CC2]: I suggest expanding the geographic range in which Delta Smelt complete their lifecycle to include the regions described in the previous paragraph, excluding San Francisco Bay. And note that recent detections occur in a subset of their previous range.

Although delta smelt are physiologically euryhaline (i.e., are able to tolerate 0.4 – 34.0 ppt), the cumulative costs associated with physiological adjustments required to achieve homeostasis across a large, fluctuating salinity gradient may be higher than the continual maintenance cost for homeostasis within the low salinity zone (Komoroske et al. 2016).

Delta smelt spawning may occur at night with several males attending a female that broadcasts her eggs onto bottom substrate (Bennett 2005; Lindberg et al. 2020). Although preferred spawning substrate is unknown, spawning habits of the delta smelt's closest relative, surf smelt (*Hypomesus pretiosus*), in addition to experimental trials, suggest that sand or small pebbles may be the preferred substrate (Bennett 2005; Lindberg et al. 2020). Hatching success peaks at water temperatures of 15°C to 16°C (59.0 °F to 60.8°F), ceasing when water temperatures exceed 20°C (68.0°F) (Bennett 2005). Water temperatures suitable for spawning occur most frequently from March to May, but ripe female delta smelt have been observed as early as January and larvae have been collected as late as July (Damon et al. 2016). Most spawning occurs at 9°C to 18°C (48.2°F to 64.4°F) (Damon et al. 2016). Delta smelt appear to have one spawning season for each generation, which makes the timing and duration of the spawning season important every year. Damon et al. (2016) found all pre-spawn females achieved spawning size around April, which would result in only one spawn per female, with subsequent spawning events being rare except in exceptional years when the thermal spawning window extends past May. Prior studies suggested that spawning locations change based on hydrological conditions (reviewed by Bennett 2005:13). However, a more recent study indicated that the majority of regional movement from juvenile and subadult rearing locations to spawning areas occurs by January, spawning habitat locations are relatively constant within and between years, and no substantial further restructuring of the population at regional scales occurs after fish move to spawning locations (Polansky et al. 2018). The main spawning locations are in the lower Sacramento and San Joaquin Rivers, as well as the north Delta including the Cache Slough complex and Sacramento Deep Water Ship Channel (Polansky et al. 2018).

Commented [CC3]: Here, thermal tolerances are focused on spawning. This is insufficient for thorough discussion. Please add temperature tolerances for entire life history of Delta Smelt.

[1] The low-salinity zone is frequently defined as waters with a salinity range of about 0.5 to 6 parts per thousand (Kimmerer 2004).

Although adult delta smelt can spawn more than once, as noted above, most spawning is complete by the time water temperature reaches 18°C (64.4°F) (Damon et al. 2016). The egg stage averages about 10 days before the embryos hatch into larvae (Bennett 2005). The larval stage averages about 30 days. Metamorphosing post-larvae appear in monitoring surveys from April into July of most years (Bennett 2005). By July, most delta smelt have reached the juvenile life stage. Delta smelt collected during the fall are considered subadults. Sampling for adult delta smelt by the Spring Kodiak Trawl survey begins in January, which generally aligns with the time period at which maturity is reached (Kurobe et al. 2016). Many delta smelt disperse to landward[2] habitats sometime after the first significant precipitation event of the winter for staging while sexual maturity is completed (Grimaldo et al. 2009; Sommer et al. 2011; Polansky et al. 2018). Some adult delta smelt exhibit very limited dispersal during the spawning season (Murphy and Hamilton 2013; Polansky et al. 2018).

In the wild, larval delta smelt are presumed to be surface-oriented, exhibiting greater dispersion during the night (Bennett 2005). In laboratory experiments, newly hatched larval delta smelt are able to manipulate their position in tanks, but there is no evidence to suggest that they can swim against prevailing currents. Juvenile delta smelt vary their position in the water column with respect to tides, water quality, and bathymetry; presumably these movements facilitate maintenance in favorable habitats (Feyrer et al. 2013). Adult delta smelt appear to use tidal migration and/or move horizontally toward shore during spawning migrations to upstream habitats (Bennett and Burau 2015). Laboratory studies of delta smelt of 32–68 millimeters (mm) standard length (SL) gave mean critical swimming velocity of around 28 centimeters (cm) per second, generally comparable to other fishes of similar size (Swanson et al. 1998).

Commented [CC4]: Add a citation for this laboratory study

From March through June, larval delta smelt rely heavily first on juvenile and then adult stages of the calanoid copepods *Eurytemora affinis* and *Pseudodiaptomus forbesi*, as well as cladocerans (Nobriga 2002; Hobbs et al. 2006; Slater and Baxter 2014) and *Sinocalanus doerrii*. Nobriga (2002) found that delta smelt larvae expressed positive selection for *E. affinis* and *P. forbesi*, consuming these prey species in greater proportion than available in the environment. Such selection was not noted for other zooplankton prey. Regional differences in food use occur, with *E. affinis* and *P. forbesi* being major prey items downstream in the low-salinity zone with a transition to *S. doerrii* and cyclopoid copepods as major prey items upstream into the Cache Slough Complex. Juvenile delta smelt (June through September) rely extensively on calanoid copepods such as *E. affinis* and *P. forbesi*, especially in fresh water (salinity < 1 ppt) and the Cache Slough Complex, but there is great variability among regions (Interagency Ecological Program 2015). Larger fish are also able to take advantage of mysids, cladocerans, and amphipods (Moyle et al. 1992; Lott 1998; Feyrer et al. 2003; Slater et al. 2019). The presence of several epibenthic species in diets therefore indicates that food sources for this species are not solely connected to pelagic pathways.

11A.1.1.3. Distribution and Abundance

The California Department of Fish and Wildlife (CDFW) conducts four fish surveys from which it develops indices of delta smelt's relative abundance. Each survey has variable capture

[2] Note that 'landward' in this context does not necessarily mean 'upstream', as there could be lateral movements (Murphy and Hamilton 2013).

efficiency (Mitchell et al. 2017) and the frequency of zero catches of delta smelt is very high, largely due to the species' rarity (Latour 2016; Polansky et al. 2018) or because the surveys are carried out independent of other factors that affect catch, such as tide (Bennett and Burau 2015) and channel location (Feyrer et al. 2013). In addition, detection probability decreases with increasing water clarity (Peterson and Barajas 2018) and relatively high numbers of delta smelt may occur in areas without long-term sampling stations (Murphy and Weiland 2019).

Commented [CC5]: The literature cited does not support this assertion. Murphy and Weiland 2019 is a critique on the use of X2 as an environmental surrogates in Delta Smelt management. The authors do not attempt to quantify the abundance of Delta Smelt outside of areas sampled. I suggest removing the last part of this sentence.

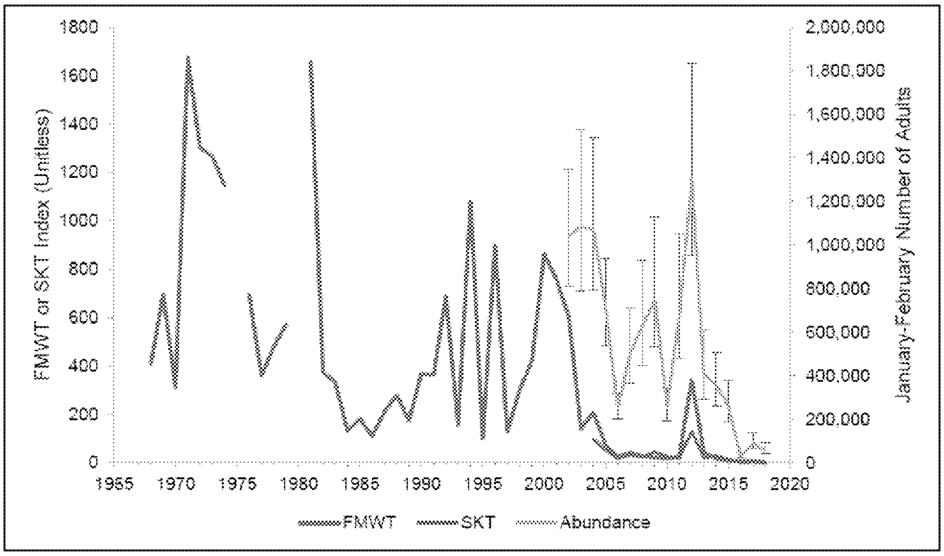
Information for delta smelt distribution and abundance can also be ascertained from other surveys that target salmonids. USFWS implemented a new smelt monitoring program in 2016 called the Enhanced Delta Smelt Monitoring (EDSM) program. This program measures the abundance and distribution of all life stages of delta smelt using a generalized random tessellation stratified design. Delta smelt population estimates are derived from this monitoring.

The distribution of the delta smelt population varies with life stage, season, and environmental conditions (Bennett 2005; Sommer and Mejia 2013; Murphy and Hamilton 2013; Hobbs et al. 2019). Subadult and adult delta smelt typically make landward movements soon after "first flush" periods of initial winter precipitation and runoff, when turbidities elevate over 10 Nephelometric Turbidity Units (NTU) (Grimaldo et al. 2009). During extreme wet years, some adults may move seaward into San Francisco Bay and the Napa River. Larval delta smelt can be broadly distributed depending on hydrologic conditions during March and April. During wet years, larval delta smelt are generally distributed seaward than in drier years. In contrast, during drier years, larval delta smelt are concentrated in the Delta. Juvenile delta smelt distribution is generally centered in the "North Delta Arc," which extends from Cache Slough to Suisun Bay and Suisun Marsh (Merz et al. 2011; Murphy and Hamilton 2013).

Trawl abundance indices indicate that the relative abundance of delta smelt has declined substantially since the 1980s. The decline in abundance reflects decades of habitat change and marginalization by nonnative species that prey on and outcompete delta smelt. The observed decline in delta smelt abundance is consistent with declines of other pelagic species in the Delta (Sommer et al. 2007; Baxter et al. 2010).

Data derived from the CDFW Fall Midwater Trawl (FMWT) surveys are used for detecting and roughly scaling interannual trends in delta smelt abundance. The abundance indices derived from the FMWT closely mirror trends in catch per unit effort (Kimmerer and Nobriga 2008; Polansky et al. 2019), but do not presently support statistically reliable population abundance estimates, though substantial progress has been made in this regard (Newman 2008). The FMWT indices have ranged from 1,673 in 1970 to 0 in 2018 and 2019, the lowest indices on record. The Summer Townet (STN) survey index was 0 in all but one year (2017) during 2015–2020. Indices from the two surveys show a similar pattern of delta smelt relative abundance that is higher prior to the mid-1980s and very low in the past decade. A recent analysis combining these and several other surveys into an 8-survey index suggested that the decline in delta smelt, as well as longfin smelt and striped bass, occurred in the early- to mid-1980s rather than the early 2000s as previously thought (Stompe et al. 2020).

The CDFW Spring Kodiak Trawl (SKT) survey monitors the adult spawning stock of delta smelt and serves as an indication for the relative number and distribution of spawners in the system. The 2018 SKT abundance index was 2.1, the second lowest on record at that time; the 2019 SKT abundance index was 0.4, the lowest on record (Tempel 2019). All CDFW relative abundance indices show a declining trend since the early 2000s (Figure 11A-1).



Source: Reclamation 2019:2–70.

Figure 11A-1. Delta Smelt Fall Midwater Trawl Index, Spring Kodiak Trawl Index, and January–February Spring Kodiak Trawl Abundance Estimate (with 95% Confidence Interval), Water Years 2002–2018

As previously noted, considerable progress has been made on estimating absolute abundance of delta smelt, including adults (Polansky et al. 2019). It has been acknowledged that the estimates are affected by factors such as fish behavior and local habitat features such as turbidity influencing catchability (Polansky et al. 2019:721–722). However, a recent simulation analysis suggested that the effects of turbidity on catchability may be limited (Tobias 2021). The 2018 absolute abundance estimate of delta smelt adults was the second lowest; however, the confidence intervals overlap so strongly that it cannot be stated whether 2018 had higher adult abundance than 2016 (Figure 11A-1). The January through February 2016 point estimates are the lowest since the SKT survey began in 2002 and suggest delta smelt experienced increased natural mortality in the extreme drought conditions during 2013–2015. While the estimate may have increased slightly in 2017, it appears to have decreased again in 2018. The continued low spawning stock of delta smelt relative to historical estimates suggest the population continues to be vulnerable to key threats (described below), especially when these stressors are occurring in consecutive years (e.g., drought) or across sequential life stages (e.g., high water temperatures).

The frequency of occurrence (percentage of samples) of delta smelt by life stage and region from monitoring in the San Francisco Estuary and Delta as assessed by Merz et al. (2011) is provided in Table 11A-1.

Table 11A-1. Average Annual Frequency (Percent) of Delta Smelt Occurrence by Life Stage, Interagency Ecological Program Monitoring Program, and Region

Region	Average Annual Frequency (%)										
Life Stage:	Larvae (<15 mm)	Sub-Juvenile (≥15, <30 mm)		Juvenile (30–55 mm)			Subadult (>55 mm)	Mature Adults (>55 mm)		Pre-Spawning[a]	Spawning[a]
Monitoring Program:	20-mm	20-mm	STN	20-mm	STN	FMWT	FMWT	BS	BMWT	KT	KT
Years of Data Used:	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2006	2002–2009	2002–2009
Time Period:	Apr–Jun	Apr–Jul	Jun–Aug	May–Jul	Jun–Aug	Sep–Dec	Sep–Dec	Dec–May	Jan–May	Jan–Apr	Jan–May
San Francisco Bay	NS	NS	NS	NS	NS	NS	NS	0.0	0.0	NS	NS
West San Pablo Bay	NS	NS	NS	NS	NS	0.2	0.0	0.0	1.2	NS	NS
East San Pablo Bay	0.0	1.0	0.0	2.8	3.6	0.7	0.6	NS	2.7	NS	NS
Lower Napa River	7.3	7.7	3.3	13.3	14.0	1.7	0.8	NS	NS	14.3	11.8
Upper Napa River	11.6	21.2	NS	12.0	NS	NS	NS	NS	NS	NS	NS
Carquinez Strait	5.7	9.3	1.1	24.4	33.7	1.9	3.3	NS	5.4	16.7	0.0
Suisun Bay (SW)	17.8	18.3	1.3	17.5	26.9	4.3	4.3	NS	4.3	23.3	5.6
Suisun Bay (NW)	2.2	8.9	1.1	21.7	34.8	7.3	10.0	NS	8.7	23.3	5.6
Suisun Bay (SE)	19.5	24.9	11.0	20.9	45.7	11.0	12.1	NS	6.5	28.3	6.9
Suisun Bay (NE)	17.8	19.2	33.6	29.7	66.7	20.3	29.3	NS	28.3	48.3	13.9
Grizzly Bay	16.3	27.6	17.9	42.9	72.8	15.0	19.6	NS	30.4	30.0	5.6
Suisun Marsh	21.4	33.6	14.2	18.5	19.2	22.8	27.2	NS	NS	62.0	23.1
Confluence	35.7	41.6	25.7	29.2	36.1	20.2	24.5	1.8	17.4	30.0	10.4
Lower Sacramento River	16.5	37.0	43.3	26.2	55.5	22.9	37.1	NS	18.8	54.4	17.8
Upper Sacramento River	10.8	8.2	1.3	0.0	0.0	2.7	8.0	5.8	16.7	21.7	15.3
Cache Slough and Ship Channel	17.2	47.3	NS	54.3	NS	9.8	26.7	NS	NS	33.9	21.1
Lower San Joaquin River	28.0	24.5	4.1	5.1	5.6	2.6	3.5	0.9	12.6	30.6	9.7

Region Life Stage:	Average Annual Frequency (%)										
	Larvae (<15 mm)	**Sub-Juvenile (≥15, <30 mm)**		**Juvenile (30–55 mm)**			**Subadult (>55 mm)**	**Mature Adults (>55 mm)**		**Pre-Spawning[a]**	**Spawning[a]**
Monitoring Program:	**20-mm**	**20-mm**	**STN**	**20-mm**	**STN**	**FMWT**	**FMWT**	**BS**	**BMWT**	**KT**	**KT**
Years of Data Used:	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2006**	**2002–2009**	**2002–2009**
Time Period:	Apr–Jun	Apr–Jul	Jun–Aug	May–Jul	Jun–Aug	Sep–Dec	Sep–Dec	Dec–May	Jan–May	Jan–Apr	Jan–May
East Delta	14.6	8.8	0.0	1.2	0.0	0.0	0.0	1.6	NS	5.7	2.3
South Delta	18.4	10.8	0.0	1.4	0.3	0.0	0.0	0.3	NS	7.1	1.1
Upper San Joaquin River	NS	NS	NS	NS	NS	NS	NS	0.2	NS	NS	NS
Sacramento Valley	NS	NS	NS	NS	NS	NS	NS	0.2	NS	NS	NS

Source: Merz et al. 2011; California Department of Fish and Wildlife n.d.

20-mm = 20-millimeter Townet; BMWT = Bay Midwater Trawl; BS = Beach Seine; FMWT = Fall Midwater Trawl; KT = Kodiak Trawl; NS = indicates no survey conducted in the given life stage and region; NE = northeast; NW = northwest; SKT = Spring Kodiak Trawl; STN = Summer Townet; SE = southeast; SW = southwest.

[a] Gonadal stages of male and female delta smelt found in Spring Kodiak Trawl database were classified by CDFW following Mager (1996). Descriptions of these reproduction stages are available at: http://www.dfg.ca.gov/delta/data/skt/eggstages.asp.

Mature adults, pre-spawning: Reproductive stagesa: females 1–3; males 1–4.

Mature adults: spawning: Reproductive stagesa: females 4; males 5.

11A.1.1.4. Stressors

Delta smelt are believed to be limited by a number of stressors, including water temperature, water quality, prey availability, entrainment at water diversions, increasing frequency and duration of droughts and contaminants (Sommer et al. 2007; Miller et al. 2012; Wagner et al. 2011; Interagency Ecological Program Management Analysis and Synthesis Team 2015; Fong et al. 2016; Hamilton and Murphy 2020). Since 2010, several conceptual models (Interagency Ecological Program Management Analysis and Synthesis Team 2015) and empirical models (Thomson et al. 2010; Maunder and Deriso 2011; Miller et al. 2012; Rose et al. 2013a; Hamilton and Murphy 2018) have explored life cycle models for the delta smelt to identify and describe the reasons for the population decline. Some of these models have recreated a trend observed in abundance indices, but each model has applied different methodology and predictive covariates. Collectively, these modeling efforts generally support water temperature, water clarity, and prey availability as key factors that limit delta smelt populations, but water diversions and predation may also have substantial impacts as well. The threats discussed below may be directly or indirectly affected by water operations.

All life stages of delta smelt are vulnerable to entrainment at the south Delta export facilities. In general, delta smelt salvage increases with increasing when certain conditions co-occur, principally when adult delta smelt move into the south Delta, when turbidity exceeds 10 to 12 NTU, and with increasing net Old and Middle River (OMR) flow reversal (i.e., more negative net OMR flows). Based on field and salvage data, Kimmerer (2008) calculated that up to 25% of the larval and juvenile delta smelt population and up to 50% of the adult delta smelt population can be entrained at the CVP and SWP annually, in years with periods of high exports. Methods to calculate proportional loss estimates have since been debated (Kimmerer 2011; Miller 2011) and work on entrainment estimation has continued (e.g., Smith 2019; Smith et al. 2020), modeling efforts suggest that entrainment losses have the potential to adversely affect the delta smelt population (Kimmerer 2011; Maunder and Deriso 2011; Rose et al. 2013a, 2013b; Kimmerer and Rose 2018). Data on the distribution of the population (see Murphy and Hamilton 2013) suggest that entrainment is likely to be at the low end of the estimated range in most years. As a result of investigations into entrainment loss, entrainment risk has been limited by restrictions on export pumping (e.g., U.S. Fish and Wildlife Service 2008:280–282; U.S. Fish and Wildlife Service 2019:40–49).

Delta smelt are most vulnerable to entrainment when, as adults, they move from brackish water into fresh water or as larvae, when they move from fresh water in the southern and central Delta into the brackish water of Suisun Bay. While some delta smelt live year-round in fresh water far from the CVP and SWP, most rear in the low-salinity regions of the estuary, also at a relatively safe distance from the SWP and CVP pumps. The timing, direction, and geographic extent of the spawning movements of adult delta smelt affect their entrainment risk (Sweetnam 1999; Sommer et al. 2011). Unlike the years prior to the 1990s, when high salvage of adult and juvenile delta smelt occurred at high, intermediate, or low export levels, the risk of entrainment for fish that move into the central Delta and south Delta is currently highest when net Delta outflow is at intermediate levels (about 20,000 to 75,000 cubic feet per second [cfs]) and OMR flow is more negative than -5,000 cfs (U.S. Fish and Wildlife Service 2008). In contrast, when adult delta smelt move upstream to the Sacramento River and into the Cache Slough region or do not move upstream at all, entrainment risk is appreciably lower. During extreme wet years, very few delta smelt (all life stages) are salvaged because the distribution shifts seaward away from the footprint of the SWP and CVP (Grimaldo et al. 2009). Hierarchical modeling has recently been developed to characterize the potential for entrainment losses of vulnerable delta smelt life stages (Smith 2019; Smith et al. 2020).

The Interagency Ecological Program Management Analysis and Synthesis Team delta smelt conceptual model report found statistically significant relationships of spring Delta outflow (represented by X2) and prior indices of parental stock (FMWT or SKT indices) as predictors of larval/early juvenile delta smelt 20-mm Survey abundance indices for the post-Pelagic Organism Decline (Sommer et al. 2007) era (Interagency Ecological Program Management Analysis and Synthesis Team 2015:153–162). This report stressed that the "results are preliminary and included for illustrative purposes only; peer-reviewed publications of these analyses need to be completed before they can be used to draw any conclusions" (Interagency Ecological Program Management Analysis and Synthesis Team 2015:152).

During the late summer and fall, Delta outflow affects the location of the low-salinity zone within the upper estuary landscape. Higher Delta outflows (or low X2) expand the low-salinity zone, while lower outflows constrict the extent of the low-salinity zone (Feyrer et al. 2011; Bever et al. 2016). During the summer and fall, it has been hypothesized that environmental conditions improve for delta smelt as X2 moves seaward and the low-salinity zone expands habitat area (Interagency Ecological Program Management Analysis and Synthesis Team 2015). The overlap of the low-salinity zone with Suisun Marsh/Bay results in a considerable increase in a habitat index calculated by Feyrer et al. (2011). However, others (e.g., Manly et al. 2015) have questioned the use by Feyrer et al. (2011) of outflow and X2 location as an indicator of delta smelt habitat because other factors may be influencing survival. Murphy and Weiland (2019) found that the low-salinity zone is not a reliable indicator of delta smelt habitat and reported that delta smelt can be found in the lower Sacramento River, east of the Delta in largely freshwater conditions, as well as in western regions of the Delta, such as Suisun Bay, where salinity levels are typically higher. As both these conditions bound the range of the species, X2 does not determine the location of other important resources such as food or predators and therefore is not, by itself, a reliable surrogate for delta smelt habitat. Recent work suggested that summer/early fall Delta outflow provides a *P. forbesi* subsidy from the upper Delta to the western portion of the low-salinity zone (Kimmerer et al. 2018; Hamilton et al. 2020), resulting in low prey abundance in the low-salinity zone, where mortality rate is high because of clam grazing; without subsidy from the Delta, abundance of *P. forbesi* would be 0 (Kimmerer et al. 2019). Kimmerer et al. (2018) did not find a statistically significant relationship between *P. forbesi* density in the Delta and Delta outflow, whereas Hamilton et al. (2020) found statistically significant decreases in mean total copepod biomass with increasing September/October flow during higher flow conditions at most monitoring locations they examined in the San Francisco Estuary and Delta (discussed further below). Variability in water temperature and turbidity are primarily driven by climate, but in general, Suisun Bay and Suisun Marsh tend to support more suitable levels of water temperature and turbidity than the Delta.

Commented [CC6]: Delta outflow affects the size and location of the low-salinity zone throughout the year and is not limited to summer and fall. Suggest deleting the first part of this sentence.

Delta smelt isconsidered a pelagic species, and their physical habitat is generally defined by water quality (Bennett 2005; Feyrer et al. 2007; Nobriga et al. 2008) with some association to bathymetric features (Feyrer et al. 2013) and velocity (Bever et al. 2016). Recent analyses indicate water body type and depth are also physical indicators of habitat quality, and seasonal prey density is an indicator of biological habitat quality (Hamilton and Murphy 2020).

Researchers have assumed that delta smelt primarily occupy the upper 2 meters of the water column, but recent work shows that juvenile Delta smelt occupy the lower bottom half of the water column or move horizontally during ebb tides (Feyrer et al. 2013). As previously mentioned, after first flush and initial dispersal, adult delta smelt appear to hold their position geographically (Polansky et al. 2018).

Multiple field and modeling studies have established the association between elevated turbidity and the presence and abundance of delta smelt. Sommer and Mejia (2013) and Nobriga et al. (2008) found that late larval and juvenile delta smelt are strongly associated with turbid water, a pattern that continues through fall (Feyrer et al. 2007). Long-term declines in turbidity may also be a key reason that juvenile delta smelt now rarely occur in the south Delta during summer (Nobriga et al. 2008). Thomson et al. (2010) found decreases in turbidity were a significant predictor of delta smelt decline in abundance over time. Grimaldo et al. (2009) found that the presence of adult delta smelt at the fish salvage facilities was linked, in part, with high turbidity associated with first flush events. Turbidity may also serve as a behavioral cue for small-scale (lateral and vertical movements in the water column) and larger-scale (migratory) delta smelt movements (Bennett and Burau 2015). The decline in turbidity appears to be attributable to a decline in sediment supply from upstream, trapping by invasive submerged aquatic vegetation (SAV), and a long-term decrease in wind speed (Hestir et al. 2016; Bever et al. 2018).

Upper water temperature limits for juvenile delta smelt survival are based on laboratory studies and corroborated by field data. Based on the critical thermal maximum (CTmax), juvenile delta smelt acclimated to 17°C (62.6°F) could not tolerate temperatures higher than 25.4°C (77.7°F) (Swanson et al. 2000). However, for juvenile delta smelt acclimated to 11.9°C (53.4°F), 15.7°C (60.3°F), and 19.7°C (67.5°F), consistently higher CTmax values were estimated—27.1°C (80.9°F), 28.2°C (82.8°F), and 28.9°C (84.0°F), respectively (Komoroske et al. 2014), which corresponded closely to the maximum water temperatures recorded in the STN and FMWT surveys. Swanson et al. (2000) used wild-caught fish, while Komoroske et al. (2014) used hatchery-reared fish, which may have contributed to the differences in results. Based on the STN survey (Nobriga et al. 2008) and the 20-mm Townet survey (Sommer and Mejia 2013), most juvenile delta smelt were predicted to occur in field samples when water temperature was below 25°C (77.0°F). In a multivariate autoregressive modeling analysis with 16 independent variables, Mac Nally et al. (2010) found that high summer (June through September) water temperature had a negative effect on delta smelt subadult abundance in the fall. Water temperature was also one of several factors affecting delta smelt life stage dynamics in the state-space model of Maunder and Deriso (2011) and in an individual-based delta smelt life cycle model (Rose et al. 2013a, 2013b).

Harmful algal blooms, in particular *Microcystis*, are hypothesized to potentially have negative effects on delta smelt (Brooks et al. 2012). While recent research has resulted in improved understanding of the factors influencing the quantity, toxicity, and location of harmful algal blooms, there are still many uncertainties about their direct and indirect effects on delta smelt relative to other factors and about what can be done to prevent them. There is no routine quantitative monitoring program in place that specifically targets harmful algae. The STN and FMWT surveys now include qualitative, visual assessment of *Microcystis*, but other quantitative techniques that detect additional harmful species and their toxicity are increasingly available (e.g., solid phase adsorption tracking) (Wood et al. 2011). Available studies in the Delta suggest that retention time and water temperature are key environmental correlates with *Microcystis* bloom amplitude and that once established, *Microcystis* is likely to be resistant to even very high flows as long as water quality (in particular water temperature) is favorable (Lehman et al. 2020).

Changes in phytoplankton production, alterations in phytoplankton species abundances observed, and the invasion of *Potamocorbula* may have had important consequences for consumer species preyed upon by delta smelt. For example, there has been a decrease in mean zooplankton size (Winder and Jassby 2011) and a long-term decline in calanoid copepods, including a major step-decline in the abundance of the copepod *E. affinis*. These changes are possibly due to predation by *Potamocorbula* (Kimmerer et al. 1994) or to indirect effects of clam grazing on copepod food supply. Predation by *Potamocorbula* may also have been important for other zooplankton species (Kimmerer 2008).

The interaction of *Potamocorbula* grazing with the water's nutrient composition is also thought to have importance for delta smelt prey availability. As summarized by USFWS (2019:115), diatoms (i.e., phytoplankton prey of delta smelt's zooplankton prey) preferentially take up ammonium over nitrate but grow more slowly using ammonium. Consumption of diatoms by *Potamocorbula* prevents sufficient diatom metabolization of ammonium to lower levels that would allow more rapid diatom growth rates and greater diatom abundance for consumption by delta smelt zooplankton prey. The largest source of dissolved ammonium in the Bay-Delta is the Sacramento Regional Wastewater Treatment Plant, for which facility upgrades reducing ammonium concentrations beginning in 2023 should demonstrate how important this nutrient source is to limiting diatom production in the Bay-Delta (U.S. Fish and Wildlife Service 2019:115). A recent analysis concluded high ammonium loading is not a driver of low productivity in the San Francisco Bay-Delta (Strong et al. 2021).

In addition to a long-term decline in calanoid copepods and mysids (Orsi and Mecum 1986) in the Upper San Francisco Estuary, there have been numerous introductions of copepod species (Winder and Jassby 2011).The calanoid copepod *P. forbesi* was first observed in the estuary in the late 1980s and has replaced *E. affinis* as the most common delta smelt prey during the summer. It may have a competitive advantage over *E. affinis* because of its more selective feeding ability. Selective feeding may allow *P. forbesi* to utilize the remaining high-quality algae in the system while avoiding increasingly more prevalent low-quality and potentially toxic food items such as *Microcystis* (Mueller-Solger et al. 2006; Ger et al. 2010). After an initial rapid increase in abundance, *P. forbesi* declined somewhat in abundance from the early 1990s in the Suisun Bay and Suisun Marsh regions, but maintained its abundance, with some variability, in the central and south Delta (Winder and Jassby 2011).

The abundance of a more recent invader, the cyclopoid copepod *Limnoithona tetraspina*, significantly increased in the Suisun Bay region beginning in the mid-1990s. It is now the most abundant copepod species in Suisun Bay and the confluence region of the estuary (Bouley and Kimmerer 2006; Winder and Jassby 2011). Gould and Kimmerer (2010) found that it grows slowly and has low fecundity. Based on these findings they concluded that the population success of *L. tetraspina* must be due to low mortality and that this small copepod may be able to avoid the visual predation to which larger copepods are more susceptible. It has been hypothesized that *L. tetraspina* is an inferior food for pelagic fishes, including delta smelt, because of its small size, generally sedentary behavior, and ability to detect and avoid predators (Bouley and Kimmerer 2006; Gould and Kimmerer 2010). Nevertheless, this copepod has been found in the guts of delta smelt when *Limnoithona* spp. occurs at extremely high densities relative to other zooplankton (Slater and Baxter 2014). Larval delta smelt will consume and grow on *L. tetraspina*, but growth is slower than with *P. forbesi* (Kimmerer et al. 2011). It remains unclear if consuming this small prey is energetically beneficial for delta smelt at all sizes or if there is a breakpoint above which larger delta smelt receive little benefit from such prey. *Acartiella sinensis*, a calanoid copepod species that invaded at the same time as *L. tetraspina*, also reached considerable densities in Suisun Bay and the western Delta over the last decade (Hennessy 2010), although its suitability as food for delta smelt remains unclear.

In addition to the previously mentioned subsidy of *P. forbesi* to the low-salinity zone from the Delta that has been positively related to Delta outflow (Kimmerer et al. 2018, 2019), Hamilton et al. (2020) conducted modeling of potential Delta Sacramento and San Joaquin river flow management actions that suggested increasing flows in fall (September and October) of wetter years generally could have negative effects to copepod biomass, whereas increases in flows in the spring (April and May) of drier years could provide regional increases in biomass, particularly in the lower Sacramento and San Joaquin Rivers. The latter result is consistent with earlier studies showing X2 to be negatively correlated with *E. affinis* density (Kimmerer 2002). In addition to *Potamocorbula* grazing, recent studies have suggested that south Delta exports also negatively affect phytoplankton or zooplankton productivity (Hammock et al. 2019a; Kimmerer et al. 2019). Tidal wetlands have been suggested to confer substantial benefits to the foraging success of delta smelt, on the basis of observed stomach fullness increased with increasing adjacent tidal wetland area (Hammock et al. 2019b).

Modeling suggests that delta smelt declines are negatively associated with metrics assumed to reflect the abundance of predators in the estuary (Maunder and Deriso 2011; Miller et al. 2012; Hamilton and Murphy 2018). These metrics are composites of the relative abundance of Mississippi silverside (*Menidia audens*), largemouth bass (*Micropterus salmoides*) and other centrarchids; these species are potential predators of concern because of their increasing abundance (Bennett and Moyle 1996; Brown and Michniuk 2007; Thomson et al. 2010) and because of inverse correlations between largemouth bass abundance and delta smelt abundance (Nobriga and Feyrer 2007; Thomson et al. 2010; Maunder and Deriso 2011). These correlations could represent predation on delta smelt by largemouth bass or, alternatively, the very different responses of the two species to changing habitat within the Delta (Moyle and Bennett 2008). Largemouth bass readily eat delta smelt when the opportunity exists (Ferrari et al. 2014). However, there is little evidence that largemouth bass are major consumers of delta smelt due to low spatial co-occurrence (Nobriga et al. 2005; Baxter et al. 2010). Thus, the inverse correlations between these species may not be mechanistic. Rather, they may reflect adaptation to, and selection for, different environmental conditions.

Moyle et al. (2016) suggested that Mississippi Silversides currently are the most important predators of delta smelt early life stages, as reflected in recent studies of delta smelt DNA in the prey consumed by silversides (Baerwald et al. 2012; Schreier et al. 2016). Mississippi silversides may also compete with delta smelt for prey and may be at an advantage over delta smelt because they spawn repeatedly throughout late spring, summer, and fall (Bennett 2005). The closely related smelt species wakasagi (*Hypomesus nipponensis*) occurs in the Delta and has prompted concern because of its broader environmental tolerance than delta smelt (Swanson et al. 2000), which could lead to its outcompeting delta smelt and hybridizing with delta smelt.

From 1963 through 1964, Stevens (1966) evaluated seasonal variation in the diets of juvenile striped bass (*Morone saxatilis*) throughout the Delta; only age-2 and age-3 striped bass contained more than trace amounts of delta smelt. The highest reported predation on delta smelt was 8% of the age-2 striped bass diet by volume during the summer. Thomas (1967) reported on spatial variation in the striped bass diet composition based on collections throughout the San Francisco Estuary and the Sacramento River above tidal influence. Delta smelt accounted for 8% of the spring diet composition and about 16% of the summer diet composition in the Delta. Although delta smelt are rare in the stomachs of striped bass (Nobriga and Feyrer 2007; Nobriga et al. 2013), a recent examination suggested that striped bass are important to controlling delta smelt because historical data indicate that declines in delta smelt before the current monitoring program began were driven by the invasion of striped bass into the estuary (Nobriga and Smith 2020).

The anticipated effects of climate change on the San Francisco Estuary and watershed, such as warmer water temperatures, greater salinity intrusion, lower snowpack contribution to spring outflows from the Delta, and the potential for frequent extreme drought (Knowles and Cayan 2002; Dettinger 2005), indicate challenges to maintaining a sustainable delta smelt population (Brown et al. 2013, 2016). A rebound in relative abundance during the very wet and cool conditions during 2011 indicated that delta smelt retained some population resilience (Interagency Ecological Program Management Analysis and Synthesis Team 2015). Examination of genetic effective population size during 2011–2014 found that delta smelt were not declining because of genetic factors and were not at immediate risk of losing genetic diversity (Finger et al. 2017). Since 2012, declines to record low population as estimated by abundance indices have been broadly associated with the 2012–2016 drought, and wetter conditions in 2017 and 2019 did not produce a rebound in delta smelt numbers similar to that seen in 2011. A more recent evaluation of effective population size has not been conducted since this further decline.

Central California's warm summers appear to be a source of energetic stress for delta smelt and warm springtime temperatures are assumed to compress the duration of their spawning season (Rose et al. 2013a; Moyle et al. 2016). Central California's climate is anticipated to get warmer (Cayan et al. 2009). Warmer estuary temperatures likely present a significant conservation challenge for delta smelt (Brown et al. 2013, 2016). Mean annual water temperatures within the Delta are expected to increase steadily during the second half of this century (Cloern et al. 2011).

Commented [CC7]: Discussion of thermal stress associated with climate change would benefit from a review of the literature relating to physiological and behavioral effects of increased temperature.

Komoroske et al. 2014 https://doi.org/10.1093/conphys/cou008

Jeffries et al. 2016, https://doi.org/10.1242/jeb.134528

Davis et al. 2019 https://doi.org/10.1093/conphys/coy076

etc...

11A.1.2. Longfin Smelt—Bay-Delta DPS

11A.1.2.1. Legal Status

On June 26, 2009, the commission ruled to list the status of longfin smelt as threatened under CESA. Longfin smelt is not listed under ESAESA, but listing has been found to be warranted for the San Francisco Bay/Sacramento–San Joaquin Delta (Bay-Delta) DPS (77 Code of Federal Regulations Part 19756).

11A.1.2.2. Life History and General Ecology

The longfin smelt (*Spirinchus thaleichthys*) is a small, euryhaline, anadromous, and semelparous fish with a life cycle of approximately 2 to 3 years (Rosenfield 2010). Longfin smelt reach 90 to 110 mm SL, with a maximum size of 120 to 150 mm SL (Moyle 2002; Rosenfield and Baxter 2007). Longfin smelt belongs to the true smelt family Osmeridae and is one of three species in the *Spirinchus* genus; the night smelt (*Spirinchus starksi*) also occurs in California, and the shishamo (*Spirinchus lanceolatus*) occurs in northern Japan (McAllister 1963:10, 15). Delta smelt and longfin smelt hybrids have been observed in the San Francisco Estuary and Delta, although these offspring are not thought to be viable because delta smelt and longfin smelt are not closely related taxonomically or genetically (Fisch et al. 2013). Longfin smelt reside and rear in San Francisco Bay and in the nearshore ocean outside the Golden Gate (Garwood 2017). They spawn in tidal fresh water in the estuary's low-salinity zone where brackish and fresh waters meet (Grimaldo et al. 2017) and in freshwater in tributaries to the Bay (Lewis et al. 2020). Longfin smelt can be distinguished from other California smelt by their long pectoral fins that reach or nearly reach the bases of the pelvic fins), their incomplete lateral line, weak or absent striations on the opercular bones, low number of scales in the lateral series, and long maxillary bones (which in adults extend just short of the posterior margin of the eye [Moyle 2002]). Populations of longfin smelt occur along the Pacific Coast of North America, from Hinchinbrook Island, in Prince William Sound, Alaska, to the San Francisco Estuary (Lee et al. 1980) and have been detected as far south as Monterey Bay (Garwood 2017).

Commented [CC8]: Expand on this to specify that younger Longfin Smelt rear within the Delta and Suisun Bay/Marsh.
See:

Dege and Brown 2004 "Effect of Outflow on Spring and Summertime Distribution and Abundance of Larval and Juvenile Fishes in the Upper San Francisco Estuary"

Merz et al. l 2013 Longfin smelt: spatial dynamics and ontogeny in the San
Francisco Estuary, California.

Or other supporting literature

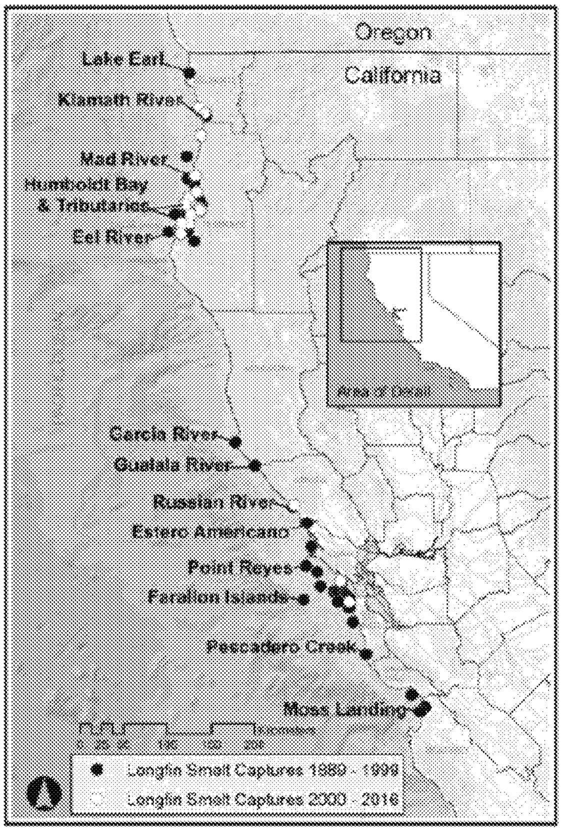
Commented [CC9]: It should be noted that spawning in Bay tributaries has only been successful in abnormally wet years as described in Lewis 2020 and Parker 2017 "Do Longfin Smelt Spawn in San Francisco Bay Tributaries?" IEP Newsletter

Longfin smelt are periodically caught in the nearshore ocean, suggesting that some individuals disperse out into the Gulf of Farallones to feed and then return to the estuary (Rosenfield and Baxter 2007). Longfin smelt have been documented in Humboldt Bay, the Eel River estuary, the Klamath River estuary,Russian River, and in smaller river estuaries from the central and northern coast of California, including Pescadero Creek, Garcia River, Gualala River, and Mad River (Figure 11A-2) (Moyle 2002; Pinnix et al. 2004; Garwood 2017). It is not known what portion of ocean-bound fish return to San Francisco Bay each year or to other coastal streams north and south of San Francisco Bay (Rosenfield and Baxter 2007; Nobriga and Rosenfield 2016).

Genetic isolation exists between the population segment of longfin smelt in the San Francisco Estuary and more northern breeding populations (Stanley et al. 1995; Israel and May 2010). Due to the low likelihood of southward migration from more northern breeding populations as close as Humboldt Bay, USFWS determined that listing as a distinct population segment is warranted (U.S. Fish and Wildlife Service 2012). The Bay-Delta distinct population segment of longfin smelt occurs throughout the San Francisco Bay and the Delta, and in coastal waters west of the Golden Gate Bridge. Within the San Francisco Estuary and Central Valley watershed, they have been observed, north as far as the town of Colusa on the Sacramento River, east as far as Lathrop on the San Joaquin River, and south as far as Alviso and Coyote Sloughs in the southern San Francisco Bay as well as various tributaries in northern San Francisco Bay (Merz et al. 2013; Hobbs et al. 2015; Lewis et al. 2020).

In Lake Washington, longfin smelt spawn over sandy substrate, but spawning substrates are unknown in the San Francisco Estuary. Longfin smelt eggs are adhesive and demersal (Moyle 2002). Evidence from Grimaldo et al. (2017) suggests spawning habitats include open shallow water and tidal marshes. Longfin smelt produce between 1,900 and 18,000 eggs, with greater fecundity in fish with greater lengths (California Department of Fish and Game 2009a).

Incubation times for egg development range between 25 and 42 days (Rosenfield 2010). Evidence for individuals spawning multiple times in a season has not been investigated but given that longfin smelt have such a broad spawning window (5–6 months), some females may undergo repeated spawning events. Newly hatched larvae have been observed in salinities up to 12 practical salinity units (psu) with peak observations occurring between 2 and 4 psu (Grimaldo et al. 2017). Early juvenile longfin smelt (20–40 mm SL) are found in salinities up to 30 psu, but most are found in salinities between 2 and 18 psu (MacWilliams et al. 2016). By late summer, late juveniles can tolerate full seawater.



Source: Garwood 2017.

Note: Locations with black circles have not necessarily been sampled since 1999, so there is no implication regarding changes in occurrence over time intended by this figure.

Figure 11A-2. Locations of Longfin Smelt Captures, 1889–2016, Excluding the San Francisco Estuary and Delta

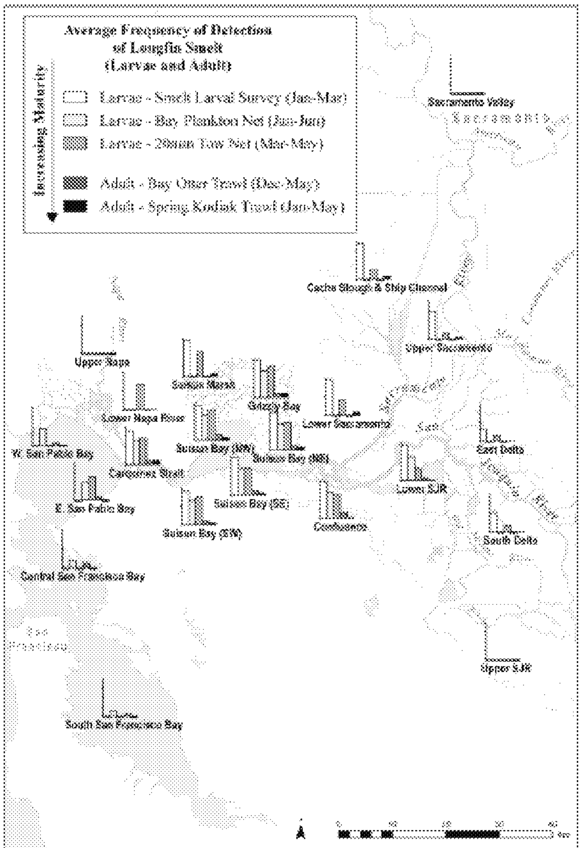
Longfin smelt are anadromous and semelparous, moving from saline to brackish or fresh water for spawning from November to May (Grimaldo et al. 2017; Lewis et al. 2020). Longfin smelt usually live for 2 years, spawn, and then die, although some individuals may spawn as 1-year-old or 3-year-old fish before dying (Rosenfield 2010). Age-2 adults appear to move into spawning areas during the late fall and early winter (Rosenfield and Baxter 2007). Spawning occurs at temperatures that range from 5°C (41.0°F) to 15°C (59.0°F) (Grimaldo et al. 2017). Peak spawning takes place in January and February of most years, when water temperatures are between 5°C (41.0°F) and 11°C (51.8°F). CDFW Smelt Larval Survey (SLS) data show that spawning appears to be centered in brackish water (2 to 4 psu), however, special studies that cover regions seaward of the SLS extent found newly hatched larvae in salinities up to 12 psu and concentrations of larvae peak between 2 and 4 psu (Grimaldo et al. 2017, 2020).. Hobbs et al. (2010) provides evidence that larvae with the greatest recruitment success to later life stages are those that reared in salinities around 2 ppt.

Newly hatched longfin smelt larvae appear to be surface-oriented and probably have little ability to control their position in the water column before they develop their air bladder (Bennett et al. 2002). Once their air bladder is developed (approximately 12 mm SL), they can control their position in the water column by undergoing reverse diel vertical migrations or tidal vertical migration, depending on flow conditions (Bennett et al. 2002). Bennett et al. (2002) suggested that the ability of longfin smelt to undergo tidal vertical migrations allows them to maintain their position on the axis of the estuary. During the first few months of their lives (approximately January through May), longfin smelt primarily prey on calanoid copepods such as *P. forbesi* and *E. affinis* before switching to mysids as soon as they are large enough to feed on them (Slater 2008; Baxter et al. 2010). Mysid density is positively related to spring Delta outflow (negatively related to spring X2) (Mac Nally et al. 2010), although note that Kimmerer (2002) found a changing relationship to X2 for the mysid *Neomysis mercedis* (negative prior to 1987; positive following 1987).

11A.1.2.3. Distribution and Abundance

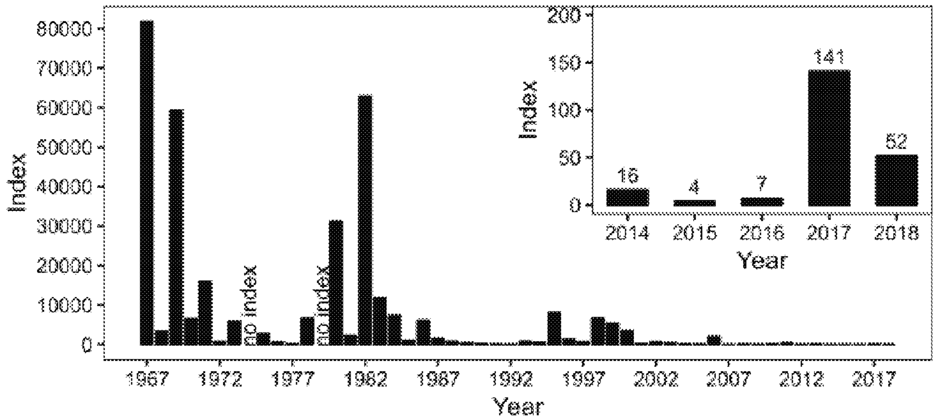
During late summer and early fall, juvenile and adult longfin smelt within the San Francisco Estuary are more common throughout San Francisco Bay than in other landward areas (Rosenfield and Baxter 2007; MacWilliams et al. 2016), although the extent of marine migration has yet to be quantified. During the spawning period in late fall and early winter, adults are more commonly found in San Francisco Bay tributaries and marshes (Lewis et al. 2020; Grimaldo et al. 2020), Suisun Bay, and the Delta (Rosenfield and Baxter 2007). Larval longfin smelt are broadly distributed throughout San Francisco Bay and its associated tributaries during wet years (MacWilliams et al. 2016; Lewis et al. 2020; Parker et al. 2017; Grimaldo et al. 2020). Analyses of multiple surveys by Merz et al. (2013) found that larvae were more frequently detected in the Delta in drier years than in wet years (Figure 11A-3; however, the limited extent of the SLS to landward regions does not account for potential spawning in tributaries of San Francisco Bay (Lewis et al. 2020). In long-term channel surveys, albeit limited to regions landward of San Pablo Bay, more than 50% of the measured larval abundance in any given year between 2009 and 2015 occurred in Suisun Bay and Suisun Marsh (Grimaldo et al. 2017). Some juveniles and adults are believed to move to the coastal ocean during the summer and fall (Rosenfield and Baxter 2007; MacWilliams et al. 2016).

Abundance indices for the longfin smelt population have undergone a decline over time. For example, there was an approximate thirty-fold reduction in the fall midwater trawl index since the early 1980s; although note that these indices do not sample large portions of the area occupied by the species (Figure 11A-4) (Rosenfield and Baxter 2007; Sommer et al. 2007; Kimmerer et al. 2009) and an index of 2-year-olds based on the San Francisco Bay Study midwater and otter trawl went down from a mean of 1,931 in 1980–1986 (prior to the *Potamocorbula* invasion) to a mean of 918 during 1987–2002, with a further decline following the onset of the Pelagic Organism Decline to a mean of 422 during 2003–2013 (Nobriga and Rosenfield 2016). The rate of decline of the population suggested by abundance indices has been particularly steep, especially since the onset of the Pelagic Organism Decline (Sommer et al. 2007; Thomson et al. 2010), although a recent analysis of an integrated dataset featuring eight different surveys suggests that the original decline dates back to the early to mid-1980s (Stompe et al. 2020). Although the population has declined, the slope of the relationship between winter-spring flow and fall longfin smelt abundance indices remains unchanged, suggesting that flow or hydrological conditions are strong drivers of their population abundance (Kimmerer et al. 2009; Maunder et al. 2015; Nobriga and Rosenfield 2016). The intercept of this relationship has dropped nearly twofold, possibly because of declining food supply related to *Potamocorbula* (Kimmerer et al. 2009).



Source: Merz et al. 2013.
Note: To calculate the annual frequency of longfin smelt detection in a region, the percentage of sampling events where longfin smelt were observed is divided by the total number of sampling events for the region. In this graphic, where no column/bar is shown in the bar graph for a region, the average annual frequency of detection for the given longfin smelt life stage(s) was zero. Where the column is below the x-axis, a survey did not sample in that region (e.g., the Smelt Larval Survey, which does not include stations west of Carquinez Strait).

Figure 11A-3. Average Annual Frequency of Longfin Smelt Detection (%) for Larval and Adult Life Stages by Region and Interagency Ecological Program Survey Type



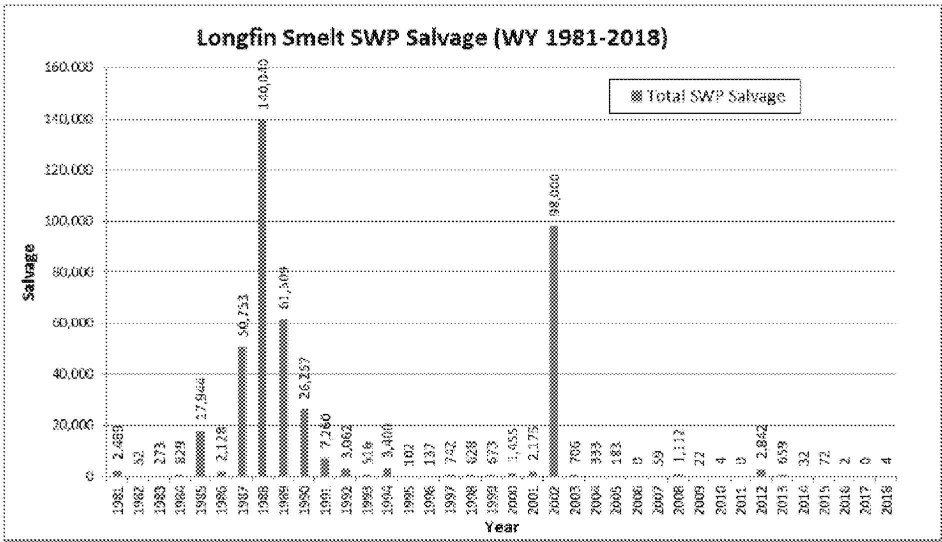
Source: White 2019.

Figure 11A-4. Longfin Smelt Fall Midwater Trawl Abundance Index, 1967–2018

11A.1.2.4. Stressors

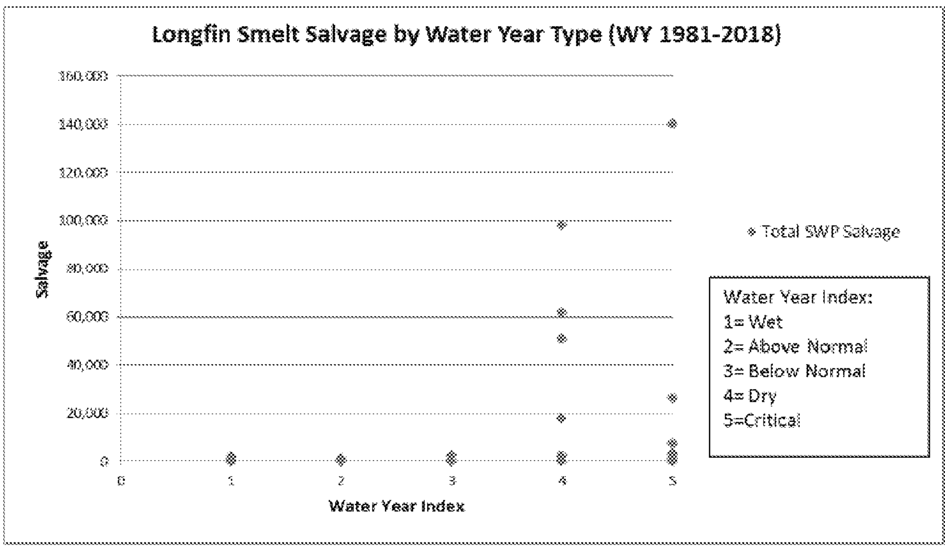
There are several threats to longfin smelt. The USFWS (2012) determination that listing is warranted for the Bay-Delta DPS concluded that reductions in freshwater flow and introduced species are threats, and that ammonium may be a threat. The discussion below also describes other threats that have been noted (e.g., California Department of Fish and Game 2009a), although as discussed further below, not all have been concluded to be of significance to the species (e.g., entrainment).

Longfin smelt are vulnerable to entrainment at the south Delta export facilities. The annual number of longfin smelt salvaged has been generally low since the 1980s, except in some years (1988, 2002), as illustrated for the SWP salvage facility in Figure 11A-5. In general, longfin smelt entrainment risk increases with reverse OMR flow (Grimaldo et al. 2009), and salvage can be higher in drier years compared to wetter years (as illustrated for the SWP salvage facility in Figure 11A-6), probably as a result of the landward shift in distribution in drier years. Figure 11A-7 shows the distribution of larval and juvenile longfin smelt salinity tolerance in water years of varying runoff.



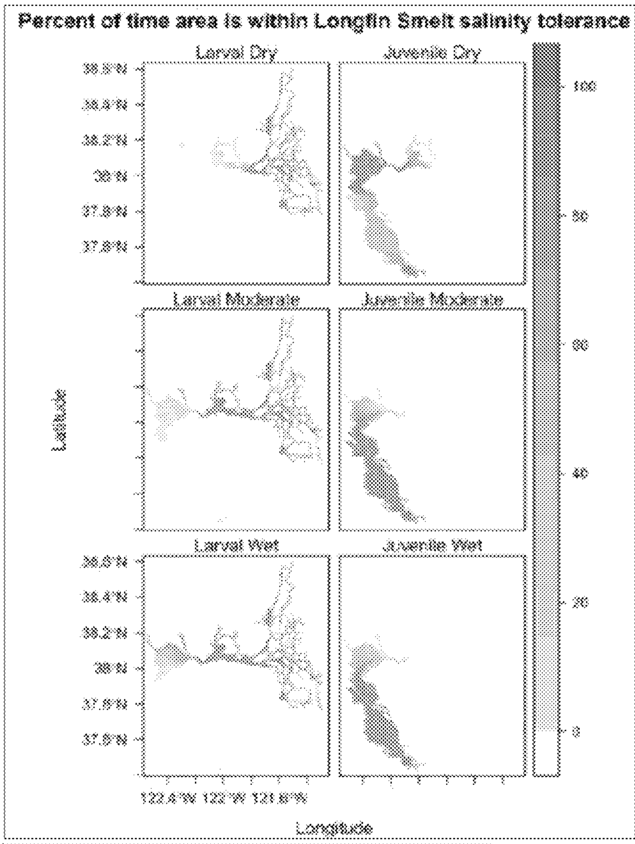
Source: California Department of Water Resources 2020:2-15

Figure 11A-5. Salvage at the State Water Project John E. Skinner Delta Fish Protective Facility, 1981-2018



Source: California Department of Water Resources 2019:2-15

Figure 11A-6. Salvage at the State Water Project John E. Skinner Delta Fish Protective Facility by Water Year Type, 1981-2018



Source: California Department of Water Resources 2019:2–16.
Note: The larval maps span January 1–March 31 and the juvenile maps span April 1–August 31. Salinities are within the tolerable range for longfin smelt based on 10th- and 90th-percentile salinities for catches in the Smelt Larval Survey (larval) and the Bay Study (juvenile). The three water years are 2014 (labeled as "dry"; Sacramento Valley runoff = 4.29 million acre-feet [MAF] (October–March) and 7.46 MAF [total water year]), 2011 (labeled as "moderate"; Sacramento Valley runoff = 12.68 MAF (October–March) and 25.21 MAF [total water year]), and 2006 (labeled as "wet"; Sacramento Valley runoff = 18.06 MAF (October–March) and 32.09 MAF [total water year]) (all runoff values based on California Data Exchange Center [2020]). The color scale is the percentage of days in the evaluated range that met the salinity tolerance criteria (green = 100%; grey = 0% days in salinity tolerance range). Note that "tolerance" is not taken to mean physiological tolerance, but as described above, the 10th–90th percentile salinity of longfin smelt catches.

Figure 11A-7. Distribution of Larval and Juvenile Longfin Smelt Salinity Tolerance in 2014 (Labeled "Dry"), 2011 (Labeled "Moderate"), and 2006 (Labeled "Wet") Water Years

Commented [CC10]: Caveat: Bay Study does not report catch of Longfin Smelt smaller than 40 mm fork length and SLS does not efficiently collect Longfin Smelt larger than 11-12 mm fork length. This leaves as substantial gap in which fish 12 - 39 mm fork length are not accounted for. Add some language acknowledging this gap in the analysis.

Larval longfin smelt are also susceptible to entrainment at the south Delta export facilities; however, because the salvage facilities generally do not sample fish smaller than 20 mm SL, it is difficult to ascertain how many larvae are entrained (California Department of Fish and Game

2009a). Larval entrainment at the SWP is likely higher during drier periods compared to wetter periods, but overall larval entrainment risk is likely low because most longfin smelt hatch downstream of the Delta (Grimaldo et al. 2017). Overall, the effect of entrainment on the longfin smelt population has not been found to be important (Maunder et al. 2015), perhaps because a small fraction of the population is estimated to be entrained on an annual basis (California Department of Water Resources 2019:4-48, 4-55).

As previously described, longfin smelt abundance indices are positively correlated with winter-spring Delta outflow or negatively correlated with winter-spring X2 (Jassby et al. 1995; Kimmerer 2002; Kimmerer et al. 2009; Baxter et al. 2010; Mac Nally et al. 2010; Thomson et al. 2010; Mount et al. 2013; Nobriga and Rosenfield 2016) or positively correlated with general indicators of hydrological conditions (e.g., watershed runoff) (Maunder et al. 2015). Numerous mechanisms have been proposed for this relationship, including lower entrainment losses, advection to suitable habitat, reduced predation due to elevated turbidity, increased retention in favorable habitats, and access to marsh habitats that are unsuitable during drier periods.

The effect of entrainment appears to be unimportant (Maunder et al. 2015) or at least has diminished in recent decades, since longfin smelt population-level entrainment losses are low (see discussion above). Vertical retention via estuarine circulation is still hypothesized to be an important mechanism that retains age-0 longfin smelt in high-quality habitats during higher flows (Kimmerer et al. 2009), but horizontal retention in large, shallow bays is now hypothesized to be an important feature that enhances longfin smelt survival and abundance during higher flows based on new data that targeted larval and juvenile longfin smelt in shallow and marsh habitats (Grimaldo et al. 2020).

Kimmerer et al. (2009) concluded that habitat volume, as defined by salinity and water clarity, may be partly responsible for the longfin smelt abundance relationship with Delta outflow (X2), but that other mechanisms such as outflow-driven retention, are more important. With respect to habitat availability, although freshwater flow affects dynamic habitat availability, recent investigations by Grimaldo et al. (2017) of stationary habitat found that larval longfin smelt were relatively abundant in tidal marsh and shallow open waters of the low-salinity zone. This work suggests that stationary shallow habitat also provides key rearing habitat for larval longfin smelt, a situation that increased when San Pablo Bay and the south San Francisco Bay became freshwater to low-salinity habitat during wet years.

Adult longfin smelt use tidal marshes for spawning (Lewis et al. 2020). Larval longfin smelt use marsh and shoal habitats as rearing habitat (Grimaldo et al. 2017; Grimaldo et al.2020). Juvenile longfin smelt are mostly found in deeper channels, often exhibiting diel movements, presumably to reduce predation risk (Bennett et al. 2002).

Commented [CC11]: However, successful spawning only occurs in Bay tributaries in abnormally wet years. Both Lewis 2019 and Parker 2017 have been cited in this document and clearly state this.

The salinity distribution in the San Francisco Estuary is not solely dependent on Delta outflow. For example, MacWilliams et al. (2016) showed that salinity in San Francisco Bay was influenced by tributaries as well (e.g., in south San Francisco Bay). Figure 11A-7 shows the availability of habitat for larval and juvenile longfin smelt based on longfin smelt salinity

Commented [CC12]: See comment on figure 11A-7 above regarding gap in analysis and add language that acknowledges this gap.

"tolerance"[3] in water years of varying hydrology. Habitat suitability is represented by the percentage of time when a specific location is within the salinity range where 80% of larval and juvenile longfin smelt were observed in the CDFW SLS and Bay Study surveys, respectively. Note that these surveys do include the full range occupied by the species and therefore limit the scope of inference regarding distribution.

Turbidity levels have declined in the Delta (Cloern et al. 2011). Although delta smelt has often been the focus for potential effects of turbidity reduction, some of the same mechanisms appear to be as important for longfin smelt (Mahardja et al. 2017). For example, young juvenile longfin smelt distribution in spring is negatively associated with water clarity (Kimmerer et al. 2009) and trends in abundance are also negatively associated with water clarity in fall (Thomson et al. 2010). Greater water clarity could reflect changes in catchability during surveys (fish are better able to avoid trawls when water is clearer) (Latour 2016) thereby resulting in potential detection biases between bottom-fishing gear, such as the otter trawl, and midwater trawls (Rosenfield and Baxter 2007) used in surveys that suffer from mismatches in location and timing with the longfin smelt spawning season (Mahardja et al. 2017).

Longfin smelt have experienced a significant decline in food resources in recent decades (Sommer 2007). A decrease in foraging efficiency and/or the availability of suitable prey for various life stages of longfin smelt may result in reduced growth, survival, and reproductive success. This may contribute to an observed lower population abundance and a downward shift in the flow-abundance index relationship, particularly after the introduction of the invasive clam *Potamacorbula amurensis* (Feyrer et al. 2003; Nobriga and Rosenfield 2016). Other factors possibly affecting food resources include ammonium, which was found to be negatively associated with longfin smelt abundance indices in the population dynamics model of Maunder et al. (2015).

The effect of nonnative predators, such as Mississippi silversides (*Medinia beryllina*) and striped bass, has been identified as a potential threat to longfin smelt populations (Sommer 2007; Rosenfield 2010), with potentially large predation losses even if the predation rate is low (California Department of Fish and Game 2009a). A composite index of predatory fish density in Central Bay and San Pablo Bay was found to be negatively associated with trends in longfin smelt abundance in population dynamics modeling by Maunder et al. (2015). Competition also occurs with species such as age-0 striped bass or American shad (*Alosa sapidissima*) (Feyrer et al. 2003), although the effect of competition on the longfin smelt population is unknown.

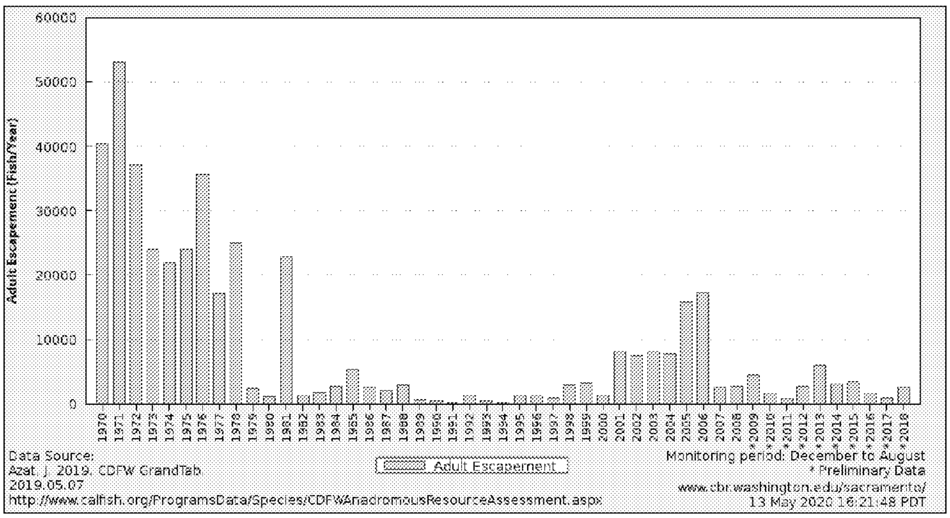
Water temperature tends to limit the upstream distribution of longfin smelt in the warmer months (Baxter et al. 2010) and spring (April–June) water temperature has been negatively correlated with survival (Maunder et al. 2015). By analogy with delta smelt (Brown et al. 2013, 2016), climate change could result in detrimental effects on longfin smelt ecology related to factors such as maturation and spawning season length and timing, as well as reduction in habitat extent; potential negative physiological effects of climate change have been demonstrated (Jeffries et al. 2016).

[3] As noted in Figure 2-5, "tolerance" is not taken to mean physiological tolerance, but as described above, the 10th–90th percentile salinity of longfin smelt catches.

11A.1.3. Winter-Run Chinook Salmon—Sacramento River ESU

11A.1.3.1. Legal Status

On May 16, 1989, the California Fish and Game Commission listed the Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) ESU as endangered under CESA due to persistent long-term declines (Figure 11A-8). The National Marine Fisheries Service (NMFS), under an emergency interim rule, listed the Sacramento River winter-run Chinook salmon ESU as a threatened species under the federal ESA in August 1989 (54 FR 32085). In 1994, NMFS reclassified the ESU as endangered due to several factors: the continued decline and increased variability of run sizes including expected weak returns due to small year classes in 1991 and 1993, and continuing threats to the species (59 FR 440). The ESU consists of one population in the mainstem of the upper Sacramento River in California's Central Valley below Keswick Dam, though efforts to reintroduce the run in Battle Creek have had success in recent years with at least 700 subadults and adults returning in 2020 as a result of juvenile releases undertaken in 2018 and 2019 (U.S. Fish and Wildlife Service 2020). NMFS reaffirmed the listing of the Sacramento River winter-run Chinook salmon ESU as endangered on June 28, 2005 (70 FR 37160), and expanded the ESU to include winter-run Chinook salmon produced by the Livingston Stone National Fish Hatchery (LSNFH) artificial propagation program in the ESU.

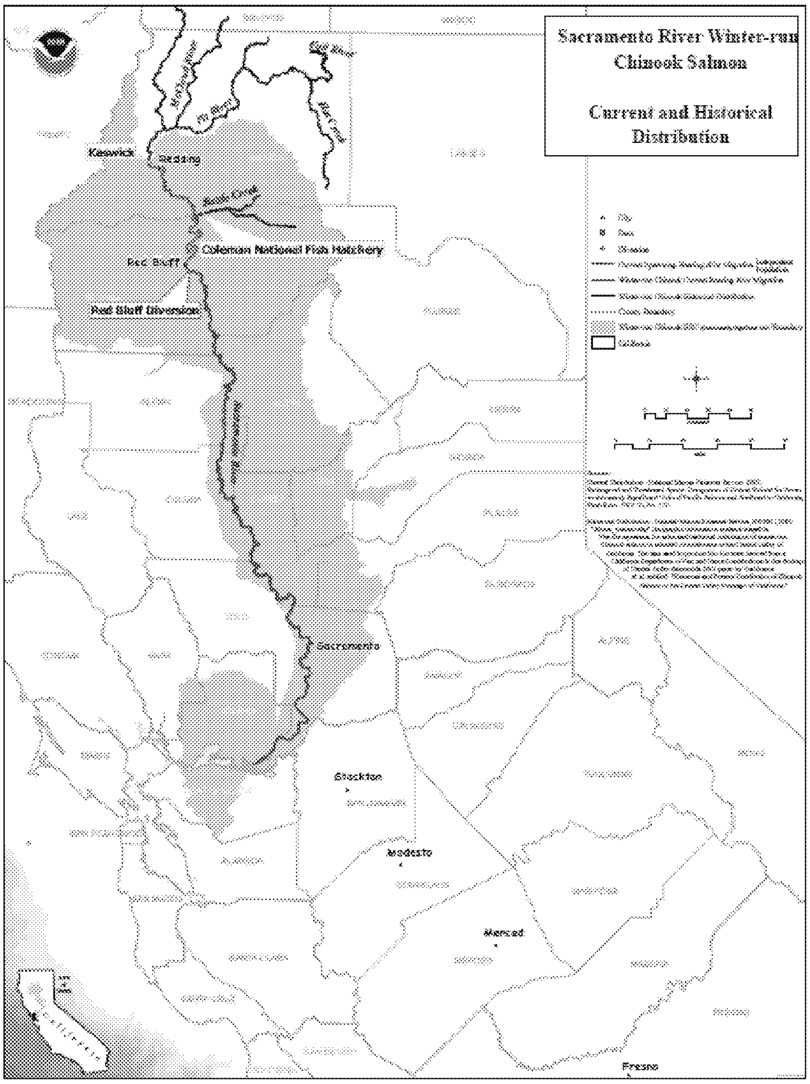


Source: Columbia Basin Research, University of Washington 2020.

Figure 11A-8. Winter-Run Chinook Salmon Adult Annual Escapement in the Central Valley, 1970–2018

11A.1.3.2. Life History and General Ecology

Adult Sacramento River winter-run Chinook salmon enter the San Francisco Bay in November to begin their spawning migration and continue upstream from December through early August to the extent of anadromy at the base of Keswick Dam (Figure 11A-9). Winter-run Chinook salmon spawn in the upper mainstem Sacramento River from mid-April through August, peaking in June and July. All known winter-run Chinook salmon production currently occurs either in the mainstem Sacramento River or LSNFH (California Department of Fish and Game 2004) although a nascent reintroduction effort in Battle Creek led to the return of at least 700 subadults and adults in 2020 (U.S. Fish and Wildlife Service 2020). Current spawning is confined to the mainstem of the Sacramento River above Red Bluff Diversion Dam (RBDD) (River Mile [RM] 243) and below Keswick Dam (RM 302) (National Marine Fisheries Service 2014). Until recent years, salmon passage was not possible above the Coleman Hatchery barrier weir located on Battle Creek.



Source: National Marine Fisheries Service 2014:12.

Figure 11A-9. Current and Historical Sacramento River Winter-Run Chinook Salmon Distribution

In addition to the Sacramento River, juveniles have also been found to rear in areas such as the lower American River, lower Feather River, Battle Creek, Mill Creek, Deer Creek, and the Delta (Phillis et al. 2018). Phillis et al. (2018) found with isotope data that 44% to 65% of surviving adults reared in nonnatal habitats as juveniles. The lower reaches of the Sacramento River, the Delta, and San Francisco Bay serve as migration corridors for both smolts and adults and are thought to serve as juvenile rearing habitat. Juvenile winter-run Chinook salmon begin to enter the Delta in October and smolt outmigration continues until April. Timing of smolt movement is thought to be strongly correlated with winter rain events that result in pulse flows in the Sacramento River (del Rosario et al. 2013). Fry and smolts are known to use the San Francisco Estuary as rearing habitat before entering the ocean (Sturrock et al. 2015). In addition to monitoring salvage of winter-run Chinook salmon at the Tracy Fish Collection Facility (TFCF) and the John E. Skinner Delta Fish Protective Facility (Skinner Fish Facility) in the south Delta, temporal occurrence of each life stage in the project area is monitored using screw trapping data in the rivers, trawls, and beach seines in the estuary and, more recently, acoustic tagging using a network of receivers located throughout the extent of their range, from Keswick Dam to the Golden Gate Bridge (e.g., Klimley et al. 2017). General life stage timing for winter-run Chinook salmon is summarized in Tables 11A-2 and 11A-3.

Commented [CC13]: Please include language that this is not an all inclusive list as there are many other streams where non-natal rearing occurs.

Table 11A-2. Temporal Occurrence of Sacramento River Winter-Run Chinook Salmon by Life Stage in the Sacramento River

Commented [CC14]: This table is not accurate. Knights Landing Sampling does not occur June-August in many years. Please make sure that table reflects when sampling is not conducted. No sampling does not indicate no presence. Additionally, when sampling has been conducted at Knights Landing in August, juvenile winter run were captured. This table needs to accurately reflect sampling timing

Relative Abundance	High (▼)			Medium (⊠)			Low (#)			None (-)		
Adults Freshwater	Month											
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River basin[a,b]	⊠	⊠	⊠	⊠	⊠	⊠	⊠	-	-	-	⊠	⊠
Upper Sacramento River spawning[c]	-	-	-	-	#	▼	▼	⊠	-	-	-	-
Juvenile Emigration	Month											
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River at Red Bluff[d]	#	#	#	-	-	-	#	⊠	⊠	⊠	⊠	⊠
Sacramento River at Knights Landing[e]	▼	⊠	#	-	-	-	-	-	-	#	⊠	▼
Sacramento trawl at Sherwood Harbor[f]	⊠	▼	▼	#	-	-	-	-	-	-	⊠	▼
Midwater trawl at Chipps Island[f]	⊠	⊠	▼	▼	#	-	-	-	-	-	-	#

Sources: [a] Yoshiyama et al. (1998); Moyle (2002) ; [b] Myers et al. (1998); [c] Williams (2006); [d] Martin et al. (2001); [e] Knights Landing Rotary Screw Trap Data, CDFW (1999-2019); [f] Delta Juvenile Fish Monitoring Program, USFWS (1995-2019), del Rosario et al. (2013)

Source: National Marine Fisheries Service 2019:67.

Table 11A-3. Temporal Occurrence of Sacramento River Winter-Run Chinook Salmon by Life Stage in the Delta

Relative Abundance	High (▼)			Medium (⊠)			Low (#)		None (-)		
Life-Stage	**Month**										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult [1]	⊠	▼	▼	▼	⊠	⊠	-	-	-	-	⊠	⊠
Juvenile [2]	#	⊠	▼	⊠	-	-	-	-	-	#	#	⊠
Salvaged [3]	⊠	▼	▼	#	#	#	-	-	-	-	-	#

[1] Adults enter the Bay November to June (Hallock and Fisher 1985) and are in spawning ground at a peak time of June to July (Vogel and Marine 1991).
[2] Juvenile presence in the Delta was determined using Delta Juvenile Fish Monitoring Program data.
[3] Months in which salvage of wild juvenile winter-run at State and Federal pumping plants occurred (National Marine Fisheries Service 2016c).

Source: National Marine Fisheries Service 2019:68.

11A.1.3.3. Distribution and Abundance

Relative distribution, abundance, and migration timing in the Delta is inferred from salvage monitoring data, the USFWS Delta Juvenile Fish Monitoring Program, the EDSM program, Sherwood and Mossdale Trawls, and the Chipps Island Trawl. Juvenile mortality in the Delta from predation by piscivorous nonnative fishes and conditions that increase risk of mortality of salmonids have been at the forefront of special studies (e.g., Demetras et al. 2016) and reviews (Grossman 2016; Lehman et al. 2019). Special studies are also underway to describe rearing in Delta bays and marshes and identify variation in quality of rearing habitat. Attachment 1 provides graphical summaries of juvenile winter-run Chinook salmon monitoring, sampling and salvage timing in the Central Valley, as produced by the Central Valley Prediction Assessment of Salmon database (SacPAS).

Commented [CC15]: These studies have been conducted, but studies have not documented that predation by non-native fishes is the lead or a major contributing factor to species declines. Please include description of study findings to highlight where increased mortality risk lies.

11A.1.3.4. Stressors

Construction of Keswick and Shasta Dams for agricultural, municipal, and industrial water supply eliminated access to approximately 200 river miles of historical holding and spawning grounds above Keswick Dam (Yoshiyama et al. 1996). Rearing habitat quantity and quality has been reduced in the upper mainstem Sacramento River as a result of channel modification and levee construction (Lindley et al. 2009). Without access to historical coldwater spawning tributaries above Shasta Dam, persistence of the winter-run Chinook salmon ESU is dependent on maintaining adequate coldwater pool in Shasta Reservoir to maintain suitable temperatures for winter-run Chinook salmon egg incubation, fry emergence, and juvenile rearing in critically dry years and extended droughts. Warm water releases during 2014 and 2015 contributed to 5.9% and 4.2% egg-to-fry survival rates to RBDD, respectively. As part of a coordinated drought response, measures taken to preserve Shasta Reservoir's coldwater pool included relaxing Wilkins Slough navigational flow requirements, relaxing D-1641 Delta water quality requirements, and delaying Settlement Contractor depletions into the fall.

Much of the historical floodplain habitat has been developed or converted, which has decreased shallow water habitat with high residence time needed for food production (Jeffres et al. 2008; Katz et al. 2017; Ahearn et al. 2006). Juveniles have access to floodplain habitat in the Yolo Bypass only during mid- to high water years, and the quantity of floodplain available for rearing during drought years is currently limited. The *Yolo Bypass Salmonid Habitat Restoration and*

Fish Passage Implementation Plan, Long-Term Operation of the Central Valley Project and State Water Project Biological Opinion Reasonable and Prudent Alternative Actions I.6.1 and I.7 (Yolo Bypass Restoration Plan) includes notching the Fremont Weir, which will provide access to floodplain habitat for juvenile salmon over a longer period (California Department of Water Resources and Reclamation 2012). Shoreline armoring and development have reduced access to floodplain rearing habitat for rearing juveniles in the Sacramento River and Delta (Boughton and Pike 2013). Floodplain availability has the potential to increase valuable prey resources and resilience in Chinook salmon (Goertler et al. 2018a, 2018b). Recent studies suggest Chinook salmon migration survival through the Yolo Bypass is comparable to that in the Sacramento River (Johnston et al. 2018; Pope et al. 2018); entry into the bypass over Fremont Weir may vary considerably even when river flow into the bypass is substantial, possibly as a function of fish cross-channel position in the Sacramento River (Pope et al. 2018); and travel time in low-flow years is more variable in the bypass than in the river (Johnston et al. 2018).

Juvenile migration corridors are affected by reverse OMR flows that are exacerbated by south Delta export facility operations at the CVP and SWP pumping plants (discussed further in Section 1.1.4, *Spring-Run Chinook Salmon*). Bidirectional flow in the Sacramento River at Georgiana Slough associated with lower Sacramento River inflow to the Delta causes juvenile Chinook salmon to enter into the interior Delta in greater numbers than with unidirectional flow at high Sacramento River inflow, which results in greater travel times and lower survival (Perry et al. 2013, 2018; see additional discussion in Section 1.1.4). Although this and other studies have typically used hatchery-origin juvenile late fall–run Chinook salmon large enough to bear acoustic tags, the general movement patterns are assumed to be representative of other races including wild-origin winter-run juveniles. The movement of juvenile Chinook salmon into Georgiana Slough reflects the combination of their river cross-sectional distribution and the splitting of water remaining in the Sacramento River and water entering Georgiana Slough as represented by the critical streakline (Hance et al. 2020). Modeling suggests south Delta exports have little influence on the proportion of Sacramento River flow entering Georgiana Slough (Cavallo et al. 2015).

Stressors thought to be of very high importance to winter-run Chinook salmon by NMFS (2014:27) include blockage of historical staging and spawning habitat by Shasta and Keswick Dams; flow fluctuations, water pollution, and water temperature impacts in the upper Sacramento River during embryo incubation; loss of juvenile rearing habitat in the form of lost natural river morphology and function, and lost riparian and instream cover; predation during juvenile rearing and outmigration; ocean harvest; and south Delta entrainment. A very recent potential threat identified for winter-run is Thiamine Deficiency Complex, possibly the result of the oceanic diet of adults transferring negative effects to juveniles (National Oceanic Atmospheric Administration Fisheries 2020a). Recent temperature modeling shows higher sensitivity to increases in water temperature because it leads to exponential increases in oxygen demand with a rise in temperature during the final weeks of egg-embryo maturation before the alevin stage (Martin et al. 2017; Anderson 2018). Recent individual-based modeling of winter-run Chinook salmon in the upper Sacramento River (Keswick Dam to RBDD) suggested that superimposition (i.e., a female salmon making a redd on top of an existing redd) and predation are the leading causes of mortality, turbidity reduces predation, and carrying capacity for larger juveniles is often reached (Dudley 2018). Further individual-based modeling suggested flow is not clearly linked to stranding risk and there is a limited effect of flow on final outmigrant count;

Commented [CC16]: Please, add language that these are the current stressors and that winter-run have been extripated from all other major tributares in the central valley and note why they have been extirpated.

the proportion of eggs being superimposed increases with increasing flow (flow increases velocity, increasing spawner energy expenditure and thereby reducing the time spent guarding the redd, allowing other spawners to make redds on top of the existing redds); and temperature has the largest effect on final juvenile outmigrant count (Dudley 2019). Note that the studies of Dudley (2018, 2019) are based on modeling and field-based surveys of factors such as superimposition to validate the modeling results have apparently not been conducted Michel (2019) found a statistically significant positive correlation between Sacramento River flow and hatchery-origin winter-run Chinook salmon smolt to adult return ratio, which was higher than the correlation with indices of marine productivity.

Climate experts predict physical changes to ocean, river, and stream environments along the U.S. West Coast that include warmer atmospheric temperatures, diminished snow pack resulting in altered stream flow volume and timing, lower late summer flows, a continued rise in stream temperatures, and increased sea-surface temperatures and ocean acidity resulting in altered marine and freshwater food-chain dynamics (Williams et al. 2016). Climate change and associated changes in water temperature, hydrology, and ocean conditions are generally expected to have substantial effects on Chinook salmon populations in the future (National Marine Fisheries Service 2014; Lindley et al. 2009). Because the winter-run Chinook salmon rely on coldwater pool in Shasta Reservoir to maintain spawning conditions in the mainstem Sacramento River, this run is particularly at risk from global warming. Drought years are predicted to occur with greater frequency in the Sacramento Valley with climate change (Purkey et al. 2008). Increased water temperature associated with lower flows favors nonnative competitors and predators that are adapted to warm water because predation rates increase in response to elevated metabolic rates of predators (Petersen and Kitchell 2001). Increasing the frequency of dry years also reduces turbidity because sediment loads are not mobilized and transported downstream. Juvenile salmon are thought to use turbid water to avoid detection by predators (Gregory and Levings 1998). Increased prevalence of SAV in the Delta reduces water flow and therefore also reduces turbidity, which has the effect of creating cover for predators and making passing salmon easier for predators to detect (Hestir et al. 2016). Finally, climate change is projected to increase the variability of ocean conditions, such as the North Pacific Gyre Oscillation, the Pacific Decadal Oscillation, and El Nino Southern Oscillations (Di Lorenzo et al. 2010). Anomalies, such as the warm water blob in the North Pacific, disrupt upwelling processes, which drive plankton production in the California Current (Leising et al. 2015). Juvenile salmon distribution is associated with oceanic plankton distribution, and mismatches in space and time that reduce access to marine prey aggregations are thought to influence early marine survival of Central Valley salmon populations (Hassrick et al. 2016). Recent studies highlight the importance of forage availability, upwelling, and thermal fronts on juvenile Chinook salmon feeding in the ocean (Sabal et al. 2020).

11A.1.4. Spring-Run Chinook Salmon—Central Valley ESU

11A.1.4.1. Legal Status

Spring-run Chinook salmon (*Oncorhynchus tshawytscha*), which were historically the most abundant run in the Central Valley, are now remnant in Butte, Mill, Deer, Antelope, and Beegum Creeks, which are all tributaries of the Sacramento River. Spring-run Chinook salmon were extirpated from most rivers by mining or dam construction (Williams 2006). Due to the small number of these populations remaining and the significant hybridization with fall-run Chinook salmon that has occurred in the mainstem of the Sacramento (Moffett 1949) and Feather Rivers (Lindley et al. 2004), spring-run Chinook salmon were listed as threatened under CESA in 1999. Native spring-run Chinook salmon have been extirpated from the San Joaquin River watershed, which represented a large portion of their historical range (see below for discussion regarding reintroduced spring-run Chinook salmon in the San Joaquin River). The Central Valley spring-run Chinook salmon ESU was listed as threatened under the ESA in 1999 because of the reduced range and small size of remaining spring-run Chinook salmon populations (64 FR 50393). On June 28, 2005, NMFS published the final hatchery listing policy (70 FR 37204) and reaffirmed the threatened status of the ESU (70 FR 37160). The ESU consists of naturally spawned spring-run Chinook salmon originating from the Sacramento River and its tributaries, and also from the Feather River Fish Hatchery Spring-Run Chinook Program (National Marine Fisheries Service 2016).

11A.1.4.2. Life History and General Ecology

Life history and habitat requirements are largely the same as those described for winter-run Chinook salmon, with differences primarily in the duration and time of year that the spring-run Chinook salmon ESU occupies freshwater habitat. Adult spring-run Chinook salmon enter fresh water as sexually immature fish between mid-February and July and remain in deep cold pools in proximity to spawning areas until late summer and early fall, when they are sexually mature and ready to spawn, depending on water temperatures (California Department of Fish and Game 1998; National Marine Fisheries Service 2009).

Spawning occurs in gravel substrate in relatively fast-moving, moderately shallow riffles or along banks with relatively high water, which promotes higher oxygen levels and reduced deposition of fines. Adult spawning conditions, incubation, and emergence from gravel is dependent on cold water temperatures (Myrick and Cech 2004). Fry emerge from gravels from November to March (Williams 2006). Post-emergent fry inhabits calm, shallow waters with fine substrates; fry depend on fallen trees, undercut banks, and overhanging riparian vegetation for refuge (Healey 1991).

Juvenile spring-run Chinook salmon can have highly variable outmigration timing based on various environmental factors (National Marine Fisheries Service 2009). Some juveniles begin outmigrating soon after emergence from gravel, whereas others oversummer and outmigrate as yearlings with the onset of intense fall storms (California Department of Fish and Game 1998). The outmigration period for spring-run Chinook salmon can extend from November to early May (National Marine Fisheries Service 2009:94) or June (California Department of Fish and Game 1998:III-9), with residency in the Delta probably lessening as the season progresses into the late spring months (California Department of Fish and Game 1998:III-9). Peak movement of yearling spring-run Chinook salmon in the Sacramento River at Knights Landing occurs in December and again in March and April (National Marine Fisheries Service 2009:94).

Juveniles prefer stream margin habitats with enough depth and velocities to provide suitable cover and foraging opportunities during rearing and downstream movement. Off-channel areas and floodplains can provide important rearing habitat. A greater availability of prey and favorable rearing conditions in floodplains increases juvenile growth rates compared with conditions in the mainstem Sacramento River, which can lead to improved survival rates during both their migration through the Delta and later in the marine environment (Sommer et al. 2001).

General life stage timing for spring-run Chinook salmon is summarized in Tables 11A-4 and 11A-5.

Table 11A-4. Temporal Occurrence of Central Valley Spring-Run Chinook Salmon by Life Stage in the Sacramento River

Relative Abundance	High (▼)								Medium (⊠)							Low (#)						None (-)		
(a) Adult Migration	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac. River Basin [a,b]	-	-	-	-	⊠	⊠	⊠	⊠	▼	▼	▼	▼	⊠	⊠	⊠	⊠	⊠	⊠	#	-	-	-	-	-
Sac. River Mainstem [b,c]	-	#	#	#	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	#	#	-	-	-	-	-	-	-	-
Adult Holding [a,b]	-	-	#	#	⊠	⊠	▼	▼	▼	▼	▼	▼	▼	▼	▼	⊠	⊠	#	#	-	-	-	-	-
Adult Spawning [a,b,c]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	#	⊠	▼	▼	⊠	#	-	-	-	-
(b) Juvenile Migration	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac. River at Red Bluff Diversion Dam [e]	▼	▼	#	#	#	#	#	#	#	-	-	-	-	-	-	-	-	-	-	-	▼	▼	▼	▼
Sac. River at Knights Landing[f]	⊠	⊠	⊠	⊠	▼	▼	▼	▼	⊠	⊠	-	-	-	-	-	-	-	-	-	-	⊠	⊠	▼	▼

Sources: [a] Yoshiyama et al. (1998); [b] Moyle (2002); [c] Myers et al. (1998); [d] Lindley et al. (2004); [e] California Department of Fish and Game (1998); [f] McReynolds et al. (2007); [g] Ward et al. (2003); [h] Snider and Titus (2000)

Note: Yearling spring-run Chinook salmon rear in their natal streams through the first summer following their birth. Downstream emigration generally occurs the following fall and winter. Most young-of-the-year spring-run Chinook salmon emigrate during the first spring after they hatch.

Source: National Marine Fisheries Service 2019:83.

Table 11A-5. Temporal Occurrence of Central Valley Spring-Run Chinook Salmon by Life Stage in the Delta

Relative Abundance	High (▼)			Medium (⊠)			Low (#)			None (-)		
Life Stage	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult [1]	⊠	▼	▼	▼	⊠	⊠	-	-	-	-	-	-
Juvenile [2]	#	#	#	▼	⊠	-	-	-	-	-	-	#
Salvaged [3]	#	#	⊠	▼	⊠	-	-	-	-	-	-	-

[1]*Adults enter the Bay late January to early February* (California Department of Fish and Game 1998) *and enter the Sacramento River in March* (Yoshiyama et al. 1998). *Adults travel to tributaries as late as July* (Lindley et al. 2004). *Spawning occurs September to October* (Moyle 2002).
[2]*Juvenile presence in the Delta based on Delta Juvenile Fish Monitoring Program data.*
[3]*Juvenile presence in the Delta based on salvage data* (National Marine Fisheries Service 2016a).

Source: National Marine Fisheries Service 2019:84.

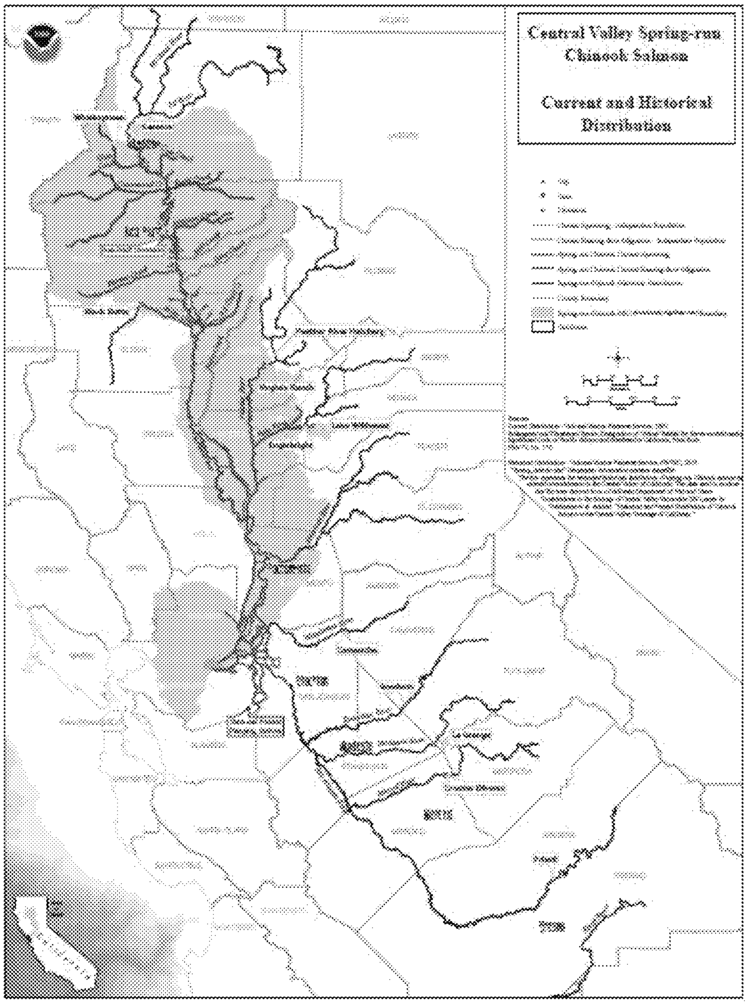
11A.1.4.3. Distribution and Abundance

Spring-run Chinook salmon were historically the dominant run of salmon in the Central Valley. The Central Valley drainage is estimated to have supported annual runs of spring-run Chinook salmon as large as 600,000 fish between the late 1880s and 1940s (California Department of Fish

Commented [CC17]: Please revise this table. It is not that there are no spring-run at Knights Landing in June, July or August, but that no sampling occurs. Presence may occur.

Commented [CC18R17]: Update table to reflect actual sampling timing, as this distorts information by failing to incorporate key information.

and Game 1998). Following construction of major dams, annual runs were estimated to be no more than 26,000 fish in the 1950s and 1960s (Azat 2012; Yoshiyama et al. 1998). Dams on the Sacramento River blocked upstream passage of spring-run Chinook salmon to historically available spawning habitat and confined them to a much smaller area of the watershed (Figure 11A-10). Today, only the mainstem Sacramento River and Butte, Mill, and Deer Creeks maintain wild spring-run Chinook salmon populations. In most years, some adults return to Antelope, Big Chico, Little Chico, Beegum, Battle, and Clear Creeks, but these populations are not considered self-sustaining. Recent surveys have documented very few spring-run Chinook salmon in the Stanislaus, Tuolumne, and Merced Rivers. Nearly 50,000 adults were counted in the San Joaquin River (Fry 1961) before the construction of Friant Dam (completed in 1942). The San Joaquin River watershed populations were essentially extirpated by the 1940s, with only small remnants of the run persisting through the 1950s in the Merced River (Hallock and Van Woert 1959; Yoshiyama et al. 1998).



Source: National Marine Fisheries Service 2014:32.

Figure 11A-10. Current and Historical Central Valley Spring-Run Chinook Salmon Distribution

Spring-run Chinook salmon populations historically occupied the headwaters of all major river systems in the Central Valley up to any natural barrier, such as an impassable waterfall (Yoshiyama et al. 1998). The Sacramento River was used by adults as a migratory corridor to spawning areas in upstream tributaries and headwater streams (California Department of Fish and Game 1998). The most complete historical record of spring-run Chinook salmon migration timing and spawning is contained in reports to the U.S. Fish Commissioners of Baird Hatchery operations on the McCloud River (California Department of Fish and Game 1998). Spring-run Chinook salmon migration in the upper Sacramento River and tributaries extended from mid-March through the end of July with a peak in late May and early June. Baird Hatchery intercepted returning adults and spawned them from mid-August through late September. Peak spawning occurred during the first half of September. The average time between the end of spring-run Chinook salmon spawning and the onset of fall-run Chinook salmon spawning at Baird Hatchery from 1888 through 1901 was 32 days.

The Central Valley spring-run Chinook salmon ESU has displayed broad fluctuations in adult abundance. Estimates of spring-run Chinook salmon in the Sacramento River and its tributaries have ranged from 1,105 in 2017 to 25,890 in 1982. This estimate does not include in-river or hatchery spawners in the lower Yuba and Feather Rivers because CDFW's GrandTab does not distinguish between fall-run Chinook salmon and spring-run Chinook salmon in these rivers.

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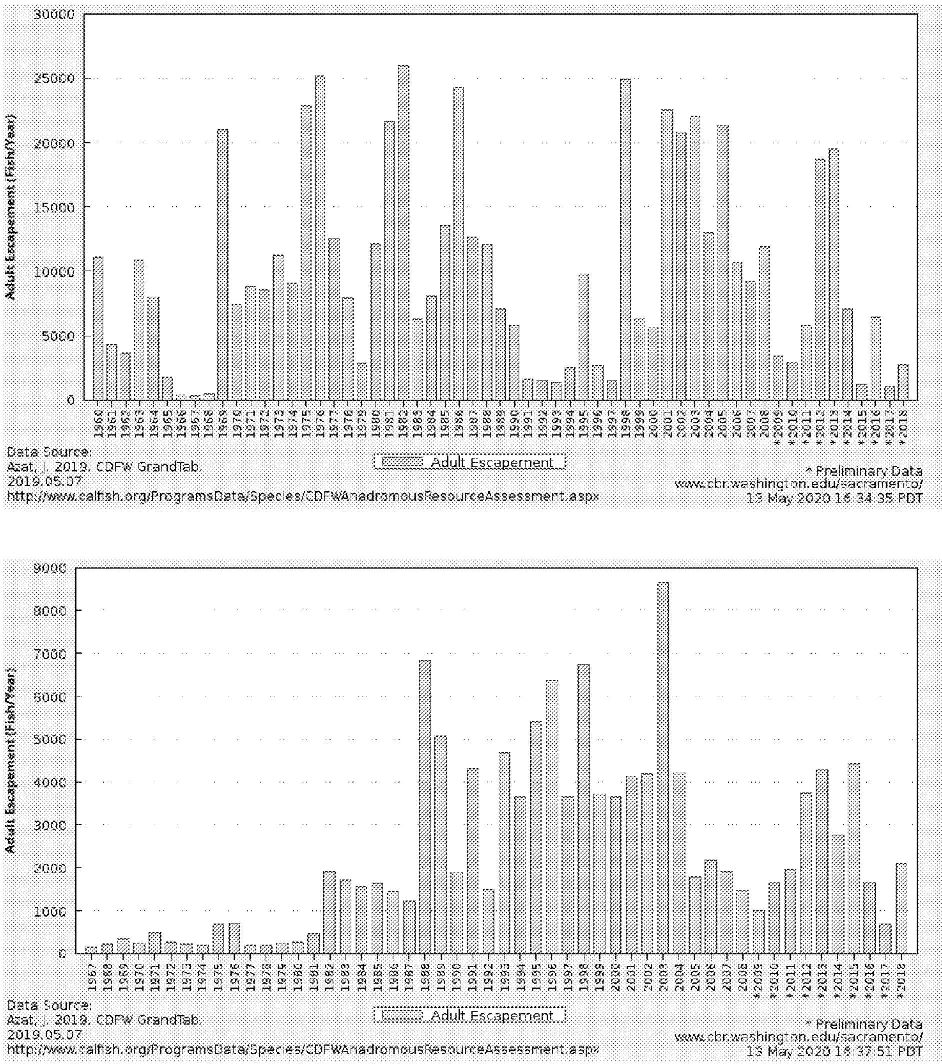
Since 1995, spring-run Chinook salmon annual run size estimates typically have been dominated by Butte Creek returns. Of the three tributaries producing naturally spawned spring-run Chinook salmon (Mill, Deer, and Butte Creeks), Butte Creek has produced an average of two-thirds of the total production over the past 10 years (California Department of Water Resources and Reclamation 2017; California Department of Fish and Wildlife 2018b). During recent years, spring-run Chinook salmon escapement estimates (excluding in-river spawners in the Yuba and Feather Rivers) have ranged from 23,696 in 2013 to 1,796 in 2017 throughout the tributaries to the Sacramento River surveyed (California Department of Fish and Wildlife 2018a).

Spring-run Chinook salmon population estimates remain low. In-river escapement was estimated to be 6,453 in 2016; 1,059 in 2017; and 2,774 in 2018 (Figure 11A-11). During these years, escapement to hatcheries ranged from 691 (2017) to 2,110 (2018) (Figure 2-9). In addition, fish monitoring is conducted throughout the year at the TFCF and the Skinner Fish Facility. Based on length-at-date criteria, during water year 2017, 26,551 wild (non-fin-clipped) juvenile spring-run and 963 hatchery (fin-clipped) spring-run Chinook salmon were observed at the TFCF and Skinner Fish Facility, and 9,487 wild juvenile spring-run and 1,010 hatchery spring-run were observed during water year 2018. Note, however, that length-at-date criteria for spring-run Chinook salmon are particularly prone to error because of the high overlap in lengths with the more abundant fall-run Chinook salmon, suggesting that actual spring-run entrainment is considerably lower than length-at-date criteria (Harvey et al. 2014). Fish monitoring is also conducted at the Rock Slough Intake by the Contra Costa Water District (CCWD). No spring-run Chinook salmon have been collected in CCWD's Fish Monitoring Program at the Rock Slough Intake since 2008.

Spring-run Chinook salmon are being reintroduced to the San Joaquin River as part of restoration efforts. In 2013, NMFS designated the Central Valley spring-run Chinook salmon reintroduced to the San Joaquin River as an experimental nonessential population in accordance with Section 10(j) of the ESA (78 FR 79622). This allows for the release of threatened California Central Valley spring-run Chinook salmon outside their current range. The population is considered an experimental, nonessential population (meaning that if the population does not survive, it will not threaten the whole ESU), because the population is geographically separate from the protected population of the same species (National Oceanic and Atmospheric Administration Fisheries 2020b). NMFS accounts for south Delta salvage of these reintroduced juveniles so that the reintroduction does not impose more than *de minimus* effects on water users (e.g., Strange 2020).



Source: Columbia Basin Research, University of Washington 2020.
Note: Vertical axis scale differs between upper and lower panel.

Figure 11A-11. Spring-Run Chinook Salmon Adult In-River (Upper) and Hatchery (Lower) Annual Escapement in the Central Valley, 1970–2018

Attachment 1 provides graphical summaries of juvenile spring-run Chinook salmon monitoring, sampling and salvage timing in the Central Valley, as produced by the Central Valley Prediction Assessment of Salmon database (SacPAS).

11A.1.4.4. Stressors

As discussed in Section 1.1.3, *Winter-Run Chinook Salmon—Sacramento River ESU*, accessible habitat for spring-run Chinook salmon has been negatively affected by inadequate flows and increased water temperatures from dam and water diversion operations on streams throughout the Sacramento River Basin. In Deer, Mill, and Antelope Creeks, losses of suitable spawning gravel, the development of deep channels and levees, pollutants and siltation from urban development, mining, and water diversions are also stressors on spring-run Chinook salmon Centra Valley ESU (National Marine Fisheries Service 2014).

The degradation and simplification of aquatic habitat in the Central Valley have reduced the resiliency of spring-run Chinook salmon to respond to additional stressors such as an extended drought, ocean harvest, and poor ocean conditions. Levee construction and maintenance projects have simplified riverine habitat and have disconnected rivers from the floodplain (National Marine Fisheries Service 2016).

Spring-run Chinook salmon migration survival and routing is linked to flow management, particularly at junctions where fish can route into the interior Delta and become entrained by the export facilities in the south Delta, as shown for acoustically tagged late fall–run Chinook salmon juveniles (e.g., Perry et al. 2018). Within the Delta, warming and stable hydrology has favored the expansion of introduced predators, which function as a source of indirect mortality by entrainment toward the export facilities.

Increased exports can influence the direction and velocity of flow in the south Delta, with high exports causing stronger reversal in flows nearer the export facilities. When Sacramento River Basin-origin fish route into the interior Delta via Georgiana Slough or the Delta Cross Channel (DCC) and enter the south Delta, entrainment from reverse flows in OMR may result in longer travel time and indirect mortality (i.e., predation) and direct mortality through loss at the export facilities, as suggested by studies of movement pathways of radio-tagged juveniles (see summary by Vogel 2011:103–105).

Flow in the south Delta tends to be more complex than in the north Delta because of the influence of radial gate operations at the head of Clifton Court Forebay and the influence of exports on OMR dynamics, as described above. This is further complicated by the presence of temporary barriers at the Head of Old River, lower inflow from the San Joaquin River, and greater tidal excursion. Highly channelized levee characteristics maintained for water conveyance diminish the potential for the Delta to function as rearing habitat for juvenile salmonids.

As discussed for winter-run Chinook salmon, juveniles have access to floodplain habitat in the Yolo Bypass only during mid- to high water years, and the quantity of floodplain available for rearing during drought years is currently limited but notching of Fremont Weir with The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Implementation Plan will provide access to floodplain habitat for juvenile salmon over a longer period (California Department of Water Resources and Reclamation 2012).

Recent work by the Collaborative Adaptive Management Team's (CAMT) Salmonid Scoping Team (SST) suggests that high correlations between inflows and exports make it difficult to evaluate their effects on salmon survival independently using statistical methods (Buchanan et al. 2018). There are very few observations of salmon survival at high export rates, which makes it difficult to determine if there is a relationship, but most acoustic tagging studies show support for a positive relationship between flow and survival (Perry et al. 2010, 2018; Michel et al. 2012). A key conclusion of the SST (2017:ES-5–ES-7) is that water export operations contribute to salmonid mortality in the Delta via direct mortality at the facilities, but direct mortality does not account for the majority of the mortality experienced in the Delta; the mechanism and magnitude of indirect effects of water project operations on Delta mortality outside the facilities is uncertain.

Temporary barriers are installed by DWR in the south Delta for the purpose of stabilizing and increasing water surface elevations to facilitate agriculture irrigation. A temporary barrier at the Head of Old River is designed to reduce movement of migrating salmonids into Old River, which would include the experimentally reintroduced spring-run Chinook salmon as part of the San Joaquin River Restoration Program. Conceptual models identified by the CAMT's SST salmon scoping team predict that survival to Chipps Island will be higher with the barriers in place by forcing salmon to avoid the interior Delta. Changes in flows resulting from the barrier installation are also expected to benefit salmonid route selection and migration rates, although localized predation around the barriers themselves is expected to increase.

Results of Chinook salmon survival and migration studies in the Sacramento and San Joaquin Rivers and Delta suggest that relationships between river flow and migration rates are more complicated than in the Pacific Northwest, where flow is more unidirectional (Zabel et al. 1998; Smith et al. 2002).. Higher survival of acoustically tagged wild-origin spring-run Chinook salmon smolts from Mill Creek was observed in a wet year (2017) compared to historic drought conditions in 2015 (Notch et al. 2020). Cordoleani et al. (2018, 2019) found higher survival for wild-origin smolts (spring-run and fall-run) in 2016 than 2015 correlated with greater flow in 2016 than 2015, and they found higher survival in 2017 than the prior two years correlated with greater flow in 2017 than those years. Cordoleani et al. (2019:1) summarized their results to note that release date and Delta flow were significantly correlated with survival rates and that the results were largely driven by 2017 data, for which fish were released a month later than those in 2015 and 2016, and Delta flow and smolt survival were significantly higher than in the previous two years. They also noted that more tagging years including measurements of more potentially important environmental factors (such as turbidity) are required to robustly identify the influence of various factors on Butte Creek spring-run Chinook outmigrant smolt survival (Cordoleani et al. 2019:1).

As previously described in the winter-run Chinook salmon account, routing down Georgiana Slough has also been shown to increase when unidirectional flow gives way to tidal influences and flow becomes more bidirectional, particularly below 20,000 cfs at Freeport (Perry et al. 2018). There is a positive correlation between through-Delta survival of large acoustically tagged late fall–run Chinook salmon and Sacramento River flow entering the Delta (Perry et al. 2018).

Historically, wherever spring-run Chinook salmon and fall-run Chinook salmon populations overlapped, they were temporally segregated and genetic integrity was maintained. However, because of difficulties associated with holding adults over the summer in the Feather River, fish were left in the river until spawning, which presumably led to mixing with fall-run Chinook salmon in the hatchery (Williams 2006:33). Loss of life history diversity limits a species' ability to deal with environmental change, such as timing of ocean productivity, and leads to increased vulnerability through a weakened portfolio effect (Carlson and Satterthwaite 2011).

Climate change may pose similar threats to spring-run Chinook salmon as were described for winter-run Chinook salmon, with increasingly high water temperatures and changes to ocean conditions being limiting factors. Like winter-run Chinook salmon, spring-run Chinook salmon are particularly vulnerable to these limiting factors because their life history is adapted to streams with snowmelt runoff, with relatively dependable, sustained high flows that allow fish to ascend to high enough elevations where water temperatures remain tolerably cool through the summer. Snowmelt runoff is relatively more important in the San Joaquin River and its major tributaries, where historically spring-run Chinook salmon were more abundant. Recoveries of coded wire tags and genetic samples suggest that spring-run Chinook salmon have a more northerly ocean distribution and mature later than winter-run Chinook salmon (Satterthwaite et al. 2018). Therefore, climate-induced changes in ocean prey distributions that limit access to coastal prey may disproportionately affect spring-run Chinook salmon that rely on marine resources to a greater degree in order to mature.

11A.1.5. Fall-Run/Late Fall–Run Chinook Salmon—Central Valley ESU

11A.1.5.1. Legal Status

The Central Valley fall- and late fall–run Chinook salmon (*Oncorhynchus tshawytscha*) ESU includes all naturally spawned populations of fall- and late fall–run Chinook salmon in the Sacramento and San Joaquin River basins and their tributaries east of Carquinez Strait, California (64 FR 50394) (Figure 2A.5-1 and Figure 2A.5-2, respectively). On September 16, 1999, after reviewing the best available scientific and commercial information, the NMFS determined that listing Central Valley fall- and late fall–run Chinook salmon was not warranted. On April 15, 2004, the Central Valley fall- and late fall–run Chinook salmon ESU was identified by NMFS as a Species of Concern (69 FR 19975). The rationale for this determination included the following items.

- The average 5-year escapement was above 190,000 fish from natural production, although 20–40% of these natural spawners were of hatchery origin.
- Long-term trends were generally stable or increasing, but it was unclear if natural populations were self-sustaining because of the influence of hatchery production.
- Short-term trends for San Joaquin River tributaries were stable or increasing.
- Concerns remained over impacts from high hatchery production and harvest levels, although ocean and freshwater harvest rates have been recently reduced.
- Approximately 40 to 50% of spawning and rearing habitats have been lost or degraded.

In a subsequent 5-year status review of California ESUs (76 FR 50447), NMFS concluded that several Chinook salmon populations identified through genetic sampling, should be included in the Central Valley fall- and late fall–run Chinook salmon ESU (Williams et al. 2011). This includes populations in the Napa and Guadalupe Rivers, along with future populations found in basins inclusive of the San Francisco/San Pablo Bay complex, which express a fall-run timing,

The Central Valley fall- and late fall-run Chinook salmon ESU is not listed under CESA. Fall- and late fall–run Chinook salmon is designated as a California species of special concern (SSC) (Moyle et al. 1995).

11A.1.5.2. Life History and General Ecology

Adult fall-run Chinook salmon migrate through the Delta and into Central Valley rivers from June through December. Adult late fall–run Chinook salmon migrate through the Delta and into the Sacramento River from October through April. Adult Central Valley fall-run and late fall–run Chinook salmon migrating into the Sacramento River and its tributaries primarily use the western and northern portions of the Delta, whereas adults entering the San Joaquin River system to spawn use the western, central, and southern Delta as a migration pathway.

Most fall-run Chinook salmon fry rear in fresh water from December through June, with outmigration as smolts occurring primarily from January through June. In general, fall-run Chinook salmon fry abundance in the Delta increases following high winter flows. Smolts that arrive in the estuary after rearing upstream migrate quickly through the Delta and Suisun and San Pablo Bays. A small number of juvenile fall-run Chinook salmon spend over a year in fresh water and outmigrate as yearling smolts the following November through April. Late fall–run fry rear in fresh water from April through the following April and outmigrate as smolts from October through February (Snider and Titus 2000). Juvenile Chinook salmon were found to spend about 40 days migrating through the Delta to the mouth of San Francisco Bay (MacFarlane and Norton 2002).

For late fall–run Chinook salmon generally, peak spawning time is typically from October to November, but can continue through December and into January. Juveniles typically emerge from the gravel in December through March and rear in fresh water for 1 to 7 months (Moyle et al. 2015:543–552). Fall- and late fall–run Chinook salmon generally outmigrate as age-0 fish, although some (8.3% in 2011) late fall–run Chinook salmon juveniles outmigrate in their second year. Outmigration is generally from April to June for late fall–run and November to May for fall-run Chinook salmon. During the most recent year for which there are records (2011), the peak outmigration for fall-run was in late December and the late fall–run peak outmigration was from mid-April to mid-May (Schraml et al. 2018).

Juvenile fall-run and late fall–run Chinook salmon migrating through the Delta toward the Pacific Ocean use the Delta, Suisun Marsh, and the Yolo Bypass for rearing to varying degrees, depending on their life stage (fry versus juvenile), size, river flows, and time of year. Movement of juvenile Chinook salmon in the estuarine environment is driven by the interaction between tidally influenced saltwater intrusion through San Francisco Bay and freshwater outflow from the Sacramento and San Joaquin Rivers (Healey 1991).

The fall-run Chinook salmon has an ocean-maturing type of life history adapted for spawning in lowland reaches of big rivers, including the mainstem Sacramento River. The late fall–run Chinook salmon has a stream-maturing type of life history (Moyle 2002). Similar to spring-run, adult late fall–run Chinook salmon typically hold in the river for 1 to 3 months before spawning, while fall-run Chinook salmon generally spawn shortly after entering fresh water. Fall-run Chinook salmon migrate upstream past RBDD on the Sacramento River between July and December, typically spawning in upstream reaches from October through March. Late fall–run Chinook salmon migrate upstream past RBDD from August to March and spawn from January to April (National Marine Fisheries Service 2009b; Tehama-Colusa Canal Authority 2008). The majority of young fall-run Chinook salmon migrate to the ocean during the first few months following emergence, although some may remain in fresh water and migrate as yearlings. Late fall–run Chinook salmon juveniles typically enter the ocean after 7 to 13 months of rearing in fresh water, at 150- to 170-mm in fork length, considerably larger and older than fall-run Chinook salmon (Moyle 2002). The primary spawning area used by fall-run and late fall–run Chinook salmon in the Sacramento River is the area from Keswick Dam downstream to RBDD. Spawning densities for all of the Chinook salmon runs are highest in this reach, but fall-run Chinook salmon generally spawn farther downstream in the reach than the other Chinook salmon runs (Gard 2013).

Based on carcass surveys and juvenile outmigration trapping, fall-run Chinook salmon typically spawn in Clear Creek from late September through early December, and peak outmigration of juveniles occurs in January and February (Earley et al. 2013). Beginning in 1995, restoration actions in Clear Creek have had a clear effect on fall-run Chinook salmon populations. The combined actions have contributed to a near fourfold increase in escapement of fall-run Chinook salmon to Clear Creek (population estimates average 1,749 from 1967 to 1991 and 7,333 from 1992 to 2017) (Clear Creek Technical Team 2018).

Feather River fall-run Chinook salmon are partially hybridized with Feather River spring-run Chinook salmon, but they largely maintain separate fall and spring upstream adult migrations. Fall-run adults return to the Feather River as sexually mature fish and spawn from September into December. The fall-run spawning period begins after the spring-run spawning period, but the spawning periods overlap considerably, leading to superimposition of spring-run redds by subsequently spawning fall-run adults. For this reason, a separation weir has been proposed to physically separate Central Valley spring-run and fall-run Chinook salmon in the river. Suitable water temperatures for Chinook salmon spawning in the Feather River are 42°F (5.5°C) to 58°F (14.4°C). Incubation may extend through March with suitable incubation temperatures between 48°F (8.9°C) and 58°F (14.4°C) (California Department of Water Resources 2007). Studies have confirmed that juvenile rearing and probably some adult spawning are associated with secondary channels within the Feather River low-flow channel. The lower velocities, smaller substrate size, and greater amount of cover (compared to the main river channel) likely make these side channels more suitable for juvenile Chinook salmon rearing. Currently, this type of habitat comprises less than 1% of the available habitat in the low-flow channel (California Department of Water Resources 2007). Juvenile Chinook salmon in the Feather River have been reported to outmigrate as young-of-the-year (YOY) (Seesholtz et al. 2004) and most appear to migrate out of the Feather River within days of emergence (National Marine Fisheries Service 2016). Juvenile outmigration from the Feather River is generally from mid-November through June, with peak outmigration occurring from January through March (National Marine Fisheries Service 2016).

The American River historically supported fall-run and perhaps late fall–run Chinook salmon (Williams 2001). Both natural-origin and hatchery-produced Chinook salmon spawn in the lower American River. An analysis by Palmer-Zwahlen et al. (2018) found that constant fractional marking results from 2013 show that approximately 86% of the fall-run Chinook salmon spawners returning to Nimbus Hatchery were hatchery-origin. Further, 71% of fall-run Chinook salmon recorded at the Hatchery Weir and 65% of carcasses were identified as hatchery fish. Adult fall-run Chinook salmon enter the lower American River from about mid-September through January, with peak migration from approximately mid-October through December (Williams 2001). Spawning in the American River occurs from about mid-October through early February, with peak spawning from mid-October through December. Chinook salmon spawning occurs within an 18-mile (29 km) stretch from Paradise Beach to Nimbus Dam; however, most spawning occurs in the uppermost 3 miles (4.8 km) (California Department of Fish and Game 2012a). Chinook salmon egg and alevin incubation occurs in the lower American River from about mid-October through April. This period varies widely from year to year, although most incubation occurs from about mid-October through January. Chinook salmon juveniles rear in the American River from about January to May (Snider and Titus 1995, 2002). Most Chinook Salmon outmigrate from the lower American River as fry between December and July; outmigration peaks February to March (Snider and Titus 2002; Pacific States Marine Fisheries Commission 2014).

In the Stanislaus River, data collected by private fishery consultants, nonprofit organizations, and CDFW demonstrate that the majority of fall-run Chinook salmon adults migrate upstream from late September through December with peak migration from late October through early November. Most Chinook salmon spawning occurs between Riverbank (RM 33, RKM 53.1) and Goodwin Dam (RM 58.4, RKM 94) (Reclamation 2012). Based on redd surveys conducted by FISHBIO, peak spawning typically occurs in November with roughly 7% of spawning occurring prior to November 1, and 2% prior to October 15. The few redds created during late September and early October are typically in the reach just below Goodwin Dam. By late October, the amount of spawning in downstream locations increases as water temperatures decrease, and the median redd location is typically around Knights Ferry (State Water Resources Control Board 2015). In 2010, over 20% of the fall-run Chinook salmon observed passing the Stanislaus River weir had adipose fin clips, indicating the presence of a coded wire tag in their snout. Since there is no hatchery on the Stanislaus River and no hatchery releases into this tributary have occurred since 2006, it is apparent that straying from other rivers is occurring (FISHBIO Environmental 2010). Rotary screw trap data indicate that about 99% of salmon juveniles migrate out of the Stanislaus River from January through May (Stanislaus River Fish Group 2004). Fry migration generally occurs from January through March, followed by smolt migration from April through May (Reclamation 2012). Watry et al. (2012) found that in both 2010 and 2011, peak passage during the pre-smolt period generally corresponded with flow pulses. Zeug et al. (2014) examined 14 years of rotary screw trap data on the lower Stanislaus River and found a strong positive response in survival, the proportion of pre-smolt migrants and the size of smolts when cumulative flow and flow variance were greater. From the data, they concluded that periods of high discharge in combination with high discharge variance are important for successful outmigration as well as migrant size and the maintenance of diverse migration strategies.

General life stage timing for Central Valley fall-run and late fall–run Chinook salmon is summarized in Tables 11A-6 and 11A-7.

Table 11A-6. Temporal Occurrence of Central Valley Fall-Run Chinook Salmon by Life Stage

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult												
Delta[1]												
Sacramento River Basin[2]												
San Joaquin River[2]												
Juvenile												
Sacramento River at Red Bluff[3]												
Delta (beach seine)[4]												
Mossdale (trawl)[4]												
West Sacramento River (trawl)[4]												
Chipps Island (trawl)[4]												
Knights Landing (trap)[5]												
Relative Abundance:	= High				= Medium				= Low			

Note: Darker shades indicate months of greatest relative abundance.

Sources:

[1] State Water Project and Federal Water Project fish salvage data 1981–1988.

[2] Yoshiyama et al. 1998; Moyle 2002; Vogel and Marine 1991.

[3] Martin et al. 2001.

[4] U.S. Fish and Wildlife Service 2001.

[5] Snider and Titus 2000.

Table 11A-7. Temporal Occurrence of Central Valley Late Fall–Run Chinook Salmon by Life Stage.

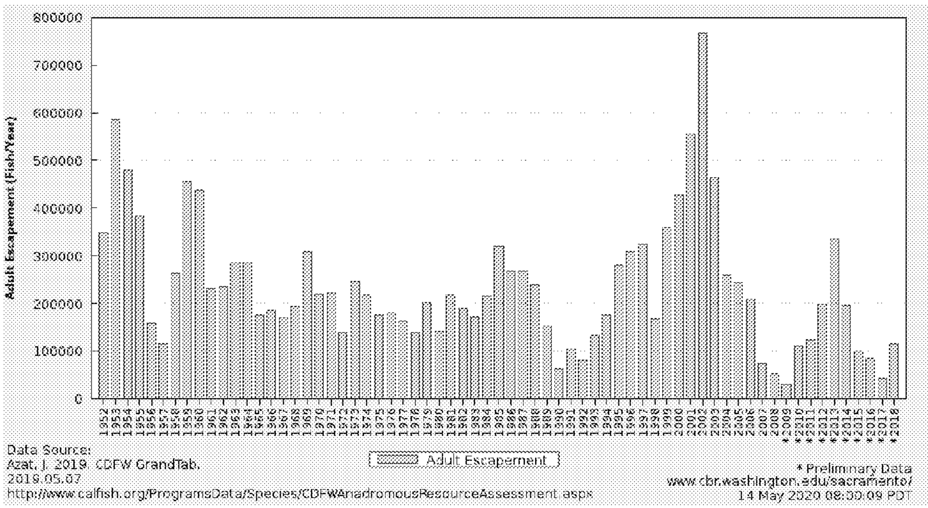
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult												
Delta[1]												
Sacramento River Basin[2]												
Juvenile												
Sacramento River at Red Bluff[3]												
West Sacramento River (trawl)[4]												
Delta (beach seine)[4]												
Chipps Island (trawl)[4]												
Knights Landing (trap)[5]												
Relative Abundance:	= High				= Medium				= Low			

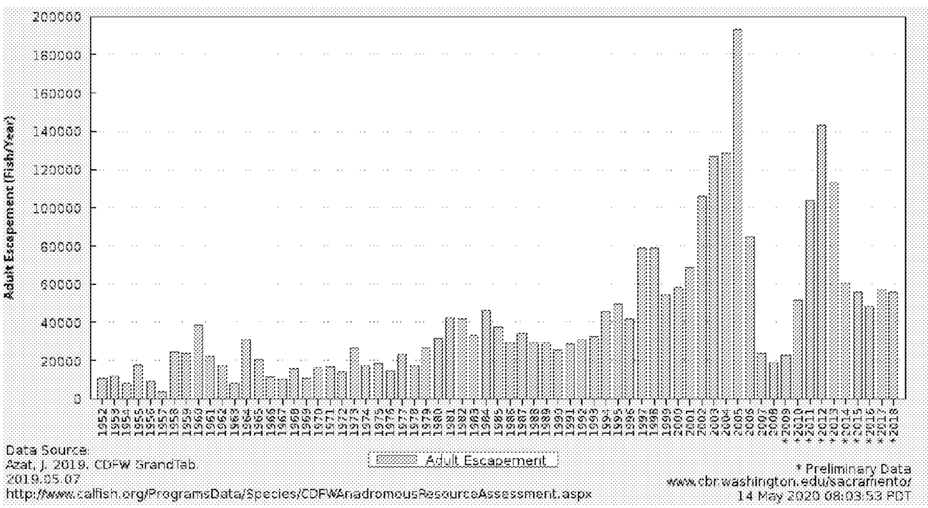
Note: Darker shades indicate months of greatest relative abundance.
Sources:
[1] Moyle 2002.
[2] Yoshiyama et al. 1998; Moyle 2002; Vogel and Marine 1991.
[3] Martin et al. 2001.
[4] U.S. Fish and Wildlife Service 2001.
[5] Snider and Titus 2000.

11A.1.5.3. Distribution and Abundance

Annual fall-run and late fall–run Chinook salmon escapement to the Sacramento River and its tributaries has generally been lower in the last decade than historically, following peaks in the late 1990s to early 2000s (California Department of Fish and Wildlife 2018a) (Figures 11A-12 and 11A-13). Hatchery fall-run escapement was relatively consistent at approximately 50,000–60,000 fish during 2014–2018 (Figure 11A-12), with hatchery escapement of late fall–run in recent years estimated to be greater than in-river numbers (Figure 11A-13). Studies have suggested that hatchery-produced Chinook salmon may contribute large (approximately 90%) proportions of Chinook salmon to the mixed-stock fishery along the central California coast (Barnett-Johnson et al. 2007). Sturrock et al. (2019) found that transport distance of hatchery-origin juvenile Chinook salmon to release sites had increased over time (particularly during droughts) and was strongly associated with straying rate (averaging 0–9% compared to 7–89% for salmon released on site versus in the bay upstream of Golden Gate Bridge, respectively), increasing the effects of hatchery releases on natural spawners. The authors suggested that decreasing variation in release location and timing could reduce spatiotemporal buffering, narrowing ocean arrival timings and increasing risk of mismatch with peak prey production. The percentage of hatchery-origin fish released downstream of the Delta has been variable over time. For example, from the mid-1980s to 2012, the proportion of hatchery fall-run Chinook salmon juveniles released downstream of the Delta by state and federal hatcheries varied from around

20% to 60% (Huber and Carlson 2015). Similarly, from 2013 to 2017, the percentage of juvenile fall-run and spring-run Chinook salmon released by state Central Valley hatcheries downstream of the Delta varied between 24% (2016) and 60% (2013) (California Department of Fish and Wildlife 2018c).

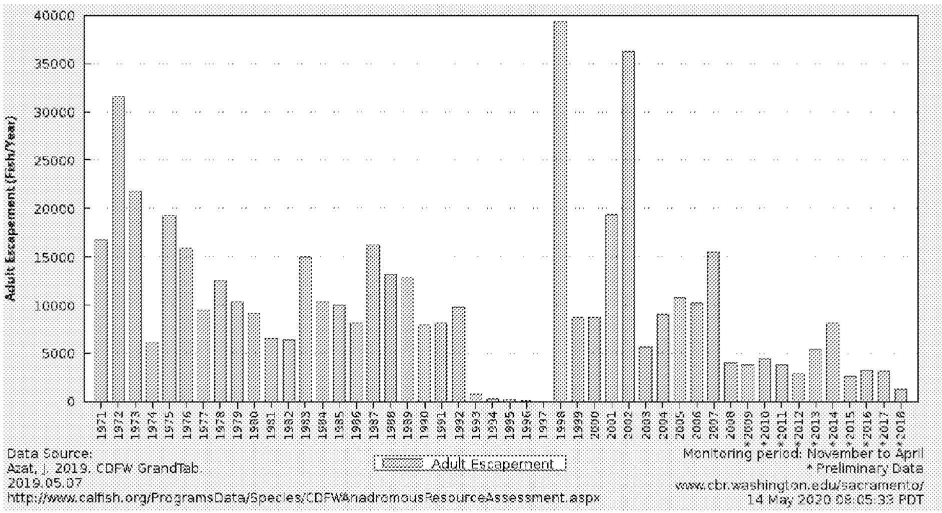


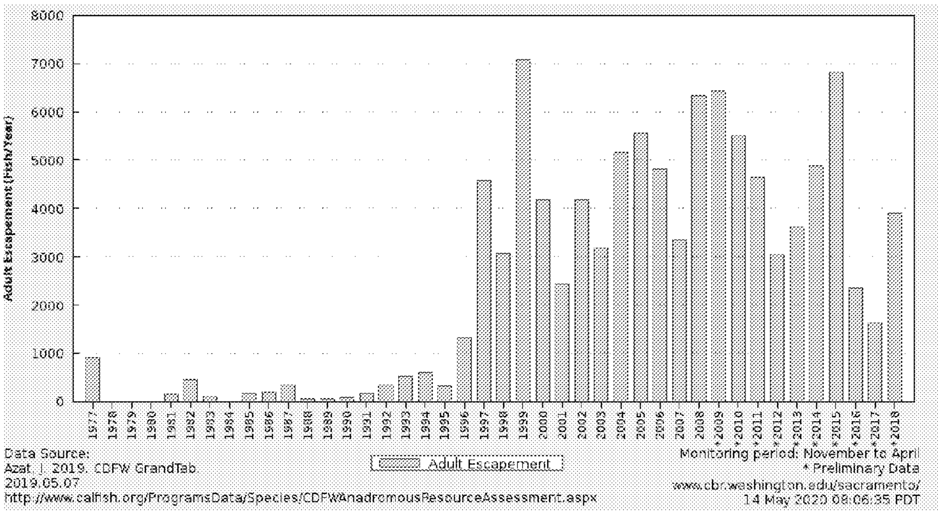


Source: Columbia Basin Research, University of Washington 2020.

Note: Vertical axis scale differs between upper and lower panel.

Figure 11A-12. Fall-Run Chinook Salmon Adult In-River (Upper) and Hatchery (Lower) Annual Escapement in the Central Valley, 1970–2018





Source: Columbia Basin Research, University of Washington 2020.
Note: Vertical axis scale differs between upper and lower panel.

Figure 11A-13. Late Fall–Run Chinook Salmon Adult In-River (Upper) and Hatchery (Lower) Annual Escapement in the Central Valley, 1970–2018

Attachment 1 provides graphical summaries of juvenile fall-run and late fall-run Chinook salmon monitoring, sampling and salvage timing in the Central Valley, as produced by the Central Valley Prediction Assessment of Salmon database (SacPAS).

11A.1.5.4. Stressors

Factors affecting fall-run and late fall–run Chinook salmon are generally similar to those discussed above for winter-run and spring-run Chinook salmon. Recent life cycle modeling for fall-run suggested that among the processes examined, the most influential were temperature experienced during egg incubation, freshwater flow during juvenile outmigration, and environmentally mediated predation during early marine residence (Friedman et al. 2019).[4] Michel (2019) found a statistically significant positive correlation between Sacramento River flow and hatchery-origin fall-run and late fall–run Chinook salmon smolt to adult return ratio, which was higher than the correlation with indices of marine productivity.

Central Valley fall-run and late fall–run Chinook salmon pass through the Delta as adults migrating upstream and juveniles outmigrating downstream. Adult fall-run and late fall–run Chinook salmon migrating through the Delta must navigate the many channels and avoid direct sources of mortality and minimize exposure to sources of nonlethal stress. Additionally, outmigrating juveniles are subject to predation and entrainment in the project export facilities and smaller diversions.

Results of mark-recapture studies conducted using juvenile Chinook salmon released into both the Sacramento and San Joaquin Rivers have shown high mortality during passage downstream through the rivers and Delta (Brandes and McLain 2001; Newman and Rice 2002; Buchanan et al. 2013). Juvenile salmon migrating from the San Joaquin River generally experience greater mortality than fish outmigrating from the Sacramento River. In years when spring flows are reduced and water temperatures are increased, mortality is typically higher in both rivers. Closing the DCC gates and installation of the Head of Old River Fish Control Gate to reduce the movement of juvenile salmon into the south Delta from the Sacramento and San Joaquin Rivers, respectively, may contribute to improved survival of outmigrating juvenile Chinook salmon from these watersheds.

Although not directly comparable to these previous coded wire tag studies in the San Joaquin River, Buchanan et al. (2013, 2015) found that survival of acoustically tagged hatchery-origin (Feather River) juvenile Chinook salmon was either not statistically different between routes (2009) or was higher through the south Delta via the Old River route than via the San Joaquin River (2010). Additionally, most fish in the Old River that survived to the end of the Delta had been salvaged from the federal water export facility on the Old River and trucked around the remainder of the Delta (Buchanan et al. 2013; San Joaquin River Group Authority 2013). Buchanan et al. (2013) indicated that the differences in their results compared to past coded wire tag studies may reflect that an alternative nonphysical barrier was being used during their investigation to examine its ability to keep fish out of the Old River instead of the Head of Old River Fish Control Gate, which is a physical barrier that reduces not only the number of fish, but also the majority of flows, from entering the Old River. Nonphysical barriers may deprive smolts routed to the San Joaquin River of the increased flows needed for improved survival and may have created habitat for increased predation at the site (Buchanan et al. 2013).

[4] The most influential environmental processes were represented in the model by daily temperature at RBDD October 1–December 1; median February flow at Colusa; and an annual index of predation by common murre at Southeast Farallon Island.

Mesick (2001) surmised that when water exports are high relative to San Joaquin River flows, little, if any, San Joaquin River water reaches San Francisco Bay, where it may be needed to help attract the salmon back to the Stanislaus River. During mid-October from 1987 through 1989, when export rates exceeded 400% of Vernalis flows, Mesick (2001) found that straying rates ranged between 11% and 17%. In contrast, straying rates were estimated to be less than 3% when Delta export rates were less than about 300% of San Joaquin River flow at Vernalis during mid-October. Marston et al. (2012) provided statistical relationships between straying rate and flow and exports, concluding that the results indicate that flow is the primary factor but that empirical data indicate that little if any pulse flow leaves the Delta when south Delta exports are elevated; they hypothesized that exports in combination with pulse flows may explain straying. Peterson et al. (2017) studied environmental factors and management actions influencing upstream migration patterns of adult fall-run Chinook in the Stanislaus River. They found that the Head of Old River rock barrier had positive and consistent influences on daily counts in the years it was installed and that managed pulse flows resulted in immediate increases in daily passages, but the response was brief and represented a small portion of the total run.

One of the limiting factors for juvenile fall-run Chinook salmon from the Stanislaus River and elsewhere in the San Joaquin River Basin appears to be the high rates of mortality for juveniles migrating through dredged channels in the Delta, particularly the Stockton Deep Water Ship Channel (Newcomb and Pierce 2010). Pickard et al. (1982) reported that the survival of juvenile fish in the ship channel is highest during flood flows or when a barrier is placed at the Head of Old River that more than doubles the flow in the ship channel. As noted in the account for spring-run Chinook salmon, the CAMT SST work suggests that high correlations between inflows and exports make it difficult to evaluate their effects on salmon survival independently using statistical methods. The Stanislaus River Fish Group (SRFG) (2004) noted that escapement is also directly correlated with springtime flows, when each brood migrates downstream as smolts. However, the cause of the mortality in the ship channel has not been studied. Buchanan and Skalski (2019) found through-Delta survival of acoustically tagged fall-run Chinook salmon smolts was positively associated with Old River flow in the strongly tidal interior Delta but not with higher San Joaquin River flow either entering the Delta from upstream or in the Delta near the riverine/tidal interface. Survival in the upstream, more riverine region of the Delta was positively associated with San Joaquin River flow measured at the riverine/tidal interface and average net flow in the interior Delta, which the authors suggested provided evidence of different mechanisms driving survival in the upstream versus downstream reaches of the Delta (Buchanan and Skalski 2019). A large portion of juvenile fall-run Chinook salmon surviving through the Delta from the San Joaquin River Basin move through the CVP salvage facility (Buchanan et al. 2018).

Dredging for gravel and gold, regulated flows, and the diking of floodplains for agriculture have substantially limited the availability of spawning and rearing habitat for fall-run Chinook salmon in the Stanislaus River. Reclamation has conducted spawning gravel augmentation to improve spawning and rearing habitats in the Stanislaus River reach between Goodwin Dam and Knights Ferry in most years since 1999. The dredged areas also contain an abundance of large predatory fish, although SRFG concluded that there is uncertainty about whether predation is a substantial source of mortality for juvenile salmon. SRFG (2004) also concluded that water diversions for urban and agricultural use in all three San Joaquin River tributaries, which reduce flows and potentially result in unsuitably warm water temperatures during spring and fall, affecting fall-run

Chinook salmon juvenile rearing and adult and juvenile migration in the lower San Joaquin River and Delta.

In the Delta, tidal and floodplain habitat areas provide important rearing habitat for foraging juvenile salmonids, including fall-run Chinook salmon. Studies have shown that juvenile salmon may spend 2 to 3 months rearing in these habitat areas, and habitat losses resulting from land reclamation and levee construction are considered to be major stressors (Williams 2010). The channeled, leveed, and riprapped river reaches and sloughs common in the Delta typically have low habitat diversity and complexity, have low abundance of food organisms, and offer little protection from predation by fish and birds.

11A.1.6. Steelhead—California Central Valley DPS

11A.1.6.1. Legal Status

The California Central Valley (CCV) steelhead (*Oncorhynchus mykiss irideus*) ESU was listed as a threatened species under ESA on March 19, 1998. This ESU includes all naturally spawned populations of steelhead in the Sacramento and San Joaquin Rivers and their tributaries, including Bay-Delta (63 FR 13347). Steelhead from San Francisco and San Pablo Bays and their tributaries were excluded from this listing but were included in the Central California Coast DPS, which is also listed as threatened under the ESA. On June 14, 2004, NMFS proposed that all west coast steelhead be reclassified from ESUs to DPSs and proposed to retain CCV steelhead as threatened (69 FR 33102). On January 5, 2006, after reviewing the best available scientific and commercial information, NMFS issued its final decision to retain the status of CCV steelhead as a threatened DPS (71 FR 834). This decision included the Coleman National Fish Hatchery and Feather River Hatchery steelhead populations. These populations were previously included in the ESU but were not deemed essential for conservation and thus not part of the listed steelhead population.

On August 15, 2011, after conducting a 5-year review, NMFS issued its findings concerning the status of the CCV steelhead DPS (76 FR 50447). Based on new information, NMFS determined that the status of the DPS was worse than the previous review (Good et al. 2005), and the DPS faces an even greater extinction risk. This review found that the decline in natural production of steelhead had continued unabated since the 2005 status review, and the level of hatchery influence on the DPS corresponds to a moderate risk of extinction.

CCV steelhead is not listed under CESA but is designated as a California SSC.

11A.1.6.2. Life History and General Ecology

Upstream migration of CCV steelhead begins with estuarine entry from the ocean as early as July and continues through February or March in most years (McEwan and Jackson 1996; National Marine Fisheries Service 2009a). Populations of steelhead occur primarily within the watersheds of the Sacramento River Basin, although not exclusively. Steelhead can spawn more than once, with postspawn adults (typically females) potentially moving back downstream through the Delta after completion of spawning in their natal streams.

Upstream migrating adult steelhead enter the Sacramento River and San Joaquin River Basins through their respective mainstem river channels. Steelhead entering the Mokelumne River system (including Dry Creek and the Cosumnes River) and the Calaveras River system to spawn are likely to move up the mainstem San Joaquin River channel before branching off into the channels of their natal rivers, although some may detour through the south Delta waterways and enter the San Joaquin River through the Head of Old River.

Steelhead entering the San Joaquin River Basin appear to have a later spawning run, with adults entering the system starting in late October through December, indicating that migration up through the Delta may begin a few weeks earlier. During fall, warm water temperatures in the south Delta waterways and water quality impairment because of low dissolved oxygen at Stockton have been suggested as potential barriers to upstream migration (National Marine Fisheries Service 2009a). Reduced water temperatures, as well as rainfall runoff and flood control release flows, provide the stimulus to adult steelhead holding in the Delta to move upriver toward their spawning reaches in the San Joaquin River tributaries. Adult steelhead may continue entering the San Joaquin River Basin through winter.

Juvenile steelhead can be found in all waterways of the Delta, but particularly in the main channels leading from their natal river systems (National Marine Fisheries Service 2009a). Juvenile steelhead are recovered in trawls from October through July at Chipps Island and at Mossdale. Chipps Island catch data indicate there is a difference in the outmigration timing between wild and hatchery-reared steelhead smolts from the Sacramento and eastside tributaries. Hatchery fish are typically recovered at Chipps Island from January through March, with a peak in February and March corresponding to the schedule of hatchery releases of steelhead smolts from the Central Valley hatcheries (Nobriga and Cadrett 2001; Reclamation 2008). The timing of wild (unmarked) steelhead outmigration is more spread out, and based on salvage records at the CVP and SWP fish collection facilities, outmigration occurs over approximately 6 months with the highest levels of recovery in February through June (Aasen 2011, 2012). Steelhead are salvaged annually at the project export facilities (e.g., 4,631 fish were salvaged in 2010, and 1,648 in 2011) (Aasen 2011, 2012).

Outmigrating steelhead smolts enter the Delta primarily from the Sacramento or San Joaquin Rivers. Mokelumne River steelhead smolts can either follow the north or south branches of the Mokelumne River through the central Delta before entering the San Joaquin River, although some fish may enter farther upstream if they diverge from the south branch of the Mokelumne River into Little Potato Slough. Calaveras River steelhead smolts enter the San Joaquin River downstream of the Port of Stockton. Although steelhead have been routinely documented by CDFW in trawls at Mossdale since 1988 (San Joaquin River Group Authority 2011), it is unknown whether successful outmigration occurs outside the seasonal installation of the barrier at the Head of Old River (between April 15 and May 15 in most years). Prior to the installation of the Head of Old River Fish Control Gate, steelhead smolts exiting the San Joaquin River Basin could follow one of two routes to the ocean, either staying in the mainstem San Joaquin River through the central Delta, or entering the Head of Old River and migrating through the south Delta and its associated network of channels and waterways.

CCV steelhead use the San Francisco and San Pablo Bays as a migration corridor to and from the ocean. The juveniles move quickly through the bays on their way to the ocean, preying on a variety of macroinvertebrates and small fish.

Steelhead are broadly divided into two life history types, summer-run steelhead and winter-run steelhead, based on their state of sexual maturity at the time of river entry. Only winter-run steelhead are currently found in Central Valley rivers and streams. Historically, CCV steelhead were distributed from the upper Sacramento and Pit River systems (upper Sacramento, McCloud, Pit, and Fall Rivers) south to the Kings River (and possibly Kern River system in wet years) (McEwan 2001). Presently, CCV steelhead are found in the Sacramento River downstream of Keswick Dam, in major tributary rivers and creeks in the Sacramento River watershed, and in major tributaries of the San Joaquin River (Stanislaus, Tuolumne, Merced Rivers) and Delta (Mokelumne and Calaveras River). The populations in the Feather and American Rivers are supported primarily by the Feather River and Nimbus Fish Hatcheries. Other major steelhead populations in the Sacramento River watershed are found in Battle, Mill, Deer, Clear, and Butte Creeks.

Adult steelhead migrate upstream past the Fremont Weir between August and March, but primarily from August through October, and they migrate upstream past RBDD during all months of the year, but primarily during September and October (National Marine Fisheries Service 2009a). The primary spawning area used by steelhead in the Sacramento River is the area from Keswick Dam downstream to RBDD. Unlike Pacific salmon, steelhead may live to spawn more than once and generally rear in freshwater streams for 2 to 4 years before outmigrating to the ocean. Both spawning areas and migratory corridors are used by juvenile steelhead for rearing prior to outmigration. The Sacramento River functions primarily as a migration channel, although some rearing habitat remains in areas with setback levees (primarily upstream of Colusa) and flood bypasses (e.g., Yolo Bypass) (National Marine Fisheries Service 2009a).

11A.1.6.3. Distribution and Abundance

Recent steelhead monitoring data are scarce for the upper portion of the Sacramento River system. Hallock (1989) reported that steelhead had declined drastically in the Sacramento River upstream of the Feather River confluence. In the 1950s, the average estimated spawning population size upstream of the Feather River confluence was 20,540 fish (McEwan and Jackson 1996). In 1991–1992, the annual run size for the total Sacramento River system was likely fewer than 10,000 adult fish (McEwan and Jackson 1996). From 1967 to 1993, the estimated number of steelhead passing the Red Bluff Pumping Plant ranged from a low of 470 to a high of 19,615 (California Hatchery Scientific Review Group 2012). Steelhead escapement surveys at Red Bluff ended in 1993.

Both steelhead and resident (non-anadromous) rainbow trout (*Oncorhynchus mykiss*) occur in Clear Creek. Adult CCV steelhead populations in Clear Creek have been relatively stable between 2003 and 2011, with redd counts ranging from 42 to 409, with an average of 176 (Giovanetti et al. 2013; Provins and Chamberlain 2019). Adult Central Valley steelhead spawn in Clear Creek from early December to mid-March. Steelhead rear in Clear Creek year-round, and outmigration can occur in any month, although peak outmigration in 2011 was from February to June (Schraml et al. 2018).

CCV steelhead adults migrate into the Feather River between July and March, and redd construction occurs from late December to March, peaking in late January (Federal Energy Regulatory Commission 2007; McEwan 2001). Spawning in the Feather River primarily occurs within the low-flow channel between the Fish Barrier Dam and the Thermalito Afterbay outlet, although a small amount of spawning occurs downstream of the Thermalito Afterbay outlet (Federal Energy Regulatory Commission 2007). Nearly half of all observed redds are constructed in the uppermost mile of the low-flow channel (Federal Energy Regulatory Commission 2007). Fry begin to outmigrate in February, soon after emerging, with the majority outmigrating between March and mid-April. Most juveniles outmigrate by September, but a small portion of juveniles that do not outmigrate rear in the river for up to 1 year, most often in secondary channels of the low-flow channel (Federal Energy Regulatory Commission 2007).

Although some spawning by steelhead in the American River occurs naturally (Hannon and Deason 2008), the population is supported primarily by the Nimbus Fish Hatchery. The total estimated steelhead return to the river (spawning naturally and in the hatchery) has ranged from 946 to 3,426 fish, averaging 2,184 fish per year from 2002 to 2010 (California Hatchery Scientific Review Group 2012). Steelhead spawning surveys have shown approximately 300 steelhead spawning in the river each year (Hannon and Deason 2008). Lindley et al. (2007) classifies the listed (i.e., naturally spawning) population of American River steelhead at a high risk of extinction because it is reportedly mostly composed of winter-run steelhead originating from Nimbus Fish Hatchery; possibly up to 90% of spawners are of hatchery origin (Hannon and Deason 2008). NMFS considers the American River population to be important to the survival and recovery of the species (National Marine Fisheries Service 2009a).

Steelhead from the American River (collected from both the Nimbus Fish Hatchery and the American River) are genetically more similar to Eel River and Mad River steelhead than other Central Valley steelhead stocks because individuals from these rivers were used as broodstock for Nimbus Fish Hatchery (Nielsen et al. 2005; California Hatchery Scientific Review Group 2012). American River steelhead exhibit a slightly later upstream migration period than other Central Valley steelhead (Lee and Chilton 2007).

Adult steelhead migrate up the American River from October through April with a peak occurring from December through March (Surface Water Resources 2001). Adult steelhead have been caught in the Nimbus Fish Hatchery trap as early as the first week of October. Spawning typically occurs in the lower American River between late December and early April, with the peak occurring in late February to early March (Hannon and Deason 2008). Spawning occurs between Nimbus Dam and Paradise Beach, although approximately 90% of spawning occurs upstream of the Watt Avenue Bridge (Hannon and Deason 2008). Embryo incubation occurs shortly after spawning in late December and generally extends through May, although incubation can occur into June in some years (Surface Water Resources 2001). Although steelhead embryo and alevin mortality from high flows in the American River has not been documented, flows high enough to mobilize spawning gravels and scour or entomb redds have been recorded during the spawning and embryo incubation periods (National Marine Fisheries Service 2009a). Juvenile *O. mykiss* are present year-round throughout the lower American River, with rearing generally upstream of spawning areas. Juveniles can rear in the lower American River for a year or more before outmigrating as smolts from January through June (Snider and Titus 2000a; Surface Water Resources 2001), although it is rare to find individuals older than YOY fry and parr (Snider and Titus 2002; Pacific States Marine Fisheries Commission 2014). Peak juvenile steelhead outmigration occurs from March through May (McEwan and Jackson 1996; Surface Water Resources 2001; Pacific States Marine Fisheries Commission 2014). Juvenile steelhead rear in the lower American River from Nimbus Dam to Paradise Beach. During summer months, juveniles occur in most major riffle areas, with the highest densities near the higher density spawning areas (Reclamation 2008). The number of juveniles in the American River decreases throughout summer (Reclamation 2008). Juveniles experience water temperature-related stress during summer and early fall (Lower American River Task Force 2002; Water Forum 2005; National Marine Fisheries Service 2014) despite laboratory studies indicating that American River steelhead may be more tolerant of high temperatures than steelhead from other rivers (Myrick and Cech 2004).

CCV steelhead were thought to be extirpated from the San Joaquin River system (National Marine Fisheries Service 2009a). However, monitoring has detected small self-sustaining (i.e., of natural origin, not of hatchery origin) populations of steelhead in the Stanislaus River and other streams previously thought to be devoid of steelhead (Stanislaus River Fish Group 2003; McEwan 2001). There is a catch-and-release steelhead fishery in the lower Stanislaus River between January 1 and October 15. Surveys of *O. mykiss* (resident rainbow trout and the anadromous steelhead) abundance and distribution conducted annually since 2009 have documented a relatively stable population. River-wide abundance estimates from 2009 to 2014 have averaged just over 20,220 (all life stages combined) and have never been estimated to be less than about 14,000 (2009). The highest densities and abundances of *O. mykiss* are consistently found in Goodwin Canyon. Key factors that may contribute to higher than average abundances in the Stanislaus River (relative to other San Joaquin River tributaries) include high gradient reaches that are typically associated with fast-water habitats, particularly in Goodwin Canyon (State Water Resources Control Board 2015).

Historically, the distribution of steelhead extended into the headwaters of the Stanislaus River (Yoshiyama et al. 1996). Steelhead currently can migrate more than 58 miles (93.3 km) up the Stanislaus River to the base of Goodwin Dam. In the Stanislaus River, there are few data regarding the migration patterns of adult steelhead since adults generally migrate during periods when river flows and turbidity are high, making fish difficult to observe with standard adult monitoring techniques. Stanislaus River weir data indicate that steelhead migrate upstream, through the south Delta and lower San Joaquin River, between September and March (Reclamation 2014). High Delta export rates relative to San Joaquin River flows at Vernalis, when adults are migrating through the Delta (presumably December through May), may result in adults straying to the Sacramento River Basin.

It is believed that steelhead spawn primarily between December and March in the Stanislaus River. Although few steelhead spawning surveys have been conducted in the Stanislaus River, spawning *O. mykiss* were documented between Goodwin Dam and Horseshoe Bar in a 2014 spawning survey (Reclamation and California Department of Water Resources 2015). The spawning adults require holding and feeding habitat with cover adjacent to suitable spawning habitat. These habitat features are relatively rare in the lower Stanislaus River because of in-river gravel mining and the scouring of gravel from riffles in Goodwin Canyon.

Juvenile steelhead rear in the Stanislaus River for at least 1 year, and usually 2 years, before migrating to the ocean. As a result, flow, water temperature, and dissolved oxygen concentration in the reach between Goodwin Dam and the Orange Blossom Bridge (their primary rearing habitat) are critical during summer (Reclamation 2012).

Small numbers of CCV steelhead smolts have been captured in rotary screw traps at Caswell State Park and near Oakdale (FISHBIO Environmental 2007; Watry et al. 2007, 2012), and data indicate that steelhead outmigrate primarily from February through May. Rotary screw traps are generally not considered efficient at catching fish as large as steelhead smolts, and the number captured is too small to estimate capture efficiency, so no steelhead smolt outmigration population estimate has been calculated. The capture of these fish in downstream migrant traps and the advanced smolting characteristics exhibited by many of the fish indicate that some steelhead/rainbow trout juveniles might outmigrate to the ocean in spring. However, it is not known whether the parents of these fish were anadromous or fluvial (i.e., migrate within fresh water). Resident populations of steelhead/rainbow trout in large streams are typically fluvial, and migratory juveniles look much like smolts.

Steelhead were historically present in the San Joaquin River, though data on their population levels are lacking (McEwan 2001). The current steelhead population in the San Joaquin River is substantially reduced compared with historical levels, although resident rainbow trout occur throughout the major San Joaquin River tributaries. Additionally, small populations of steelhead persist in the lower San Joaquin River and tributaries (e.g., Stanislaus, Tuolumne, and possibly Merced Rivers) (Zimmerman et al. 2009; McEwan 2001). Steelhead/rainbow trout of anadromous parentage occur at low numbers in all three major San Joaquin River tributaries. These tributaries have a higher percentage of resident rainbow trout compared to the Sacramento River and its tributaries (Zimmerman et al. 2009). Presence of steelhead smolts from the San Joaquin River Basin is estimated annually by CDFW based on the Mossdale Trawl (San Joaquin River Group Authority 2011). The sampling trawls capture steelhead smolts, although usually in small numbers. One steelhead smolt was captured and returned to the river during the 2009 sampling period (San Joaquin River Group Authority 2010), and three steelhead were captured and returned in both 2010 and 2011 (Speegle et al. 2013).

General life stage timing for CCV steelhead is summarized in Tables 11A-8 and 11A-9.

Table 11A-8. Temporal Occurrence of Central Valley Steelhead by Life Stage

Relative Abundance	High (▼)						Medium (⊠)					Low (#)				None (-)								
Migration Life Stage: (a) Adult	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
[1]Sacramento R. at Fremont Weir	#	#	#	#	#	-	-	-	-	-	-	#	#	#	#	⊠	▼	▼	▼	⊠	#	#	#	#
[2]Sacramento R. at Red Bluff Diversion Dam	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	⊠	⊠	▼	⊠	#	#	#	#
[3]San Joaquin River	▼	▼	⊠	⊠	#	#	-	-	-	-	-	-	#	#	#	#	⊠	⊠	⊠	⊠	⊠	⊠	▼	▼
Migration Life Stage: (b) Juvenile	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
[1,3]Sacramento R. near Fremont Weir	#	#	#	#	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	#	#	#	#	#	#	⊠	⊠	⊠	⊠	#	#
[4]Sacramento R. at Knights Landing	▼	▼	▼	▼	⊠	⊠	⊠	⊠	#	#	#	#	-	-	-	-	-	-	-	-	#	#	#	#
[5]Chipps Island (clipped)	⊠	⊠	▼	▼	⊠	⊠	#	#	#	#	-	-	-	-	-	-	-	-	-	-	-	-	#	#
[5]Chipps Island (unclipped)	⊠	⊠	⊠	⊠	▼	▼	▼	▼	▼	▼	⊠	⊠	#	#	-	-	-	-	-	-	-	#	#	#
[6]San Joaquin R. at Mossdale	-	-	#	#	⊠	⊠	▼	▼	▼	▼	#	#							#	#	-	-	-	-

Sources: [1] Hallock et al. (1957); [2] McEwan (2001); [3] California Department of Fish and Game (2007); [4] NMFS analysis of 1998-2018 CDFW data; [5] NMFS analysis of 1998-2018 USFWS data; [6] NMFS analysis of 2003-2018 USFWS data.

Source: National Marine Fisheries Service 2019:100.

Table 11A-9. Temporal Occurrence of Central Valley Steelhead by Life Stage in the Delta

Relative Abundance	High (▼)			Medium (⊠)		Low (#)			None (-)		
Life Stage	Month										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult [1]	⊠	⊠	⊠	⊠	▼	-	#	⊠	▼	⊠	⊠	⊠
Juvenile [2]	#	⊠	⊠	▼	▼	#	#	-	#	-	-	#
Salvaged [3]	⊠	▼	▼	⊠	#	#	-	-	-	-	#	#

1Adult presence was determined using information in Moyle (2002), Hallock et al. (1961), and California Department of Fish and Wildlife (2013b).
2Juvenile presence in the Delta was determined using Delta Juvenile Fish Monitoring Program data.
3Months in which salvage of wild juvenile steelhead at State and Federal pumping plants occurred; values in cells are salvage data reported by the facilities (He and Stuart 2016).

Source: National Marine Fisheries Service 2019:101).

Attachment 1 provides graphical summaries of juvenile steelhead monitoring, sampling and salvage timing in the Central Valley, as produced by the Central Valley Prediction Assessment of Salmon database (SacPAS).

11A.1.7. Steelhead—Central California Coast DPS

11A.1.7.1. Distribution, Life History, and Habitat Requirements

Central California Coast steelhead (*Oncorhynchus mykiss irideus*) DPS are winter-run steelhead and therefore are at or near sexual maturity when they enter fresh water during late fall and winter. They typically enter San Francisco Bay in early winter, although they have been seen in the bay as early as August (Goals Project 2000). Central California coast steelhead from San Francisco and San Pablo Bays spawn in tributaries of the bays, including the Guadalupe and Napa Rivers and Sonoma Creek. They spawn from late December through April. Juvenile steelhead typically rear in fresh water for a longer time period than other salmonids, typically ranging from 1 to 3 years. Throughout their range, steelhead typically remain at sea for one to four growing seasons before returning to fresh water to spawn.

Migrating adult steelhead require deep holding pools with cover such as underwater ledges and caverns. The juveniles are primarily drift feeders and may forage in open water of estuarine subtidal and riverine tidal wetland habitats. The estuarine diet of juvenile steelhead includes emergent aquatic insects, aquatic insect larvae, snails, amphipods, opossum shrimp (mysids), and small fish.

Transit times and migratory pathways of juvenile steelhead within San Francisco Bay have been studied with hatchery-raised smolts released into the lower Sacramento River (Chapman et al. 2015). The smolts transited the estuary (Benicia to Golden Gate Bridge) rapidly (2–4 days) and mostly used flows in the main channel during their migration. Fewer smolts were detected in marinas, tributaries, and other shallow areas surrounding the estuary. Many of the smolts moved upstream during flood tides and downstream during ebb tides. The study results suggested that these smolts did not use the estuary for feeding, rearing, or smoltification purposes (Chapman et al. 2015).

Central California coast steelhead spawn in several drainages of San Francisco and San Pablo Bays, including the Guadalupe River, Coyote Creek, San Francisquito Creek, Sonoma Creek, and the Napa River (Leidy et al. 2005). Historically, most streams with suitable habitat within the San Francisco Estuary supported central California coast steelhead populations. Current runs are estimated at fewer than 10,000 fish in San Francisco Bay tributaries (Goals Project 2000).

11A.1.8. Green Sturgeon—Southern DPS

11A.1.8.1. Legal Status

The North American green sturgeon (*Acipenser medirostris*) population is composed of two DPSs: the Northern DPS, which includes all populations in the Eel River and northward; and the Southern DPS, which includes all populations south of the Eel River. The Northern DPS green sturgeon currently spawns in the Klamath River in California and the Rogue River in Oregon, and is designated as a Species of Concern (69 FR 19975). Only the Southern DPS is found in the Plan Area.

After a status review was completed in 2002 (Adams et al. 2002), NMFS determined that the Southern DPS did not warrant listing as threatened or endangered but should be identified as a Species of Concern. This determination was challenged on April 7, 2003. NMFS updated its status review on February 22, 2005, and determined that the Southern DPS should be listed as threatened under ESA (National Marine Fisheries Service 2005). NMFS published a final rule on April 7, 2006, that listed the Southern DPS as threatened (71 FR 17757); the rule took effect on June 6, 2006. Included in the listing are the spawning population in the Sacramento River and fish living in the Sacramento River, the Delta, and the San Francisco Estuary.

In September 2008, NMFS proposed critical habitat for the Southern DPS (73 FR 52084). NMFS made a final critical habitat designation for the Southern DPS on October 9, 2009 (74 FR 52300). Designated areas in California include the Sacramento River, lower Feather River, and lower Yuba River; the Delta; and Suisun, San Pablo, and San Francisco Bays (National Marine Fisheries Service 2012c).

On May 21, 2009, NMFS proposed an ESA Section 4(d) rule to apply ESA take prohibitions to the Southern DPS. NMFS published the final 4(d) rule and protective regulations on July 2, 2010 (75 FR 30714).

11A.1.8.2. Life History and General Ecology

Green sturgeon reach maturity around 14 to 16 years of age and can live to be 70 years old, returning to their natal rivers every 3 to 5 years for spawning (Van Eenennaam et al. 2005). Adult green sturgeon move through the Delta from February through April, arriving at holding and spawning locations the upper Sacramento River between April and June (Heublein 2006; Kelly et al. 2007). Following their initial spawning run upriver, adults may hold for a few weeks to months in the upper river before moving back downstream in fall (Vogel 2008; Heublein et al. 2009), or they may migrate immediately back downstream through the Delta. Radio-tagged adult green sturgeon have been tracked moving downstream past Knights Landing during summer and fall, typically in association with pulse flows in the river (Heublein et al. 2009), similar to behavior exhibited by adult green sturgeon on the Rogue River and Klamath River systems (Erickson et al. 2002; Benson et al. 2007).

Similar to other estuaries along the West Coast of North America, adult and subadult green sturgeon frequently congregate in the San Francisco Estuary during summer and fall (Lindley et al. 2008). Specifically, adults and subadults may reside for extended periods in the central Delta as well as in Suisun and San Pablo Bays, presumably for feeding, because bays and estuaries are preferred feeding habitat rich in benthic invertebrates (e.g., amphipods, bivalves, and insect larvae). In part because of their bottom-oriented feeding habits, sturgeon are at risk of harmful accumulations of toxic pollutants in their tissues, especially pesticides such as pyrethroids and heavy metals such as selenium and mercury (Israel and Klimley 2008; Stewart et al. 2004). Subadult and adult green sturgeon occupy a diversity of depths within bays and estuaries for feeding and migration. Tagged adults and subadults within the San Francisco Estuary and Delta occupy waters over shallow depths of less than 33 feet (10 m), either swimming near the surface or foraging along the bottom, although recent studies suggested adults tend to be benthically oriented in the San Francisco Estuary and Delta (Chapman et al. 2019). Juvenile green sturgeon are largely oriented at or near the bottom (Thomas et al. 2019).

Green sturgeon larval distribution is estimated to extend at least 62 miles downstream from spawning habitats on the Sacramento and Feather Rivers in high-flow years. This estimated downstream distribution corresponds with the Colusa area on the Sacramento River (RM 157) and the confluence of the Sacramento and Feather Rivers near Verona (RM 80) for larvae originating in the Sacramento River and Feather River, respectively (Heublein et al. 2017a:14). Juveniles are believed to use the Delta for rearing for the first 1 to 3 years of their lives before moving out to the ocean and are likely to be found in the main channels of the Delta and the larger interconnecting sloughs and waterways, especially within the central Delta and Suisun Bay and Suisun Marsh. Project operations at the DCC have the potential to reroute green sturgeon as they outmigrate through the lower Sacramento River to the Delta (Israel and Klimley 2008; Vogel 2011). When the DCC is open, there is no passage delay for adults, but juveniles could be diverted from the Sacramento River into the interior Delta. This has been shown to reduce the survival of juvenile Chinook salmon (Brandes and McLain 2001; Newman and Brandes 2010; Perry et al. 2012), but it is unknown whether it has similar effects on green sturgeon.

The Sacramento River provides habitat for green sturgeon spawning, adult holding, foraging, and juvenile rearing. Sturgeon spawn in deep pools (averaging about 28 feet or 8.5 m deep) (National Marine Fisheries Service 2018). Suitable spawning temperatures and spawning substrate exist for green sturgeon in the Sacramento River upstream and downstream of RBDD (Reclamation 2008). Although the upstream extent of historical green sturgeon spawning in the Sacramento River is unknown, the observed distribution of sturgeon eggs, larvae, and juveniles indicates that spawning occurs from Hamilton City to as far upstream as the Inks Creek confluence and possibly up to the Cow Creek confluence (Brown 2007; Poytress et al. 2013). Adult green sturgeon that migrate upstream in April, May, and June are completely blocked by the Anderson-Cottonwood Irrigation District (ACID) diversion dam (National Marine Fisheries Service 2009b), rendering approximately 3 miles of spawning habitat upstream of the diversion dam inaccessible. Based on the distribution of sturgeon eggs, larvae, and juveniles in the Sacramento River, CDFW (2002) indicated that green sturgeon spawn in late spring and early summer, although they periodically spawn in late summer and fall (as late as October) (Heublein et al. 2009, 2017b; National Marine Fisheries Service 2018). Green sturgeon eggs are believed generally to hatch about a week after fertilization (Heublein et al. 2017b). The number of green sturgeon accessing the upper Sacramento River appears to have increased following the decommissioning of RBDD (Steel et al. 2019).

Green sturgeon from the Sacramento River are genetically distinct from their northern counterparts, indicating a spawning fidelity to their natal rivers (Israel et al. 2004), even though individuals can range widely (Lindley et al. 2008). Larval green sturgeon have been regularly captured during their dispersal stage at about 2 weeks of age (24 to 34 mm fork length) in rotary screw traps at RBDD (California Department of Fish and Game 2002) and at about 3 weeks old when captured at the Glenn-Colusa Irrigation District (GCID) intake (Van Eenennaam et al. 2001). Young green sturgeon appear to rear for the first 1 to 2 months in the Sacramento River between Keswick Dam and Hamilton City (California Department of Fish and Game 2002).

Southern DPS North American green sturgeon are thought to have historically spawned in the Sacramento, Feather, and San Joaquin Rivers (Adams et al. 2007). Green sturgeon are long-lived, reach maturity around 15 years old, and usually spawn every 3 to 4 years (National Marine Fisheries Service 2015). Adults enter San Francisco Bay around late winter through early spring and generally migrate to spawning areas from late February through April. Spawning mainly occurs April through late July, with some occurring in late summer and early fall (Heublein et al.

2017a). A significant portion of the spawning habitat was lost with the construction of Oroville Dam (Federal Energy Regulatory Commission 2007; Yoshiyama et al. 2001; Schick et al. 2005). While regular occurrence of green sturgeon has been verified in the Sacramento River, only intermittent observations of spawning, at the Thermalito Afterbay outlet, have been reported in the lower Feather River (Beamesderfer et al. 2007; Seesholtz and Manuel 2012). After hatching, green sturgeon larvae possess limited swimming ability and generally seek refuge in low-velocity and complex habitats, such as large cobble substrate (Kynard et al. 2005). While little is known about green sturgeon rearing, it is likely that juveniles rear near spawning habitat for a few months or more before migrating to the Delta (Heublein et al. 2017b:15).

Green sturgeon is also present in the San Joaquin River, but at considerably lower numbers than white sturgeon (*Acipenser transmontanus*). Between 2007 and 2012, anglers reported catching six green sturgeon in the San Joaquin River (Jackson and Van Eenennaam 2013). In 2017, environmental DNA testing confirmed the identity of a green sturgeon observed in the Stanislaus River at Knights Ferry. Although the reported presence of green sturgeon in the San Joaquin River coincides with the spawning migration period of green sturgeon within the Sacramento River, no evidence of spawning has been detected (Jackson and Van Eenennaam 2013).

General life stage timing for southern DPS green sturgeon is summarized in Tables 11A-10 and 11A-11.

Table 11A-10. Temporal Occurrence of Southern Distinct Population Segment Green Sturgeon by Life Stage

Relative Abundance	High (▼)						Medium (⊠)								Low (#)					None (-)				
Life-Stage: (a) Adult-sexually mature[1]	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac River (river mile 332.5-451)	#	#	#	#	⊠	⊠	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	⊠	⊠	⊠
Sac River (<river mile 332.5)	#	#	#	⊠	⊠	⊠	⊠	⊠	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#
Sac-SJ-SF Estuary	#	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	#	#
(b) Larva	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac River (<river mile 332.5)	-	-	-	-	-	#	⊠	⊠	▼	▼	▼	▼	▼	▼	⊠	⊠	⊠	⊠	#	#	-	-	-	-
(c) Juvenile (≤6 months old)	Month																							
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Sac River (<river mile 332.5)	-	-	-	-	-	-	-	#	⊠	⊠	⊠	⊠	▼	▼	▼	▼	▼	▼	▼	⊠	⊠	⊠	⊠	⊠
(d) Juvenile (≤5 months old)	Month																							

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac River (<river mile 391)	⊠ ⊠	⊠ ⊠	# #	# #	# #	# ⊠	⊠ ⊠	⊠ ▼	▼ ▼	▼ ▼	▼ ▼	▼ #
(e) Sub-Adults and Non-spawning adults	Month											
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac-SJ-SF Estuary	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠ ⊠	▼ ▼	▼ ▼	▼ ▼	▼ ▼	▼ ▼	▼ ▼	⊠ ⊠
Pacific Coast	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠ ⊠
Coastal Bays & Estuaries	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠ ⊠	⊠ ⊠	▼ ▼	▼ ▼	▼ ▼	▼	▼	▼ ▼ ▼	▼ ⊠ ⊠

[1] *Sexually mature adults (≥4.8 feet TL females, ≥ 3.9 feet TL males including pre- and post- spawning individuals)*

Sources: (a) (Heublein et al. 2009); (DuBois and Danos 2018; Klimley et al. 2015a; Mora et al. 2018; Poytress et al. 2015); (b) (Heublein et al. 2017; Poytress et al. 2015); (c) (Heublein et al. 2017; Poytress et al. 2015); (d) (California Department of Fish and Game 2002; Heublein et al. 2017; Poytress et al. 2015; Radtke 1966); (e) (DuBois and Danos 2018; Erickson and Webb 2007; Huff et al. 2011; Lindley et al. 2011; Lindley et al. 2008; Moser and Lindley 2007). Outside of Sac-SJ-SF estuary (e.g. Columbia R., Grays Harbor, Willapa Bays).

Source: National Marine Fisheries Service 2019:113–114.

Table 11A-11. Temporal Occurrence of Southern Distinct Population Segment Green Sturgeon by Life Stage in the Delta

Relative Abundance	High (▼)	Medium (⊠)	Low (#)	None (-)

Life Stage	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult [1]	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠
Juvenile [2]	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠
Salvaged [3]	#	#	#	#	#	-	⊠	▼	#	#	#	#

[1] *Adult presence was determined to be year round according to information in (California Department of Fish and Game 2008; California Department of Fish and Game 2009; California Department of Fish and Game 2010a; California Department of Fish and Game 2011; California Department of Fish and Game 2012; California Department of Fish and Wildlife 2013a; California Department of Fish and Wildlife 2014a; Lindley et al. 2008; Moyle 2002).*

[2] *Juvenile presence in the Delta was determined to be year round by using information in (USFWS Delta Juvenile Fish Monitoring Program data), (Moyle et al. 1995; Radtke 1966).*

Source: National Marine Fisheries Service 2019:115.

11A.1.8.3. Distribution and Abundance

The current population status is unknown (Beamesderfer et al. 2007; Adams et al. 2007). A genetic analysis of green sturgeon larvae captured in the Sacramento River resulted in an estimate of the number of adult spawning pairs upstream of RBDD ranging from 32 to 124 between 2002 and 2006 (Israel 2006). Using results from acoustic telemetry and dual-frequency identification sonar (DIDSON) studies to locate green sturgeon in the Sacramento River to derive an adult spawner abundance estimate of 2,106 fish (95% confidence interval = 1,246–2,966), Mora et al. (2018) applied a conceptual demographic structure to the adult population estimate and generated a subadult sDPS green sturgeon population estimate of 11,055 (95% confidence interval = 6,540–15,571), together with an estimate of 4,387 juveniles (95% confidence interval = 2,595–6,179). It should be noted that the estimate does not include spawning adults in the lower Feather or Yuba Rivers (National Marine Fisheries Service 2019), with spawning confirmed in the Feather River (Seesholtz et al. 2015). Mora et al. (2018) cautioned that their juvenile and subadult green sturgeon estimates are less reliable than their adult estimates because the former were based on the ratios from a modeling study; the percentage of juvenile sturgeon is particularly uncertain because so little is known about this life stage. Additionally, the modeling study upon which the juvenile and subadult estimates are based requires four assumptions that Mora et al. (2018) admitted are rarely met: (1) constant recruitment, (2) population equilibrium, (3) stable size and age structure, and (4) a lack of density dependence. Mora et al. (2018) suggested, however, that their study provided a rough estimate of total abundance that is suitable for assessing the impacts of take, such as that observed in coastal trawl fisheries and at large water diversions.

Juvenile green sturgeon and white sturgeon are periodically (although rarely) collected from the lower San Joaquin River at south Delta water diversion facilities and other sites (National Marine Fisheries Service 2009b; Aasen 2011, 2012). Green sturgeon are salvaged from the south Delta diversion facilities and are generally juveniles greater than 10 months but less than 3 years old (Reclamation 2008). NMFS (2005) suggested that the high percentage of San Joaquin River flows contributing to the TFCF could mean that some entrained green sturgeon originated in the San Joaquin River Basin. Anglers have reported catching a few green sturgeon in recent years in the San Joaquin River (California Department of Fish and Game 2012b).

11A.1.8.4. Stressors

In part because of their bottom-oriented feeding habits, sturgeon are at risk of harmful accumulations of toxic pollutants in their tissues, especially pesticides such as pyrethroids and heavy metals such as selenium and mercury (Israel and Klimley 2008; Stewart et al. 2004).

NMFS (2009b) noted that, similar to winter-run Chinook salmon, the restriction of spawning habitat for green sturgeon to only one reach of the Sacramento River increases the vulnerability of this spawning population to catastrophic events, which is one of the primary reasons that the Southern DPS of green sturgeon was federally listed as a threatened species in 2006. However, there is evidence that green sturgeon may also spawn in the Feather River, although perhaps irregularly (Seesholtz et al. 2015).

11A.1.9. White Sturgeon

11A.1.9.1. Status, Distribution, Life History, and Habitat Requirements

White sturgeon are generally similar to green sturgeon in terms of their biology and life history. Like green sturgeon and other sturgeon species, white sturgeon are late-maturing and infrequent spawners, which makes them vulnerable to overexploitation and other sources of adult mortality. White sturgeon are believed to be most abundant within the San Francisco Estuary and Delta region (Moyle 2002). Both nonspawning adults and juveniles can be found throughout the Delta year-round (Radtke 1966; Kohlhorst et al. 1991; Moyle 2002; California Department of Water Resources et al. 2013). When not undergoing spawning or ocean migrations, adults and subadults are usually most abundant in brackish portions of the San Francisco Estuary and Delta (Kohlhorst et al. 1991). White sturgeon is not presently listed under the ESA or CESA but is a California SSC (Moyle et al. 2015:102–117). Overall, information on trends in adults and juveniles suggests that numbers are declining (Moyle 2002; National Marine Fisheries Service 2009a).

The Central Valley population of white sturgeon spawns mainly in the Sacramento and Feather Rivers, with occasional spawning in the San Joaquin River (Moyle 2002; Jackson 2013).

Spawning-stage adults generally move into the lower reaches of rivers during winter prior to spawning and migrate upstream in response to higher flows to spawn from February to early June (McCabe and Tracy 1994; Schaffter 1997).

After absorbing yolk sacs and initiating feeding, YOY white sturgeon make an active downstream migration that disperses them widely to rearing habitat throughout the lower rivers and the Delta (McCabe and Tracy 1994). White sturgeon larvae have been observed to be flushed farther downstream in the Delta and Suisun Bay in high outflow years, but are restricted to more interior locations in low outflow years (Stevens and Miller 1970). White sturgeon larvae are periodically collected in various locations throughout the Delta in general larval fish monitoring (e.g., 20-mm Townet survey) in late winter and spring and in salvage at federal and state Delta pumping facilities, so that larval distribution generally is suggested to range from downriver of spawning habitats (primarily in the Sacramento and San Joaquin Rivers) to the approximate downstream extent of the Delta at Chipps Island (Heublein et al. 2017a). From 1995 through 2019, white sturgeon larvae were collected in the 20-mm Townet survey in 89% of wet, 67% of above normal, and 40% of below normal water year types (Table 11A-12). No white sturgeon larvae were collected in any critical or dry water years (California Department of Fish and Wildlife 2020), consistent with previous observations from Stevens and Miller (1970).

Table 11A-12. Annual Number of White Sturgeon Larvae Collected in the 20-mm Survey, 1995–2019

Year	Water Year Type	Number of White Sturgeon Larvae Collected
1995	W	4
1996	W	1
1997	W	0
1998	W	81
1999	W	7
2000	AN	16
2001	D	0
2002	D	0
2003	AN	2
2004	BN	0
2005	AN	0
2006	W	15
2007	D	0
2008	C	0
2009	D	0
2010	BN	0
2011	W	8
2012	BN	0
2013	D	0
2014	C	0

Year	Water Year Type	Number of White Sturgeon Larvae Collected
2015	C	0
2016	BN	137
2017	W	73
2018	BN	6
2019	W	34

Source: California Department of Fish and Wildlife 2020.

Salinity tolerance increases with increasing age and size (McEnroe and Cech 1985), allowing white sturgeon to access a broader range of habitat in the San Francisco Estuary (Israel et al. 2008). During dry years, white sturgeon have been observed following brackish waters farther upstream, while the opposite occurs in wet years (Kohlhorst et al. 1991). Adult white sturgeon tend to concentrate in deeper areas and tidal channels with soft bottoms, especially during low tides, and typically move into intertidal or shallow subtidal areas to feed during high tides (Moyle 2002). These shallow water habitats provide opportunities for feeding on benthic organisms, such as opossum shrimp (mysids), amphipods, the invasive overbite clam (*Potamocorbula amurensis*), and small fishes (Israel et al. 2008; Kogut 2008). White sturgeon also have been found in tidal habitats of medium sized tributary streams to the San Francisco Estuary, such as Coyote Creek and Guadalupe River in the South Bay and Napa and Petaluma Rivers and Sonoma Creek in the north bay (Leidy 2007).

Numerous factors likely affect the white sturgeon population in the Delta, similar to those for green sturgeon. Survival during early life history stages may be adversely affected by insufficient flows, lack of rearing habitat, predation, warm water temperatures, decreased dissolved oxygen, chemical toxicants in the water, and entrainment at diversions (Cech et al. 1984; Israel et al. 2008). Historical habitats, including shallow intertidal feeding habitats, have been lost in the Delta because of channelization. Overexploitation by recreational fishing and poaching also likely has been an important factor adversely affecting numbers of adult sturgeon (Moyle 2002), although new regulations were implemented in 2007 by CDFW to reduce harvest. The relatively high current levels of exploitation (annually nearly 14%) will likely continue to decrease the population size in the future (albeit with considerable uncertainty); maintaining a stable population would likely require low levels of exploitation (<3%) (Blackburn et al. 2019). Like green sturgeon, there have historically been substantial passage problems for white sturgeon such as the Fremont Weir (Sommer et al. 2014). Positive correlations exist between white sturgeon year class strength indices and Delta outflow (Fish 2010). Vessel strikes are a source of injury and mortality to white sturgeon in the San Francisco Estuary and Delta, although the proportion of fish affected is not known (Hildebrand et al. 2016; Demetras et al. 2020).

Central Valley white sturgeon are most abundant within the San Francisco Estuary and Delta, but the population spawns mainly in the Sacramento River (Moyle 2002). White sturgeon larvae rear primarily in the Sacramento River and the Delta (Moyle 2002; Israel et al. 2008). White sturgeon are found in the Sacramento River primarily downstream of RBDD (Tehama-Colusa Canal Authority 2008), with most spawning between Knights Landing and Colusa (Schaffter 1997).

The population status of white sturgeon in the Sacramento River is unclear. Overall, limited information on trends in adult and juvenile abundance in the Delta population suggests that numbers are declining (Reis-Santos et al. 2008). Adults ready to spawn generally move into the lower reaches of the Sacramento River during winter, and then migrate upstream in response to higher flows and spawn from February to early June (Schaffter 1997; McCabe and Tracy 1994). Most spawning in the Sacramento River occurs in April and May between Knights Landing and Colusa (Kohlhorst 1976). YOY white sturgeon juveniles make an active downstream migration that disperses them widely to rearing habitat throughout the lower Sacramento River and Delta (McCabe and Tracy 1994; Israel et al. 2008). Statistical analysis has demonstrated a positive relationship between Delta outflow and recruitment of white sturgeon year classes (Kohlhorst et al. 1991).

White sturgeon are known to use the lower Feather River primarily for spawning, embryo development, and early rearing. Limited quantitative information is available on the status of white sturgeon in the lower Feather River, but the spawning population was most likely much larger prior to construction of Oroville Dam in 1961 (Israel et al. 2008). Sixteen white sturgeon were recorded from creel surveys and sightings during 2006, and more were captured by anglers in 2007 (Israel et al. 2008). Numerous factors likely limit the success of the white sturgeon population in the lower Feather River, but loss of historical habitat, alteration of temperatures and flows caused by the Oroville Project, and recreational fishing and poaching are expected to be among the most important factors. General information on white sturgeon life history traits is provided in the section above on the Sacramento River area.

Small numbers of white sturgeon inhabit the American River, as evidenced by white sturgeon report cards submitted to CDFW by anglers in recent years (e.g., DuBois and Harris 2015, 2016; DuBois and Danos 2017, 2018). These individuals were caught in fall, winter, and spring months, the majority of which were caught in winter. Very little other information about use of the American River by white sturgeon is available.

Little is known about white sturgeon populations inhabiting the San Joaquin River. Spawning-stage adults generally move into the lower reaches of rivers during winter prior to spawning, then migrate upstream to spawn in response to higher flows (Schaffter 1997; McCabe and Tracy 1994). Based on tag returns from white sturgeon tagged in the Delta and recovered by anglers, Kohlhorst et al. (1991) estimated that over 10 times as many white sturgeon spawn in the Sacramento River as in the San Joaquin River. CDFW fisheries catch information for the San Joaquin River obtained from fishery report cards (California Department of Fish and Game 2008, 2009b, 2010, 2011, 2012b; California Department of Fish and Wildlife 2013, 2014a) documented that anglers upstream of State Route 140 annually caught between 8 and 25 mature white sturgeon between 2007 and 2013. Below State Route 140 downstream to Stockton, anglers annually caught between 2 and 35 mature white sturgeon over the same time period. Most of the white sturgeon caught were released.

White sturgeon spawning in the San Joaquin River was documented for the first time in 2011 and confirmed in 2012. Viable white sturgeon eggs were collected in 2011 at one sampling location downstream of Laird Park (Gruber et al. 2012) and in 2012 at four sampling locations generally between Laird Park and the Stanislaus River confluence (Jackson and Van Eenennaam 2013). Although the majority of sturgeon likely spawn in the Sacramento River, the results of these surveys confirm that white sturgeon do spawn in the San Joaquin River in both wet- and dry-year conditions and may be an important source of production for the white sturgeon population in the Sacramento–San Joaquin River system.

White sturgeon are uncommon in the Klamath and Trinity Rivers (National Research Council 2004). Although historically there may have been small spawning runs in these rivers, there are no recent reports of white sturgeon spawning in this system. Currently almost all sturgeon found in the Klamath River basin above the estuary are green sturgeon (Moyle 2002).

11A.1.10. Pacific Lamprey

11A.1.10.1. Status, Distribution, Life History, and Habitat Requirements

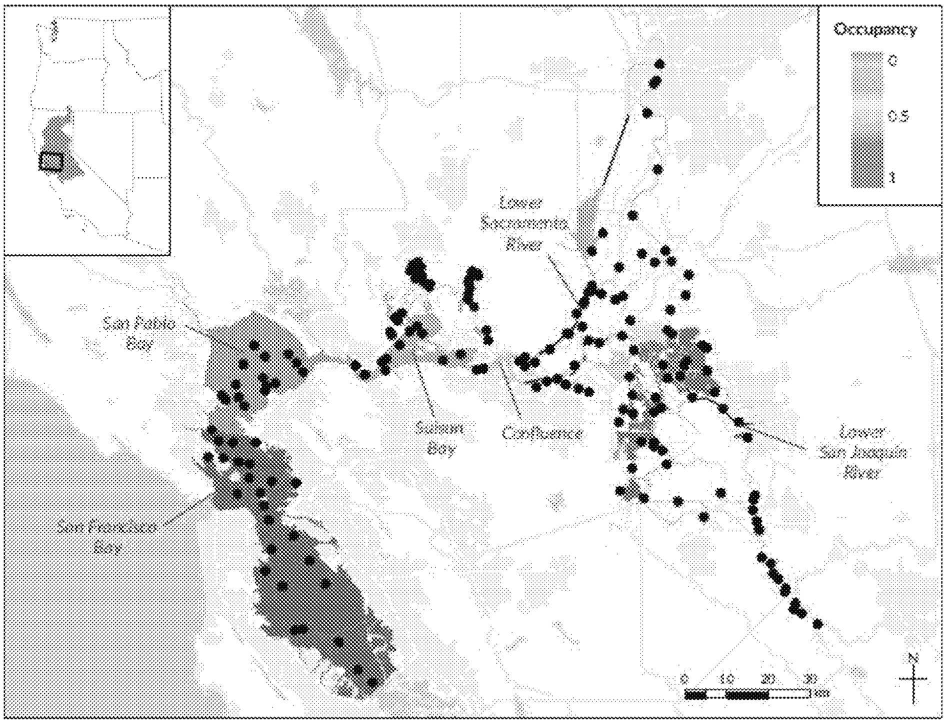
Pacific lamprey (*Entosphenus tridentatus*) is a widely distributed species that uses the Delta for upstream migration as adults, for downstream migration as juveniles, and for rearing as ammocoetes (the larval stage of lamprey) (Hanni et al. 2006; Moyle et al. 2009). Pacific lamprey is present in the north, central, and south Delta, and ammocoetes are present year-round in all of the regions (California Department of Water Resources et al. 2013). Limited information on the status of Pacific lamprey in the Delta exists, but the number of lamprey inhabiting the Delta is likely greatly suppressed compared with historical levels, as suggested by the loss of access to historical habitat and apparent population declines throughout California and the Sacramento and San Joaquin River Basins (Moyle et al. 2009). Pacific lamprey is designated as a California SSC (Moyle et al. 2015).

Limited data indicate most adult Pacific lamprey migrate though the Delta en route to upstream holding and spawning grounds in the early spring through early summer (Hanni et al. 2006). As documented in other large river systems, it is likely that some adult migration through the Delta occurs from late fall and winter through summer and possibly over an even broader period (Robinson and Bayer 2005; Hanni et al. 2006; Moyle et al. 2009; Clemens et al. 2012; Lampman 2011). Data from the FMWT survey in the lower Sacramento and San Joaquin Rivers and Suisun Bay suggest that peak outmigration of Pacific lamprey through the Delta coincides with high-flow events from fall through spring (Hanni et al. 2006). Some outmigration likely occurs year-round, as observed at sites farther upstream (Hanni et al. 2006) and in other river systems (Moyle 2002). Some Pacific lamprey ammocoetes likely spend part of their extended (5 to 7 years) freshwater residence rearing in the Delta, particularly in the upstream, freshwater portions (California Department of Water Resources et al. 2013).

Pacific lamprey adults enter the Sacramento River from the Delta primarily during about March through June and hold in the river for about a year prior to spawning (Moyle et al. 2015). Spawning occurs in gravel redds in the upper river from March through July. The eggs and pro-larvae incubate for about 1 to 1.5 months. After the larvae (ammocoetes) emerge, they drift downstream and burrow into fine sediments primarily in off-channel habitats, where they rear (Schultz et al. 2014; Moyle et al. 2015). After 5 or more years, the ammocoetes metamorphose to the macropthalmia (juvenile) stage and migrate downstream to the Delta and ocean. Migration downstream is closely associated with rainfall events, with most migrants sampled in the upper Sacramento River being collected on the day of a rainfall event or the following 2 days (Goodman et al. 2015).

River flow potentially affects survival of Pacific lamprey eggs and larvae, and the migratory habitat of the juveniles and adults. Pacific lamprey build their spawning redds in shallow water (about 0.5 to 3.5 feet or 0.15 to 1 m) (Gunckel et al. 2009; Schultz et al. 2014; Moyle et al. 2015), so reductions in water level can dewater the redds. The larvae select habitats, often off-channel, with fine sediments, low flow velocity, and shallow depths (approximately 1 ft or 0.3 m), so they are vulnerable to stranding by reductions in water level.

In the San Francisco Estuary and Delta, occupancy of habitat by lamprey (including Pacific lamprey, western river lamprey [*Lampetra ayresii*], and Kern brook lamprey [*Lampetra hubbsi*] combined) was found to be greatest in the north and central Delta, with zero to low occupancy in the south Delta, San Joaquin River, and San Francisco Bay (Figure 11A-14). Predicted occupancy of habitat declines with increasing temperature; for example, in the lower Sacramento River, occupancy probability ranges from nearly 1 at very low temperatures (below 10°C [50.0°F]) to below 0.25 at temperatures around 25°C (77.0°F) (Goertler et al. 2019).



Source: Goertler et al. 2019.
Note: Data examined were for 2006–2016. Filled black circles are sampling sites.

Figure 11A-14. Mean Modeled Lamprey Occupancy Estimates Mapped by Region with Sites used in the Single-Season Lamprey Occupancy Model

There are no data on Pacific lamprey spawning specific to Clear Creek, but they are assumed to occur throughout the accessible portion of Clear Creek downstream of Whiskeytown Dam. Pacific lamprey are inferred to spawn and rear in Clear Creek because ammocoetes have been routinely collected in the screw trap at RM 1.7 (RKM 2.7). Lamprey life cycles in Clear Creek are assumed to follow those elsewhere in California. Pacific lamprey inhabit accessible reaches of the lower Feather River (California Department of Water Resources 2003). Little information is available on factors limiting Pacific lamprey populations in the lower Feather River, but they are likely affected by many of the same factors as salmon and steelhead because of parallels in their life cycles. Hannon and Deason (2008) have documented Pacific lamprey spawning in the nearby American River between early January and late May, with peak spawning typically occurring in early April. Pacific lamprey ammocoetes rear in the lower Feather River or American River for all or part of their 5- to 7-year freshwater residence.

Limited information on Pacific lamprey status in the Stanislaus River exists, but the species has experienced loss of access to historical habitat and apparent population declines throughout California and the Sacramento and San Joaquin River Basins (Moyle et al. 2009). Pacific lamprey ammocoetes are expected to rear in the Stanislaus River for all or part of their 5- to 7-year freshwater residence. Data from rotary screw trapping in the nearby Mokelumne and Tuolumne Rivers suggest that outmigration of Pacific lamprey generally occurs from early winter through early summer (Hanni et al. 2006). Catches of juvenile Pacific lampreys in trawl surveys of the mainstem San Joaquin River, near the mouth of the Stanislaus River at Mossdale, occurred during winter and spring. Significant numbers of lampreys of unknown species and unspecified life stage have been captured during rotary screw trapping on the Stanislaus River at Oakdale (FISHBIO Environmental 2007) and Caswell (Watry et al. 2007).

Pacific lamprey are an anadromous species that is important to local tribes and supports a subsistence fishery on the lower Trinity River. Adult Pacific lamprey may begin their upstream migration during all months of the year, but peak upstream migration typically occurs from December through June (Larson and Belchik 1998; Petersen Lewis 2009). After entering fresh water, Pacific lamprey hold through summer and most of the winter before reaching sexual maturity. Pacific lamprey undergo a secondary migration in the late winter or early spring from holding areas to spawning grounds; spawning occurs during the spring (Robinson and Bayer 2005; Clemens et al. 2012; Lampman 2011). Therefore, adult Pacific lamprey can be found in the Trinity River throughout the year. Ammocoetes rear within fine substrates in depositional areas and remain in the Trinity River and tributaries for up to 7 years before outmigrating to the ocean (Moyle 2002; Reclamation and Trinity County 2006). Limited data are available on the distribution and abundance of Pacific lamprey in the Trinity River. They are expected to have a distribution similar to anadromous salmonids that use the mainstem Trinity River and accessible reaches of larger tributaries. Pacific lamprey abundance in the Trinity River is believed to be declining based on information from Tribal fishermen who catch lamprey in the lower Klamath River (Petersen Lewis 2009). Parallels in the lifecycle of Pacific lamprey make them susceptible to many of the same factors as salmon and steelhead. Reduced access to historical spawning and rearing habitats in the Trinity River above Lewiston Dam, degraded spawning and rearing habitat resulting from operations of dams and water diversions, impacts from historic mining practices, and predation by nonnative invasive species (e.g., brown trout) have likely contributed to adverse effects on the Trinity River Pacific lamprey population.

11A.1.11. Western River Lamprey

11A.1.11.1. Status, Distribution, Life History, and Habitat Requirements

The river lamprey is not listed under ESA or CESA. On January 27, 2003, a broad group of West Coast conservation organizations petitioned the USFWS to list river lamprey, along with three other lamprey species on the West Coast, as threatened or endangered (Klamath-Siskiyou Wildlands Center et al. 2003). However, the petition was declined in a 90-day finding on December 27, 2004, citing insufficient evidence that listing was warranted (69 FR 77158).

River lamprey are found in large coastal streams from just north of Juneau, Alaska, to the San Francisco Bay (Vladykov and Follett 1958, Wydoski and Whitney 1979). The Sacramento and San Joaquin River Basins are at the southern edge of their range (Moyle et al. 2009). River lamprey seem to be primarily associated with the lower portions of certain large river systems, and most records for California are from the lower Sacramento–San Joaquin system, especially the Stanislaus and Tuolumne Rivers (Moyle et al. 1995; Moyle 2002). In the Sacramento River, they have been documented upstream to RBDD (Hanni et al. 2006; Moyle et al. 2009). River lamprey have also been collected in the Feather and American Rivers and Mill and Cache Creeks (Vladykov and Follett 1958; Hanni et al. 2006; Moyle et al. 2009). Quantitative data on populations are extremely limited, but loss and degradation of historical habitats suggest populations may have declined. The river lamprey is considered a California Species of Special Concern (Moyle et al. 2015).

River lamprey life history is poorly known, especially in California (Moyle et al. 2015). The adults migrate from the ocean to spawning areas during the fall and late winter (Beamish 1980). Spawning is believed to occur February through May in small tributary streams (Moyle 2002). The redds are built at the upstream end of small riffles (Moyle 2002). After the larvae (ammocoetes) emerge, they drift downstream and burrow into sediments in pools or side channels where they rear. After several years, the larvae metamorphose in late July and the juveniles (macropthalmia) migrate downstream in the following year from May to July (Moyle 2002).

River flow potentially affects survival of river lamprey eggs and larvae, and migratory habitat of the juveniles and adults. River lamprey build their spawning redds in shallow water (Moyle et al. 2015), so reductions in water level can dewater the redds. Assuming river lamprey larvae habitat requirements are similar to those of Pacific lamprey, the larvae select habitats that are often off-channel, with low flow velocity and shallow depths; therefore, they are vulnerable to stranding by reductions in water level.

Sacramento River Pacific lamprey adults enter the Sacramento River from the Delta primarily about March through June and hold in the river for about a year prior to spawning (Moyle et al. 2015). Spawning occurs in gravel redds in the upper river from March through July. The eggs and pro-larvae incubate for about 1 to 1.5 months. After the larvae (ammocoetes) emerge, they drift downstream and burrow into fine sediments primarily in off-channels habitats, where they rear (Schultz et al. 2014; Moyle et al. 2015). After 5 or more years, the ammocoetes metamorphose to the macropthalmia (juvenile) stage and migrate downstream to the Delta and ocean, typically migrating from March through June during pulse flow events (Moyle et al. 2015).

River lamprey have been collected in the Feather River, but there is little information about their use of the Feather River (Vladykov and Follett 1958; Hanni et al. 2006; Moyle et al. 2009). Spawning is generally in spring, at least in other locations (Beamish 1980), with adult-sized river lamprey collected in the Feather River from mid-November to early May (Hanni et al. 2006). There are no monitoring programs that target river lamprey. Quantitative data on populations are limited, but loss and degradation of historical habitats suggest populations may have declined. River lamprey are inconspicuous, often overlooked, and ammocoetes can be difficult to distinguish from ammocoetes of the co-occurring Pacific lamprey. Hanni et al. (2006) summarized distribution data and did not include specific information for the American River or Stanislaus River. It is possible that the species occurs in these areas based on available habitat. River lamprey have been collected in the San Joaquin River at Mossdale, suggesting spawning somewhere in the San Joaquin River Basin.

11A.1.12. Sacramento Hitch

11A.1.12.1. Status, Distribution, Life History, and Habitat Requirements

Sacramento hitch (*Lavinia exilicauda exilicauda*) is a California SSC (Moyle et al. 2015). The species historically occurred in low-elevation streams throughout the Sacramento and San Joaquin Valleys and in the Delta, but are now extirpated from the San Joaquin River and tributaries between Friant Dam and the Merced River (Brown 2000, as cited by Moyle et al. 2015; California Department of Fish and Game 2007, as cited in Moyle et al. 2015). Within the San Francisco Estuary and Delta vicinity, there are historical records (from before the water development of the 1950s) for Sacramento hitch in Coyote Creek and Alameda Creek. However, the species may have been introduced to Arroyo Valle through water transfers from the Central Valley. Furthermore, it is unknown if populations in these streams are reproducing or are sustained from reservoir or historical stream populations (Leidy 2007). The species occurs in some urban streams and may tolerate highly altered habitats. Sacramento hitch face continued threats from population fragmentation (e.g., dams), agriculture (e.g., flow alteration and pollution), estuary alteration, and nonnative species. The species appears to be in long-term decline and mainly consists of scattered, small populations over a broad area. However, there is only moderate concern for overall species extinction in part due to its fairly secure establishment in some areas (Moyle et al. 2015).

Moyle et al. (2015:2) summarized habitat and distribution: Spawning takes place mainly in riffles of streams tributary to lakes, river, and sloughs after flows increase in response to spring rains, but spawning requirements are in need of further documentation. Moyle et al. (2015:2) indicate that YOY hitch spend the next two months after hatching shoaling in shallow water or staying close to aquatic plants before moving out into more open water at around 50-mm fork length. The species is distributed in the Sacramento River Basin but no longer in the San Joaquin River Basin and in some locations in the north Delta (Moyle et al. 2015:2–3).

11A.1.13. Sacramento Splittail

11A.1.13.1. Status, Distribution, Life History, and Habitat Requirements

The Sacramento splittail (*Pogonichthys macrolepidotus*) was listed as threatened under ESA on February 8, 1999 (64 FR 5963). This ruling was challenged by two lawsuits (*San Luis & Delta-*

Mendota Water Authority v. Anne Badgley et al. and *State Water Contractors et al. v. Michael Spear et al.*). On June 23, 2000, the Federal Eastern District Court of California found the ruling to be unlawful and on September 22 of the same year remanded the determination back to the USFWS for re-evaluation of their original listing decision. Upon further evaluation, Sacramento splittail was removed from the ESA on September 22, 2003 (68 FR 55139). On August 13, 2009, the Center for Biological Diversity (2009) challenged the 2003 decision to remove Sacramento splittail from the ESA. However, on October 7, 2010, the USFWS found that listing of Sacramento splittail was not warranted (75 FR 62070). The Sacramento splittail is designated as a California SSC by the CDFW.

Sacramento splittail are found primarily in marshes, turbid sloughs, and slow-moving river reaches throughout the Delta subregion (Sommer et al. 1997, 2008). Sacramento splittail are most abundant in moderately shallow, brackish tidal sloughs and adjacent open-water areas, but they also can be found in freshwater areas with tidal or riverine flow (Moyle et al. 2004).

Adult Sacramento splittail typically migrate upstream from brackish areas in January and February and spawn in fresh water, particularly on inundated floodplains when they are available, in March and April (Sommer et al. 1997; Moyle et al. 2004; Sommer et al. 2008). A substantial amount of Sacramento splittail spawning occurs in the Yolo and Sutter Bypasses and the Cosumnes River area of the Delta (Moyle et al. 2004). Spawning also can occur in the San Joaquin River during high-flow events (Sommer et al. 1997, 2008). However, not all adults migrate significant distances to spawn, as evidenced by spawning in the Napa and Petaluma Rivers (Feyrer et al. 2005).

Although juvenile Sacramento splittail are known to rear in upstream areas for a year or more (Baxter 1999), most move to the Delta after only a few weeks or months of rearing in floodplain habitats along the rivers (Feyrer et al. 2006). Juveniles move downstream into the Delta from April to August (Meng and Moyle 1995; Feyrer et al. 2005). Juvenile size at outmigration downstream from the Yolo Bypass was found to generally be around 30–40-mm fork length (Feyrer et al. 2006). Sacramento splittail recruitment is largely limited by extent and period of inundation of floodplain spawning habitats, with abundance observed to spike following wet years and dip after dry years (Moyle et al. 2004). However, the 5- to 7-year life span buffers the adult population abundance (Sommer et al. 1997; Moyle et al. 2004). Other factors that may adversely affect the splittail population in the Delta include entrainment, predation, changed estuarine hydraulics, nonnative species (Moyle et al. 2004), pollutants (Greenfield et al. 2008), and limited food.

Historically, Sacramento splittail were widespread in the Sacramento River from Redding to the Delta (Rutter 1908, as cited in Moyle et al. 2004). This distribution has become somewhat reduced in recent years (Sommer et al. 1997, 2007). During drier years there is evidence that spawning occurs farther upstream (Feyrer et al. 2005). Adult Sacramento splittail migrate upstream in the lower Sacramento River to above the mouth of the Feather River and into the Sutter and Yolo Bypasses (Sommer et al. 1997; Feyrer et al. 2005; Sommer et al. 2007). Each year, mainly during the spring spawning season, a small number of individuals have been documented at the Red Bluff Pumping Plant and the entrance to the GCID intake (Moyle et al. 2004).

As previously noted, nonreproductive adult Sacramento splittail are most abundant in moderately shallow, brackish areas in the Delta and Suisun Bay, but can also be found in freshwater areas with tidal or riverine flow (Moyle et al. 2004). Adults typically migrate upstream from brackish areas in January and February and spawn in fresh water on inundated floodplains in March and April (Moyle et al. 2004; Sommer et al. 2007). In the Sacramento drainage, the most important spawning areas appear to be the Yolo and Sutter Bypasses, in years that they are inundated. However, some spawning occurs almost every year along inundated river edges and backwaters created by small increases in flow. Sacramento splittail spawn in the Sacramento River from Colusa to Knights Landing in most years (Feyrer et al. 2005).

Most juvenile Sacramento splittail move from upstream areas downstream into the Delta from April through August (Meng and Moyle 1995; Sommer et al. 2007). The production of YOY Sacramento splittail is largely influenced by extent and duration of inundation of floodplain spawning habitats, with abundance spiking following wet years and declining after dry years (Sommer et al. 1997; Moyle et al. 2004; Feyrer et al. 2006). Other factors that may affect the Sacramento splittail adult population include pumping at the CVP and SWP south Delta export facilities, flood control operations and infrastructure, entrainment by irrigation diversions, recreational fishing, changed estuarine hydraulics, pollutants, and nonnative species (Moyle et al. 2004; Sommer et al. 2007).

Sacramento splittail enter the lower Feather River primarily in wet years. On the lower Feather River, February through May is believed to encompass the period of Sacramento splittail spawning, egg incubation, and initial rearing (Sommer et al. 2008, California Department of Water Resources 2004a). Sacramento splittail use shallow flooded vegetation for spawning. Most spawning in the Feather River is thought to occur downstream of the Yuba River confluence (Federal Energy Regulatory Commission 2007). The primary factor that likely limits the lower Feather River population of Sacramento splittail is availability of spawning and rearing habitats as related to inundation of floodplains (Moyle et al. 2004; California Department of Water Resources 2004).

Sacramento splittail likely spawn in the lower reaches of the American River, particularly in wetter conditions (Moyle et al. 2004). Mature individuals begin a gradual upstream migration toward spawning areas between late November and late January (Moyle et al. 2004). Spawning typically occurs between late February and early July (Wang 2010). Although juvenile Sacramento splittail can rear in upstream areas for a year or more (Baxter 1999), most move downstream after only a few weeks of rearing (Reclamation 2008a). Most juveniles move downstream into the Delta from April to August (Meng and Moyle 1995).

In wet years Sacramento splittail have been found in the San Joaquin River as far upstream as Salt Slough (Baxter 1999, 2000; Brown and Moyle 1993; Saiki 1984). Historically, Sacramento splittail were widespread in the San Joaquin River and found upstream to Tulare and Buena Vista Lakes, where they were harvested by native peoples (Moyle et al. 2004). Spawning typically takes place on inundated floodplains from February through June, with peak spawning in March and April. Today, Sacramento splittail likely ascend the San Joaquin River to Salt Slough during wet years (Baxter 1999). During dry years, Sacramento splittail are uncommon in the San Joaquin River and occur only downstream of the Tuolumne River (Moyle et al. 2004). Most spawning takes place in the flood bypasses, along the lower reaches of the Sacramento and

San Joaquin Rivers and major tributaries, and lower Cosumnes River and similar areas in the western Delta.

11A.1.14. Hardhead

11A.1.14.1. Status, Distribution, Life History, and Habitat Requirements

Hardhead (*Mylopharodon conocephalus*) is a California SSC (Moyle et al. 2015). The species is found throughout the Sacramento–San Joaquin River Basin and are fairly common in the Sacramento River and the lower reaches of the American and Feather Rivers. In other parts of their range, populations have declined or have become increasingly isolated (Moyle 2002). Hardhead also inhabit reservoirs and are abundant in a few impoundments where water level fluctuations prevent black bass from reproducing in large numbers (Moyle 2002). Hardhead tend to be absent from areas that have been highly altered (Moyle et al. 1995) or that are dominated by introduced fish species, especially centrarchids (species of the black bass and sunfish) (Moyle et al. 1995). Hardhead are omnivorous, with a diet consisting mostly of benthic invertebrates and aquatic plants, but also including drifting insects. In reservoirs, hardhead also prey on zooplankton (Moyle et al. 1995).

Hardhead spawn mainly in April and May, but some may spawn as late as August in the foothill regions of the upper San Joaquin River (Wang 2010). They migrate upstream and into tributary streams as far as 45 miles (72.4 km) to spawning sites. Spawning behavior has not been documented, but it is assumed to be similar to that of the pikeminnow, which deposit their eggs over gravel-bottomed riffles, runs, and at the head of pools (Moyle et al. 1995). Spawning substrates may also include sand and decomposed granite (Wang 2010).

Hardhead larvae and juveniles likely inhabit stream margins with abundant cover and move into deeper habitats as they grow larger. Adults occupy the deepest part of pools. Juvenile and adult hardhead are present in the Sacramento River year-round. They tend to prefer water temperatures near 67°F (19.4°C) (Thompson et al. 2012), but have been captured at RBDD, where water temperatures are generally much cooler (Tucker et al. 1998).

Hardhead are present in very low abundance in the San Francisco Estuary and Delta, as reflected by electrofishing in the 1980s and 2000s (Brown and Michniuk 2007) and very few individuals being collected at the SWP/CVP south Delta fish salvage facilities (California Department of Water Resources 2020:4-62).

In 2004 and 2005, hardhead were found at only 2 of 31 sampling locations upstream of Whiskeytown Dam (both in the mainstem Clear Creek) (Wulff et al. 2012). Hardhead are also found in Whiskeytown Reservoir (National Park Service 1999).

Hardhead are fairly common year-round in the lower reaches of the American River (Moyle 2002). Although migratory behavior of hardhead in the American River individuals is unknown, individuals from other large rivers, such as the Sacramento River, migrate into tributary streams during April and May. Hardhead typically spawn between April and May (Moyle 2002). Although hardhead early life history is largely unknown, young individuals likely remain along stream edges with dense cover and move into deeper water as they grow, which allows migrants to move back downstream in the current (Moyle 2002).

In the San Joaquin drainage, hardhead are present throughout tributary streams, but are largely absent from the mainstem San Joaquin River as a result of periodic desiccation during the dry season. Hardhead are widely distributed in foothill streams and may be found in a few reservoirs such as Redinger and Kerkhoff Reservoirs upstream of Millerton Reservoir on the San Joaquin River.

11A.1.15. Central California Roach

11A.1.15.1. Status, Distribution, Life History, and Habitat Requirements

The Sacramento–San Joaquin Roach (*Lavinia symmetricus symmetricus*), a California SSC, is part of the California Roach complex, which consists of various subspecies (Moyle 2002). Central California roach is a small (usually less than 10-cm total length), stout-bodied minnow that occurs in tributaries to the Sacramento and San Joaquin Rivers and tributaries to San Francisco Bay. Their historic distribution in the upper Sacramento River Basin is poorly understood, but their upstream range limit is thought to have been Pit River Falls (Moyle et al. 2015).

Central California roach are found in small, high gradient, often intermittent tributaries but appear to be poorly adapted to lakes and reservoirs. Where dams have been constructed on Central Valley streams, Central California roach persist only in small tributaries to the resultant reservoirs (Moyle et al. 2015). Their absence from reservoirs is likely due both to habitat alteration and to the presence of introduced predatory fish species. Central California roach is a California SSC (Moyle et al. 2015). They primarily inhabit small streams, but may occur in backwaters with dense riparian cover along the mainstem rivers (Baumsteiger and Moyle 2019). Central California roach frequent a wide variety of habitats, which are often isolated by downstream barriers. They are adaptable fish and tolerate relatively high water temperatures and low oxygen levels (Moyle et al. 2016). They spawn from March through early July, usually when water temperatures exceed about 61°F or 16.1°C (Moyle 2002). Hatching takes place in 2 to 3 days, and fry remain in crevices until they can actively swim. Roach are omnivores, eating such items as terrestrial insects, filamentous algae, aquatic insect larvae and adults, crustaceans, and detritus.

Central California roach are present in very low abundance in the San Francisco Estuary and Delta, as reflected by electrofishing in the 1980s and 2000s (Brown and Michniuk 2007) and none being collected at the SWP/CVP south Delta fish salvage facilities (California Department of Water Resources 2020:4-62).

In 2004 and 2005, Central California roach were found in 3 of 11 surveyed streams upstream of Whiskeytown Dam. They were confined to Clear Creek and its tributary Cline Gulch upstream of the Carr Powerhouse and Grizzly Gulch upstream of Whiskeytown Reservoir. They were also found in Paige-Boulder Creek, a tributary of Clear Creek downstream of Whiskeytown Dam. Where found, Central California roach may be locally abundant, second in abundance only to riffle sculpin and, in some locations, Sacramento sucker (Wulff et al. 2012).

11A.1.16. Sacramento Perch

11A.1.16.1. Status, Distribution, Life History, and Habitat Requirements

Sacramento perch (*Archoplites interruptus*) is the only species of the family Centrarchidae (i.e., sunfishes) that naturally occurs west of the Rocky Mountains (Moyle 2002). The native range of Sacramento perch includes the Central Valley, Pajaro and Salinas Rivers, tributaries to the San Francisco Estuary (e.g., Alameda Creek), and Clear Lake (in Lake County) (Crain and Moyle 2011). Sacramento perch is extinct in its native range (Moyle et al. 2015:1).

Sacramento perch are often associated with beds of rooted, submerged, and emergent vegetation and other submerged objects. Sacramento perch are able to tolerate a wide range of physicochemical water conditions. This tolerance is thought to be an adaptation to fluctuating environmental conditions resulting from floods and droughts. Thus, Sacramento perch do well in highly alkaline water (McCarraher and Gregory 1970; Moyle 1976). Most populations today are established in warm, turbid, moderately alkaline reservoirs or farm ponds. Spawning occurs during spring and early summer when water temperatures are about 18°C to 29°C (64.4°F to 84.2°F), and usually begins by the end of March, continuing through early August (McCarraher and Gregory 1970).

Sacramento perch were apparently largely gone from the Delta by the time of the major fish surveys of the 1950s and 1960s (Moyle 2002). Because Sacramento perch are tolerant of a wide range of conditions, they would still likely be abundant throughout their native range in the absence of introduced centrarchids, especially crappie and sunfishes, which successfully compete with Sacramento perch (Moyle 2002) and may prey on their embryos and larvae (Moyle 2002). Interspecific competition for food and space may be the single most important cause of the Sacramento perch decline (Moyle 2002).

Only two Sacramento perch have been reportedly salvaged at the SWP and CVP fish salvage facilities between 1959 and 2005, while only two have been reportedly caught during Delta fisheries surveys during the same period (Bay Delta and Tributaries Project 2010). However, these salvage numbers represent only the actual number of Sacramento perch counted, not the actual number of Sacramento perch salvaged.

11A.1.17. Starry Flounder

11A.1.17.1. Status, Distribution, Life History, and Habitat Requirements

Starry flounder (*Platichthys stellatus*) is a species for which essential fish habitat (EFH for Pacific Groundfish) exists in the San Francisco Estuary and Delta. The overall extent of Pacific Groundfish EFH includes all water and substrate in depths that are less than or equal to 11,483 feet (3,500 meters) to the mean higher high water level or the upriver extent of saltwater intrusion (upstream area and landward where waters have salinities less than 0.5 ppt), known spawning habitat and thermal refugia, complex channels and floodplains and areas containing estuarine and marine SAV.

Starry flounder is a flatfish that belongs to the family Pleuronectidae (Moyle 2002). Starry flounder range from north of the Bering Strait south to Los Angeles Harbor. Older juveniles and adults are found from 75 miles (120.7 km) upstream to the outer continental shelf at 375 m (1230 ft) depth, but most adults are found at less than 150 m (492 ft) depth. Most juvenile fish are found in shallow, fresh to brackish water, and shift to salinities of 10–15 ppt as they mature, but appear to remain within estuaries through at least their second year (Baxter et al. 1999; Moyle 2002). During the late fall and winter, mature starry flounder probably migrate to shallow coastal waters to spawn (Orcutt 1950). Adults primarily inhabit coastal marine waters (Orcutt 1950; Haertel and Osterberg 1967; Bottom and others 1984; Hieb and Baxter 1993). Distribution of age-0 juveniles within the San Francisco Estuary and Delta is primarily in Suisun Bay and San Pablo Bay, with lower abundance in the west Delta (Baxter 1999:410). Starry flounder older than age 1 (age-1+ fish) occur principally in San Pablo Bay, Suisun Bay, and Central Bay (Baxter et al. 1999:411–412).

In general, abundance indices from the past decade suggest a decline relative to several decades ago, consistent with declines in commercial and recreational catch (ICF International 2016a:5.E-12 and 5.E-13). Starry flounder are found on different substrates including gravel, clean shifting sand, hard stable sand, and mud substrata, but fishermen report the largest catches over soft sand. Prey from mud (sternapsid worms) and sand (*Siliqua patula* clams) habitats have been observed in the stomach of a single individual, suggesting fish move freely from one habitat type to another (Orcutt 1950). Starry flounder also consume crabs, shrimps, worms, clams and clam siphons, other small mollusks, small fishes, nemertean worms, and brittle stars (Hart 1973). Starry flounder can tolerate a wide range of salinities. In the Sacramento and San Joaquin Rivers, starry flounder have been observed in salinities of 0.02–0.06 ppt (i.e., essentially fresh water) (Orcutt 1950), and have been collected 75 miles (120.7 km) upstream in the Columbia River. Age-0 and age-1+ starry flounder are a common species in estuarine habitats along the West Coast (see Orcutt 1950; Sopher 1974; Pearson 1989; Emmett et al. 1991; Baxter et al. 1999; Kimmerer 2002). Spawning occurs primarily during the winter months of December and January (Orcutt 1950). Starry flounder reach approximately 110 mm in length by the end of their first year. By the time they reach age 2 many fish have migrated to ocean habitats adjacent to their natal estuaries. Starry flounder become reproductively mature at age 2 for males and age 3 for females, which equates to approximately 28 cm in males and approximately 35 cm in females. Adults may move seasonally into shallow coastal waters to spawn, perhaps in proximity to estuaries to take advantage of estuarine circulation which would advect fertilized eggs near the bottom into nursery areas.

Hieb and Baxter (1993) established specific habitat criteria for starry flounder YOY (<70 mm) in the San Francisco Estuary: 90% were collected from intertidal and subtidal habitats <7 m in depth, and with accompanying salinities of <22%. The exclusivity of fresh and brackish water rearing habitat in age-0 and age-1 starry flounder coupled with the relationship between freshwater outflow and abundance makes a strong case for estuarine dependence (Emmett et al. 1991; Hieb and Baxter 1993). However, spawning in coastal areas and variation in abundance during high outflow years suggest that coastal ocean conditions as well as high outflow work in conjunction to determine year class abundance (Hieb and Baxter 1993). There is a significant correlation between Delta outflow (X2) and indices of starry flounder abundance in the San Francisco Estuary and Delta, although the mechanism underlying the correlation does not appear to be related to extent of habitat and may be related to enhanced transport to estuarine rearing grounds by increased residual circulation with increased outflow (Kimmerer et al. 2009). It is unknown the extent to which this potential enhanced transport and apparent greater abundance in the San Francisco Estuary and Delta with greater outflow may contribute to overall coastwide starry flounder abundance (Grimaldo 2018:13-14).

11A.1.18. Northern Anchovy

11A.1.18.1. Status, Distribution, Life History, and Habitat Requirements

Northern anchovy (*Engraulis mordax*) is a species for which EFH exists in the San Francisco Estuary and Delta and is one of the species managed under the Coastal Pelagic Species Fishery Management Plan (FMP). The overall extent of Coastal Pelagic EFH is based on a thermal range bordered by the geographic area where the managed coastal pelagic species in the FMP occur at any life stage, where these species have occurred historically during periods of similar environmental conditions, or where environmental conditions do not preclude colonization by these species. Species diversity and abundance declines on an upstream gradient as determined by the tolerance of individual species for low and variable salinity conditions.

Northern anchovy is distributed along the West Coast from British Columbia to Baja, California (Miller and Lea 1972). The central subpopulation, which is present in the project area, ranges from approximately San Francisco, California, to Punta Baja, Baja California. Members of the central population move north during the summer and south during the winter (Haugen and others 1969). Northern anchovy is an important forage fish for other resident and migratory species in the San Francisco Estuary and Delta, including salmon, jacksmelt (*Atherinopsis califoniensis*), and striped bass (Baxter et al. 1999:167). It supports a moderate commercial fishery for live bait (Smith and Kato 1979). The annual abundance of northern anchovy is highly variable between years. Surveys have shown that the greatest densities occur in Central, San Pablo, and South Bays, and only in late summer were they collected in appreciable numbers in Suisun Bay (Baxter et al. 1999).

Northern anchovy is a small fish typically found in schools near the surface of the water. They are short-lived, rarely living past 4 years of age. A portion of the population reaches maturity at the end of their first year, about 50% by the end of their second year, and all are mature by their third or fourth year (Clark and Phillips 1952). Female anchovy are batch spawners, spawning 20,000 to 30,000 eggs a year in two or three events (Baxter 1967). Spawning can occur during every month of the year and is temperature dependent, increasing in late winter and early spring and peaking from February to April. They spawn in nearshore areas across their entire range, in the upper 50 meters of the water column. Spawning in the bay occurs at higher temperatures and lower salinities than spawning in coastal areas (McCrae 1994; Bergen and Jacobson 2001). Both northern anchovy eggs and larvae are found near the surface, and eggs need 2 to 4 days to hatch, depending on water temperatures. The San Francisco Bay is a very productive nursery area because of high abundance of food for both larvae and adults, advective losses are lower than in adjacent coastal waters, and the bay is warmer, with varying salinity allowing for eggs and larvae throughout the year (Reclamation 2008). Anchovies feed diurnally either by filter feeding or biting, depending on the size of the food. Juvenile and adult anchovy feed at a higher trophic level than larvae, selectively feeding on larger zooplankton (mysids), fish eggs, and fish larvae and have been observed to eat small fish at times, even their own species (Baxter 1967).

Larvae eat phytoplankton and dinoflagellates, while larger larvae pick up copepods and other zooplankton. Larger female anchovies can consume up to 4%–5% of their total body weight per day. Competitors with the anchovy for food include sardines and other schooling planktivores, such as jacksmelt and topsmelt (*Atherinops affinis*). These species are also potential predators of young anchovy life stages (Goals Project 2000).

Factors affecting anchovy production are mostly natural influences, such as ocean temperature (California Department of Fish and Game 2001). Offshore within the California Current, temperature, upwelling, and stable stratification of the water column are believed to work together to produce conditions that are favorable to anchovy larvae (Lasker 1975). Investigation of the correlations between Delta outflow (X2) and indices of abundance and habitat did not find statistically significant relationships (Kimmerer et al. 2009). The distribution of northern anchovy shifted toward higher salinity when *Potamocorbula* invaded in the mid- to late 1980s, reducing summer abundance by >90% in the low-salinity region of the San Francisco Estuary and Delta (Kimmerer 2006).

11A.1.19. Striped Bass

11A.1.19.1. Status, Distribution, Life History, and Habitat Requirements

Striped bass is a recreationally important anadromous species introduced into the Sacramento and San Joaquin River Basins between 1879 and 1882 (Moyle 2002). Despite their nonnative status and piscivorous feeding habits, striped bass are considered important because they are a major game fish in the Delta. Striped bass use the Delta as a migratory route and for rearing and seasonal foraging. Striped bass spend the majority of their lives in salt water, returning to fresh water to spawn. When not migrating for spawning, adult striped bass in the San Francisco Estuary and Delta are found in San Pablo Bay, San Francisco Bay, and the Pacific Ocean (Moyle 2002). Adult striped bass spend about 6 to 9 months of the year in San Francisco and San Pablo Bays (Hassler 1988). Striped bass also use deeper areas of many of the larger channels in the Delta, in addition to large embayments such as Suisun Bay.

Spawning occurs in spring, primarily in the Sacramento River between Sacramento and Colusa and in the San Joaquin River between Antioch and Venice Island (Farley 1966). Eggs are free-floating and negatively buoyant and hatch as they drift downstream, with larvae occurring in shallow and open waters of the lower reaches of the Sacramento and San Joaquin Rivers, the Delta, Suisun Bay, Montezuma Slough, and Carquinez Strait. According to Hassler (1988), the distribution of larvae in the estuary depends on river flow. In low-flow years, all striped bass eggs and larvae are found in the Delta, while in high-flow years, the majority of eggs and larvae are transported downstream into Suisun Bay.

YOY striped bass distribute themselves in accordance with the estuarine salinity gradient (Kimmerer 2002; Feyrer et al. 2007), indicating that salinity is a major factor affecting their habitat use and geographic distributions. Kimmerer (2002) found that distributions of fish species, including striped bass, substantially overlapped with the low-salinity zone. Older striped bass are increasingly flexible about their distribution relative to salinity (Moyle 2002). Statistically significant correlations between indices of age-0 abundance or survival in the San Francisco Estuary and Delta have been found with Delta outflow (X2) (e.g., Kimmerer et al. 2009; Mac Nally et al. 2010), with evidence for greater extent of habitat as the mechanism (Kimmerer et al. 2009). However, subsequent density-dependent survival after the first summer dampens the effects of flow on subsequent recruitment (Kimmerer et al. 2000).

The entrainment of striped bass has been observed at the south Delta export facilities, including Clifton Court Forebay (Stevens et al. 1985; Bowen et al. 1998; Aasen 2012). In water year 2011, salvage of striped bass at export facilities (approximately 550,000 fish) continued a generally low trend observed since the mid-1990s. Prior to 1995, annual striped bass salvage was generally above 1 million fish (Aasen 2012). DWR et al. (2013) reported that striped bass longer than 24 mm were effectively screened at TFCF and bypassed the pumps. However, planktonic eggs, larvae, and juveniles smaller than 24 mm in length received no protection from entrainment. Although the percentage entrainment of YOY juveniles during June through September at the south Delta export facilities was estimated to be appreciable (median of 33%, maximum of 99%), any population-level effect may have been obscured by variability in total mortality and possibly salvage operations success, or the density-dependent effect during and after this life stage (Kimmerer et al. 2000, 2001).

Striped bass, primarily YOY, are one of the pelagic fish of the upper estuary that have shown substantial variability in their populations, with evidence of long-term declines (Kimmerer et al. 2000; Sommer et al. 2007). A substantial proportion of the variability in abundance index patterns has been associated with variation of outflow in the estuary (Jassby et al. 1995; Kimmerer et al. 2001; Loboschefsky et al. 2012), although this is disputed by some stakeholders (Bourez 2011). However, surveys showed that population levels for YOY striped bass began to decline sharply around 1987 and 2002 (Thomson et al. 2010), despite relatively moderate hydrology, which typically supports at least modest fish production (Sommer et al. 2007). Moyle (2002) cites causes of decline in striped bass to include climatic factors, entrainment at project export facilities in the south Delta, other diversions, pollutants, reduced estuarine productivity, invasions by alien species, and human exploitation. Kimmerer et al. (2000, 2001) attribute the decline in juvenile YOY striped bass to declining carrying capacity, likely related to food limitation. Loboschefsky et al. (2012) showed that there had been no long-term decline for age-1 and older striped bass as of 2004.

Striped bass occur in the lower Feather River and have been reported to occur in the Thermalito Forebay (Federal Energy Regulatory Commission 2007). Striped bass are a popular sport fish in the lower Feather River during periods when they migrate upstream to spawn. Little is known about striped bass use of the Feather River, although acoustically tagged striped bass released in the Feather River spent more time in the river than acoustically striped bass released in the Sacramento River (Sabal et al. 2019). These acoustically tagged striped bass generally seemed to follow seasonal prey sources, with the most time spent in the San Francisco and San Pablo Bays during the summer, and greatest detections in Delta in the winter, with an overall variability to behavior that may have allowed persistence since the original introduction of the species (Sabal et al. 2019).

Striped bass are year-round inhabitants of the American River from the confluence with the Sacramento River to Nimbus Dam, with highest densities during summer (Surface Water Resources 2001; Moyle 2002). Although specific spawning locations in the American River are not well understood, the river is believed to serve as a nursery area for YOY and subadult striped bass (Surface Water Resources 2001). They provide a locally important sportfishing resource.

Striped bass occur in the Stanislaus River, and they support a sport fishery when adult fish migrate upstream to spawn. Striped bass have been observed at Lovers Leap and at Knights

Ferry from May through the end of June. These adult fish were observed in all habitats (U.S. Fish and Wildlife Service 2002; Kennedy and Cannon 2005). The distribution of striped bass in the Stanislaus River is thought to be limited to downstream of the historic Knights Ferry Bridge because of a set of falls about 3 feet (0.91 m) tall in the area (U.S. Fish and Wildlife Service 2002b). Ainsley et al. (2013) reported that striped bass were collected in May at two locations on the mainstem San Joaquin River between the Head of Old River and the mouth of the Stanislaus River.

11A.1.20. American Shad

11A.1.20.1. Status, Distribution, Life History, and Habitat Requirements

American shad is a recreationally important anadromous species introduced into the Sacramento and San Joaquin River Basins in the 1870s (Moyle 2002). American shad spend most of their adult life at sea and may make extensive migrations along the coast. American shad become sexually mature while in the ocean and migrate through the Delta to spawning areas in the Sacramento, Feather, American, and Yuba Rivers. Some spawning also takes place in the lower San Joaquin, Mokelumne, and Stanislaus Rivers (U.S. Fish and Wildlife Service 1995). The spawning migration may begin as early as February, but most adults migrate into the Delta in March and early April (Skinner 1962). Migrating adults generally take 2 to 3 months to pass through the Delta (Painter et al. 1979). They enter the Feather River annually in spring to spawn and are present in the lower Feather River from May through mid-December during the adult immigration, spawning, and outmigration periods of their life cycle (California Department of Water Resources 2003). Adult American shad migrate into the lower American River to spawn during the late spring, typically during April through early July (California Department of Fish and Game 1986). American shad migrate up the Stanislaus River to spawn in the late spring and support a sport fishery during that period. American shad have been observed on occasion from June through July at Lovers Leap (U.S. Fish and Wildlife Service 2002b; Kennedy and Cannon 2005). American shad were found primarily in the faster habitats and were observed in schools of 20 or more (U.S. Fish and Wildlife Service 2002b). Little is known about American shad in the San Joaquin River. They may spawn in the San Joaquin River system, but their abundance is unknown. Sport fishing for American shad occurs seasonally in the San Joaquin River. A unique, successfully reproducing landlocked population of American shad exists in Millerton Lake.

Water temperature is an important factor influencing the timing of spawning. American shad are reported to spawn at water temperatures ranging from approximately 46°F (7.8°C) to 79°F (26.1°C) (U.S. Fish and Wildlife Service 1967), although optimal spawning temperatures are reported to range from about 60°F (15.5°C) to 70°F (21.1°C) (Bell 1986; California Department of Fish and Game 1980; Leggett and Whitney 1972; Painter et al. 1979; Leidy 1984). Spawning takes place mostly in the main channels of rivers, and generally about 70% of the spawning run is made up of first-time spawners (Moyle 2002).

Shad have remarkable abilities to navigate and to detect minor changes in their environment (Leggett 1973). Although homing is generally assumed in the Sacramento River and its tributaries, there is some evidence that numbers of first-time spawning fish are proportional to flows of each river at the time the shad arrive. When suitable spawning conditions are found, American shad school and broadcast their eggs throughout the water column. The optimal temperature for egg development is reported to occur at 62°F (16.7°C). At this temperature, eggs hatch in 5 to 8 days; at temperatures near 75°F (23.9°C), eggs would hatch in 3 days (MacKenzie et al. 1985). Egg incubation and hatching, therefore, are coincident with the spawning period.

Fertilized eggs are slightly negatively buoyant, are not adhesive, and drift in the current. Newly hatched larvae are found downstream of spawning areas and can be rapidly transported downstream by river currents because of their small size. Juvenile American shad rear in the Sacramento River from Colusa to Sacramento, the lower Feather River below the Yuba River, and the Sacramento River portion of the Delta (Stevens et al. 1987). As previously noted, rearing also takes place in the Mokelumne River near the DCC. Based on density, juvenile rearing in the American and Yuba Rivers appears less than other areas (Stevens et al. 1987). Overall, in contrast to striped bass, an appreciable portion of the American shad population appears to rear upstream of the Delta based on density in seine catches (Stevens et al. 1987). Some juvenile shad may rear in the Delta for up to a year before outmigrating to the ocean (U.S. Fish and Wildlife Service 1995). Outmigration from the Delta begins in late June and continues through November (Painter et al. 1979).

Juvenile American shad are frequently encountered in the Delta during the FMWT survey and in fish salvage monitoring at the south Delta SWP and CVP fish facilities (California Department of Water Resources et al. 2013). American shad use of the Delta has been observed to vary with salinity (e.g., X2) and outflows (Kimmerer 2002). Statistically significant negative correlations exist between X2 and indices of abundance in the San Francisco Estuary and Delta, with the mechanism potentially being related to the extent of available habitat (Kimmerer et al. 2009).

American shad are entrained at the TFCF (Bowen et al. 1998) and in the Clifton Court Forebay, mostly during May through December when young American shad migrate downstream. The American shad population in the Sacramento and San Joaquin River Basins has declined since the late 1970s, most likely because of increased diversion of water from rivers and the Delta, combined with changing ocean conditions, and possibly pesticides (Moyle 2002). Salvage of American shad at project export facilities in water year 2011 represented nearly 659,000 fish (Aasen 2012), with similar but slightly lower salvage in 2010 (545,125 fish) (Aasen 2011).

11A.1.21. Threadfin Shad

11A.1.21.1. Status, Distribution, Life History, and Habitat Requirements

Threadfin shad (*Dorosoma petenense*) were intentionally introduced to provide forage for game fish. Threadfin shad were planted by CDFW in reservoirs throughout California, with the Sacramento and San Joaquin River Basins planted in 1959. From these transplants, they have become established in the Sacramento–San Joaquin River system and the Delta. Threadfin shad live mainly in fresh water and become progressively less abundant as salinity increases. Juveniles form dense schools and, in estuaries, are found in water of all salinities, although they are most abundant in fresh water. Threadfin shad are fast-growing but short-lived; few live longer than 2 years. Spawning takes place in California in April through August, peaking in June and July when water temperatures exceed 20°C (68°F), although spawning has been observed at 14°C to 18°C (57.2°F to 64.4°F). The embryos hatch in 3 to 6 days and larvae immediately assume a planktonic existence.

As noted by Baxter et al. (2010:75), threadfin shad is widely distributed but is most commonly encountered and most abundant in the southeastern Delta, especially the San Joaquin River near and just downstream of Stockton, where suitable abiotic habitat coincides with high prey abundance (Feyrer et al. 2009); these regions also have a relatively high density of SAV, which provides important spawning and larval rearing habitat (Grimaldo et al. 2004). Baxter et al. (2010) also noted that historical surveys by Turner (1966) found relatively high abundance in the northeast Delta in dead-end sloughs.

Threadfin shad are susceptible to entrainment in water diversions and the species is salvaged at the SWP and CVP south Delta fish salvage facilities in higher abundance than any other fish species. Herbold et al. (2005) estimated annual salvage from approximately 1.5 million to about 10 million during 1994–2005. Some evidence for correlations with abundance indices has been found for water clarity, indices of predator and prey abundance, and south Delta exports (Mac Nally et al. 2010; Thomson et al. 2010).

11A.1.22. Black Bass

11A.1.22.1. Largemouth Bass

Status, Distribution, Life History, and Habitat Requirements

Largemouth bass is a nonnative species to California. They were introduced in California in 1891 (Dill and Cordone 1997; Moyle 2002) and have since been introduced to suitable waters, including streams and reservoirs, throughout the state. They are an important invasive species in the Delta.

Largemouth bass first spawn during their second or third spring at about 17.8 cm in length. Spawning is limited to fresh water (Moyle 2002). The males begin building nests when the water temperature reaches about 60°F (15.5°C). Spawning takes place from April through June, at temperatures up to 75°F (23.9°C). Nests are shallow pits in depths of 3 to 7 feet (0.91 to 2.1 m) and are often built next to submerged objects. Females lay their eggs in one or more nests. The eggs hatch in 2 to 5 days and sac fry usually spend 5 to 8 days in or near the nest (Moyle 1976). For the first month or two after hatching, fry feed mainly on zooplankton. YOY bass stay close to shore in schools that swim in the open water. By the time they reach about 2 inches in length, the juveniles feed largely on aquatic insects and fish fry, including other largemouth bass, and after they reach 10 to 12.5 cm, they prey primarily on fish and crayfish. Largemouth bass are thought to be a major predator of juvenile Chinook salmon and other native fish species in the Delta (Nobriga and Feyrer 2007). In addition to the Delta, they occur in lower riverine habitats such as in the Feather River and American River. Their growth rate is highly variable, depending on genetic background, food availability, inter- and intra-specific competition, temperature regimes, and other environmental factors. Maximum size for the species is approximately 30 inches total length and the maximum age is 16 years (Moyle 1976).

Largemouth bass prefer warm, quiet waters with aquatic vegetation and low turbidity. They are known to tolerate dissolved oxygen levels as low as 1 milligram of oxygen per liter (mg/L) (Lee et al. 1980; Moyle 2002). The species thrives in areas with high levels of infestation by nonnative aquatic plants (Brown and Michniuk 2007). Recent studies suggest juvenile and larger largemouth bass abundance is positively correlated with water temperature, whereas juvenile largemouth bass abundance is greatest at intermediate levels of SAV but larger fish are widespread even in areas with limited SAV (Conrad et al. 2016). A study in the San Joaquin River between the Head of Old River and Stockton in 2015–2016 found a mean of 333 largemouth bass per kilometer, which were estimated to consume 3 to 5 fall-run Chinook salmon per day per kilometer during the peak of the salmon outmigration period, compared to up to 24 salmon consumed per day per kilometer by striped bass (Michel et al. 2018).

11A.1.22.2. Smallmouth Bass

Status, Distribution, Life History, and Habitat Requirements

Smallmouth bass (*Micropterus dolomieu*) are most common in large, clear lakes and cool, clear streams with large amounts of cover. In streams they prefer complex habitat with a variety of pools, riffles, runs, rocky bottoms, and overhanging trees, while lake populations concentrate in narrow bays along shores where rocky shelves project under water. Optimal water temperature differs with age, as adults tend to stay in areas that are 25°C to 27°C (77.0°F to 80.6°F), while younger fish prefer areas which are 29°C to 31°C (84.2°F to 87.8°F), reflecting their more shallow water environment. Regardless of age, however, temperatures greater than 35°C (95.0°F) are metabolically stressful, and temperatures over 38°C (100.4 °F) are lethal. Smallmouth bass are also restricted in their habitat choice by the amount of dissolved oxygen in the water. Although they can survive in areas with 1 to 3 milligrams of oxygen per liter, they require at least 6 mg/L for normal growth rates (University of California, Agriculture and Natural Resources 2019a). Juveniles and populations in crowded lakes may school, but this is rare and the majority are solitary hunters that stalk around some kinds of submerged debris. This localizes populations to such a degree that several reproductively independent groups can exist within a single lake. Foraging occurs throughout the day but is most intense in the evening and the early morning. Crustaceans and aquatic insects make up the majority of a smallmouth bass's diet until it reaches 3 to 5 cm TL, at which point crayfish and fish become more important. By the time an individual reaches 10 to 15 cm TL, these larger food items dominate the diet. Smallmouth bass are opportunistic, however, and insects, amphibians, and small mammals are not uncommon sources of food (University of California, Agriculture and Natural Resources 2019a).

Smallmouth bass reach maturity in their third or fourth spring, at which point they move into shallower water. Spawning begins in May and can continue into June or July. Males construct nests 30 to 60 cm (1 to 2 ft) in diameter, preferably in rubble, gravel, or sand 1 meter (3.3 ft) deep with submerged logs, boulders, and other submerged objects acting as cover. This is only the optimal environment, however, and nests can be found on a variety of substrates varying in depth from 0.5 to 5 meters (1.6 to 16.4 ft). These nests may be built close together, but they are not colonial and males defend the nests against other males as vigorously as they would against predators. Spawning is initiated by a female repeatedly swimming by a nest, changing colors, and keeping her head down in a mating posture. Eventually the pair circle the nest, with the male nipping at the female and the female occasionally rubbing her abdomen on the nest floor. The pair then settle into the nest and release their eggs and milt simultaneously. Smallmouth bass are mostly monogamous, but the larger fish spawn earlier in the season and may have the opportunity to spawn again. Each female may release 2,000 to 21,000 eggs into her nest. The males guard the embryos and fan water over them to provide more oxygen. After hatching, it takes 1 to 2 weeks before fry become free swimming, and the male still guards them for another

1 to 4 weeks after that until they are too active to be herded. At 2 to 3 cm TL, the young disperse to shallow water where high mortality rates are suffered because of predation and high stream flows. Those that survive generally grow to between 6 cm and 18 cm in their first year, and between 25 cm and 41 cm in their fourth, while stream populations grow at a decidedly slower rate. The largest individual on record weighed 4.1 kilograms (University of California, Agriculture and Natural Resources 2019a). All life stages of smallmouth bass can occur in the freshwater regions of the Delta.

11A.1.22.3. Spotted Bass

Status, Distribution, Life History, and Habitat Requirements

Spotted bass (*Micropterus punctulatus*) are most common in moderately sized, clear, low-gradient rivers and reservoirs. In streams they spend most of their time hiding in pools, avoiding riffles or backwaters with heavy plant growth. Reservoir populations stay along steep rocky banks toward the upstream end of the reservoir. During the summer they can be found in temperatures between 24°C and 31°C (75.2°F and 87.8°F), and despite a low tolerance for brackish water, they have been found in salinities up to 10 ppt. Juveniles can easily be seen schooling in shallow areas close to shore, but adults are more solitary and spend most of their time 1 meter to 4 meters deep or even farther down when temperatures equalize in winter. Like most fish, the spotted bass's diet expands as a fish gets older. Fry eat mostly zooplankton and small insects, and then move on to crustaceans and larger aquatic insects as juveniles. Individuals between 75 mm and 150 mm feed on aquatic insects, fish, crayfish, and terrestrial insects, eventually preferring crayfish (University of California, Agriculture and Natural Resources 2019b).

Maturity is reached in the second or third year and spawning occurs when temperatures reach 15°C to 18°C (59°F to 64.4°F), continuing until temperatures reach 22°C to 23°C (71.6°F to 73.4 °F) in early June. Males move to shallow water in March and early April, where they construct nests 40 to 80 cm in diameter. Lake nests are built in areas 0.5 to 4.5 meters deep with large rocks and rubble or gravel, while nearly any area with low current can be used in rivers. These nests may be built close together, but spotted bass are not colonial and males defend the nests as vigorously against other males as they would against predators. Spawning is initiated by a female repeatedly swimming by a male's nest, changing colors, and keeping her head down in a mating posture. Eventually the pair circles the nest, with the male nipping at the female and the female occasionally rubbing her abdomen on the nest floor. The pair then settle into the nest and release their eggs and milt simultaneously. Spotted bass are mostly monogamous, but some males may have more than one nest. Each female lays 2,000 to 14,000 eggs per nest. The male tends to and defends the nest for up to 4 weeks until the fry disperse at 30 millimeters total length (mm TL). Growth varies with habitat. Warmwater reservoirs support the highest growth, and cold streams support the slowest. On average, however, individuals reach 65 to 170 mm TL in their first year and 245 to 435 mm TL in their fourth. Few live longer than 4 or 5 years, and the largest recorded individual for California was 450 mm TL (University of California, Agriculture and Natural Resources 2019b). All life stages of spotted bass can occur in the freshwater regions of the Delta.

11A.1.23. California Bay Shrimp

11A.1.23.1. Status, Distribution, Life History, and Habitat Requirements

A summary of California bay shrimp (*Crangon franciscorum*) was provided by Baxter et al. (1999:78–79), upon which this account is largely based. Bay shrimp include several species of *Crangon*, primarily *C. franciscorum*. They are fished commercially by trawlers in the San Francisco Estuary and Delta and sold as bait to sport anglers. From 1980 to 1995, the fishery annually landed between 100,000 and 200,000 pounds, although landings were considerably greater (2–3 million pounds) in the 1920s and 1930s, when bay shrimp were sold for human consumption. The fishery was concentrated in South Bay in the late 1980s to early 1990s probably because of lower salinity water from sewage treatment plant discharges. There appears to have been a general decline in landings in the past two decades, with only one year above 100,000 pounds and most years since 2005 having 60,000 pounds or less in landings (ICF International 2016b:4–295).

Bay shrimp migrate seasonally in response to salinity, temperature, and maturity or life stage: for example, *C. franciscorum* larvae hatch in winter/early spring in Central Bay or the Gulf of the Farallones, with post-larvae and juveniles migrating upstream to rear in lower salinity, warmer areas such as San Pablo and Suisun Bays during the summer, before migrating downstream in fall/winter to complete the life cycle. Diet is variable by location and size and may consist of mysid shrimps, amphipods, bivalves, and copepods, for example. Bay shrimp are preyed upon by many fish in the estuary, including striped bass, staghorn sculpin, and green and white sturgeon, as well as other taxa such as harbor seals and diving ducks. The overall distribution is broad: for example, the dominant species *C. franciscorum* ranges from southeast Alaska to San Diego, California.

As with some other species in the San Francisco Estuary and Delta, there is a statistically significant negative correlation between abundance index and X2, which does not appear to be related to extent of habitat and may be related to enhanced transport to estuarine rearing grounds by increased residual circulation with increased outflow (Kimmerer et al. 2009).

11A.1.24. Southern Resident Killer Whale

11A.1.24.1. Status, Distribution, Life History, and Habitat Requirements

This species account was adapted from the DWR (2020) Final EIR for Long-Term Operation of the SWP. Southern resident killer whales (*Orcinus orca*) are found primarily in the coastal waters offshore of British Columbia and Washington and Oregon in summer and fall (National Marine Fisheries Service 2008). During winter, southern resident killer whales are sometimes found off the coast of central California and more frequently off the Washington coast (Hilborn et al. 2012).

The 2005 listing (70 FR 69903) of southern resident killer whale DPS as endangered lists several factors that may be limiting the recovery of killer whales, including the quantity and quality of prey, accumulation of toxic contaminants, and sound and vessel disturbance. The *Recovery Plan for Southern Resident Killer Whales* (National Marine Fisheries Service 2008) posits that reduced prey availability forces whales to spend more time foraging, which may lead to reduced reproductive rates and higher mortality rates. Reduced food availability may lead to mobilization of fat stores, which can release stored contaminants and adversely affect reproduction or immune function (National Marine Fisheries Service 2008).

The Independent Science Panel reported that southern resident killer whales depend on Chinook salmon as a critical food resource (Independent Science Panel and ESSA Technologies 2012). Hanson et al. (2010) analyzed tissues from predation events and feces to confirm that Chinook salmon were the most frequent prey item for the southern resident killer whale in two regions of the whale's summer range off the coast of British Columbia and Washington State, representing more than 90% of the diet in July and August. Samples indicated that when southern resident killer whales are in inland waters from May through September, they consume Chinook salmon stocks that originate from regions that include the Fraser River, Puget Sound, the Central British Columbia Coast, West and East Vancouver Island, and California's Central Valley (Hanson et al. 2010).

Significant changes in food availability for southern resident killer whale have occurred over the past 150 years, largely due to human impacts on prey species. Salmon abundance has been reduced over the entire range of southern resident killer whale, from British Columbia to California. NMFS (2008) indicates that wild salmon have declined primarily due to degraded aquatic ecosystems, overharvesting, and production of fish in hatcheries. NMFS (2008) supports restoration efforts, including habitat, harvest, and hatchery management considerations, and continued use of existing NMFS authorities under the ESA and Magnuson-Stevens Fishery Conservation and Management Act to ensure an adequate prey base.

Central Valley streams produce Chinook salmon that contribute to the diet of southern resident killer whale. The number of Central Valley Chinook salmon that annually enter the ocean and survive to a size susceptible to predation by southern resident killer whale is not known. NMFS (2019:131) reviewed available information from sources such as fishery harvest, escapement data, and diet studies for Chinook salmon stocks on the West Coast and concluded that Central Valley Chinook salmon constitute a sizeable percentage of Chinook salmon that would be expected to be encountered by southern resident killer whale in coastal waters off California and Oregon, and at least a small portion of Chinook salmon in the ocean as far north as British Columbia. As summarized by NMFS (2019:132–133), a recent report evaluated 30 stocks of West Coast Chinook salmon for recovery priority to increase southern resident killer whales' prey base, based on each stock's contribution to diet, degree of spatiotemporal overlap, and whether it would be consumed during times of killer whale reduced body condition or diversified diet. Central Valley stocks ranked 13 (spring-run Chinook salmon), 16 (fall and late fall–run Chinook salmon), and 21 (winter-run Chinook salmon) (National Marine Fisheries and Washington Department of Fish and Wildlife 2018:7-8).

11A.2 Special-Status Aquatic Species Table

Table 11A-13. Special-Status Aquatic Species Identified as Having the Potential to Occur in the Study Area

Common Name	Scientific Name	Status[a] Federal/State	Range and General Habitat Description	Potential for Occurrence
Delta Smelt	*Hypomesus transpacificus*	T/E	San Pablo Bay, Napa River, Suisun Bay, Suisun Marsh, Delta, Sacramento River, San Joaquin River, and Mokelumne River. Prefer salinities less than 6 parts-per-thousand	High
Longfin Smelt	*Spirinchus thaleichthys*	C/T	Coastal Pacific Ocean, San Francisco Bay, Coyote and Alviso Sloughs, San Pablo Bay, Napa River, Suisun Bay, Suisun Marsh, Delta, Sacramento River, and San Joaquin River. Peak spawning occurs when water temperatures are between 5°C and 11°C (41°F and 51.8°F) and centered in brackish water	High
Winter Run-Chinook Salmon – Sacramento River ESU	*Oncorhynchus tshawytscha*	E/E	Pacific Ocean, San Francisco Bay, Suisun Bay, Suisun Marsh, Delta, and the mainstems and tributaries of the Sacramento and San Joaquin River Basins. Spawn on gravel substrate and rear in stream margins, off-channel areas, and floodplains	High
Spring-Run Chinook Salmon – Central Valley ESU	*Oncorhynchus tshawytscha*	T/T	Pacific Ocean, San Francisco Bay, Suisun Bay, Suisun Marsh, Delta, and the mainstems and tributaries of the Sacramento and San Joaquin River Basins. Spawn on gravel substrate and rear in stream margins, off-channel areas, and floodplains	High
Fall-Run/Late Fall-Run Chinook Salmon – Central Valley ESU	*Oncorhynchus tshawytscha*	SC/SSC	Pacific Ocean, San Francisco Bay, Suisun Bay, Suisun Marsh, Delta, and the mainstems and tributaries of the Sacramento and San Joaquin River Basins. Spawn on gravel substrate and rear in stream margins, off-channel areas, and floodplains	High
Steelhead – Central Valley DPS	*Oncorhynchus mykiss irideus*	T/SSC	Pacific Ocean, San Francisco Bay, Suisun Bay, Suisun Marsh, and Delta, and the mainstems and tributaries of the Sacramento and San Joaquin River Basins. Reduced temperatures and increased flow stimulate spawning runs	High

Common Name	Scientific Name	Status[a] Federal/State	Range and General Habitat Description	Potential for Occurrence
Steelhead – Central California Coast DPS	*Oncorhynchus mykiss irideus*	T/–	Pacific Ocean, San Francisco and San Pablo Bays, including Guadalupe River, Coyote Creek, San Francisquito Creek, Sonoma Creek, and Napa River. Adults require deep holding pools with cover and juveniles forage in riverine tidal wetlands and open water of estuarine subtidal areas	High
Green Sturgeon – Southern DPS	*Acipenser medirostris*	T/SSC	Pacific Ocean, San Francisco Bay, Suisun Bay, Suisun Marsh, and Delta, and in Sacramento, Feather, and San Joaquin Rivers. Spawning takes place in deep pools and rearing occurs in main channels and larger interconnecting sloughs and waterways	High
White Sturgeon	*Acipenser transmontanus*	–/SSC	Pacific Ocean, San Francisco Bay and tributaries (Coyote and Sonoma Creeks, and in Guadalupe, Napa, and Petaluma Rivers), Suisun Bay, Suisun Marsh, Delta, and in Sacramento, Feather, and San Joaquin Rivers. Deeper pools and tidal channels with soft bottoms	High
Pacific Lamprey	*Entosphenus tridentatus*	SC/SSC	San Francisco Bay and its tributaries, Suisun Bay, Suisun Marsh, Delta, and in Sacramento, San Joaquin, Feather, Stanislaus, Mokelumne, Tuolumne, and Trinity Rivers. Build spawning redds in shallow water (about 0.5 to 3.5 feet).	High
Western River Lamprey	*Lampetra ayresii*	–/SSC	Sacramento, San Joaquin, Stanislaus, Tuolumne, Feather, America Rivers, and in Mill and Cache Creek. Spawn in gravel redds and rear in fine sediments in off-channel habitats.	High
Kern Brook Lamprey	*Lampetra hubbsi*	–/SSC	Lower San Joaquin River below Millerton Reservoir	High
Sacramento Hitch	*Lavinia exilicauda exilicauda*	–/SSC	Low-elevation streams throughout the Sacramento River Basin and in the north Delta. Spawn in riffles of streams tributary to lakes, river, and sloughs and rear in shallow water or close to aquatic plants	High

Common Name	Scientific Name	Status[a] Federal/State	Range and General Habitat Description	Potential for Occurrence
Sacramento Splittail	*Pogonichthys macrolepidotus*	–/SSC	Suisun Bay, Suisun Marsh, Delta, and in Sacramento, Feather, America, San Joaquin, and Cosumnes Rivers. Moderately shallow, brackish tidal sloughs and adjacent open-water areas, freshwater areas with tidal or riverine flow.	High
Hardhead	*Mylopharodon conocephalus*	–/SSC	Sacramento and San Joaquin River Basins including American and Feather Rivers, and rarely in Delta and San Francisco Estuary. Spawn in gravel-bottomed riffles, runs and at the head of pools and rear in stream margins with abundant cover	High
Central California Roach	*Lavinia symmetricus symmetricus*	–/SSC	Tributaries to the Sacramento and San Joaquin Rivers and tributaries to San Francisco Bay. Small streams and backwaters of mainstem rivers with dense riparian cover	High
Sacramento Perch	*Archoplites interruptus*	–/SSC	Native range includes the Central Valley, Pajaro and Salinas Rivers, tributaries to the San Francisco Estuary, and Clear Lake. Associated with beds of rooted, submerged, and emergent vegetation and other submerged objects.	High
Starry Flounder	*Platichthys stellatus*	–/–	Coastal Pacific Ocean, San Francisco Bay, San Pablo Bay, Suisun Bay, Sacramento River, and San Joaquin River. Found on different substrates including soft sand, gravel, clean shifting sand, hard stable sand, and mud substrata	High
Northern Anchovy	*Engraulis mordax*	–/–	Pacific Ocean, San Francisco Bay, San Pablo Bay, Suisun Bay. Spawn in the upper 50 meters of water column in nearshore areas	High
Striped Bass	*Morone saxatilis*	–/–	Pacific Ocean, San Francisco Bay, San Pablo Bay, Suisun Bay, Suisun Marsh, Delta, Sacramento River, San Joaquin River, Feather River, American River, and Stanislaus River. Occupy moderately shallow areas down to deeper areas of channels.	High
American Shad	*Alosa sapidissima*	–/–	Pacific Ocean, San Francisco Bay, San Pablo Bay, Suisun Bay, Suisun Marsh, Delta, and Sacramento, Feather, American, Yuba, lower San Joaquin, Mokelumne, and Stanislaus Rivers. Spawn in main channels of rivers and rear upstream of Delta	High

Common Name	Scientific Name	Status[a] Federal/State	Range and General Habitat Description	Potential for Occurrence
Threadfin Shad	*Dorosoma petenense*	–/–	Suisun Bay, Suisun Marsh, Delta, and throughout the Sacramento and San Joaquin River Basins. Spawn and rear in areas with submerged aquatic vegetation	High
Largemouth Bass	*Micropterus salmoides*	–/–	Delta and lower river habitats of Feather and American Rivers. Warm, quiet waters with aquatic vegetation and low turbidity.	High
Smallmouth Bass	*Micropterus dolomieu*	–/–	Freshwater regions of the Delta and in large, clear lakes and cool, clear streams with large amounts of cover. Spawn in rubble, gravel, or sand 1 meter deep with submerged logs, boulders and other objects acting as cover.	High
Spotted Bass	*Micropterus punctulatus*	–/–	Freshwater regions of the Delta and in moderately sized, clear, low-gradient rivers and reservoirs. Juveniles school in areas close to shore and adults are solitary and stay at depths between 1 and 4 meters.	High
California Bay Shrimp	*Crangon franciscorum*	–/–	Coastal Pacific Ocean, San Francisco Bay, San Pablo Bay, and Suisun Bay. Rear in lower salinity, warmer areas during summer	High
Southern Resident Killer Whale	*Orcinus orca*	E/–	Coastal Pacific Ocean. Consume Chinook salmon from central California	High

Table source: California Department of Fish and Wildlife 2020, Moyle et al. 2015
[a] Status Explanations:
Federal:
– = not listed under the federal Endangered Species Act
E = listed as endangered under the federal Endangered Species Act
T = listed as threatened under the federal Endangered Species Act
C = candidate for listing under the federal Endangered Species Act
SC = Species of Concern as identified by National Marine Fisheries Service or U.S. Fish and Wildlife Service
State:
– = not listed under the California Endangered Species Act
E = listed as endangered under the California Endangered Species Act
T = listed as threatened under the California Endangered Species Act
C = candidate for listing under the California Endangered Species Act
SSC = California species of special concern

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Gray = Reference not cited.

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Appendix 11F

Smelt Analysis

This document has not yet been reviewed by the Authority or Reclamation and does not represent the agencies input, positions, or policies. All content is subject to change.

Appendix 11F Smelt Analysis

11F.1 Introduction

This appendix describes quantitative methods and supplementary results used in the impact analyses of delta smelt and longfin smelt: the *Eurytemora affinis*–X2 analysis for smelt prey, the Delta outflow–longfin smelt abundance analysis (based on Nobriga and Rosenfield 2016), the X2–longfin smelt abundance index analysis, and tidal habitat restoration mitigation calculations for longfin smelt.

11F.2 *Eurytemora affinis*–X2 Analysis

This analysis followed Kimmerer's (2002) methods to conduct an analysis of the relationship between the smelt zooplankton prey *Eurytemora affinis* and spring (March–May) X2 for the period from 1980 to 2017, as described by Greenwood (2018). The main steps in preparing the data for analysis were as follows:

1. Historical zooplankton data were obtained from California Department of Fish and Wildlife (2018).
    a. Data were subset to only include surveys 3, 4, and 5 (March–May).
    b. Specific conductance was converted to salinity by applying Schemel's (2001) method, then only samples within the low salinity zone (salinity = 0.5–6) were selected.
    c. A constant of 10 was added to *E. affinis* adult catch per unit effort (number per cubic meter) in each sample, then the resulting value was $\log_{10}$-transformed.
    d. The $\log_{10}$-transformed values were averaged first by month, and then by year.
2. Historical X2 data were obtained from DAYFLOW (https://www.water.ca.gov/Programs/Environmental-Services/Compliance-Monitoring-And-Assessment/Dayflow-Data).
    a. For years prior to water year 1997 (which is the year DAYFLOW X2 values began to be provided), the DAYFLOW daily predictive equation for X2 was used, based on a starting value from Anke Mueller-Solger (see Greenwood 2018 for details).
    b. The mean March–May X2 was calculated for each year.

Similar to Kimmerer (2002), a general linear model was used to regress mean annual $\log_{10}$-transformed *E. affinis* catch per unit effort against mean March–May X2, including a step change between 1987 and 1988 to reflect the *Potamocorbula amurensis* clam invasion and a step change between 2002 and 2003 to reflect the onset of the Pelagic Organism Decline (POD; Thomson et al. 2010). The interaction of X2 and the step change was included in a full model, but the interaction was not statistically significant, so the model was rerun with only X2 and the step changes included. These analyses were conducted in SAS 9.4 software.[1] The statistical outputs indicate that there is little difference in the coefficients for the post-*Potamocorbula* and POD step changes, whereas both coefficients were significantly less than the coefficient for the pre-*Potamocorbula* period. Regression coefficients from the model were stored for prediction of *E. affinis* relative abundance for the No Action Alternative (NAA) and Alternative 1–3 scenarios.

The stored regression coefficients from the regression of historical *E. affinis* catch per unit effort vs. X2 and step changes were then applied to the NAA and Alternative 1–3 scenarios using PROC PLM in SAS 9.4 software. The basic regression model being applied was:

$$\log_{10}(E.\ affinis\ \text{catch per unit effort}) = 3.9404 - 0.0152\ (\text{mean March–May X2}) - 0.7863$$

where 3.9404 is the intercept and -0.7863 is the coefficient for the POD step change. Predictions were back-transformed to the original measurement scale (catch per unit effort, number per cubic meter) for summary of results. X2 inputs for the analysis came from the DSM2 modeling of water years 1922–2003 for the NAA and Alternative 1–3 scenarios.

Results of the analysis are summarized in the main body of Chapter 11, *Aquatic Biological Resources*. Tables 11F-1 through 11F-5 provide supplemental information also discussed in the main body of Chapter 11.

Table 11F-1. *Eurytemora affinis*–X2 Analysis: Mean and 95% Prediction Limits, NAA.

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1922	154	21	850
1923	125	16	695
1924	64	4	392
1925	120	15	669
1926	111	13	620
1927	174	25	956
1928	129	17	714
1929	73	5	432
1930	106	12	596
1931	62	3	380
1932	102	11	575
1933	75	6	444

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Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1934	85	8	493
1935	135	18	744
1936	148	20	815
1937	134	18	740
1938	196	29	1,082
1939	70	5	420
1940	155	22	855
1941	191	28	1,056
1942	188	27	1,038
1943	164	23	905
1944	94	10	538
1945	118	15	659
1946	125	16	694
1947	87	8	501
1948	108	13	609
1949	96	10	543
1950	122	15	676
1951	149	20	821
1952	202	30	1,121
1953	151	21	830
1954	145	20	800
1955	84	8	486
1956	183	27	1,011
1957	113	14	630
1958	192	28	1,061
1959	107	12	599
1960	93	10	532
1961	94	10	536
1962	108	13	605
1963	157	22	862
1964	82	7	474
1965	160	22	880
1966	118	15	657
1967	203	30	1,121
1968	113	14	632
1969	201	30	1,112

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1970	140	19	771
1971	167	24	917
1972	100	11	567
1973	161	23	884
1974	180	26	990
1975	150	21	825
1976	63	4	387
1977	59	3	368
1978	176	25	970
1979	132	17	733
1980	162	23	891
1981	104	12	588
1982	194	28	1,070
1983	205	30	1,134
1984	147	20	812
1985	87	9	503
1986	145	20	800
1987	86	8	499
1988	84	8	488
1989	97	11	553
1990	72	5	427
1991	76	6	450
1992	88	9	505
1993	188	27	1,037
1994	74	6	438
1995	202	30	1,117
1996	186	27	1,029
1997	147	20	809
1998	201	30	1,110
1999	166	23	912
2000	143	19	789
2001	97	10	550
2002	122	15	680
2003	158	22	872

Table 11F-2. *Eurytemora affinis*–X2 Analysis: Mean and 95% Prediction Limits, Alternative 1A.

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1922	152	21	837
1923	125	16	693
1924	65	4	393
1925	119	15	664
1926	109	13	613
1927	173	25	951
1928	127	16	706
1929	73	6	432
1930	105	12	592
1931	62	3	380
1932	100	11	568
1933	74	6	438
1934	84	8	486
1935	132	17	728
1936	146	20	807
1937	133	17	736
1938	195	29	1,080
1939	70	5	419
1940	155	22	853
1941	191	28	1,055
1942	188	27	1,037
1943	164	23	904
1944	93	10	533
1945	118	15	659
1946	125	16	692
1947	86	8	494
1948	105	12	593
1949	94	10	538
1950	120	15	667
1951	148	20	816
1952	202	30	1,120
1953	150	21	829
1954	144	20	795
1955	84	8	486

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1956	182	26	1,006
1957	111	13	623
1958	191	28	1,057
1959	106	12	598
1960	93	10	529
1961	93	10	531
1962	106	12	594
1963	155	22	856
1964	82	7	475
1965	158	22	869
1966	116	14	646
1967	202	30	1,119
1968	113	14	630
1969	201	30	1,111
1970	140	19	771
1971	166	24	915
1972	99	11	562
1973	160	23	883
1974	179	26	989
1975	149	20	823
1976	63	3	384
1977	59	3	368
1978	175	25	961
1979	131	17	723
1980	162	23	890
1981	103	12	579
1982	194	28	1,070
1983	205	30	1,134
1984	147	20	812
1985	87	8	501
1986	144	20	796
1987	85	8	493
1988	84	8	488
1989	97	10	550
1990	70	5	418
1991	76	6	446

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1992	86	8	499
1993	186	27	1,023
1994	73	6	432
1995	201	30	1,111
1996	186	27	1,025
1997	147	20	809
1998	200	30	1,109
1999	165	23	910
2000	143	19	788
2001	95	10	542
2002	123	15	681
2003	156	22	859

Table 11F-3. *Eurytemora affinis*–X2 Analysis: Mean and 95% Prediction Limits, Alternative 1B.

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1922	152	21	838
1923	125	16	693
1924	65	4	393
1925	119	15	664
1926	109	13	613
1927	172	25	946
1928	127	16	706
1929	73	6	432
1930	105	12	592
1931	62	3	380
1932	100	11	568
1933	74	6	438
1934	85	8	491
1935	132	17	728
1936	146	20	807
1937	133	17	736
1938	195	29	1,080
1939	70	5	418

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1940	155	22	855
1941	191	28	1,055
1942	188	27	1,037
1943	164	23	904
1944	93	10	533
1945	119	15	661
1946	125	16	692
1947	86	8	494
1948	106	12	594
1949	95	10	539
1950	120	15	667
1951	148	20	816
1952	202	30	1,120
1953	151	21	829
1954	144	20	795
1955	84	8	488
1956	182	26	1,006
1957	112	13	624
1958	192	28	1,059
1959	107	12	599
1960	93	10	529
1961	94	10	535
1962	106	12	595
1963	155	22	855
1964	82	7	475
1965	158	22	869
1966	116	14	646
1967	202	30	1,116
1968	113	14	631
1969	201	30	1,111
1970	140	19	772
1971	166	24	915
1972	99	11	562
1973	160	23	883
1974	179	26	989
1975	149	20	823

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1976	63	3	385
1977	60	3	369
1978	174	25	961
1979	131	17	723
1980	162	23	890
1981	103	12	581
1982	194	28	1,070
1983	205	30	1,134
1984	147	20	812
1985	87	8	500
1986	144	20	796
1987	85	8	492
1988	84	8	487
1989	97	10	550
1990	70	5	418
1991	75	6	445
1992	86	8	498
1993	186	27	1,024
1994	73	6	432
1995	201	30	1,111
1996	186	27	1,025
1997	147	20	809
1998	200	30	1,109
1999	165	23	910
2000	143	19	788
2001	95	10	540
2002	123	16	683
2003	156	22	860

Table 11F-4. *Eurytemora affinis*–X2 Analysis: Mean and 95% Prediction Limits, Alternative 2.

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1922	152	21	837
1923	125	16	693

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1924	65	4	392
1925	119	15	664
1926	109	13	613
1927	173	25	951
1928	127	16	706
1929	73	6	432
1930	105	12	592
1931	62	3	380
1932	100	11	568
1933	74	6	438
1934	85	8	491
1935	132	17	728
1936	147	20	808
1937	133	17	736
1938	195	29	1,080
1939	70	5	419
1940	155	22	853
1941	191	28	1,055
1942	188	27	1,037
1943	164	23	904
1944	93	10	533
1945	118	15	659
1946	125	16	692
1947	86	8	494
1948	105	12	593
1949	94	10	538
1950	119	15	665
1951	148	20	816
1952	202	30	1,120
1953	151	21	829
1954	144	20	795
1955	84	8	486
1956	182	26	1,006
1957	111	13	623
1958	191	28	1,057
1959	106	12	598

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1960	93	10	529
1961	93	10	531
1962	106	12	594
1963	155	22	855
1964	82	7	475
1965	158	22	869
1966	116	14	646
1967	202	30	1,119
1968	113	14	630
1969	201	30	1,111
1970	140	19	772
1971	166	24	915
1972	99	11	562
1973	160	23	883
1974	179	26	989
1975	149	20	823
1976	63	3	384
1977	60	3	369
1978	174	25	961
1979	131	17	723
1980	162	23	890
1981	103	12	581
1982	194	28	1,070
1983	205	30	1,134
1984	147	20	812
1985	87	8	501
1986	144	20	796
1987	85	8	493
1988	84	8	488
1989	97	10	551
1990	70	5	418
1991	76	6	446
1992	86	8	498
1993	186	27	1,023
1994	73	6	432
1995	201	30	1,111

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1996	186	27	1,027
1997	147	20	809
1998	200	30	1,109
1999	165	23	910
2000	143	19	788
2001	95	10	542
2002	123	15	681
2003	156	22	860

Table 11F-5. *Eurytemora affinis*–X2 Analysis: Mean and 95% Prediction Limits, Alternative 3.

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1922	152	21	838
1923	125	16	693
1924	65	4	393
1925	119	15	664
1926	109	13	614
1927	172	25	948
1928	127	16	706
1929	73	6	433
1930	105	12	592
1931	62	3	380
1932	101	11	568
1933	74	6	438
1934	84	8	486
1935	132	17	728
1936	146	20	807
1937	133	17	737
1938	195	29	1,080
1939	69	5	415
1940	155	22	856
1941	191	28	1,057
1942	188	27	1,037
1943	164	23	904

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1944	93	10	533
1945	116	14	647
1946	125	16	692
1947	87	8	499
1948	107	12	599
1949	95	10	541
1950	120	15	666
1951	148	20	815
1952	202	30	1,120
1953	151	21	829
1954	144	20	795
1955	86	8	496
1956	182	26	1,006
1957	112	13	624
1958	192	28	1,061
1959	106	12	598
1960	93	10	530
1961	93	10	532
1962	105	12	593
1963	155	22	855
1964	81	7	473
1965	158	22	869
1966	116	14	646
1967	201	30	1,115
1968	113	14	630
1969	201	30	1,113
1970	140	19	772
1971	166	24	915
1972	99	11	561
1973	160	22	882
1974	179	26	989
1975	149	20	822
1976	63	3	384
1977	59	3	366
1978	175	25	962
1979	131	17	724

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1980	162	23	890
1981	103	12	581
1982	194	28	1,070
1983	205	30	1,134
1984	147	20	812
1985	87	8	500
1986	145	20	802
1987	85	8	492
1988	84	8	488
1989	98	11	556
1990	70	5	418
1991	75	6	443
1992	87	8	501
1993	186	27	1,024
1994	73	6	432
1995	201	30	1,111
1996	186	27	1,025
1997	147	20	809
1998	200	30	1,109
1999	165	23	910
2000	143	19	788
2001	95	10	540
2002	123	16	684
2003	156	22	860

11F.3 Delta Outflow–Longfin Smelt Abundance Analysis (Based on Nobriga and Rosenfield 2016)

Nobriga and Rosenfield (2016) examined various formulations of a Ricker (1954) stock-recruitment model to simulate fall midwater trawl indices through time. They found that December–May Delta outflow had a positive association with recruits per spawner and that juvenile recruitment from age 0 to age 2 was density dependent (lower survival with greater numbers of juveniles) but cautioned that the density dependence in the model may be too strong.[2] As described by California Department of Water Resources (2020:4-178), it should also be noted that analyses relying on surveys such as the fall midwater trawl index do not fully encompass the range of longfin smelt and do not reflect potential changes in catchability over time because of factors such as increased water clarity and gear avoidance (Latour 2016) that are the subject of ongoing investigations. Nonetheless, the model represents the best available option for assessing potential impacts of Alternatives 1–3.

11F.3.1. Reproduction of Nobriga and Rosenfield (2016) Model

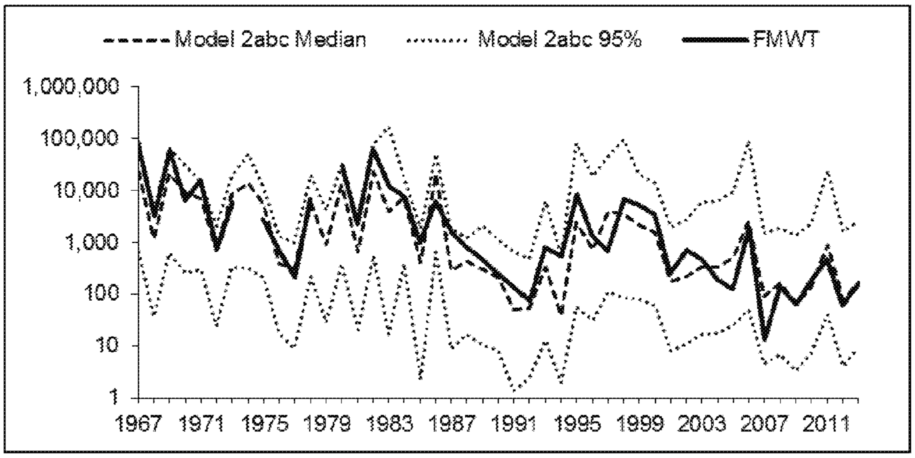
This analysis reproduced the methods described in Nobriga and Rosenfield (2016) for calculation of the two-life-stage model referred to as the "2abc" model, which includes the embedded hypotheses that understanding the trend in age-0 LFS relative abundance requires explicit modeling of spawning and recruit relative abundance, that the production of age-0 fish is density dependent, and that juvenile survival from age 0 to age 2 has changed over time. For purposes of this effects analysis, the "2abc" model was selected because its median predictions visually fit recent years of empirical data better than the other model evaluated.

Model input data used to reproduce the "2abc" model were as provided in Table 2 of Nobriga and Rosenfield (2016). The input data are provided in Appendix A of Greenwood and Phillis (2018). The analyses were run in R software (R Core Team 2016).

Graphical comparison of the reproduction of the "2abc" model to the original Nobriga and Rosenfield (2016) "2abc" model (Figure 11F-1 and Figure 11F-2) suggests that the reproduced model was a reasonable approximation of the original model (i.e., the reproduction of the method was reasonably successful). It should be noted that the original "2abc" model 95% confidence intervals are wider than the reproduction utilized in this analysis. However, the model coefficients and standard errors are identical between the original and reproduced models. Therefore, the reproduced "2abc" model utilized in this analysis is considered appropriate, and the differences in 95% confidence intervals among the original and reproduced models do not affect the comparison of the scenarios discussed below.

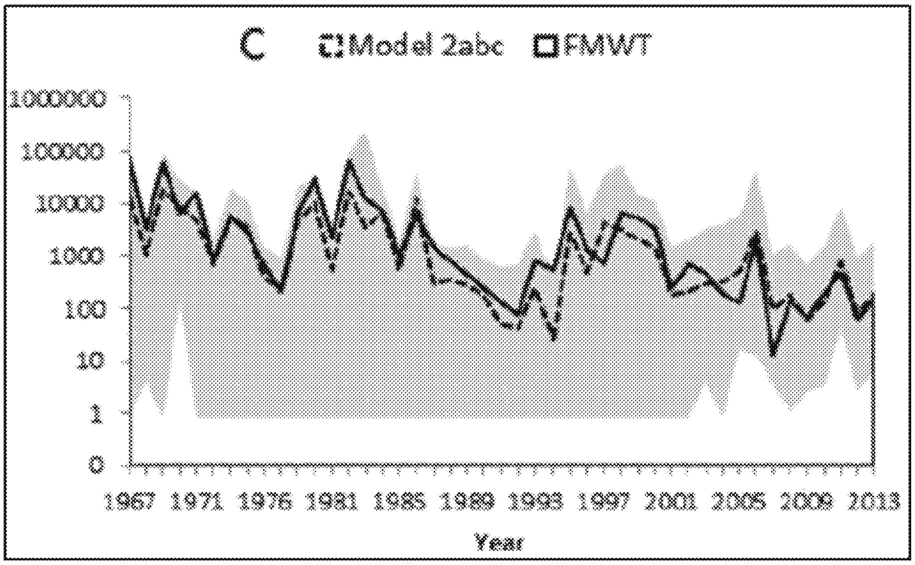
Commented [CC1]: Provide a table of output results to allow for a quantitative comparison between original and reproduced results, as well as actual FMWT indices.

[2] Comments on the draft Environmental Impact Report for Long-Term Operation of the California State Water Project suggested that a form of stock-recruitment function other than the Ricker method used by Nobriga and Rosenfield (2016) would be appropriate for exploration, such as the Beverton-Holt method (California Department of Water Resources 2020:4-178). The Beverton-Holt method was explored for the FEIR but was found to be a poorer fit to the empirical data than the Ricker method, so the Ricker method consistent with Nobriga and Rosenfield (2016) was retained (California Department of Water Resources 2020:4-178). For the present impact analysis of Alternatives 1–3 compared to NAA, the Ricker method was also retained, consistent with California Department of Water Resources (2020) and Nobriga and Rosenfield (2016).



Source: California Department of Water Resources (2020:E-86).
FMWT = fall midwater trawl.

Figure 11F-1. Reproduction of Nobriga and Rosenfield (2016) 2abc Model Predictions Compared to Historical Fall Midwater Trawl Survey Longfin Smelt Abundance Index.



Source: California Department of Water Resources (2020:E-86).
Grey shading indicates 95% interval.
FMWT = fall midwater trawl.

Figure 11F-2. Original (Figure 6c of Nobriga and Rosenfield 2016) 2abc Model Predictions Compared to Historical Fall Midwater Trawl Survey Longfin Smelt Abundance Index.

11F.3.2. Calculation of Delta Outflow Model Inputs for Scenario Comparison

To obtain the required first principal component (PC1) model inputs for comparison of the NAA and Alternative 1–3 scenarios, it was first necessary to reproduce the principal components analysis (PCA). Following Nobriga and Rosenfield (2016), historical daily Delta outflow data were acquired from the DAYFLOW database.[3] Flow data were averaged for December to May by month and year and the Principal Component Analysis was conducted using the 'PCA' function in the R package FactoMineR (Le et al. 2008) on water years 1956–2013. The resulting PC1 outputs were very similar to the original values computed by Nobriga and Rosenfield (2016), suggesting that the reported method had been successfully reproduced.[4] The 'predict PCA' function was then used to predict PC1 values for the NAA and Alternative 1–3 scenarios for water years 1922–2003 based on the CalSim modeling of the scenarios, on the same projection as the PCA. The resulting PC1 values were used as the input for the model simulation of the flow scenarios described in the next section.

Commented [CC2]: Provide a table or more detailed summary of the differences between Nobriga and Rosenfield 2016 PC1 the PC1 used in this analysis.

11F.3.3. Model Simulation to Compare Scenarios

Model simulation to compare the NAA and Alternative 1–3 scenarios used the PC1 flow inputs. To produce a simulation for the 1922–2003 time series, and consistent with Nobriga and Rosenfield (2016), the model was initiated with 2 years (i.e., years 1922 and 1923) of Fall Mid-water Trawl (FMWT) indices equal to 798, which represents the median observed FMWT index from 1967 to 2013. The simulation was conducted for two juvenile survival functions:

- 'good', which used the pre-1991 relatively high survival for simulation over the full 1922–2003 time series;
- 'poor', which used the post-1991 relatively low survival for simulation over the full 1922–2003 simulation time series.

Following Nobriga and Rosenfield (2016), 1,000 stochastic simulations were conducted in which random draws were made based on the mean and standard error of the model parameters. Consistent with Nobriga and Rosenfield (2016), the variability among the estimates was examined using the 95% intervals. Violin plots were used to illustrate the distribution of simulated FMWT indices. Results of the analysis are summarized in the main body of Chapter 11, *Aquatic Biological Resources*.

11F.4 X2–Longfin Smelt Abundance Index Analysis

The method is the same as that used recently by California Department of Water Resources (2020). The methods described herein are the same as those used in that application; the methods description below was adapted from California Department of Water Resources (2020:E2-1).

[3] https://www.water.ca.gov/Programs/Environmental-Services/Compliance-Monitoring-And-Assessment/Dayflow-Data

[4] The small differences may have arisen because of varying PCA algorithms in different statistical software packages, for example.

The analysis essentially updated previously described X2-abundance index regressions (Kimmerer et al. 2009, Mount et al. 2013) by adding additional years of data. Updating the analysis allowed full accounting of sources of error in the predictions, allowing calculation of prediction intervals from estimates of X2, as recommended by Simenstad et al. (2016), for the NAA and Alternative 1–3 scenarios.

Longfin smelt fall-mid-water trawl index data were obtained (http://www.dfg.ca.gov/delta/data/fmwt/indices.asp?view=single), including indices for 1967–2014 (excluding 1974 and 1979, when there was no sampling). For each index year, mean X2 during January–June was calculated based on X2 from the DAYFLOW database (https://data.cnra.ca.gov/dataset/dayflow), in addition to calculated X2 for earlier years.[5]

Similar to Mount et al. (2013), GLMs were run, predicting longfin smelt fall midwater trawl relative abundance index as a function of X2 and step changes in 1987/1988 and 2002/2003:

$$\mathrm{Log_{10}}(\mathrm{FMWT\ index}_y) = a + b\cdot(\mathrm{mean\ X2}_y) + c\cdot\mathrm{period}_y$$

Where y indicates year, a is the intercept, b is the coefficient applied to the mean Delta outflow, and c takes one of three values for period: 0 for the pre-*Potamocorbula* period (1967–1987), and values to be estimated for post-*Potamocorbula* (1988–2002) and Pelagic Organism Decline (POD; 2003–2014) periods.

Regarding the months used for mean X2, Mount et al. (2013:67) noted the following:

> *The months selected in the original analysis [by Jassby et al. 1995] were based on the assumption that the (unknown) X2 mechanism operated during early life history of Longfin Smelt, which smelt experts linked to this period. Autocorrelation in the X2 values through months means that statistical analysis provides little guidance for improving the selection of months. A better understanding of the mechanism(s) underlying the relationship would probably allow this period to be narrowed and focused, but for now there is little basis for selecting a narrower period for averaging X2.*

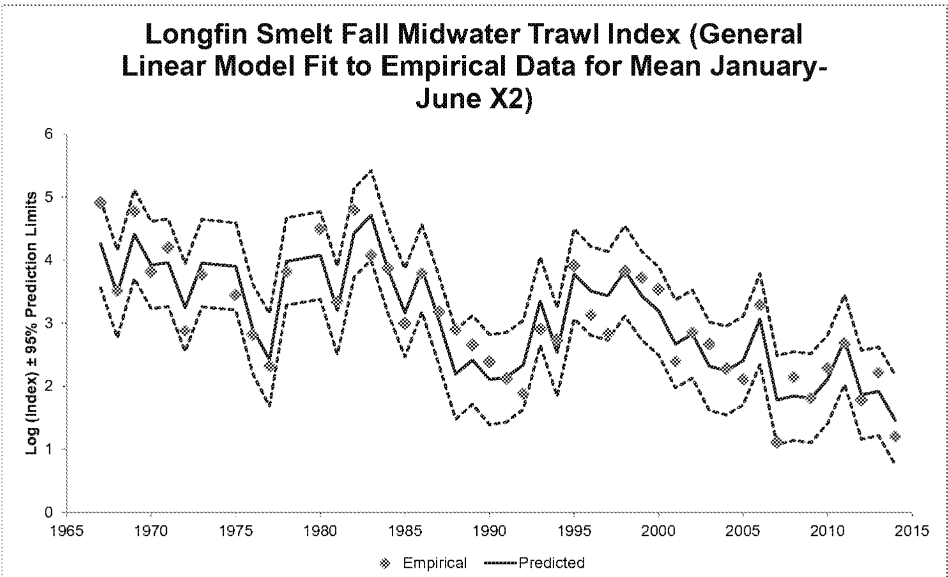
Mount et al. (2013) compared the fit of X2 averaging periods for January–June (i.e., the original period used by Jassby et al. 1995, also used by Kimmerer et al. 2009) and March–May; they selected the former because the fit to the empirical data was slightly superior. In the present analysis, both the January–June and March–May averaging periods were compared for their adequacy of fit, using standard criteria (Akaike's Information Criterion adjusted for small sample sizes, AIC_c; and variation explained, r^2). This showed that the January–June X2 averaging period was better supported in terms of explaining variability in the FWMT index (Table 11F-6; Figure 11F-3), so this averaging period was used in the subsequent comparison of the NAA and Alternative 1–3 scenarios based on DSM2 outputs of X2.

[5] DAYFLOW provides X2 estimates from water year 1997 onwards, so the DAYFLOW equation (X2(t) = 10.16 + 0.945*X2(t-1) – 1.487log(QOUT(t))) was used to provide X2 for earlier years, based on a starting unpublished estimate of X2 (Mueller-Solger 2012 as cited by Greenwood [2018: 3]).

Table 11F-6. Parameter Coefficients for General Linear Models Explaining Longfin Smelt Fall Midwater Trawl Index as a Function of Mean January–June and March–May X2 and Step Changes in 1987/1988 (*Potamocorbula* Invasion) and 2002/2003 (Pelagic Organism Decline).

Parameter	January–June Estimate	January–June Standard Error	January–June *P*	March–May Estimate	March–May Standard Error	March–May *P*
a (Intercept)	7.3059	0.3299	< 0.0001	6.8100	0.3224	< 0.0001
b (X2)	-0.0542	0.0049	< 0.0001	-0.0475	0.0047	< 0.0001
c (Period: Post-*Potamocorbula*)	-0.5704	0.1174	< 0.0001	-0.6368	0.1271	< 0.0001
c (Period: POD)	-1.4067	0.1244	< 0.0001	-1.4581	0.1351	< 0.0001
Fit	-	-	-	-	-	-
AIC_c[1]	-47.4904	-47.4904	-47.4904	-39.5492	-39.5492	-39.5492
r^2	0.8666	0.8666	0.8666	0.8414	0.8414	0.8414

Note:
[1] The difference of ~8 AIC_c units between the two GLMs indicates that the January–June mean X2 GLM is better supported in terms of explaining the patterns in the data (Burnham et al. 2011).



Source: California Department of Water Resources 2020:E2-3.

Figure 11F-3. Fit to Empirical Data of General Linear Model Predicting Longfin Smelt Fall Midwater Trawl Relative Abundance Index as a Function of Mean January–June X2 and Step Changes for *Potamocorbula* and Pelagic Organism Decline.

For the comparison of the NAA and Alternative 1–3 scenarios, mean January–June X2 was calculated for each year of the 1922–2003 simulation based on DSM2 X2 outputs. The X2-abundance index GLM calculated as above was used to estimate abundance index for the scenarios, based on the POD period coefficient in addition to the intercept and X2 slope terms. The basic equation used was (see also Table 11F-6):

$$\log_{10}(\text{Longfin Smelt FMWT index}) = 7.3059 - 0.0542*(\text{January–June X2}) - 1.4067$$

The log-transformed abundance indices were back-transformed to a linear scale for comparison of scenarios. In order to illustrate the variability in predictions from the X2-abundance index GLM, annual estimates were made for the mean and upper and lower 95% prediction limits of the abundance indices, as recommended by Simenstad et al. (2016). Statistical analyses were conducted with PROC GLM and PROC PLM in SAS/STAT software, Version 9.4 of the SAS System for Windows.[6]

Results of the analysis are summarized in the main body of Chapter 11, *Aquatic Biological Resources*. Tables 11F-7 through 11F-11 provide supplemental information also discussed in the main body of Chapter 11.

Table 11F-7. X2–Longfin Smelt Abundance Index Analysis: Mean and 95% Prediction Limits, NAA.

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1922	351	61	1,824
1923	171	26	902
1924	12	-6	102
1925	148	21	787
1926	111	14	598
1927	526	94	2,742
1928	189	29	993
1929	21	-4	151
1930	94	11	516
1931	9	-6	90
1932	82	8	453
1933	25	-3	169
1934	42	0	254
1935	219	35	1,145
1936	303	52	1,577

[6] Copyright 2002–2012, SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1937	215	34	1,124
1938	795	145	4,178
1939	18	-5	135
1940	359	62	1,865
1941	733	133	3,843
1942	692	126	3,623
1943	437	77	2,274
1944	62	4	353
1945	140	20	745
1946	170	26	898
1947	45	1	270
1948	103	12	558
1949	65	5	367
1950	153	22	814
1951	312	53	1,622
1952	892	163	4,698
1953	323	56	1,680
1954	284	48	1,482
1955	39	0	240
1956	635	115	3,321
1957	117	15	631
1958	744	135	3,904
1959	96	11	527
1960	59	4	340
1961	61	4	349
1962	100	12	545
1963	370	65	1,922
1964	35	-1	219
1965	397	70	2,064
1966	138	19	735
1967	893	163	4,706
1968	119	16	639
1969	868	158	4,570
1970	249	41	1,302
1971	456	81	2,372
1972	77	7	432

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1973	402	71	2,090
1974	591	107	3,085
1975	317	54	1,649
1976	11	-6	97
1977	7	-7	78
1978	553	99	2,884
1979	207	33	1,086
1980	414	73	2,155
1981	90	10	492
1982	765	139	4,017
1983	927	169	4,890
1984	300	51	1,561
1985	46	1	275
1986	284	48	1,482
1987	44	1	266
1988	40	0	244
1989	69	6	391
1990	20	-4	145
1991	27	-3	178
1992	47	1	279
1993	689	125	3,609
1994	23	-4	160
1995	882	161	4,645
1996	672	122	3,516
1997	296	50	1,542
1998	864	158	4,548
1999	448	80	2,334
2000	271	45	1,411
2001	68	5	384
2002	158	23	835
2003	384	67	1,999

Table 11F-8. X2–Longfin Smelt Abundance Index Analysis: Mean and 95% Prediction Limits, Alternative 1A.

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1922	333	57	1,732
1923	169	25	892
1924	12	-6	103
1925	144	21	765
1926	105	13	572
1927	516	92	2,688
1928	181	28	955
1929	21	-4	152
1930	92	10	505
1931	9	-6	90
1932	78	7	432
1933	23	-4	160
1934	39	0	240
1935	202	32	1,060
1936	293	50	1,525
1937	211	34	1,106
1938	789	144	4,143
1939	18	-5	135
1940	355	62	1,848
1941	731	133	3,834
1942	690	125	3,615
1943	435	77	2,262
1944	59	4	341
1945	140	20	746
1946	168	25	888
1947	42	0	256
1948	93	10	508
1949	62	4	354
1950	146	21	776
1951	305	52	1,586
1952	891	162	4,693
1953	322	55	1,676
1954	278	47	1,449
1955	39	0	241

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1956	624	113	3,262
1957	113	14	608
1958	736	134	3,860
1959	96	11	523
1960	58	3	333
1961	59	4	337
1962	93	10	511
1963	359	63	1,870
1964	35	-1	220
1965	379	66	1,972
1966	129	18	692
1967	886	162	4,669
1968	118	15	633
1969	866	158	4,558
1970	250	41	1,303
1971	453	80	2,357
1972	75	7	417
1973	401	71	2,087
1974	588	106	3,072
1975	313	54	1,632
1976	10	-6	94
1977	7	-7	78
1978	536	96	2,792
1979	197	31	1,035
1980	412	73	2,141
1981	84	9	463
1982	765	139	4,014
1983	927	169	4,890
1984	299	51	1,558
1985	45	1	271
1986	279	47	1,455
1987	42	0	254
1988	40	0	244
1989	68	5	385
1990	18	-5	133
1991	25	-3	172

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1992	44	1	265
1993	660	120	3,454
1994	21	-4	152
1995	866	158	4,561
1996	663	120	3,470
1997	295	50	1,536
1998	861	157	4,534
1999	445	79	2,316
2000	269	45	1,403
2001	64	5	364
2002	159	23	839
2003	365	64	1,897

Table 11F-9. X2–Longfin Smelt Abundance Index Analysis: Mean and 95% Prediction Limits, Alternative 1B.

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1922	334	58	1,740
1923	169	25	892
1924	12	-6	103
1925	144	21	765
1926	106	13	573
1927	507	91	2,643
1928	181	28	954
1929	21	-4	152
1930	92	10	505
1931	9	-6	90
1932	78	7	432
1933	23	-4	160
1934	41	0	250
1935	202	32	1,061
1936	293	50	1,525
1937	211	34	1,106
1938	789	144	4,143
1939	18	-5	133

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1940	359	63	1,867
1941	731	133	3,835
1942	691	125	3,616
1943	435	77	2,262
1944	59	4	341
1945	141	20	752
1946	168	25	888
1947	43	0	257
1948	93	10	509
1949	62	4	356
1950	146	21	776
1951	304	52	1,585
1952	891	162	4,693
1953	322	55	1,676
1954	278	47	1,447
1955	40	0	245
1956	624	113	3,262
1957	113	14	611
1958	740	135	3,879
1959	96	11	525
1960	58	3	332
1961	60	4	346
1962	94	11	513
1963	359	63	1,868
1964	35	-1	220
1965	379	66	1,972
1966	129	18	692
1967	880	161	4,637
1968	118	15	637
1969	866	158	4,562
1970	250	41	1,303
1971	453	81	2,358
1972	74	7	415
1973	401	71	2,088
1974	588	106	3,072
1975	313	54	1,632

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1976	10	-6	94
1977	7	-7	79
1978	534	96	2,785
1979	197	31	1,035
1980	412	73	2,142
1981	85	9	471
1982	765	139	4,014
1983	927	169	4,890
1984	299	51	1,558
1985	45	1	269
1986	279	47	1,457
1987	42	0	252
1988	40	0	243
1989	68	5	383
1990	18	-5	133
1991	25	-3	171
1992	44	1	265
1993	663	120	3,467
1994	21	-4	152
1995	867	158	4,563
1996	664	120	3,475
1997	295	50	1,536
1998	861	157	4,534
1999	445	79	2,316
2000	269	45	1,403
2001	63	4	359
2002	160	24	846
2003	366	64	1,903

Table 11F-10. X2–Longfin Smelt Abundance Index Analysis: Mean and 95% Prediction Limits, Alternative 2.

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1922	333	57	1,732
1923	169	25	892

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1924	12	-6	103
1925	144	21	766
1926	106	13	572
1927	516	93	2,689
1928	181	28	955
1929	21	-4	152
1930	92	10	505
1931	9	-6	90
1932	78	7	432
1933	23	-4	160
1934	41	0	250
1935	202	32	1,060
1936	294	50	1,530
1937	211	34	1,106
1938	789	144	4,143
1939	18	-5	135
1940	355	62	1,848
1941	731	133	3,835
1942	691	125	3,616
1943	435	77	2,262
1944	59	4	341
1945	140	20	746
1946	168	25	888
1947	42	0	256
1948	93	10	508
1949	62	4	354
1950	145	21	769
1951	305	52	1,586
1952	891	163	4,693
1953	322	55	1,676
1954	278	47	1,449
1955	39	0	241
1956	624	113	3,262
1957	113	14	608
1958	736	134	3,860
1959	96	11	523

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1960	58	3	333
1961	59	4	337
1962	93	10	510
1963	359	63	1,868
1964	35	-1	220
1965	379	66	1,972
1966	129	18	692
1967	886	162	4,669
1968	118	15	633
1969	866	158	4,558
1970	250	41	1,303
1971	453	81	2,358
1972	75	7	417
1973	401	71	2,087
1974	588	106	3,072
1975	313	54	1,632
1976	10	-6	94
1977	7	-7	79
1978	534	96	2,786
1979	197	31	1,035
1980	412	73	2,142
1981	85	9	471
1982	765	139	4,014
1983	927	169	4,890
1984	299	51	1,558
1985	45	1	271
1986	279	47	1,455
1987	42	0	254
1988	40	0	244
1989	68	6	386
1990	18	-5	133
1991	25	-3	172
1992	44	1	265
1993	660	120	3,454
1994	21	-4	152
1995	866	158	4,562

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1996	667	121	3,492
1997	295	50	1,536
1998	861	157	4,535
1999	445	79	2,316
2000	269	45	1,403
2001	64	5	365
2002	158	23	839
2003	366	64	1,902

Table 11F-11. X2–Longfin Smelt Abundance Index Analysis: Mean and 95% Prediction Limits, Alternative 3.

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1922	334	58	1,740
1923	169	25	892
1924	12	-6	103
1925	144	21	764
1926	106	13	575
1927	510	91	2,658
1928	181	28	954
1929	22	-4	153
1930	92	10	504
1931	9	-6	90
1932	78	7	434
1933	23	-4	160
1934	39	0	240
1935	202	32	1,061
1936	293	50	1,526
1937	212	34	1,109
1938	789	144	4,143
1939	17	-5	129
1940	360	63	1,872
1941	734	133	3,849
1942	691	125	3,617
1943	435	77	2,263

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1944	59	4	341
1945	131	18	698
1946	168	25	888
1947	44	1	267
1948	96	11	525
1949	64	5	362
1950	145	21	772
1951	304	52	1,583
1952	891	162	4,692
1953	322	55	1,677
1954	277	47	1,446
1955	43	0	261
1956	624	113	3,262
1957	113	14	611
1958	743	135	3,899
1959	96	11	523
1960	58	3	334
1961	59	4	340
1962	93	10	508
1963	359	63	1,868
1964	35	-1	217
1965	379	66	1,972
1966	129	18	692
1967	875	160	4,611
1968	118	15	633
1969	871	159	4,584
1970	250	41	1,303
1971	453	81	2,359
1972	74	7	414
1973	400	70	2,079
1974	589	106	3,073
1975	313	54	1,630
1976	10	-6	94
1977	6	-7	76
1978	537	96	2,799
1979	198	31	1,039

Year	Mean Estimate	Lower 95% Prediction Limit	Upper 95% Prediction Limit
1980	412	73	2,143
1981	86	9	472
1982	765	139	4,015
1983	927	169	4,890
1984	299	51	1,558
1985	45	1	269
1986	286	48	1,492
1987	41	0	252
1988	40	0	244
1989	71	6	400
1990	18	-5	133
1991	25	-3	168
1992	45	1	270
1993	661	120	3,459
1994	21	-4	152
1995	867	158	4,564
1996	664	120	3,475
1997	295	50	1,536
1998	861	157	4,534
1999	445	79	2,316
2000	269	45	1,403
2001	63	4	359
2002	160	24	849
2003	366	64	1,903

11F.5 Tidal Habitat Restoration Mitigation Calculations for Longfin Smelt

Tidal habitat restoration mitigation for longfin smelt was calculated based on the same method recently applied by California Department of Water Resources (2019:5-5). The method applied is that of Kratville (2010), who combined statistical relationships between export:inflow (E:I) ratio and proportion of particles entrained from various particle injection locations included in DSM2-PTM runs by Kimmerer and Nobriga (2008) with areas of habitat represented by groups of particle injection locations. The logistic equations for these particle injection locations that were applied in the analysis to mean CalSim-modeled E:I during February–June were as follows (Nobriga pers. comm.; see Kratville 2010 for further explanation of station codes):

- Antioch: Proportional entrainment = 1-(1/(1+ 0.00271028300855596*$e^{6.84578776491213*E:I}$))
- Bacon Island: Proportional entrainment = 1-(1/(1+ 0.0036006783164324*$e^{48.0279532945984*E:I}$))
- Collinsville: Proportional entrainment = 1-(1/(1+ 0.00122681735447479*$e^{7.34600447344753*E:I}$))
- Franks Tract East: Proportional entrainment = 1-(1/(1+ 0.0882721350895259*$e^{6.51283857598075*E:I}$))
- Franks West: Proportional entrainment = 1-(1/(1+ 0.0321221161869743*$e^{5.5544157874989*E:I}$))
- Georgiana Slough: Proportional entrainment = 1-(1/(1+ 0.0556193254426028*$e^{7.53188118299606*E:I}$))
- Hood: Proportional entrainment = 1-(1/(1+ 0.0370940945312037*$e^{6.00721899458561*E:I}$))
- Medford Island: Proportional entrainment = 1-(1/(1+ 0.00592509281258315*$e^{34.8002358833536*E:I}$))
- Mossdale: Proportional entrainment = 1-(1/(1+ 0.111111111111111*$e^{26.6493233888825*E:I}$))
- North Fork Mokelumne: Proportional entrainment = 1-(1/(1+ 0.0610234435346189*$e^{7.28620279196804*E:I}$))
- Potato Slough: Proportional entrainment = 1-(1/(1+ 0.0163841512024925*$e^{23.708308398635*E:I}$))
- Rio Vista: Proportional entrainment = 1-(1/(1+ 0.0076755045686138*$e^{6.69498358561645*E:I}$))
- Ryde: Proportional entrainment = 1-(1/(1+ 0.0117017438595754*$e^{6.7207341005591*E:I}$))
- South Fork Mokelumne: Proportional entrainment = 1-(1/(1+ 0.0389615268878375*$e^{14.4737516748024*E:I}$))
- Stockton: Proportional entrainment = 1-(1/(1+ 0.00840706847099802*$e^{32.6988703978096*E:I}$))
- Three Mile Slough: Proportional entrainment = 1-(1/(1+ 0.0157935505682666*$e^{6.10724605041376*E:I}$))
- Twitchell Island: Proportional entrainment = 1-(1/(1+ 0.0342441647821108*$e^{6.37831755748149*E:I}$))
- Vernalis: Proportional entrainment = 1-(1/(1+ 0.111111111111111*$e^{27.3073879175582*E:I}$))
- Victoria Canal: Proportional entrainment = 1-(1/(1+ 0.0000001283874368*$e^{219.722457733622*E:I}$))

The mean estimate of particle proportional entrainment from application of these equations was calculated for four geographic zones, with this mean estimate of particle entrainment then being multiplied by the area of each zone:

- Lower Sacramento (Antioch, Collinsville, Rio Vista, Ryde, Three Mile Slough): 19,140.69 acres
- Hood and West Dela San Joaquin (Hood, Twitchell Island): 6,080.929 acres
- Georgiana Slough/North Fork Mokelumne (Georgiana Slough, North Fork Mokelumne): 2,704.28 acres
- San Joaquin (Bacon Island, Franks Tract East, Franks Tract West, Medford Island, Mossdale, Potato Slough, South Fork Mokelumne, Stockton, Vernalis, Victoria Canal): 21,124.31 acres

The overall area of effect for each scenario was calculated as 10% of the area of the above calculations, consistent with calculations for the mitigation requirements used by California Department of Fish and Game (2009) and California Department of Water Resources (2019). Results of the mitigation calculations for the number of acres that Alternatives 1–3 were in excess of NAA are provided in the main body of Chapter 11, *Aquatic Biological Resources*.

11F.6 References Cited

11F.6.1. Printed References

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11F.6.2. Personal Communications

Nobriga, Matthew. Fish Biologist, Bay Delta Fish and Wildlife Office, U.S. Fish and Wildlife Service, Sacramento, CA. May 14, 2012—Email containing Excel file < logistic_parameters.xls> sent to Marin Greenwood, Aquatic Ecologist, ICF, Sacramento, CA.

Appendix 11B

Upstream Fisheries Impact Assessment Quantitative Methods

This document has not yet been reviewed by the Authority or Reclamation and does not represent the agencies input, positions, or policies. All content is subject to change.

Appendix 11B Upstream Fisheries Impact Assessment Quantitative Methods

This appendix summarizes fisheries impact assessment quantitative methods related to upstream temperature, spawning habitat weighted usable area, redd dewatering, redd scour/entombment, the SALMOD model, rearing flows, rearing habitat weighted usable area, juvenile stranding, and upstream migration of salmon and sturgeon adults. Other fisheries impact assessment quantitative methods are discussed in various other appendices.

11B.1 Upstream Temperature Methods

11B.1.1. Introduction

For the Sacramento River and American River, the water temperature analysis was completed utilizing daily modeled water temperature outputs from the HEC-5Q model, in addition to monthly modeled water temperature outputs from the Reclamation Temperature Model for the Feather River. Because there would be negligible or no differences in instream flows between each alternative and the NAA in the Trinity, Stanislaus, and San Joaquin Rivers and in Clear Creek, and because water temperatures can only be affected by differences in flow between alternatives, no temperature modeling was needed to conclude that there would be no temperature-related effects on aquatic resources in these waterways.

There were multiple methods used in this effects analysis to determine whether there would be effects of the Project on aquatic resources. The methods vary by river, race/species, and life stage (Table 11B-1). The first analysis evaluated the results of physical water temperature models that overlapped fish presence in space and time to assess potential water temperature-related effects to aquatic resources. The second analysis determined the frequency and magnitude either above one or more water temperature index values or outside one or more water temperature index ranges for each life stage, race/species, and location. The third and fourth methods involved an evaluation of water temperature-related mortality in the Sacramento River using the Martin and Anderson Egg Mortality Models for winter-run Chinook salmon and SALMOD for all races of Chinook salmon.

No water temperature analyses were conducted for the Trinity River, Stanislaus River, San Joaquin River, and Clear Creek because preliminary review of the CalSim II flow outputs indicated that there were negligible differences in flows between the NAA and all alternatives in these waterways (Appendix 5B2, *River Operations).* The only water temperature model inputs affected by the alternatives would be flow. Therefore, because difference in flows would be negligible, difference in water temperatures would be negligible.

Table 11B-1. Water Temperature Analysis Methods Used in Each River, Species, and Life Stage

Life stage(s)	Method Used			
	Physical Model Output Characterization	**Water Temperature Index Value/Range Analysis**	**Martin and Anderson Egg Mortality Models**	**SALMOD – Temperature-Related Mortality**
Sacramento River				
Winter-run Chinook Salmon				
Spawning, egg incubation, and alevins	X	X	X	X
Fry and juvenile rearing	X	X		X
Juvenile emigration	X	X		
Adult immigration	X	X		
Adult holding	X	X		
Spring-run Chinook Salmon				
Spawning, egg incubation, and alevins	X	X		X
Fry and juvenile rearing	X	X		X
Juvenile emigration	X	X		
Adult immigration	X	X		
Adult holding	X	X		
Fall-/Late Fall-run Chinook Salmon				
Spawning, egg incubation, and alevins	X	X		X
Fry and juvenile rearing	X	X		X
Juvenile emigration	X	X		
Adult immigration	X	X		
Adult holding	X	X		
Steelhead				
Spawning, egg incubation, and alevins	X	X		
Kelt emigration	X	X		
Juvenile rearing	X	X		
Smolt emigration (not migrant parr)	X	X		
Adult immigration	X	X		
Adult holding	X	X		
Green Sturgeon				
Spawning and egg incubation	X	X		
Pre- and post-spawn adult holding	X	X		
Post-spawn emigration	X	X		

Life stage(s)	Method Used			
	Physical Model Output Characterization	Water Temperature Index Value/Range Analysis	Martin and Anderson Egg Mortality Models	SALMOD – Temperature-Related Mortality
Larval to Juvenile rearing and emigration	X	X		
Adult immigration	X	X		
White Sturgeon				
Spawning and egg incubation	X	X		
Juvenile rearing and emigration	X	X		
Adult immigration and holding	X	X		
Pacific Lamprey				
Spawning and egg incubation	X	X		
Ammocoete rearing and emigration	X	X		
River Lamprey				
Spawning and egg incubation	X	X		
Ammocoete rearing and emigration	X	X		
Hardhead				
Non-spawning life stages	X	X		
Spawning	X	X		
Sacramento Hitch				
Spawning	X	X		
Sacramento Splittail				
Spawning	X	X		
Striped Bass				
Spawning, embryo incubation, and initial rearing	X	X		
Larvae, fry, and juvenile rearing and emigration	X	X		
American Shad				
Spawning, embryo incubation, and initial rearing	X	X		
Larvae, fry, and juvenile rearing and emigration	X	X		

Life stage(s)	Method Used			
	Physical Model Output Characterization	**Water Temperature Index Value/Range Analysis**	**Martin and Anderson Egg Mortality Models**	**SALMOD – Temperature-Related Mortality**
Largemouth Bass				
Spawning	X	X		
Feather River				
Winter-run Chinook Salmon				
Non-natal rearing	X	X		
Spring-run Chinook Salmon				
Spawning, egg incubation, and alevins	X	X		
Fry and juvenile rearing	X	X		
Juvenile emigration	X	X		
Adult immigration	X	X		
Adult holding	X	X		
Fall-run Chinook Salmon				
Spawning, egg incubation, and alevins	X	X		
Fry and juvenile rearing	X	X		
Juvenile emigration	X	X		
Adult immigration	X	X		
Adult holding	X	X		
Steelhead				
Spawning, egg incubation, and alevins	X	X		
Kelt emigration	X	X		
Juvenile rearing	X	X		
Smolt emigration	X	X		
Adult immigration	X	X		
Adult holding	X	X		
Green Sturgeon				
Spawning, egg incubation	X	X		
Pre- and post-spawn adult holding	X	X		
Post-spawn emigration	X	X		
Larval to Juvenile rearing and emigration	X	X		
Adult immigration	X	X		
White Sturgeon				
Spawning and egg incubation	X	X		

Life stage(s)	Method Used			
	Physical Model Output Characterization	**Water Temperature Index Value/Range Analysis**	**Martin and Anderson Egg Mortality Models**	**SALMOD – Temperature-Related Mortality**
Juvenile rearing and emigration	X	X		
Adult immigration and holding	X	X		
Pacific Lamprey				
Spawning and egg incubation	X	X		
Ammocoete rearing and emigration	X	X		
River Lamprey				
Spawning and egg incubation	X	X		
Ammocoete rearing and emigration	X	X		
Hardhead				
Non-spawning life stages	X	X		
spawning	X	X		
Sacramento Hitch				
Spawning	X	X		
Sacramento Splittail				
Spawning	X	X		
Striped Bass				
Spawning, embryo incubation, and initial rearing	X	X		
Larvae, fry, and juvenile rearing and emigration	X	X		
American Shad				
Spawning, embryo incubation, and initial rearing	X	X		
Larvae, fry, and juvenile rearing and emigration	X	X		
Largemouth Bass				
Spawning	X	X		
American River				
Winter-run Chinook Salmon				
Non-natal rearing	X	X		

Life stage(s)	Method Used			
	Physical Model Output Characterization	**Water Temperature Index Value/Range Analysis**	**Martin and Anderson Egg Mortality Models**	**SALMOD – Temperature-Related Mortality**
Steelhead				
Spawning, egg incubation, and alevins	X	X		
Kelt emigration	X	X		
Juvenile rearing	X	X		
Smolt emigration	X	X		
Adult immigration	X	X		
Adult holding	X	X		
Fall-run Chinook Salmon				
Spawning, egg incubation, and alevins	X	X		
Fry and juvenile rearing	X	X		
Juvenile emigration	X	X		
Adult immigration	X	X		
Adult holding	X	X		
Pacific Lamprey				
Spawning and egg incubation	X	X		
Ammocoete rearing and emigration	X	X		
River Lamprey				
Spawning and egg incubation	X	X		
Ammocoete rearing and emigration	X	X		
Hardhead				
Non-spawning life stages	X	X		
Spawning	X	X		
Sacramento Hitch				
Spawning	X	X		
Sacramento Splittail				
Spawning	X	X		
Striped Bass				
Spawning, embryo incubation, and initial rearing	X	X		
Larvae, fry, and juvenile rearing and emigration	X	X		

Life stage(s)	Method Used			
	Physical Model Output Characterization	Water Temperature Index Value/Range Analysis	Martin and Anderson Egg Mortality Models	SALMOD – Temperature-Related Mortality
American Shad				
Spawning, embryo incubation, and initial rearing	X	X		
Larvae, fry, and juvenile rearing and emigration	X	X		
Largemouth Bass				
Spawning	X	X		

11B.1.1. Detailed Methods

11B.1.1.1. Physical Model Output Characterization

Patterns in water temperatures at key locations within the Sacramento, Feather, and American rivers were evaluated for each month that a life stage of each race/species was present and were summarized at the beginning of the water temperature section for each impact statement. The purpose of this characterization was to identify whether there were any locations, months, or water year types in which differences in water temperatures between the NAA and each alternative could potentially cause an effect. It included an evaluation between the NAA and each alternative of exceedance plots of mean monthly water temperature by month and comparisons of exceedance values, long-term averages, and average water temperatures by month and water year type, all of which is reported in Appendix 6C, *River Temperature Modeling*. If a specific result appeared concerning based on best professional judgment, the month, water year type, and location with the concerning result was flagged as requiring close examination in the results of the remaining water temperature evaluation. In addition, specifics of the month, water year type, and location with the concerning result were closely reviewed to determine the cause of the result and to determine whether the modeled effect could be avoided during real time operations.

11B.1.1.2. Water Temperature Threshold Analysis

This analysis determined the frequency and magnitude of exceedance above one or more water temperature index values or outside one or more index ranges obtained from the scientific literature and USEPA guidance (USEPA 2003) for each race/species and life stage at multiple locations within the Sacramento River (Table 11B-2), Feather River (Table 11B-3), and American River (Table 11B-4). These index values and index ranges typically characterize the suitable, optimal, acceptable, and observed temperature range needed for survival, growth, or presence. The list of index values for salmonids and green sturgeon was originally compiled to assess potential upstream water temperature-related effects for the California WaterFix Section 7 consultation (NMFS 2016). The list of index values and ranges for other species were primarily taken from the 2017 Sites DEIR/DEIS (Sites Project Authority and US Bureau of Reclamation 2017), Appendix 12D, *Water Temperature Index Value Selection Rationale*, with supplemental information taken from the scientific literature as necessary.

For fish species not listed under the ESA or CESA, the frequency of exceedance above one or more water temperature index values or outside one or more index ranges was evaluated. For ESA-/CESA-listed fish species, both the frequency and magnitude of exceedance above water temperature index values was evaluated. Although sufficient information is available using only the frequency of exceedance to assess potential significant impacts or adverse effects for NEPA/CEQA purposes, NMFS has previously requested an analysis of both the frequency and magnitude of exceedance for Section 7 purposes because it provides additional information used in their jeopardy/adverse modification opinion. Therefore, this enhanced analysis was conducted for listed salmonids (plus fall-/late fall-run Chinook salmon) and green sturgeon for the Sites Reservoir Biological Assessment. Thus, the results of this analysis were available for this EIR/EIS.

Because USEPA (2003) criteria are provided as seven-day average daily maximum (7DADM) and water temperature model outputs are monthly means, an additional conversion step was performed to convert 7DADM values into monthly means, which involved first calculating daily mean and maximum values from historical stream gage data for multiple locations in the Sacramento, Feather, and American Rivers obtained from the California Data Exchange Center web site (cdec.ca.gov). The 7DADM was calculated for each day using the mean of that day and the preceding 6 days. Next, the difference between 7DADM and mean daily values was calculated for each day. Finally, for each location, the mean monthly difference between 7DADM and mean daily values was calculated. This difference was used as a conversion value to adjust water temperature index values. These conversion values are presented by month in Table 11B-5, Table 11B-6, and Table 11B-7 for the Sacramento, Feather, and American Rivers, respectively. No conversions were necessary for index values and index ranges that did not use USEPA 7DADM guidance.

The index value/range analysis consisted of three steps. First, for the NAA and each alternative, the total number of days (Sacramento and American Rivers) or months (Feather River) across the 82-year modeling period with a modeled temperature that exceeded a given index value or was outside a given index range in Table 11B-2, Table 11B-3, and Table 11B-4 was divided by the total number of days months for each month of the year and water year type to provide the frequency of exceedance above the index value or occurrence outside the index range. The difference in frequency of exceedance or occurrence outside the range between NAA and each alternative was then calculated for each month and water year type.

Second, for listed species (plus fall-/late fall-run Chinook salmon) only, the magnitude of exceedance above a temperature index value was calculated. For all days (Sacramento and American Rivers) or months (Feather River) that the modeled temperature exceeded a given temperature index value as shown in Table 11B-2, Table 11B-3, and Table 11B-4, the cumulative degrees exceeded were summed as a degree-day or a degree-month total by month and water year type across the 82-year modeling period and divided by the total number of days or months, respectively, that the index value was exceeded, to provide the average daily/monthly magnitude of exceedance for those days/months that exceeded the index temperature. The difference in average daily/monthly magnitude of exceedance between NAA and each alternative was then calculated for each month and water year type. Combined, these calculations provided a magnitude and frequency of exceedance above a given temperature index value.

The final step identified in which months and water year types there would be a biologically meaningful effect. This differed between listed and non-listed species. For listed species (plus fall-/late fall-run Chinook salmon), this step evaluated both frequency and magnitude combined. A *biologically meaningful* effect was defined as the months and water year types in which water temperature results met two criteria: (1) the difference in frequency of exceedance between NAA and an alternative was greater than 5%, and (2) the difference in average daily exceedance was greater than 0.5°F. The 5% criterion was based on best professional judgment of fisheries biologists from NMFS, CDFW, DWR, and Reclamation. The 0.5°F criterion was based on: (1) a review of the water temperature-related mortality rates for steelhead eggs and juveniles (D. Swank pers. comm.), and (2) a reasonable water temperature differential that could be resolved through real-time reservoir operations. The 0.5°F value was applied to all species/races and life stages although it was based on data for steelhead eggs and juveniles. For those months and water year types that met these two conditions, a thorough review was conducted to determine whether these patterns were persistent across multiple years and whether the differences could be alleviated during real time operations (i.e., the results are due to a model artifact when in reality, the system would not be operated in this way). Further, when results from a month and/or water year type met these two criteria, exceedance plots were reviewed to determine whether the results may be due to one or two outliers. If this was found to be the case, it was concluded that the effect was not persistent enough to be biologically relevant.

For non-listed species, the final step involved an evaluation of only the frequency of exceedance above a water temperature index value or occurrence outside a water temperature index range. A *biologically meaningful* effect was defined as the months and water year types in which the difference between NAA and an alternative in frequency of exceedance above a water temperature index value or occurrence outside a water temperature index range was greater than 5%. As with listed species, a thorough review was conducted to determine whether these patterns were persistent across multiple years and whether the differences could be alleviated during real time operations. Further, when results from a month and/or water year type met the criterion, exceedance plots were reviewed to determine whether the results may be due to one or two outliers. If this was found to be the case, it was concluded that the effect was not persistent enough to be biologically relevant.

Table 11B-2. Water Temperature Index Values and Index Ranges Used for Water Temperature Index Value/Range Analyses, Sacramento River

Commented [CC1]: Please provide similar analyses for areas south of the Red Bluff, such indices will be useful for considering project impacts in the stretches of river from Hamilton City to the Delta.

Species	Life Stage	Period	Location	Index Value/Range (°F)		Sources/Notes
				Mean Daily	7DADM[1]	
Winter-run Chinook Salmon	Spawning, Egg Incubation, and Alevins	Apr-Oct	Keswick		55.4	USEPA 2003
			Clear Creek		55.4	USEPA 2003
			Balls Ferry		55.4	USEPA 2003
			Bend Bridge		55.4	USEPA 2003
			Red Bluff		55.4	USEPA 2003
	Fry and Juvenile Rearing and Emigration	Jul-Mar	Keswick		61	USEPA 2003; core juvenile rearing[2]
			Clear Creek		61	USEPA 2003; core juvenile rearing
			Balls Ferry		61	USEPA 2003; core juvenile rearing
			Bend Bridge		61	USEPA 2003; core juvenile rearing
			Red Bluff		61	USEPA 2003; core juvenile rearing
			Hamilton City		64	USEPA 2003; non-core juvenile rearing[3]
	Adult Immigration	Dec-Aug	Keswick		68	USEPA 2003
			Bend Bridge		68	USEPA 2003
			Red Bluff		68	USEPA 2003
	Adult Holding	Jan-Aug	Keswick		61	USEPA 2003
			Balls Ferry		61	USEPA 2003
			Red Bluff		61	USEPA 2003
		Aug-Dec	Keswick		55.4	USEPA 2003

Species	Life Stage	Period	Location	Index Value/Range (°F)		Sources/Notes
				Mean Daily	7DADM[1]	
Spring-run Chinook Salmon	Spawning, Egg Incubation, and Alevins		Clear Creek		55.4	USEPA 2003
			Balls Ferry		55.4	USEPA 2003
			Bend Bridge		55.4	USEPA 2003
			Red Bluff		55.4	USEPA 2003
	Fry and Juvenile Rearing and Emigration	Year-round	Keswick		61	USEPA 2003; core juvenile rearing
			Clear Creek		61	USEPA 2003; core juvenile rearing
			Balls Ferry		61	USEPA 2003; core juvenile rearing
			Bend Bridge		61	USEPA 2003; core juvenile rearing
			Red Bluff		61	USEPA 2003; core juvenile rearing
			Hamilton City		64	USEPA 2003; non-core juvenile rearing
	Adult Immigration	Mar-Sep	Keswick		68	USEPA 2003
			Bend Bridge		68	USEPA 2003
			Red Bluff		68	USEPA 2003
	Adult Holding	Apr-Sep	Keswick		61	USEPA 2003
			Balls Ferry		61	USEPA 2003
			Red Bluff		61	USEPA 2003
Fall-run Chinook Salmon	Spawning, Egg Incubation, and Alevins	Sep-Jan	Keswick		55.4	USEPA 2003
			Clear Creek		55.4	USEPA 2003
			Balls Ferry		55.4	USEPA 2003
			Bend Bridge		55.4	USEPA 2003
			Red Bluff		55.4	USEPA 2003

Species	Life Stage	Period	Location	Index Value/Range (°F)		Sources/Notes
				Mean Daily	7DADM[1]	
	Fry and Juvenile Rearing and Emigration	Dec-Jun	Keswick		61	USEPA 2003; core juvenile rearing
			Clear Creek		61	USEPA 2003; core juvenile rearing
			Balls Ferry		61	USEPA 2003; core juvenile rearing
			Bend Bridge		61	USEPA 2003; core juvenile rearing
			Red Bluff		61	USEPA 2003; core juvenile rearing
			Hamilton City		64	USEPA 2003; non-core juvenile rearing
	Adult Immigration	Jul-Dec	Keswick		68	USEPA 2003
			Bend Bridge		68	USEPA 2003
			Red Bluff		68	USEPA 2003
	Adult Holding	Jul-Aug	Keswick		61	USEPA 2003
			Balls Ferry		61	USEPA 2003
			Red Bluff		61	USEPA 2003
Late Fall-run Chinook Salmon	Spawning, Egg Incubation, and Alevins	Dec-Jun	Keswick		55.4	USEPA 2003
			Clear Creek		55.4	USEPA 2003
			Balls Ferry		55.4	USEPA 2003
			Bend Bridge		55.4	USEPA 2003
			Red Bluff		55.4	USEPA 2003
	Fry and Juvenile Rearing and Emigration	Mar-Jan	Keswick		61	USEPA 2003; core juvenile rearing
			Clear Creek		61	USEPA 2003; core juvenile rearing

Species	Life Stage	Period	Location	Index Value/Range (°F)		Sources/Notes
				Mean Daily	7DADM[1]	
			Balls Ferry		61	USEPA 2003; core juvenile rearing
			Bend Bridge		61	USEPA 2003; core juvenile rearing
			Red Bluff		64	USEPA 2003; non-core juvenile rearing
			Hamilton City		64	USEPA 2003; non-core juvenile rearing
	Adult Immigration	Nov-Apr	Keswick		68	USEPA 2003
			Bend Bridge		68	USEPA 2003
			Red Bluff		68	USEPA 2003
Steelhead	Spawning, Egg Incubation, and Alevins	Nov-Apr	Keswick	53		McCullough et al. 2001
				56		NMFS 2009
			Clear Creek	53		McCullough et al. 2001
				56		NMFS 2009
			Balls Ferry	53		McCullough et al. 2001
				56		NMFS 2009
			Bend Bridge	53		McCullough et al. 2001
				56		NMFS 2009
			Red Bluff	53		McCullough et al. 2001
				56		NMFS 2009
	Kelt Emigration	Feb-May	Keswick		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
			Bend Bridge		68	USEPA 2003

Species	Life Stage	Period	Location	Index Value/Range (°F)		Sources/Notes
				Mean Daily	7DADM[1]	
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
			Red Bluff		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
	Juvenile Rearing	Year-round	Keswick	63		Intermediate value of ranges of optimal growth from Grabowski 1973; Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005; and Beakes et al. 2014
					69	Sullivan et al. 2000
			Clear Creek	63		Intermediate value of ranges of optimal growth from Grabowski 1973; Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005; and Beakes et al. 2014
					69	Sullivan et al. 2000
			Balls Ferry	63		Intermediate value of ranges of optimal growth from Grabowski 1973; Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005; and Beakes et al. 2014
					69	Sullivan et al. 2000

Species	Life Stage	Period	Location	Index Value/Range (°F)		Sources/Notes
				Mean Daily	7DADM[1]	
			Bend Bridge	63		Intermediate value of ranges of optimal growth from Grabowski 1973; Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005; and Beakes et al. 2014
					69	Sullivan et al. 2000
			Red Bluff	63		Intermediate value of ranges of optimal growth from Grabowski 1973; Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005; and Beakes et al. 2014
					69	Sullivan et al. 2000
	Smoltification	Jan-Mar	Keswick	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988
			Clear Creek	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988
			Balls Ferry	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988
			Bend Bridge	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988
			Red Bluff	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988

Species	Life Stage	Period	Location	Index Value/Range (°F)		Sources/Notes
				Mean Daily	7DADM[1]	
	Smolt Emigration (excludes migrant parr)	Nov-Jun	Keswick		61	USEPA 2003
					64	USEPA 2003
			Clear Creek		61	USEPA 2003
					64	USEPA 2003
			Balls Ferry		61	USEPA 2003
					64	USEPA 2003
			Bend Bridge		61	USEPA 2003
					64	USEPA 2003
			Red Bluff		61	USEPA 2003
					64	USEPA 2003
	Adult Immigration	Aug-Mar	Keswick		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
			Bend Bridge		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
			Red Bluff		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
	Adult Holding	Sep-Nov	Keswick		61	USEPA 2003
			Balls Ferry		61	USEPA 2003
			Red Bluff		61	USEPA 2003
Green Sturgeon	Spawning and Embryo Incubation	Mar-Jul	Bend Bridge	63		
			Red Bluff	63		

Species	Life Stage	Period	Location	Index Value/Range (°F)		Sources/Notes
				Mean Daily	7DADM[1]	
			Hamilton City	63		Upper end of optimal range for embryonic development (Van Eenennaam 2005)
	Non-Spawning Adult Presence (Immigration, Pre- and Post-Spawn Holding)	Aug-Feb	Bend Bridge	66		Assumes that adults are at least as tolerant to temperatures as larvae and juveniles
				73		Houston 1988; Erickson et al. 2002
			Red Bluff	66		Assumes that adults are at least as tolerant to temperatures as larvae and juveniles
				73		Houston 1988; Erickson et al. 2002
			Hamilton City	66		Assumes that adults are at least as tolerant to temperatures as larvae and juveniles
				73		Houston 1988; Erickson et al. 2002
		Year-round	Knights Landing	66		Assumes that adults are at least as tolerant to temperatures as larvae and juveniles
				73		Houston 1988; Erickson et al. 2002
	Larval to Juvenile Rearing and Emigration	Year-round	Bend Bridge	66		Upper end of optimal range for bioenergetics performance of Age 0/1 sturgeon with full or reduced food supply (Mayfield and Cech 2004)
			Red Bluff	66		
			Hamilton City	66		

Species	Life Stage	Period	Location	Index Value/Range (°F)		Sources/Notes
				Mean Daily	7DADM[1]	
White Sturgeon	Spawning and Embryo Incubation	Feb-May	Hamilton City	61		Optimal egg incubation range upper limit (Israel et al. 2011)
				68		Embryo hatching upper limit (Israel et al. 2011)
	Juvenile Rearing and Emigration	Year-round	Hamilton City	66		Stress observed in juvenile white sturgeon above 66°F (Israel et al. 2011)
	Adult Immigration and Holding	Nov-May	Hamilton City	77		Upper limit of suitable water temperatures for adults (Israel et al. 2011)
Pacific Lamprey	Spawning and Egg Incubation	Apr-Aug	Keswick	50-64		High survival and low occurrence of embryonic developmental abnormalities observed in this range (Meeuwig et al. 2002, 2005)
			Red Bluff	50-64		
	Ammocoete Rearing and Emigration	Year-round	Keswick	72		Significant decrease in survival and increase in developmental abnormalities observed above 72°F (Meeuwig et al. 2002, 2005)
			Red Bluff	72		
River Lamprey	Spawning and Egg Incubation	Feb-Jul	Keswick	50-64		High survival and low occurrence of embryonic developmental abnormalities observed in this range (Meeuwig et al. 2002, 2005)
			Red Bluff	50-64		
	Ammocoete Rearing and Emigration	Year-round	Keswick	72		Significant decrease in survival and increase in developmental abnormalities observed above 72°F (Meeuwig et al. 2002, 2005)
			Red Bluff	72		

Species	Life Stage	Period	Location	Index Value/Range (°F)		Sources/Notes
				Mean Daily	7DADM[1]	
Hardhead	Spawning	Apr-Jun	Keswick	59-64		Optimal range (Wang 1986)
			Red Bluff	59-64		
	Non-spawning Life Stages	Year-round	Keswick	65-82		Widest observed range (Cech et al. 1990, Moyle 2002, Southern California Edison Company 2007)
			Red Bluff	65-82		
Sacramento Hitch	Spawning	Mar-Jul	Red Bluff	57-79		Moyle 2002
			Butte City	57-79		Moyle 2002
Sacramento Splittail	Spawning	Feb-May	Hamilton City	45-75		Observed range of suitable water temperatures (Moyle et al. 2004)
Striped Bass	Spawning, Embryo Incubation, and Initial Rearing	Apr-Jun	Butte City	59-68		Optimal range (Moyle 2002)
	Larvae, Fry, and Juvenile Rearing and Emigration	Year-round	Butte City	61-71		Optimal range (Fay et al. 1983)
American Shad	Spawning, Embryo Incubation, and Initial Rearing	Apr-Jun	Red Bluff	60-70		Optimal range (Bell 1986, Painter et al. 1980, Leggett and Whitney 1972, Painter et al. 1979, Rich 1987)
			Butte City	60-70		
	Larvae, Fry, and Juvenile Rearing and Emigration	Year-round	Red Bluff	63-77		Optimal range (Moyle 2002)
			Butte City	63-77		
Largemouth Bass	Spawning	Mar-Jun	Keswick	54-75		Acceptable range for spawning and incubation (Moyle 2002)
			Red Bluff	54-75		

[1] 7DADM = Seven Day Average Daily Maximum
[2] Core = "moderate to high density" (USEPA 2003)
[3] Non-core = "low to moderate density" (USEPA 2003)

Table 11B-3. Water Temperature Index Values and Index Ranges Used for Water Temperature Index Value/Range Analyses, Feather River

Species	Life Stage	Period	Location	Index Value/Range (°F) Mean Monthly	Index Value/Range (°F) 7DADM[1]	Source/Note
Winter-run Chinook Salmon	Non-Natal Rearing	Jul-Mar	LFC above Thermalito		64	USEPA 2003; non-core juvenile rearing[2]
			HFC at Gridley		64	USEPA 2003; non-core juvenile rearing
Spring-run Chinook Salmon	Spawning, Egg Incubation, and Alevins	Sep-Feb	LFC below Fish Dam		55.4	USEPA 2003
			HFC below Thermalito		55.4	USEPA 2003
	Fry and Juvenile Rearing and Emigration	Nov-Jun	LFC below Fish Dam		61	USEPA 2003; core juvenile rearing[3]
			HFC below Thermalito		64	USEPA 2003; non-core juvenile rearing
	Adult Immigration	Mar-Jun	LFC below Fish Dam		68	USEPA 2003
			HFC below Thermalito		68	USEPA 2003
	Adult Holding	Apr-Sep	LFC below Fish Dam		61	USEPA 2003
			HFC below Thermalito		61	USEPA 2003
Fall-run Chinook Salmon	Spawning, Egg Incubation, and Alevins	Oct-Feb	LFC below Fish Dam		55.4	USEPA 2003
			HFC below Thermalito		55.4	USEPA 2003
	Fry and Juvenile Rearing and Emigration	Nov-May	LFC below Fish Dam		61	USEPA 2003; core juvenile rearing
			HFC below Thermalito		64	USEPA 2003; non-core juvenile rearing
	Adult Immigration	Aug-Dec	LFC below Fish Dam		68	USEPA 2003
			HFC below Thermalito		68	USEPA 2003
	Adult Holding	Aug-Dec	LFC below Fish Dam		61	USEPA 2003
			HFC below Thermalito		61	USEPA 2003

Species	Life Stage	Period	Location	Index Value/Range (°F)		Source/Note
				Mean Monthly	7DADM[1]	
Steelhead	Spawning, Egg Incubation, and Alevins	Dec-May	LFC below Fish Dam	53		McCullough et al. 2001
			HFC below Thermalito	53		McCullough et al. 2001
	Kelt Emigration	Feb-May	LFC below Fish Dam		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
			HFC below Thermalito		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
	Juvenile Rearing	Year-round	LFC below Fish Dam	63		Intermediate value of ranges of optimal growth from Grabowski 1973; Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005; and Beakes et al. 2014
					69	USEPA 2003
			HFC below Thermalito	63		Intermediate value of ranges of optimal growth from Grabowski 1973; Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005; and Beakes et al. 2014
					69	USEPA 2003
	Smoltification	Jan-Mar	LFC below Fish Dam	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988
			HFC below Thermalito	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988
	Smolt Emigration	Dec-Jun	LFC below Fish Dam		61	USEPA 2003
			HFC below Thermalito		64	USEPA 2003
	Adult Immigration	Aug-Mar	LFC below Fish Dam		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
					68	USEPA 2003

Species	Life Stage	Period	Location	Index Value/Range (°F)		Source/Note
				Mean Monthly	7DADM[1]	
			HFC below Thermalito	70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
	Adult Holding	Sep-Nov	LFC below Fish Dam		61	USEPA 2003
			HFC below Thermalito		61	USEPA 2003
Green Sturgeon	Spawning and Embryo Incubation	Mar-Jul	LFC below Fish Dam	63		Upper end of optimal range for embryonic development (Van Eenennaam 2005)
			HFC below Thermalito	63		
			HFC at Gridley	63		
	Non-Spawning Adult Presence (Immigration, Pre- and Post-Spawn Holding)	Aug-Nov	LFC below Fish Dam	66		Assumes that adults are at least as tolerant to temperatures as larvae and juveniles
				73		Houston 1988; Erickson et al. 2002
			HFC below Thermalito	66		Assumes that adults are at least as tolerant to temperatures as larvae and juveniles
				73		Houston 1988; Erickson et al. 2002
			HFC at Gridley	66		Assumes that adults are at least as tolerant to temperatures as larvae and juveniles
				73		Houston 1988; Erickson et al. 2002
	Larval to Juvenile Rearing and Emigration	Year-round	LFC below Fish Dam	66		Upper end of optimal range for bioenergetics performance of Age 0/1 sturgeon with full or reduced food supply (Mayfield and Cech 2004)
			HFC below Thermalito	66		
			HFC at Gridley	66		
White Sturgeon	Spawning and Embryo Incubation	Feb-May	LFC below Fish Dam	61		Optimal egg incubation range upper limit (Israel et al. 2011)
			HFC below Thermalito	61		
			HFC at Mouth	61		
	Juvenile Rearing and Emigration	Year-round	LFC below Fish Dam	66		Stress observed in juvenile white sturgeon above 66°F (Israel et al. 2011)
			HFC below Thermalito	66		
			HFC at Mouth	66		
		Nov-May	LFC below Fish Dam	77		

Species	Life Stage	Period	Location	Index Value/Range (°F)		Source/Note
				Mean Monthly	7DADM[1]	
	Adult Immigration and Holding		HFC below Thermalito	77		Upper limit of suitable water temperatures for adult (Israel et al. 2011)
			HFC at Mouth	77		
Pacific Lamprey	Spawning and Egg Incubation	Apr-Aug	LFC below Fish Dam	50-64		High survival and low occurrence of embryonic developmental abnormalities observed in this range (Meeuwig et al. 2002, 2005)
			HFC below Thermalito	50-64		
			HFC at Mouth	50-64		
	Ammocoete Rearing and Emigration	Year-round	LFC below Fish Dam	72		Significant decrease in survival and increase in developmental abnormalities observed above 72°F (Meeuwig et al. 2002, 2005)
			HFC below Thermalito	72		
			HFC at Mouth	72		
River Lamprey	Spawning and Egg Incubation	Feb-Jul	LFC below Fish Dam	50-64		High survival and low occurrence of embryonic developmental abnormalities observed in this range (Meeuwig et al. 2002, 2005)
			HFC below Thermalito	50-64		
			HFC at Mouth	50-64		
	Ammocoete Rearing and Emigration	Year-round	LFC below Fish Dam	72		Significant decrease in survival and increase in developmental abnormalities observed above 72°F (Meeuwig et al. 2002, 2005)
			HFC below Thermalito	72		
			HFC at Mouth	72		
Hardhead	Spawning	Apr-Jun	LFC below Fish Dam	59-64		Optimal range (Wang 1986)
			HFC below Thermalito	59-64		
			HFC at Mouth	59-64		
	Non-Spawning Life Stages	Year-round	LFC below Fish Dam	65-82		Widest observed range (Cech et al. 1990, Moyle 2002, Southern California Edison Company 2007)
			HFC below Thermalito	65-82		
			HFC at Mouth	65-82		
Sacramento Hitch	Spawning	Mar-Jul	LFC below Fish Dam	57-79		Moyle 2002
			HFC below Thermalito	57-79		

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Species	Life Stage	Period	Location	Index Value/Range (°F)		Source/Note
				Mean Monthly	7DADM[1]	
Sacramento Splittail	Spawning	Feb-May	HFC at Mouth	45-75		Observed range of suitable water temperatures (Moyle et al. 2004)
Striped Bass	Spawning, Embryo Incubation, and Initial Rearing	Apr-Jun	HFC below Thermalito	59-68		Optimal range (Moyle 2002)
			HFC at Mouth	59-68		
	Larvae, Fry, and Juvenile Rearing and Emigration	Year-round	HFC below Thermalito	61-71		Optimal range (Fay et al. 1983)
			HFC at Mouth	61-71		
American Shad	Spawning, Embryo Incubation, and Initial Rearing	Apr-Jun	HFC below Thermalito	60-70		Optimal range (Bell 1986, Painter et al. 1980, Leggett and Whitney 1972, Painter et al. 1979, Rich 1987)
			HFC at Mouth	60-70		
	Larvae, Fry, and Juvenile Rearing and Emigration	Jul - Nov	HFC below Thermalito	63-77		Optimal range (Moyle 2002)
			HFC at Mouth	63-77		
Largemouth Bass	Spawning	Mar-Jun	HFC below Thermalito	54-75		Acceptable range for spawning and incubation (Moyle 2002)
			HFC at Mouth	54-75		

[1] 7DADM = Seven Day Average Daily Maximum
[2] Core = "moderate to high density" (USEPA 2003)
[3] Non-core = "low to moderate density" (USEPA 2003)

Table 11B-4. Water Temperature Index Values and Index Ranges Used for Water Temperature Index Value/Range Analyses, American River

Species	Life Stage	Period	Location	Index Value/Range (°F) Mean Daily	Index Value/Range (°F) 7DADM[1]	Source/Note
Winter-run Chinook Salmon	Non-Natal Rearing	Jul-Apr	Watt Ave		64	USEPA 2003; non-core location[2]
Fall-run Chinook Salmon	Spawning, Egg Incubation, and Alevins	Oct-Feb	Below Nimbus		55.4	USEPA 2003
			Watt Ave		55.4	USEPA 2003
	Fry and Juvenile Rearing and Emigration	Jan-May	Below Nimbus		61	USEPA 2003; core juvenile rearing[3]
			Watt Ave		64	USEPA 2003; non-core juvenile rearing
	Adult Immigration	Sep-Dec	Below Nimbus		68	USEPA 2003
			Watt Ave		68	USEPA 2003
	Adult Staging	Jul-Dec	Below Nimbus		61	USEPA 2003
			Watt Ave		61	USEPA 2003
Steelhead	Spawning, Egg Incubation, and Alevins	Dec-May	Below Nimbus	53		McCullough et al. 2001
			Watt Ave	53		McCullough et al. 2001
	Kelt Emigration	Feb-May	Below Nimbus		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
			Watt Ave		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
	Juvenile Rearing	Year-round	Below Nimbus	63		Intermediate value of ranges of optimal growth from Grabowski 1973; Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005; and Beakes et al. 2014
					69	Sullivan et al. 2000

Species	Life Stage	Period	Location	Index Value/Range (°F) Mean Daily	7DADM[1]	Source/Note
			Watt Ave	63		Intermediate value of ranges of optimal growth from Grabowski 1973; Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005; and Beakes et al. 2014
					69	Sullivan et al. 2000
	Smoltification	Jan-Mar	Below Nimbus	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988
			Watt Ave	54		Zaugg and Wagner 1973; Adams et al. 1975; Zaugg 1981; Hoar 1988
	Smolt Emigration	Dec-Jun	Below Nimbus		61	USEPA 2003; core location
			Watt Ave		64	USEPA 2003; non-core location
	Adult Immigration	Oct-Apr	Below Nimbus		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
			Watt Ave		68	USEPA 2003
				70		Average of studies cited in Richter and Kolmes 2005 (for upper end of suboptimal range)
	Adult Holding	Oct-Nov	Below Nimbus		61	USEPA 2003
			Watt Ave		61	USEPA 2003
Pacific Lamprey	Spawning and Egg Incubation	Mar-Jul	Below Nimbus	50-64		High survival and low occurrence of embryonic developmental abnormalities observed in this range (Meeuwig et al. 2002, 2005)
			Watt Ave	50-64		
			Mouth	50-64		
	Ammocoete Rearing and Emigration	Year-round	Below Nimbus	72		Significant decrease in survival and increase in developmental abnormalities observed above 72°F (Meeuwig et al. 2002, 2005)
			Watt Ave	72		
			Mouth	72		
River Lamprey	Spawning and Egg Incubation	Feb-Jul	Below Nimbus	50-64		High survival and low occurrence of embryonic developmental abnormalities observed in this range (Meeuwig et al. 2002, 2005)
			Watt Ave	50-64		
			Mouth	50-64		

Species	Life Stage	Period	Location	Index Value/Range (°F)		Source/Note
				Mean Daily	7DADM[1]	
	Ammocoete Rearing and Emigration	Year-round	Below Nimbus	72		Significant decrease in survival and increase in developmental abnormalities observed above 72°F (Meeuwig et al. 2002, 2005)
			Watt Ave	72		
			Mouth	72		
Hardhead	Spawning	April - June	Below Nimbus	59-64		Optimal range (Wang 1986)
	Non-Spawning Life Stages	Year-round	Watt Ave	65-82		Widest observed range (Cech et al. 1990, Moyle 2002, Southern California Edison Company 2007)
Sacramento Hitch	Spawning	Mar-July	Below Nimbus	57-79		Moyle 2002
			Watt Ave	57-79		
Sacramento Splittail	Spawning	Feb-May	Mouth	45-75		Observed range of suitable water temperatures (Moyle et al. 2004)
Striped Bass	Spawning, Embryo Incubation, and Initial Rearing	Apr-Jun	Watt Ave	59-68		Optimal range (Moyle 2002)
			Mouth	59-68		
	Larvae, Fry, and Juvenile Rearing and Emigration	Year-round	Watt Ave	61-71		Optimal range (Fay et al. 1983)
			Mouth	61-71		
American Shad	Spawning, Embryo Incubation, and Initial Rearing	Apr-Jun	Watt Ave	60-70		Optimal range (Bell 1986, Painter et al. 1980, Leggett and Whitney 1972, Painter et al. 1979, Rich 1987)
			Mouth	60-70		
	Larvae, Fry, and Juvenile Rearing and Emigration	Jul-Nov	Watt Ave	63-77		Optimal range (Moyle 2002)
			Mouth	63-77		
Largemouth Bass	Spawning	Mar-Jun	Watt Ave	54-75		Acceptable range for spawning and incubation (Moyle 2002)

[1] 7DADM = Seven Day Average Daily Maximum
[2] Non-core = "low to moderate density" (USEPA 2003)
[3] Core = "moderate to high density" (USEPA 2003)

Table 11B-5. Conversion Factors (°F) for USEPA (2003) Seven-Day Average Daily Maximum (7DADM) Water Temperature Index Values to Monthly Mean, Sacramento River[1].

Month	Keswick	Clear Creek	Balls Ferry	Bend Bridge	Red Bluff	Wilkins Slough[2]
January	-0.36	-1.01	-0.75	-0.67	-0.86	0.0
February	-0.28	-1.11	-0.86	-0.62	-0.97	-0.3
March	-0.17	-1.29	-0.94	-0.66	-1.23	-0.3
April	-0.25	-1.66	-1.47	-0.95	-1.55	-0.6
May	-0.36	-1.73	-2.18	-1.59	-1.47	-1.4
June	-0.32	-1.55	-2.25	-1.87	-0.96	-1.2
July	-0.36	-1.41	-2.18	-2.01	-0.90	-1.3
August	-0.43	-1.74	-2.06	-1.61	-0.94	-1.3
September	-0.30	-2.00	-1.76	-1.16	-1.70	-2.0
October	-0.25	-1.73	-1.25	-0.91	-1.83	-1.4
November	-0.38	-1.37	-1.10	-0.99	-1.53	-1.3
December	-0.82	-1.42	-1.30	-1.24	-1.48	-1.0

1 Based on historical data from 2003-2014 for all sites except Wilkins Slough, which is based on historical data from November 2012 through June 2015. For a given location and month, values in this table were added to 7DADM index values in Table 11B-2 such that actual values used in the evaluation for each month were lower than those listed in Table 11B-2.

2 Because there is no flow gage at Hamilton City, Wilkins Slough data were used to calculate the conversion factor for Hamilton City

Table 11B-6. Conversion Factors (°F) for USEPA (2003) Seven-Day Average Daily Maximum (7DADM) Water Temperature Index Values to Monthly Mean, Feather River[1,2].

Month	RM 66.3 (Downstream of Hatchery)	RM 58.7 (Downstream of Afterbay Outlet)	RM 25.5 (Shanghai Bend)
January	-0.76	-0.52	-0.45
February	-0.83	-0.56	-0.58
March	-0.93	-0.60	-0.60
April	-0.88	-0.78	-1.06
May	-1.06	-0.87	-1.34
June	-1.10	-1.37	-1.74
July	-1.82	-1.41	-1.30
August	-2.08	-1.37	-1.04
September	-2.16	-1.58	-1.48
October	-1.36	-1.20	-1.51
November	-0.92	-1.15	-1.45
December	-0.94	-0.78	-0.96

[1] Based on historical data from 2002-2014. For a given location and month, values in this table were added to 7DADM index values in Table 11B-3 such that actual values used in the evaluation were lower than those listed in Table 11B-3.

[2] RM 66.3 conversion factors were used for both locations in the LFC (below Fish Dam and above Thermalito); RM58.7 conversion factors were used for the HFC below Thermalito Afterbay Outlet; RM 25.5 conversion factors were used for the HFC at Gridley Bridge.

Table 11B-7. Conversion Factors (°F) for USEPA (2003) Seven-Day Average Daily Maximum (7DADM) Maximum Water Temperature Index Values to Monthly Mean, American River[1].

Month	Below Nimbus Dam	Watt Ave
January	-0.44	-1.01
February	-0.15	-1.05
March	-0.25	-1.29
April	-0.40	-1.72
May	-0.60	-2.05
June	-0.44	-2.55
July	-0.50	-3.17
August	-0.70	-3.11
September	-0.59	-2.52
October	-0.60	-2.01
November	-0.80	-1.65
December	-0.77	-1.26

[1] Based on historical data from 2003-2014. For a given location and month, values in this table were added to 7DADM index values in Table 11B-4 such that actual values used in the evaluation were lower than those listed in Table 11B-4.

11B.1.1.3. Winter-Run Chinook Salmon Egg Mortality Analysis based on Martin et al. (2017)

Background

The dissolved oxygen content of the water passing through the gravel substrate and sustaining Winter-Run Chinook Salmon eggs is positively correlated with temperature; warm, anoxic conditions result in egg mortality. This analysis attempted to isolate the thermal component of egg mortality from other components such as density-dependent mortality and redd dewatering. Both the Martin et al. (2017) model described in this section and the Anderson (2018) model (described below in Section 11B.1.2.4, *Winter-Run Chinook Salmon Egg Mortality Analysis based on Anderson (2018)*) begin by modeling a redd's lifetime by counting the days required to cross a known cumulative degree-days threshold, and both estimate mortality as a linear, increasing function of temperature past a known temperature threshold, but each model uses a different set of assumptions to implement this conceptual model. The methods were applied to a set of simulated redds and the results were summarized on a seasonal level for comparison of mortality outcomes between DCR 2015 Without and With Project scenario HEC5Q model runs.

Martin et al. (2017) identified a discrepancy between laboratory and field estimates of egg mortality and proposed a mechanism based on differing flow velocities in the laboratory and field environments. They then outlined a model for estimating temperature-dependent egg mortality in the field and fit its parameters to Sacramento River Winter-Run Chinook Salmon population data collected between 1996 and 2015 (Martin et al., 2017).

Mortality Calculations

The first step in the Martin et al. (2017) model is to estimate a redd's date of emergence. Individual eggs within the redd hatch but stay within the gravel substrate of the redd and become alevins. These alevins later depart the redd in the emergence stage. The redd's estimated date of emergence is intended to represent the point in the average egg's life span where it leaves the gravel substrate of the redd.

The Martin et al. (2017) model estimates the date of emergence using a linear relationship between water temperature (T, in °F) and maturation: Rate of maturation = 0.00058 * T - 0.018 (Zeug et al. 2012). For each simulated redd, the Zeug et al. (2012) equation was applied to daily temperatures starting the day after redd creation until the cumulative sum of daily maturation rates is greater than one. The day on which this occurs is considered the date of emergence for the redd.

Daily survival is then calculated for every day of the redd's lifespan. Below a temperature threshold of 11.9°C, no temperature-dependent mortality is recorded, and the survival is 1. For each degree C above the threshold, 0.024 is subtracted from the daily survival. The product of the natural exponents of daily survivals is the total survival, and one minus survival is the estimated mortality fraction for that simulated redd.

In summary, the Martin et al. (2017) model uses the Zeug et al. (2012) equation to estimate date of emergence, then estimates daily mortality for each day of the redd's lifespan using a linear relationship.

Spatiotemporal Distribution of Simulated Winter-Run Chinook Salmon Eggs

The Martin et al. (2017) model was applied to HEC5Q Sacramento River temperature results using the same spatiotemporal distribution of redds in each year. The distribution is the averaged location and timing of redds counted in California Department of Fish and Wildlife Winter-Run aerial survey data from 2007 to 2014. Simulated redds were created and subjected to mortality calculations. All simulated redds' mortalities were combined in a sum, weighted by the spatiotemporal distribution, to estimate the total seasonal mortality fraction.

No assumption was made regarding the total number of redds, as density-dependent mortality is not considered in this calculation; results indicate only the percentage of the total seasonal Winter-Run Chinook Salmon egg population in the upper Sacramento River that is estimated to have succumbed to temperature-dependent mortality. Because a large percentage of modeled redds survived into October and the HEC5Q simulation ends at September of 2003, temperature-dependent egg mortality was only estimated for the 1922–2002 water years.

Tables 11B-8 and 11B-9 indicate the river miles and dates for which simulated redds were created as well as the proportion of the total Winter-Run Chinook Salmon egg population which each location or time represents. The same temporal distribution was assumed for all locations.

Table 11B-8. Spatial Distribution of Simulated Redds Used in the Martin et al. (2017) Model of Winter-Run Chinook Salmon Egg Mortality

River Reach	River Mile	Mean Percentage (2007-2014)
Keswick to A.C.I.D. Dam.	298	46.4%
A.C.I.D. Dam to Highway 44 Bridge	296	46.1%
Highway 44 Br. to Airport Rd. Br.	284	6.7%
Airport Rd. Br. to Balls Ferry Br.	275	0.3%
Balls Ferry Br. to Battle Creek.	271	0.2%
Battle Creek to Jellys Ferry Br.	266	0.2%
Jellys Ferry Br. to Bend Bridge	257	0.1%
Bend Bridge to Red Bluff Diversion Dam	242	0.0%

Table 11B-9. Temporal Distribution of Simulated Redds Used in the Martin et al. (2017) Model of Winter-Run Chinook Salmon Egg Mortality

Date (month/day)	Mean Percentage (2007-2014)
5/15	5.4%
6/1	5.9%
6/9	7.8%
6/16	13.3%
6/24	16.0%
7/1	15.9%
7/9	14.2%
7/16	10.4%
7/24	6.7%
8/1	3.1%
8/16	1.4%

11B.1.1.4. Winter-Run Chinook Salmon Egg Mortality Analysis based on Anderson (2018)

Anderson (2018) developed a model that built on Martin et al.'s (2017) findings but differed in two key assumptions. While Martin et al. (2017) applied mortality to each day of a redd's lifespan from birth past hatching to emergence, Anderson (2018) used a short critical period instead. Using field data from 2002 through 2015, a critical period just before hatching was found to provide the best fit (Anderson 2018). This analysis used a critical period of five days in length, following the implementation of the Anderson (2018) model on the SacPAS website (http://www.cbr.washington.edu/sacramento/fishmodel/).

Instead of using the Zeug et al. (2012) equation to estimate date of emergence, the Anderson (2018) model uses a different equation to estimate date of hatching. Like the Zeug et al. (2012) equation, daily temperatures are correlated to daily maturation and a cumulative sum of daily maturation is calculated until maturation crosses a known threshold. The date on which this occurs is the hatching date, and in this implementation of the Anderson (2018) model the five days before hatching are the days on which mortality is estimated.

The daily equation was calibrated as by Alderdice and Velsen (1978): ln(Daily development rate) = $\ln(k) + b * (\ln(T - c))$, where $k = 0.08646$, $b = 1.23473$, $c = -2.26721$, and temperature is measured in °C. The day on which the cumulative sum of daily development rate passes 100 is considered the redd hatching date.

Like the Martin et al. (2017) model, the Anderson (2018) model assumes a linear relationship between mortality and temperature, with zero mortality below a threshold. The threshold was set identical to the Martin et al. (2017) model at 11.9 C, while the slope is not 0.024 but 0.5. This is unsurprising; calibration to substantially the same dataset will naturally result in a much higher slope, or a much larger mortality impact per degree C above the threshold, for a model that only applies mortality to five days instead of the full lifespan of the redd. The same formulae for adding up daily survivals and finding a total mortality estimate were used as for the Martin et al. (2017) model, as described above in *Mortality Calculations*. The same spatiotemporal redd weighting was applied as the Martin et al. (2017) model; see description above in *Spatiotemporal Distribution of Simulated Winter-Run Chinook Salmon Eggs*.

11B.2 Spawning Habitat Weighted Usable Area

11B.2.1. Introduction

Weighted usable area (WUA) analysis provides estimates of the amount of suitable spawning and rearing habitat of fishes available in rivers and streams at various levels of flow. WUA is computed as the surface area of physical habitat available weighted by its suitability. Habitat suitability is determined from field studies of the distributions of redds or rearing juveniles with respect to flow velocities, depths, and substrate or cover characteristics in the river. These data are used in model simulations (PHABSIM) that estimate the availability of suitable habitat in a portion of the river at a given flow. WUA curves showing suitable habitat availability versus flow are generated from the simulations.

For this RDEIR/SDEIS, spawning WUA was estimated for winter-run, spring-run, fall-run, and late fall–run Chinook salmon and California Central Valley steelhead in the Sacramento, Feather and American Rivers. Fry and juvenile rearing WUA were estimated only for the Sacramento River because no acceptable rearing WUA curves are available for the Feather and American Rivers. Spawning and rearing WUA was estimated for the No Action Alternative (NAA) and Alternatives 1A, 1B, 2, and 3 (hereinafter referred to as Alternatives 1–3) from CALSIM II flow data for each month of the 82-year period of record.

11B.2.2. Sacramento River

The WUA curves used for Chinook salmon and steelhead spawning habitat in the Sacramento River were obtained from two U.S. Fish and Wildlife Service reports (U.S. Fish and Wildlife Service 2003a, 2006). Modeling assumptions used to derive spawning WUA curves include that the suitability of physical habitat for salmon and steelhead spawning is largely a function of substrate particle size, water depth, and flow velocity. The race- or species-specific suitability of the habitat with respect to these variables is determined by cataloguing conditions at active redds and is used to develop habitat suitability criteria (HSC) for each race or species of fish. Hydraulic modeling is then used to estimate the amount of habitat available for different HSC levels at different river flows, and the results are used to develop spawning habitat WUA curves (Bovee et al. 1998). The WUA curves and tables are used to look up the amount of spawning WUA available at different flows during the spawning periods of the race or species.

U.S. Fish and Wildlife Service (2003a) provides WUA curves and tables for spawning winter-run, fall-run, and late fall–run Chinook salmon and steelhead for three segments of the Sacramento River encompassing the reach from Keswick Dam to Battle Creek (Figure 11B-1). The WUA tables were updated in 2006 (U.S. Fish and Wildlife Service 2006). No WUA curves were developed for spring-run Chinook salmon, but as discussed later, the fall-run curves were used to quantify spring-run spawning habitat. Also as further discussed below, the HSC used to develop the steelhead WUA curve for Sacramento River spawning were obtained from investigations of steelhead redds in the American River (U.S. Fish and Wildlife Service 2003b) because few steelhead redds were observed in the Sacramento River. Figure 11B-2 through Figure 11B-5 show the flow versus spawning WUA results for winter-run, fall-run, late fall–run and steelhead in the three river segments (Segment 6 = Keswick to Anderson-Cottonwood Irrigation District [ACID] Dam, Segment 5 = ACID Dam to Cow Creek, and Segment 4 = Cow Creek to Battle Creek) as provided by U.S. Fish and Wildlife Service (2006). Figure 11B-6 shows spawning WUA results for fall-run in an additional downstream segment (Segment 3 = Battle Creek to Red Bluff Diversion Dam) because spawning for fall run occurs further downstream than it does for the other salmon runs. Note that for Segment 6, separate WUA curves were developed for periods when the ACID Dam boards were installed (April through October) and for when the boards were out because installation of the boards affects water depths and velocities for some of the sampling transects used to develop the curves.

Because several tributaries enter the Sacramento River between Keswick Dam and Battle Creek, flows generally differ among the segments. For the U.S. Fish and Wildlife Service studies, Sacramento River flows were measured directly at the sampling transects and were estimated as the sum of Keswick Dam flow releases and tributary gauge readings upstream of the transects. To estimate WUA for the effects analysis, the segment flows were estimated using Sacramento River CALSIM II flows at Keswick Dam, the Clear Creek confluence, and Battle Creek. Keswick Dam flows were used for Segment 5 upstream of the Clear Creek confluence. For Segment 6, the WUA curves for the months when the ACID Dam boards are installed (April through October) were used with the Keswick Dam flows for those months and the WUA curves for the months when the ACID Dam boards are out were used with the flows for the rest of the year. To evaluate the relative importance of results from the three segments for each race or species in the effects analysis, the typical spawning distributions of the salmon with respect to the segments (Table 11B-10) was estimated from aerial redd surveys conducted by California

Department of Fish and Wildlife (ICF 2016). All the races other than fall-run primarily spawn upstream of the Battle Creek confluence, and most fall-run spawning occurs upstream of the RBDD. Little is known about steelhead spawning locations in the Sacramento River, although it was assumed for this analysis that, because of constraints on water temperature and other habitat features, individuals spawn between Keswick Dam and RBDD, where nearly all Chinook salmon spawn (Table 11B-10).

Table 11B-10. Distributions of Spawning Redds among WUA River Segments as Percent of Total in the Sacramento River for Chinook Salmon Runs.

Segment	Description	River Miles	Winter-run	Spring-run	Fall-run	Late fall–run
6	Keswick to ACID[a]	302-298.5	45.0%	12.4%	16.3%	67.6%
5	ACID to Cow Creek	298.5-280	54.6%	66.0%	25.9%	12.7%
4	Cow Creek to Battle Creek	280-271	0.4%	12.8%	18.4%	9.2%
3	Battle Creek to RBDD	271-243	0.0%	4.9%	22.8%	4.3%
—	Downstream of RBDD	—	0.0%	4.0%	16.6%	6.2%

[a] ACID = Anderson-Cottonwood Irrigation District

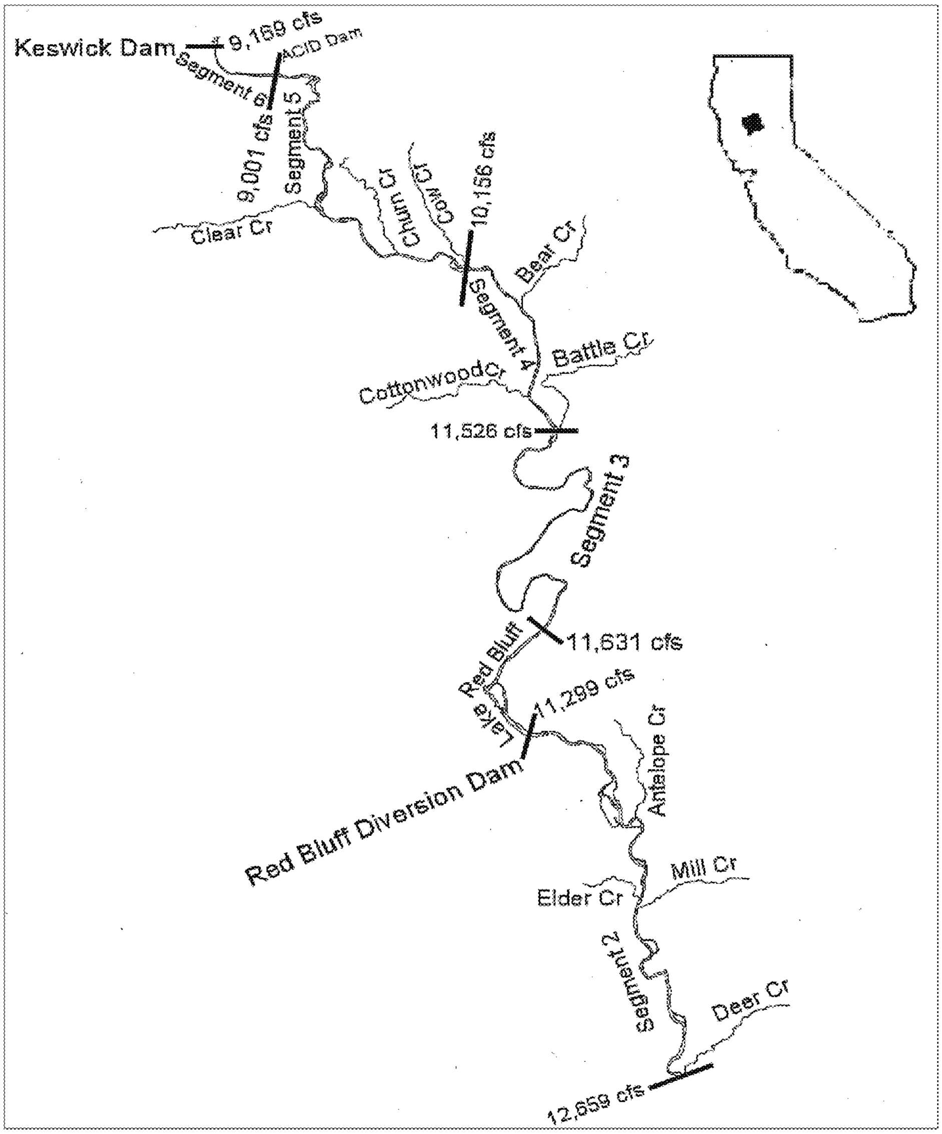

Figure 11B-1. Segments 2–6 of the Sacramento River Used in U.S. Fish and Wildlife Service Studies to Determine Spawning and Rearing Weighted Usable Area (WUA) (flows in the figure are the average flows at the upstream boundary of each segment for October 1974 to September 1993). Source: U.S. Fish and Wildlife Service 2003a.

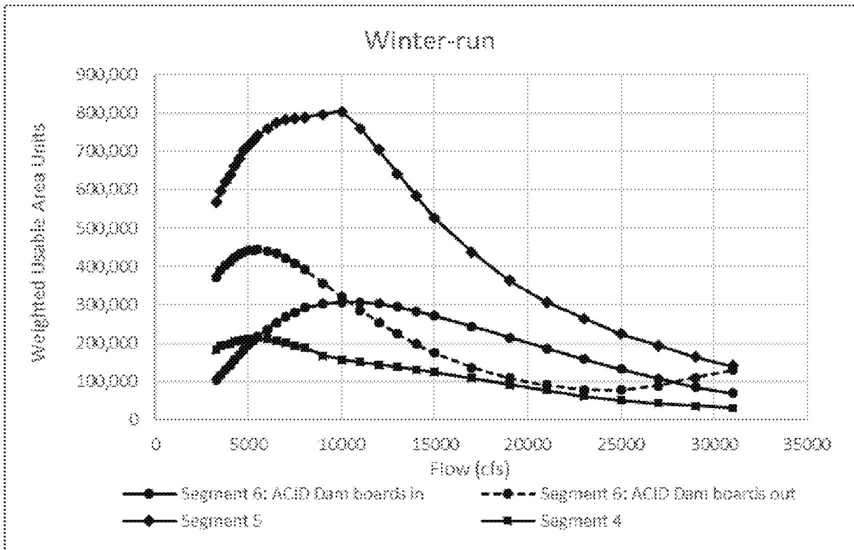

Figure 11B-2. Spawning WUA curves for Winter-Run Chinook Salmon in the Sacramento River, Segments 4 to 6. ACID = Anderson-Cottonwood Irrigation District.

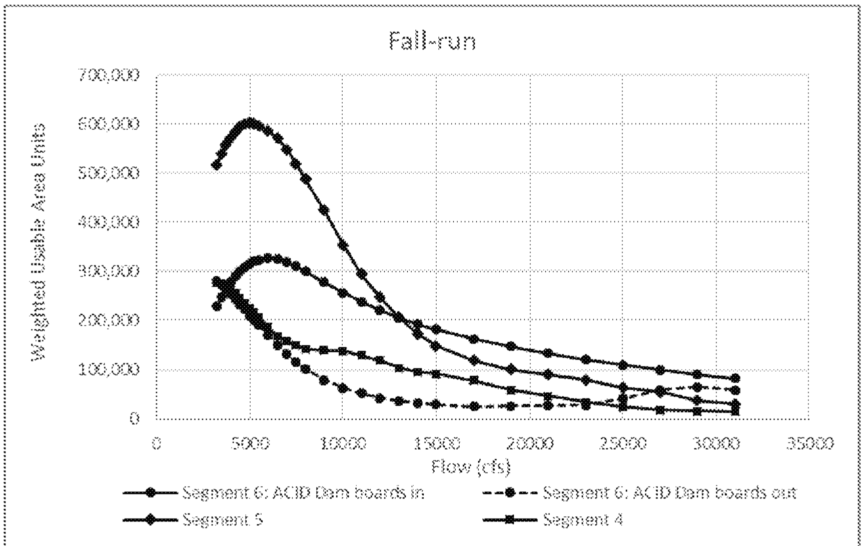

Figure 11B-3. Spawning WUA Curves for Fall-Run Chinook Salmon in the Sacramento River, Segments 4 to 6. The fall-run curves were also used to quantify spring-run Chinook salmon WUA, as discussed in the text. ACID = Anderson-Cottonwood Irrigation District.

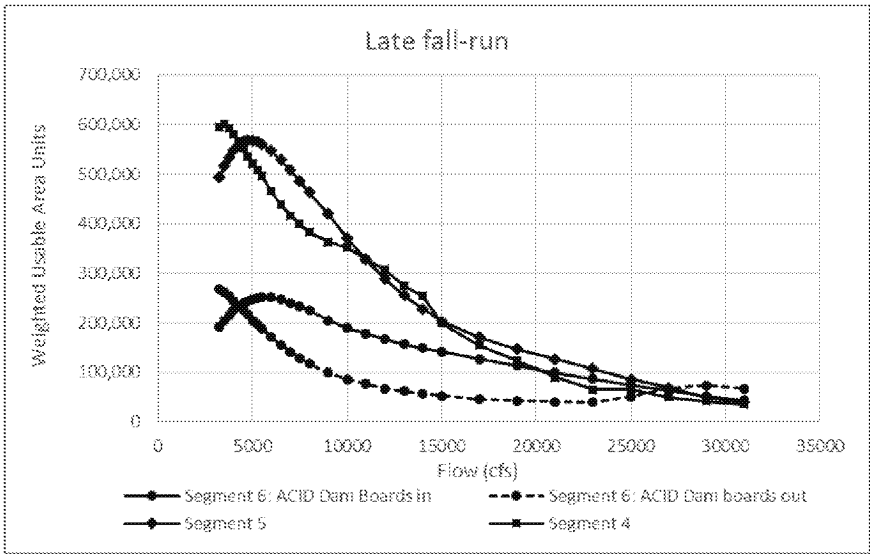

Figure 11B-4. Spawning WUA Curves for Late Fall–Run Chinook Salmon in the Sacramento River, Segments 4 to 6. ACID = Anderson-Cottonwood Irrigation District.

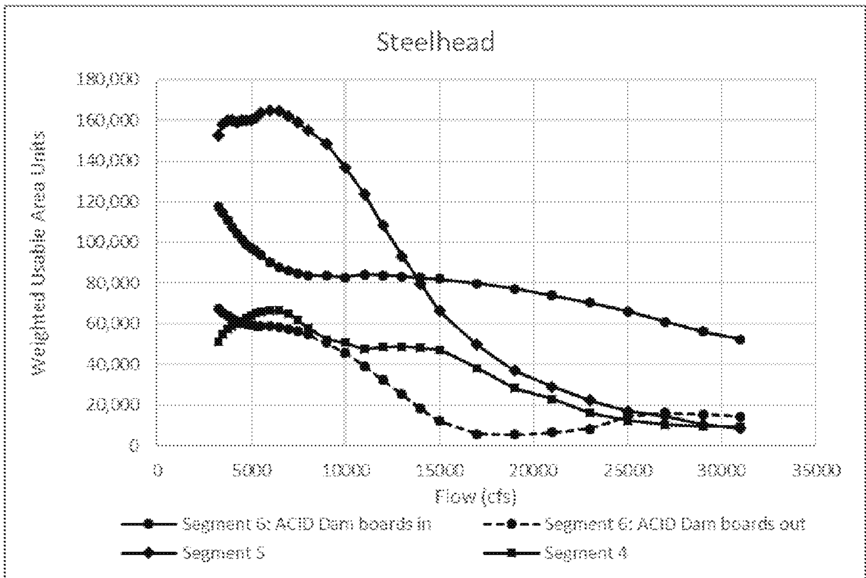

Figure 11B-5. Spawning WUA curves for Steelhead in the Sacramento River, Segments 4 to 6. ACID = Anderson-Cottonwood Irrigation District.

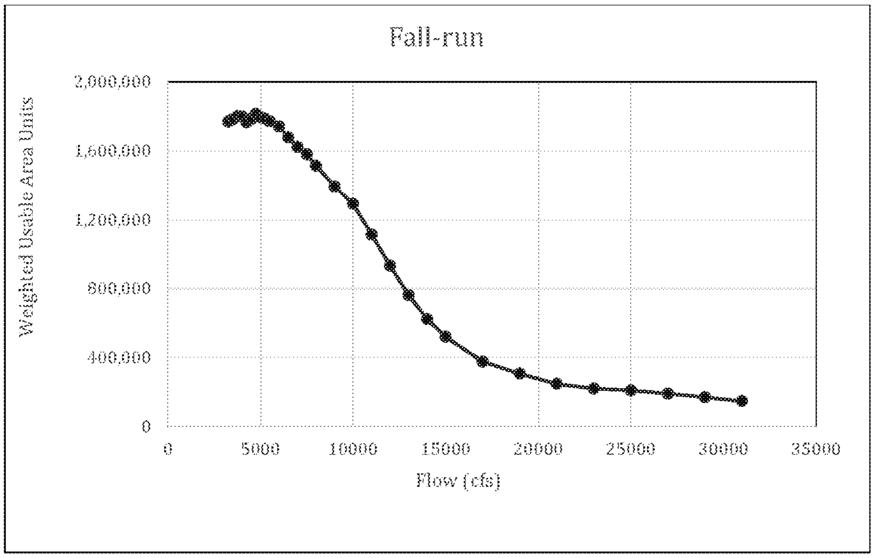

Figure 11B-6. Spawning WUA Curve for Fall–Run Chinook Salmon in the Sacramento River, Segment 3.

Because there are no spring-run Chinook salmon WUA curves in the U.S. Fish and Wildlife Service documentation, the previous practice (described below) has been to use fall-run Chinook salmon WUA curves to model spring-run habitat. Two models that currently produce spawning WUA outputs for spring-run Chinook salmon, SALMOD and SacEFT, derive the spring-run WUA results using the fall-run Chinook salmon spawning WUA curves as surrogates (Bartholow 2004; ESSA Technologies 2011). Mark Gard, who led the U.S. Fish and Wildlife Service studies that produced the Sacramento River WUA curves, has endorsed this practice (Gard pers. comm.). However, this practice introduces uncertainty to the spring-run Chinook salmon results. Although fall-run spawning WUA curves were used as surrogates for spring-run spawning, CALSIM II flows for the months of spring-run spawning, not those of fall-run spawning, were used to compute the spring-run WUA results.

A potential limitation of the Sacramento River spawning WUA curves for steelhead is the use of previously obtained American River steelhead HSC used in developing the curves (U.S. Fish and Wildlife Service 2003b). HSC data were not collected by U.S. Fish and Wildlife Service for steelhead in the Sacramento River because very few steelhead redds were observed and because the steelhead redds could not be distinguished from those of resident rainbow trout. The validity of this substitution could not be tested and is uncertain (U.S. Fish and Wildlife Service 2003a).

A further limitation of the WUA curves presented above, as of all such habitat-based studies, is that they assume the channel characteristics of the river during the time of field data collection by U.S. Fish and Wildlife Service (1995–1999), such as proportions of mesohabitat types, have remained in dynamic equilibrium to the present time and would continue to do so through the life of the Project. If the channel characteristics substantially change, the shape of the curve may no longer be applicable.

Differences in the mean spawning WUA under Alternatives 1–3 and NAA were examined for the months of the spawning period under each water year type and all water year types combined. Differences in mean spawning WUA of greater than 5% were flagged in the results tables to highlight results with the largest differences.

11B.2.3. Feather River

The relationships between instream flows and Chinook salmon and steelhead spawning habitat availability (WUA) in the Feather River developed by Payne and Allen (2004) were used in this effects analysis to determine effects of changing flows on Chinook salmon (spring-run and fall-run) and steelhead spawning WUA in the lower Feather River (Figure 11B-7 and Figure 11B-8). Although spring-run, fall-run and steelhead spawn in both the upper Feather River between the Fish Barrier Dam and Thermalito Afterbay Outlet and the lower Feather River downstream of the Thermalito Afterbay Outlet, Alternatives 1–3 would have no effect on flow in the upper river (Low Flow Channel), so differences in WUA between Alternatives 1–3 and the NAA were estimated only for the lower river (High Flow Channel).
Differences in the mean spawning WUA under Alternatives 1–3 and the NAA and were examined for the months of the spawning period for each species and race under each water year type and all water year types combined. Differences in mean spawning WUA of greater than 5% were flagged in the results tables to highlight the largest differences.

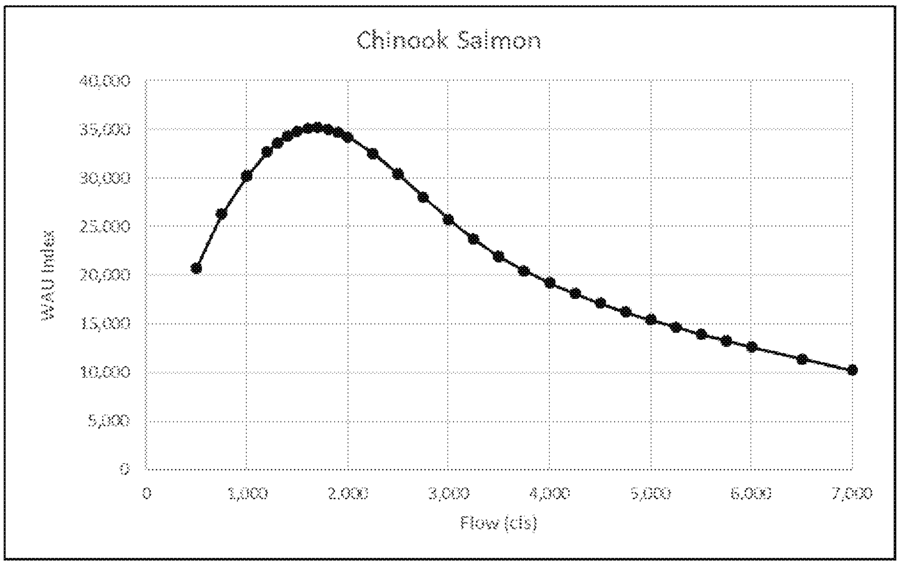

Figure 11B-7. Spawning WUA for Chinook Salmon (spring-run and fall-run) in the Feather River below Thermalito Afterbay Outlet.

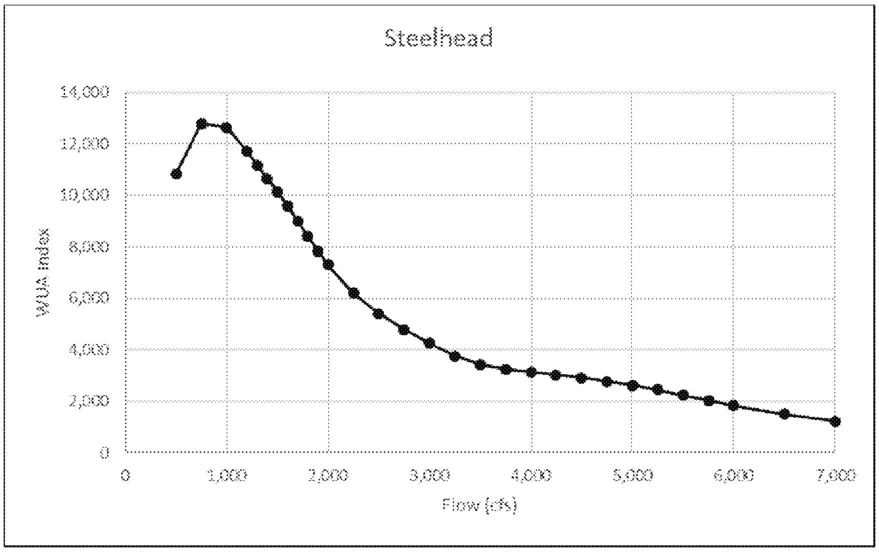

Figure 11B-8. Spawning WUA for California Central Valley Steelhead in the Feather River below Thermalito Afterbay Outlet.

11B.2.4. American River

The WUA curves used for fall-run Chinook salmon and steelhead spawning habitat in the American River were obtained from Bratovich et al. (2107), which provides spawning WUA curves for fall-run and steelhead in eight reaches of the American River. The eight reaches lie within the approximately 10-mile river reach from Nimbus Dam downstream to Riverbend Side Channel, where most salmon and steelhead spawning occurs. Figure 11B-9 and Figure 11B-10 show composite WUA curves for flow versus spawning that combine the WUA results for the eight reaches. For this effects analysis, CALSIM II flows at Nimbus Dam were used to compute fall-run and steelhead spawning WUA from the composite WUA curves and tables.

Differences in the mean spawning WUA under Alternatives 1–3 and the NAA were examined for the months of the spawning period under each water year type and all water year types combined. Differences in mean spawning WUA of greater than 5% were flagged in the results tables to highlight results with the largest differences.

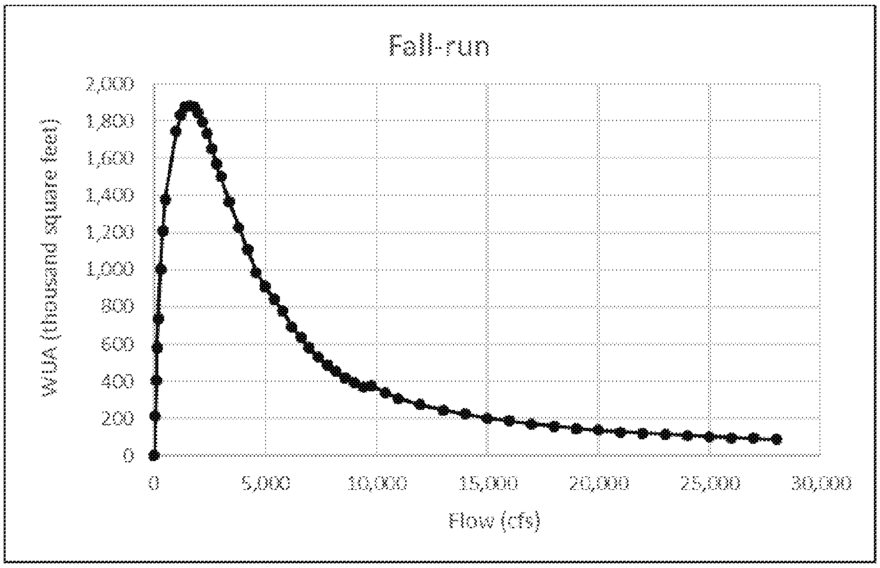

Figure 11B-9. Composite Spawning WUA for Fall-Run Chinook Salmon in the American River.

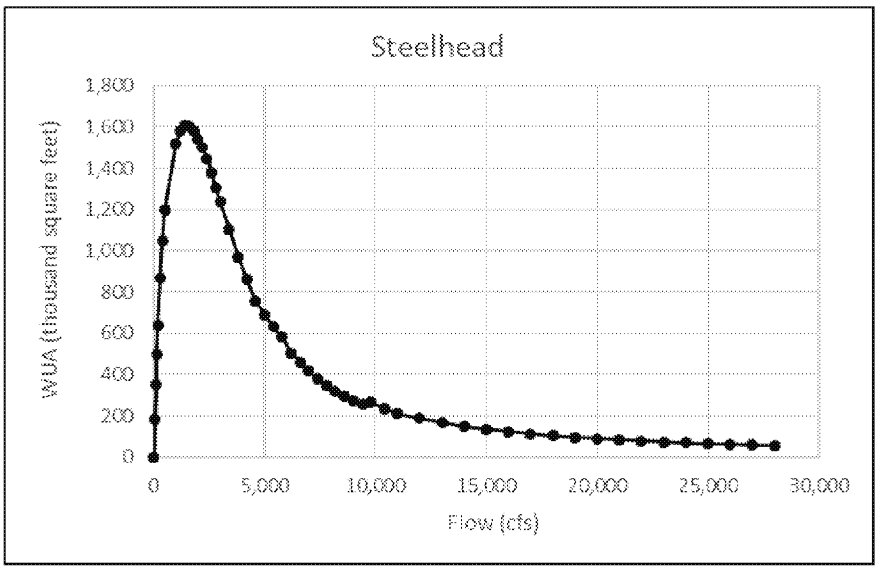

Figure 11B-10. Composite Spawning WUA for Steelhead in the American River.

11B.3 Redd Dewatering

Redd dewatering occurs when the water level drops below the depth of the redds or drops low enough to produce depth and flow velocity conditions that are inadequate to sustain incubating eggs or alevins in the redds. The redd dewatering analyses for the Sacramento, Feather, and American Rivers are based on the maximum reduction in flow from the initial flow, or *spawning flow*, that occurs over the duration of an egg cohort. The duration of a cohort in a redd includes egg incubation and alevin development to emergence from the gravel. Based on technical assistance from NMFS, cohort duration was estimated as 3 months for the four Chinook salmon races (fall-run, spring-run, winter-run, and late fall–run) and steelhead. The minimum flow of the egg cohort period is referred to herein as the *dewatering flow*. If flows during the 3 months subsequent to spawning are all greater than the spawning flow, no dewatering is assumed to occur. The analysis assumes that in Sacramento River, for which USRDOM daily time-step flow data are available, a new egg cohort begins each day of the spawning period. The spawning period is assumed to end 3 months prior to the end of the full spawning and incubation period. No daily time-step flow data were available for the Feather or American Rivers, so CALSIM II data, which has a monthly time-step, were used for redd dewatering analyses in these rivers. These analyses assume a new egg cohort begins each month of the spawning period. It should be noted that the use of monthly time-step flow estimates likely underestimates redd dewatering rates, but this potential bias is expected to affect all Project scenarios equally.

11B.3.1. Sacramento River

Flows from the spring-run spawning period and spawning distribution (Table 11B-11) were used to look up the percent of spring-run redds dewatered. The percentage of redds in the Sacramento River lost to dewatering was estimated using tables in U.S. Fish and Wildlife (USFWS) (2006) that relate spawning and dewatering flows to percent reductions in species-specific spawning habitat weighted usable area (WUA). See Table 11B-12 through Table 11B-19. USFWS (2006) developed the dewatering tables for winter-run, fall-run, late fall–run Chinook salmon and steelhead, but not for spring-run Chinook salmon. Therefore, as was done for the WUA curves, the fall-run salmon tables (Table 11B-14 and Table 11B-15) were used to estimate spring-run redd dewatering. The validity of substituting the fall-run tables for spring-run is discussed below in Section 11B.7.1, *Sacramento River*. Note that separate tables were developed for periods when the Anderson-Cottonwood Irrigation District (ACID) Dam boards are installed (April through October) and for when the boards are out because installation of the boards affects water levels for some of the sampling transects used to produce the tables.

The field studies used for USFWS (2006) were conducted in the Sacramento River between Keswick Dam and Battle Creek at the same locations as the spawning WUA studies discussed in Section 11B.2, *Spawning Habitat Weighted Usable Area*. USRDOM flow data are available for three locations in the Keswick Dam to Battle Creek river section: Keswick Dam (River Mile [RM] 302), the Sacramento River at Clear Creek (RM 289), and the Sacramento River at Battle Creek (RM 271). In contrast to the WUA studies, a single relationship for flows was developed for the entire river section, but the flows used to estimate redd dewatering in the current analysis were those that best matched the longitudinal distribution of the redds of the different salmon runs in the river as estimated from aerial redd surveys conducted by California Department of Fish and Wildlife from 2003 through 2019 (Table 11B-11). The redd distributions of steelhead in the Sacramento River is poorly known but is expected to be similar to that of spring-run. Therefore, Keswick Dam flows were used for winter-run and late fall–run, Sacramento River at Clear Creek flows were used for spring-run and steelhead, and Sacramento River at Battle Creek flows were used for fall-run. Redd dewatering was computed for these flows under Alternatives 1–3 and the No Action Alternative (NAA).

Table 11B-11. Average 2003–2019 Distributions of Spawning Redds of Chinook Salmon runs in the Sacramento River as Percent of Total, from Aerial Redd Surveys by California Department of Fish and Wildlife.

Description	River Miles	Winter-run	Spring-run	Fall-run	Late fall–run
Keswick to ACID[a]	302–298	44.6%	12.8%	19.5%	71.3%
ACID to Highway 44	298–296	38.8%	33.9%	6.6%	5.2%
Highway 44 to Airport Rd.	296–284	15.7%	29.7%	14.7%	3.9%
Airport Rd. to Balls Ferry Br.	284–275	0.6%	11.1%	19.4%	8.9%
Balls Ferry Br. To Battle Creek	275–271	0.2%	7.4%	12.5%	5.9%
Battle Creek to Jellys Ferry Br.	271–266	0.1%	1.5%	15.2%	3.1%
Jellys Ferry Br. to Bend Bridge	266–257	0.1%	2.6%	8.0%	1.2%
Bend Bridge to RBDD[b]	257–242	0.0%	0.8%	4.2%	0.6%

[a] ACID = Anderson-Cottonwood Irrigation District
[b] RBDD = Red Bluff Diversion Dam

Table 11B-12. Percent Redd Dewatered Look-up Table for Winter-Run Chinook Salmon with ACID Dam Boards Out (the percent of redds dewatered are looked up at the intersection of the "Spawning Flow" columns and "Dewatering Flow" rows)

		Spawning Flow																
		3,500	3,750	4,000	4,250	4,500	4,750	5,000	5,250	5,500	6,000	6,500	7,000	7,500	8,000	9,000	10,000	11,000
Dewatering Flow	3,250	0.8	1.5	2.2	3	3.9	4.9	5.8	7	8.2	11	13.8	16.7	19.7	22.6	28.8	34.8	39.4
	3,500		0.6	1	1.4	2	2.7	3.4	4.2	5.1	7.2	9.5	12.1	14.7	17.4	23.4	29.5	34.3
	3,750			0.2	0.5	0.8	1.2	1.6	2.1	2.8	4.3	6.1	8.3	10.6	13.1	18.9	25.1	30
	4,000				0.2	0.4	0.7	1	1.4	2	3.2	4.7	7.6	8.9	11.3	16.9	23.1	27.9
	4,250					0.1	0.3	0.5	0.8	1.2	2.2	3.4	5.9	7	9.1	14.3	20.3	25
	4,500						0.2	0.3	0.6	0.8	1.7	2.6	3.9	5.5	7.6	12.2	17.8	22.3
	4,750							0.1	0.3	0.5	1.2	1.9	2.9	4.3	5.8	10.2	15.5	19.8
	5,000								0.2	0.4	0.9	1.5	2.4	3.5	4.8	8.7	13.8	17.9
	5,250									0.2	0.6	1.1	1.8	2.7	3.8	7	11.8	15.7
	5,500										0.3	0.8	1.4	2.1	3	5.8	10.3	14.1
	6,000											0.2	0.6	1.1	1.7	3.7	7.7	10.9
	6,500												0.1	0.4	0.8	2.2	5.5	8.4
	7,000													0.2	0.4	1.2	3.5	5.6
	7,500														0.2	0.7	2.6	4.3
	8,000															0.3	1.9	3.2
	9,000																1.2	1.8
	10,000																	0.4
	11,000																	
	12,000																	
	13,000																	
	14,000																	
	15,000																	
	17,000																	
	19,000																	
	21,000																	
	23,000																	
	25,000																	
	27,000																	
	29,000																	

Table 11B-12 (cont.)

		Spawning Flow											
		12,000	13,000	14,000	15,000	17,000	19,000	21,000	23,000	25,000	27,000	29,000	31,000
Dewatering Flow	3,250	43.2	46.2	49.1	51.4	55	57.6	59.9	62.6	64.7	68.9	73.3	77.3
	3,500	38.3	41.5	44.6	47.1	51	53.6	56.1	58.8	61.1	65.4	70.2	74.5
	3,750	34.1	37.5	40.6	43.2	47.2	50	52.5	55.4	57.7	62.3	67.4	72
	4,000	32.1	35.5	38.6	41.2	45.4	48.2	50.7	53.6	56.1	60.8	66.1	70.8
	4,250	29.1	32.5	35.5	38.2	42.4	45.3	47.8	50.8	53.4	58.3	63.8	68.8
	4,500	26.3	29.6	32.6	35.3	39.6	42.5	45.1	48.2	51	56	61.7	66.9
	4,750	23.7	26.9	29.9	32.7	37	40	42.7	45.9	48.8	54	59.9	65.4
	5,000	21.6	24.7	27.7	30.4	34.8	37.9	40.6	43.8	44.1	52.3	58.4	64.1
	5,250	19.4	22.4	25.4	28.2	32.7	35.8	38.6	41.9	45.2	50.7	57	62.8
	5,500	17.6	20.6	23.5	26.2	30.7	33.9	36.8	40.1	43.5	49	55.5	61.5
	6,000	14	16.7	19.4	22	26.4	29.6	32.6	35.9	39.6	45.4	52.2	58.5
	6,500	11.2	13.6	16.2	18.8	23.1	26.2	29.3	32.7	36.5	42.6	49.7	56.4
	7,000	7.9	10.1	12.4	14.8	19	22.3	25.6	29.2	33.3	39.7	47.2	54.1
	7,500	6.3	8.1	10.2	12.4	16.3	19.7	23	26.7	31	37.6	45.3	52.5
	8,000	4.9	6.6	8.6	10.5	14.3	17.7	21.1	25	29.3	36.1	44.1	51.4
	9,000	3	4.4	6	7.8	11.4	14.7	18.3	22.1	26.6	33.6	41.9	49.5
	10,000	1.3	2.3	3.7	5.3	8.6	11.8	15.4	19.3	23.8	30.6	39.7	47.5
	11,000	0.6	1.2	2.2	3.5	6.4	9.5	13.2	17.1	21.7	28.5	37.6	45.6
	12,000		0.2	0.9	1.8	4.1	7	10.5	14.7	19.3	26.3	35.7	43.8
	13,000			0.4	1	2.8	5.3	8.7	13	17.5	24.5	34	42.3
	14,000				0.4	1.6	4.2	7.5	11.8	16.2	23	32.6	41
	15,000					0.9	2.8	5.9	10.6	14.9	21.8	31.5	40.1
	17,000						1.3	3.9	7.8	11.8	18.3	28.1	36.9
	19,000							1.4	4	7.1	13	22.5	31.7
	21,000								1.3	3.6	9.2	18.7	28
	23,000									1.4	6.2	15.4	24.6
	25,000										0	8.3	15.2
	27,000											1.6	3.6
	29,000												0.6

Table 11B-13. Percent Redd Dewatered Look-up Table for Winter-Run Chinook Salmon with ACID Dam Boards In (the percent of redds dewatered are looked up at the intersection of the "Spawning Flow" columns and "Dewatering Flow" rows)

		Spawning Flow																
		3,500	3,750	4,000	4,250	4,500	4,750	5,000	5,250	5,500	6,000	6,500	7,000	7,500	8,000	9,000	10,000	11,000
Dewatering Flow	3,250	1.2	2.2	3.1	4.1	5.2	6.4	7.5	8.8	10.2	13	16	18.9	21.9	24.7	30.5	35.9	40.1
	3,500		0.9	1.4	2	2.7	3.6	4.4	5.3	6.3	8.5	11	13.6	16.2	18.9	24.7	30.4	34.8
	3,750			0.4	0.8	0.2	1.7	2.2	2.8	3.5	5.1	7	9.3	11.7	14.2	19.9	25.9	30.5
	4,000				0.4	0.7	1.1	1.4	1.9	2.5	3.8	5.4	7.5	9.8	12.2	17.7	23.7	28.3
	4,250					0.3	0.5	0.8	1.1	1.5	2.6	3.9	5.6	7.6	9.7	15	20.7	25.2
	4,500						0.3	0.5	0.8	1.1	1.9	2.9	4.3	5.9	7.9	12.6	18.1	22.4
	4,750							0.2	0.4	0.7	1.3	2.1	3.1	4.5	6.1	10.5	15.7	20
	5,000								0.3	0.5	1	1.6	2.5	3.7	5	9	14	18.1
	5,250									0.3	0.7	1.2	1.9	2.9	3.9	7.3	11.9	15.9
	5,500										0.4	0.9	1.5	2.3	3.2	6.1	10.5	14.3
	6,000											0.3	0.7	1.3	1.9	4	8	11.3
	6,500												0.2	0.5	1	2.4	5.8	8.8
	7,000													0.3	0.5	1.4	3.8	6.1
	7,500														0.3	0.9	2.9	4.8
	8,000															0.4	2.1	3.7
	9,000																1.3	2.4
	10,000																	0.9
	11,000																	
	12,000																	
	13,000																	
	14,000																	
	15,000																	
	17,000																	
	19,000																	
	21,000																	
	23,000																	
	25,000																	
	27,000																	
	29,000																	

Table 11B-13 (cont.)

		Spawning Flow											
		12,000	13,000	14,000	15,000	17,000	19,000	21,000	23,000	25,000	27,000	29,000	31,000
Dewatering Flow	3,250	43.4	46	48.4	50.3	53.5	56	58.9	62.4	65.4	69.5	73.7	77.2
	3,500	38.5	41.1	43.9	46.1	49.6	52.3	55.3	58.8	61.9	65.9	69.9	73.5
	3,750	34.4	37.3	40	42.4	46.1	49	52.1	55.7	58.8	62.8	66.7	70.2
	4,000	32.2	35.3	38	40.4	44.2	47.2	50.3	53.9	57	61.1	65	68.5
	4,250	29.2	32.2	34.9	37.4	41.4	44.4	47.5	51.2	54.4	58.5	62.3	65.7
	4,500	26.3	29.3	32	34.6	38.6	41.7	45	48.7	52	56	59.8	63.2
	4,750	23.7	26.7	29.5	32.1	36.3	39.5	42.8	46.6	49.9	53.9	57.6	61.1
	5,000	21.7	24.6	27.4	29.9	34.2	37.4	40.8	44.6	48	51.9	55.7	59.1
	5,250	19.5	22.5	25.2	27.9	32.2	35.6	39	42.8	46.4	50.3	54.1	57.5
	5,500	17.9	20.7	23.5	26.1	30.5	33.9	37.4	41.2	44.8	48.7	52.4	55.8
	6,000	14.5	17.1	19.8	22.3	26.8	30.2	33.7	37.5	41.3	45.1	48.8	52.2
	6,500	11.8	14.3	16.8	19.3	23.7	27.2	30.7	34.7	38.4	42.3	45.9	49.3
	7,000	8.7	10.9	13.3	15.7	20.1	23.7	27.5	31.5	35.4	39.4	42.9	46.2
	7,500	7	9	11.2	13.5	17.7	21.4	25.2	29.3	33.2	37.2	40.7	44
	8,000	5.7	7.6	9.7	11.8	15.9	19.6	23.5	27.7	31.6	35.7	39.1	42.4
	9,000	4	5.6	7.4	9.4	13.3	16.9	20.8	24.9	28.7	32.8	36.3	39.6
	10,000	2.2	3.6	5.2	7	10.5	14	17.7	18.6	25.4	28.9	32.6	35.8
	11,000	1.1	2	3.1	4.6	7.6	10.5	13.8	17.4	20.6	23.5	26.7	29.4
	12,000		0.5	1.2	2.2	4.2	6.4	9.1	12.1	14.6	16.8	19.1	21.1
	13,000			0.5	1.1	2.6	4.4	6.7	9.2	11.7	13.5	15.3	17
	14,000				0.5	1.7	3.5	5.5	8.2	10.1	11.7	13.4	14.9
	15,000					0.7	2.1	3.9	6.8	8.6	10.1	11.6	13
	17,000						0.9	2.5	4.9	6.5	7.7	9.1	10.4
	19,000							1	2.5	3.6	4.4	5.5	6.6
	21,000								0.9	1.6	2.1	3	4
	23,000									0.4	0.6	1.1	1.9
	25,000										0.3	0.9	1.6
	27,000											0.3	0.7
	29,000												0.3

Table 11B-14. Percent Redd Dewatered Look-up Table for Fall-Run Chinook Salmon (Also Used for the Spring-Run Chinook Salmon Analysis) with ACID Dam Boards Out (the percent of redds dewatered are looked up at the intersection of the "Spawning Flow" columns and "Dewatering Flow" rows)

	Spawning Flow																
Dewatering Flow	3,500	3,750	4,000	4,250	4,500	4,750	5,000	5,250	5,500	6,000	6,500	7,000	7,500	8,000	9,000	10,000	11,000
3,250	1	2	3.4	4.8	6.6	8.4	10.6	12.9	15.3	20.6	26.2	31.7	37	41.5	50.2	56.3	60.4
3,500		1	2.1	3.2	4.6	6.2	8.1	10.1	12.2	17	22.2	27.4	29.2	37	45.9	52.8	57.3
3,750			0.9	1.6	2.6	3.9	5.5	7.3	9.2	13.6	18.4	23.1	28	32.4	41.5	48.7	53.6
4,000				0.9	1.7	2.8	4.1	5.7	7.3	11.4	15.8	20.3	24.8	29	38	45.7	50.7
4,250					0.8	1.6	2.7	4	5.4	8.9	13	17.2	21.6	25.8	34.9	42.8	48
4,500						0.8	1.7	2.8	4	6.9	10.4	14.2	18.2	22.1	30.9	38.8	44.2
4,750							0.8	1.6	2.5	4.8	7.6	10.8	14.2	17.6	25.8	33.2	38.8
5,000								0.7	1.3	3.2	5.6	8.6	11.6	14.7	22.6	30.2	36
5,250									0.7	2.1	4.2	6.8	9.4	12.3	19.8	27.2	33.1
5,500										1.4	3.2	5.4	7.7	10.3	17.6	24.9	31
6,000											1.2	2.8	4.6	6.4	12.9	19.7	25.8
6,500												1.3	2.6	4.2	9.8	15.6	21.1
7,000													0.9	2	6.6	11.8	17.3
7,500														0.8	4.4	9.1	14.1
8,000															2.6	6.6	11.5
9,000																2.2	5.5
10,000																	0.9
11,000																	
12,000																	
13,000																	
14,000																	
15,000																	
17,000																	
19,000																	
21,000																	
23,000																	
25,000																	
27,000																	
29,000																	

Table 11B-14 (cont.)

	Spawning Flow											
Dewatering Flow	12,000	13,000	14,000	15,000	17,000	19,000	21,000	23,000	25,000	27,000	29,000	31,000
3,250	62.9	63.7	65.3	66.4	66.8	65.7	67.8	71.3	74.5	80.4	87.3	92
3,500	60.1	61.1	63	64.2	64.9	63.8	66	69.5	73	79.1	86.2	91
3,750	56.9	58.3	60.3	61.8	62.7	61.7	64	67.7	71.4	77.7	84.9	89.6
4,000	54.3	55.9	58.2	59.9	61.2	60.2	62.7	66.5	70.4	77.1	84.1	88.8
4,250	51.8	53.6	56	58.1	59.6	58.8	61.3	65	68.5	75.7	83.1	87.8
4,500	48.3	50.2	52.8	55.1	57.1	56.4	59	62.7	66.2	73.3	81.8	86.5
4,750	43.3	45.6	48.6	51.4	54	53.7	56.6	60.4	64.5	71.7	80.3	85
5,000	40.6	43	46.1	49.1	52.2	52.2	55.2	59.1	63.3	70.6	79.4	84.1
5,250	37.7	40.2	43.5	46.5	50	50.2	53.5	57.4	60.7	68	78.2	83
5,500	35.8	38.4	41.7	44.8	48.3	48.8	52.3	56.1	60.1	67.5	77.3	82
6,000	30.9	33.8	37.3	40.6	45	45.8	49.5	53.2	57.2	65	75.4	80
6,500	26.5	29.2	32.7	36.1	41	42.4	46.5	50.4	54.8	63	73.3	77.7
7,000	22.8	25.8	29.3	32.9	38.3	40	44.4	48.3	52.9	61.3	71.8	76.1
7,500	20	23.2	26.9	30.7	36.4	38.2	42.8	46.8	51.9	60.5	70.9	75.3
8,000	17.2	20.9	24.9	28.9	34.9	36.6	41.3	45.4	50.5	59.3	70.2	74.7
9,000	10.6	14.4	18.4	22.5	29.2	31.9	37.4	41.8	47.7	57	68.2	72.6
10,000	4.5	7.7	12	16.4	23.5	26.9	33	38.5	44.5	54.1	65.9	70.5
11,000	2.7	5.3	9	13.6	21.4	24.8	30.2	35.3	41.8	51.6	63.7	68.4
12,000		1.6	4.7	9	16.8	20.6	27	32.9	39.8	50	62.3	67.2
13,000			1.6	4.8	12.2	16.9	24.4	31.3	38.1	48.4	60.8	65.9
14,000				2.6	9.5	14.8	22.1	28.9	36.2	46.8	59.5	64.7
15,000					5.3	11.1	18.5	26.2	33.5	44.6	57.6	63.1
17,000						4.1	11.3	18.5	26.1	37.8	51.5	57.9
19,000							4.6	10.8	18.8	30.4	44.2	51.1
21,000								4.2	11.7	23.9	38.4	46.3
23,000									6.7	17.8	31.2	38.9
25,000										2.3	6.4	10.7
27,000											1.8	5.3
29,000												2.2

Table 11B-15. Percent Redd Dewatered Look-up Table for Fall-Run Chinook Salmon (Also Used for the Spring-Run Chinook Salmon Analysis) with ACID Dam Boards In (the percent of redds dewatered are looked up at the intersection of the "Spawning Flow" columns and "Dewatering Flow" rows)

	Spawning Flow																
Dewatering Flow	3,500	3,750	4,000	4,250	4,500	4,750	5,000	5,250	5,500	6,000	6,500	7,000	7,500	8,000	9,000	10,000	11,000
3,250	1.0	2.0	3.3	4.7	6.2	7.8	9.7	11.7	13.6	17.8	22.2	26.3	30.2	33.4	39.5	43.5	46.0
3,500		1.0	2.0	3.1	4.4	5.7	7.4	9.2	10.9	14.8	18.8	22.8	23.9	29.8	36.2	40.8	43.6
3,750			0.9	1.6	2.5	3.6	5.1	6.7	8.3	11.9	15.6	19.3	23.0	26.2	32.8	37.7	40.9
4,000				0.9	1.7	2.6	3.8	5.3	6.6	10.0	13.5	16.9	20.4	23.5	30.1	35.4	38.7
4,250					0.8	1.5	2.5	3.7	5.0	7.8	11.1	14.4	17.8	20.9	27.5	33.1	36.6
4,500						0.8	1.6	2.6	3.7	6.0	8.9	11.9	15.0	17.8	24.4	29.9	33.6
4,750							0.8	1.6	2.4	4.3	6.6	9.1	11.8	14.3	20.3	25.7	29.5
5,000								0.7	1.3	2.9	4.9	7.2	9.6	11.9	17.7	23.1	26.9
5,250									0.6	1.9	3.5	5.6	7.7	9.7	15.3	20.4	24.1
5,500										1.2	2.7	4.4	6.2	8.1	13.5	18.5	22.3
6,000											1.0	2.3	3.7	5.1	9.8	14.5	18.3
6,500												1.1	2.1	3.3	7.4	11.5	15.0
7,000													0.7	1.6	5.0	8.6	12.1
7,500														0.6	3.4	6.7	9.9
8,000															2.0	4.9	8.1
9,000																1.6	3.8
10,000																	1.2
11,000																	
12,000																	
13,000																	
14,000																	
15,000																	
17,000																	
19,000																	
21,000																	
23,000																	
25,000																	
27,000																	
29,000																	

Table 11B-15 (cont.)

		Spawning Flow											
		12,000	13,000	14,000	15,000	17,000	19,000	21,000	23,000	25,000	27,000	29,000	31,000
Dewatering Flow	3,250	47.6	48.0	49.3	50.5	52.0	52.5	55.1	57.6	57.4	59.0	61.1	63.3
	3,500	45.5	46.0	47.4	48.8	50.4	50.8	53.4	55.9	55.7	57.2	59.3	61.6
	3,750	43.1	43.9	45.5	47.0	48.7	49.1	51.8	54.3	54.1	55.6	57.6	59.8
	4,000	41.2	42.2	43.8	45.5	47.5	47.9	50.5	53.1	52.9	54.5	56.3	58.5
	4,250	39.2	4.0	42.1	43.9	46.0	46.4	49.0	51.3	50.8	52.5	54.4	56.5
	4,500	36.4	37.6	39.4	41.4	43.6	43.9	46.4	48.7	47.8	49.1	51.6	53.7
	4,750	32.6	34.0	36.1	38.3	40.8	41.1	43.6	45.7	44.9	46.0	48.3	50.3
	5,000	30.0	31.2	33.2	35.3	37.6	37.6	39.8	41.7	40.5	41.3	43.2	45.1
	5,250	27.1	28.2	29.9	31.8	33.9	33.5	35.4	36.8	34.6	35.0	37.4	39.0
	5,500	25.3	26.4	28.0	29.7	31.5	31.0	32.7	33.8	31.7	31.9	33.6	35.1
	6,000	21.5	22.7	24.4	26.2	28.2	27.5	29.0	29.8	27.1	27.1	28.7	29.8
	6,500	18.3	19.5	21.1	23.0	25.2	24.7	26.4	27.1	24.4	24.2	25.3	26.3
	7,000	15.6	17.0	18.7	20.7	23.2	22.8	24.5	25.1	22.4	22.1	23.2	24.0
	7,500	13.7	15.3	17.1	19.3	21.9	21.5	23.3	23.9	21.3	21.0	21.9	22.7
	8,000	11.8	13.7	15.7	17.9	20.7	20.2	21.9	22.4	19.8	19.4	20.5	21.4
	9,000	7.2	9.2	11.3	13.6	16.8	16.8	18.9	19.6	17.2	16.8	17.9	18.5
	10,000	3.0	4.9	7.2	9.8	13.3	13.8	16.2	17.4	14.9	14.5	15.9	16.7
	11,000	1.9	3.4	5.4	8.2	12.1	12.2	14.5	15.6	13.3	12.8	14.1	15.0
	12,000		1.0	2.8	5.4	9.4	10.0	12.5	14.0	11.9	11.5	12.9	13.9
	13,000			1.0	3.0	6.9	8.1	11.1	13.1	11.0	10.7	12.1	13.1
	14,000				1.8	5.4	7.0	9.8	11.8	10.0	9.9	11.4	12.4
	15,000					2.8	4.8	7.7	10.2	8.6	8.7	10.4	11.5
	17,000						1.8	5.0	7.5	6.5	6.8	8.5	10.0
	19,000							2.3	4.8	4.6	5.0	6.9	8.4
	21,000								1.9	2.0	2.6	4.7	6.6
	23,000									0.7	1.6	3.6	5.7
	25,000										1.2	3.0	5.0
	27,000											1.2	3.3
	29,000												1.5

Table 11B-16. Percent Redd Dewatered Look-up Table for Late Fall–Run Chinook Salmon with ACID Dam Boards Out (the percent of redds dewatered are looked up at the intersection of the "Spawning Flow" columns and "Dewatering Flow" rows)

		Spawning Flow																
		3,500	3,750	4,000	4,250	4,500	4,750	5,000	5,250	5,500	6,000	6,500	7,000	7,500	8,000	9,000	10,000	11,000
Dewatering Flow	3,250	0.9	1.5	2.6	3.6	4.9	6.3	8	9.8	11.7	15.9	20.1	24.1	28	31.5	37.8	42.7	45.6
	3,500		0.9	1.6	2.4	3.4	4.5	6	7.6	9.3	13.1	17.1	21	24.9	28.2	35	40.2	43.3
	3,750			0.8	1.1	2	2.9	4.1	5.5	7	10.5	14.2	17.8	21.6	25	32	37.5	40.7
	4,000				0.7	1.2	2	3	4.2	5.5	8.8	12.1	15.6	19.2	22.5	29.5	35.3	38.7
	4,250					0.6	1.1	1.9	3	4.1	6.9	10	13.4	16.9	20.1	27.3	33.3	36.8
	4,500						0.6	1.2	2.1	3.1	5.5	8.3	11.3	14.6	17.7	24.8	30.8	34.5
	4,750							0.6	1.3	2	4	6.3	9	11.8	14.7	21.5	27.6	31.5
	5,000								0.5	1	2.6	4.6	7	9.6	12.2	18.9	25.2	29.3
	5,250									0.5	1.8	3.5	5.6	7.9	10.4	16.9	23.1	27.4
	5,500										1.3	2.7	4.6	6.7	8.9	15.3	21.5	25.8
	6,000											0.9	2.3	3.8	5.5	11.2	17.1	21.7
	6,500												1	2.1	3.5	8.3	13.4	17.6
	7,000													0.8	1.8	5.9	10.4	14.4
	7,500														0.7	3.9	7.9	11.5
	8,000															2.2	5.5	8.9
	9,000																1.7	3.9
	10,000																	1.2
	11,000																	
	12,000																	
	13,000																	
	14,000																	
	15,000																	
	17,000																	
	19,000																	
	21,000																	
	23,000																	
	25,000																	
	27,000																	
	29,000																	

Table 11B-16 (cont.)

		Spawning Flow											
		12,000	13,000	14,000	15,000	17,000	19,000	21,000	23,000	25,000	27,000	29,000	31,000
Dewatering Flow	3,250	47.8	48.9	50.6	52.6	55.5	57.5	61.6	67.3	73.5	79.8	86.6	91.1
	3,500	45.6	46.8	48.6	50.7	53.6	55.5	59.6	65.4	71.5	78.3	85.4	90.1
	3,750	43.3	44.6	46.5	48.6	51.5	53.3	57.4	63.3	69.6	76.6	83.9	88.5
	4,000	41.5	42.8	44.8	46.9	49.9	51.8	55.9	61.8	68.3	75.6	82.9	87.6
	4,250	39.7	41.1	43.1	45.3	48.4	50.2	54.3	60.2	66.6	74.2	81.7	86.5
	4,500	37.5	38.9	41	43.3	46.5	48.3	52.4	58.1	64.5	72.2	80.2	85
	4,750	34.6	36.6	38.5	40.9	44.2	46	50.1	55.3	62.4	70.2	78.4	83.3
	5,000	32.6	34.3	36.7	39.1	42.6	44.5	48.6	54.2	60.8	68.9	77.3	82.3
	5,250	30.8	32.5	34.9	37.5	41.1	42.9	47	52.6	58.9	67	76	81.1
	5,500	29.4	31.2	33.2	36.1	39.7	41.6	45.7	51.2	57.7	65.9	74.9	80
	6,000	25.5	27.5	29.9	32.6	36.4	38.3	42.3	47.7	54.1	62.7	72.1	77.3
	6,500	21.7	23.8	26.4	29.1	33.1	35.1	39.2	44.5	50.9	59.7	69.1	74
	7,000	18.6	20.7	23.2	26.1	30.3	32.4	36.4	41.6	48	57	66.6	71.6
	7,500	16	18.4	21.1	24	28.3	30.4	34.5	39.6	46.3	55.4	65.2	70.3
	8,000	13.3	16	18.9	21.9	26.3	28.3	32.5	37.6	44.3	53.7	63.7	69
	9,000	7.8	10.5	13.6	16.7	21.5	23.7	28.1	33.2	40.2	50	60.5	65.9
	10,000	3.1	5.6	8.8	12.1	17	19.6	24	29.8	36.7	46.7	57.4	62.9
	11,000	2.3	4.1	6.7	10	15.2	17.4	21.8	26.9	34	44.2	55.1	60.7
	12,000		1.2	3.4	6.5	11.7	14.2	18.7	24.5	31.8	42.2	53.3	58.9
	13,000			1.1	3.4	8.3	11.3	16.2	22.7	29.9	40.3	51.5	57.2
	14,000				1.9	6.4	9.8	14.6	21.1	28.3	38.8	50.1	55.9
	15,000					3.3	6.7	11.7	18.8	26	36.7	48.2	54.1
	17,000						3.5	7	13.1	20.3	31.1	42.9	49.1
	19,000							2.5	7.1	14.4	25.2	36.9	43.2
	21,000								3.1	9.3	20	32.1	39.1
	23,000									5.1	14.5	25.7	32.6
	25,000										1.8	5.2	9.4
	27,000											1.4	4.4
	29,000												1.6

Table 11B-17. Percent Redd Dewatered Look-up Table for Late Fall–Run Chinook Salmon with ACID Dam Boards In (the percent of redds dewatered are looked up at the intersection of the "Spawning Flow" columns and "Dewatering Flow" rows)

	Spawning Flow																
Dewatering Flow	3,500	3,750	4,000	4,250	4,500	4,750	5,000	5,250	5,500	6,000	6,500	7,000	7,500	8,000	9,000	10,000	11,000
3,250	0.9	1.7	2.6	3.7	4.9	6.2	7.8	9.5	11.3	15.1	18.9	22.5	26	29.1	34.9	39.4	42.3
3,500		0.9	1.6	2.4	3.4	4.5	5.9	7.4	9	12.5	16.1	19.6	23.1	26.1	32.3	37.1	40.1
3,750			0.8	1.1	2	2.9	4.1	5.5	6.9	10.1	13.4	16.7	20.1	23.1	29.5	34.6	37.8
4,000				0.7	1.3	2	3	4.2	5.4	8.4	11.5	14.7	17.9	20.9	27.3	32.7	36
4,250					0.7	1.2	2	3	4.1	6.7	9.6	12.6	15.8	18.7	25.2	30.8	34.2
4,500						0.6	1.3	2.1	3.1	5.3	7.9	10.7	13.6	16.4	22.9	28.4	32
4,750							0.6	1.3	2.1	3.9	6	8.5	11.1	13.7	19.9	25.4	29.1
5,000								0.6	1.1	2.6	4.4	6.6	8.9	11.3	17.4	22.9	26.7
5,250									0.5	1.7	3.3	5.2	7.3	9.5	15.3	20.7	24.4
5,500										1.2	2.5	4.3	6.1	8.1	13.7	19.1	22.8
6,000											0.9	2.1	3.4	5	10	15.1	19
6,500												0.9	1.9	3.1	7.4	11.8	15.4
7,000													0.8	1.6	5.2	9.1	12.5
7,500														0.7	3.5	6.9	9.9
8,000															2	4.9	7.7
9,000																1.5	3.3
10,000																	1
11,000																	
12,000																	
13,000																	
14,000																	
15,000																	
17,000																	
19,000																	
21,000																	
23,000																	
25,000																	
27,000																	
29,000																	

Table 11B-17 (cont.)

		Spawning Flow											
		12,000	13,000	14,000	15,000	17,000	19,000	21,000	23,000	25,000	27,000	29,000	31,000
Dewatering Flow	3,250	44.6	46	47.9	50.1	53.4	55.4	59.2	63.7	66.8	69.7	74.4	79.1
	3,500	42.6	44	46	48.2	51.5	53.5	57.2	61.8	64.6	67.8	72.6	77.3
	3,750	40.5	42	44	46.3	49.6	51.5	55.1	59.7	62.6	65.6	70.4	75.1
	4,000	38.8	40.4	42.4	44.8	48.1	50	53.6	58.3	61.1	64.3	68.9	73.5
	4,250	37.1	38.7	40.8	43.2	46.5	48.3	51.9	56.4	59	62.2	66.9	71.5
	4,500	34.9	36.5	38.6	41.1	44.4	46.1	49.6	53.9	56.3	59.2	64.1	68.7
	4,750	32.2	33.8	36	38.5	41.9	43.5	46.8	50.6	53.2	55.9	60.6	65.1
	5,000	29.8	31.4	33.5	35.9	39.1	40.5	43.6	47.5	49.3	51.9	56.3	60.6
	5,250	27.5	28.9	30.9	33.2	36.3	37.3	40.2	43.6	44.8	46.9	51.4	55.5
	5,500	25.9	27.3	28.9	31.4	34.2	35.1	37.8	41	42.1	43.9	48	51.9
	6,000	22.2	23.7	25.6	27.7	30.6	31.3	33.7	36.4	37	38.6	42.4	45.9
	6,500	18.8	20.3	22.3	24.5	27.4	28.1	30.5	33	33.3	34.5	37.8	40.8
	7,000	16	17.6	19.6	21.8	24.9	25.5	27.8	30.2	30.2	31.1	34.3	37.1
	7,500	13.7	15.5	17.6	20	23.1	23.8	26	28.3	28.4	29.2	32.2	35.2
	8,000	11.4	13.5	15.7	18.1	21.3	21.8	24.1	26.3	26.2	27	30.1	33.1
	9,000	6.6	8.7	11.1	13.6	17	17.7	20.1	22.2	22.1	22.8	25.8	28.7
	10,000	2.7	4.6	7	9.8	13.3	14.3	16.7	19.3	19	19.4	22.3	25.1
	11,000	2	3.4	5.4	8.1	12	12.6	16.6	17	16.7	17	19.9	22.6
	12,000		0.9	2.7	5.3	9.1	10	12.3	15	14.7	14.9	17.7	20.5
	13,000			0.9	2.8	6.5	7.8	10.4	13.7	13.3	13.6	16.3	19
	14,000				1.7	5.1	6.7	9.2	12.4	12.1	12.4	15	17.7
	15,000					2.5	4.2	6.9	10.6	10.3	10.8	13.3	16
	17,000						2.4	4.3	7.5	7.7	8.2	10.6	13.2
	19,000							1.7	4.2	5.1	5.8	8.1	10.5
	21,000								2	2.7	3.5	5.8	8.4
	23,000									1.1	2.1	4.3	7.4
	25,000										1.3	3.4	6.4
	27,000											1.3	4
	29,000												1.5

Table 11B-18. Percent Redd Dewatered Look-up Table for CCV Steelhead with ACID Dam Boards Out (the percent of redds dewatered are looked up at the intersection of the "Spawning Flow" columns and "Dewatering Flow" rows)

		Spawning Flow																
		3,500	3,750	4,000	4,250	4,500	4,750	5,000	5,250	5,500	6,000	6,500	7,000	7,500	8,000	9,000	10,000	11,000
Dewatering Flow	3,250	1.2	2.6	3.7	4.9	6.8	8.9	10.9	13.3	15.7	19.9	23.4	26.2	28.5	31.1	37.2	43.5	49.8
	3,500		1.6	2.4	3.2	4.7	6.4	8	10.2	12.4	16.5	19.9	22.8	25.1	27.7	33.8	40.1	46.2
	3,750			0.5	1.2	2.5	3.8	5.3	7.3	9.1	12.7	15.9	18.9	21.1	23.9	30.3	36.5	42.4
	4,000				0.8	1.9	2.9	4	5.7	7.3	10.5	13.4	16	18.2	20.8	27.1	33.5	39.5
	4,250					1.1	2.2	3.2	4.8	6.2	9.3	12	14.6	16.7	19.1	25.3	31.5	37.3
	4,500						1.1	1.9	3.3	4.5	7.1	9.6	12	14	16.3	22.4	28.5	34.2
	4,750							0.8	2	2.8	5.1	7.4	9.7	11.6	13.8	19.8	25.8	31.4
	5,000								1.1	1.8	3.7	5.8	8	9.7	11.8	17.7	23.8	26.6
	5,250									0.8	2.4	4.2	6.2	7.7	9.4	14.9	21.1	26.8
	5,500										1.5	3.2	5	6.1	7.8	13	19.1	24.6
	6,000											1.3	2.7	3.8	5.3	10.2	15.9	21.2
	6,500												2.8	1.3	2.6	6.9	12.1	17.2
	7,000													0.5	1.3	4.8	9.4	14.3
	7,500														0.7	3.8	8.1	12.7
	8,000															2.8	6.7	10.9
	9,000																2.6	5.3
	10,000																	1.9
	11,000																	
	12,000																	
	13,000																	
	14,000																	
	15,000																	
	17,000																	
	19,000																	
	21,000																	
	23,000																	
	25,000																	
	27,000																	
	29,000																	

Table 11B-18 (cont.)

		Spawning Flow											
		12,000	13,000	14,000	15,000	17,000	19,000	21,000	23,000	25,000	27,000	29,000	31,000
Dewatering Flow	3,250	56.6	63.7	70.7	76.8	84.2	86.5	88.5	89.1	91	91.3	93.1	94.7
	3,500	52.9	60	67.1	73.6	81.4	84	86.4	87.4	89.9	90.5	92.3	94
	3,750	49	55.9	63	69.7	77.8	80.9	84.3	85.9	88.9	89.7	91.7	93.8
	4,000	46	52.9	60	66.8	74.9	78.2	82.1	84.1	88.1	89.4	91.6	93.7
	4,250	43.6	50.3	57.3	64.1	72.3	75.6	79.8	82	86.8	88.3	91	93.3
	4,500	40.3	46.9	53.7	60.5	69.4	73.1	77.4	79.4	84.3	86.3	89.7	92.2
	4,750	37.3	43.7	50.2	57	66.1	70.1	74.6	77	83.1	85.5	89.2	91.9
	5,000	35.4	41.7	48.2	55	64.1	68.2	72.8	75.2	82.1	85	88.8	91.6
	5,250	32.6	38.7	45.2	51.9	61.3	66.1	70.8	73.2	79.3	82.9	88.1	90.8
	5,500	30.1	36	42.2	48.8	58.2	63.6	69.2	71.9	78.2	82.1	87.2	89.9
	6,000	26.6	32.3	38.4	44.7	53.8	58.8	64.6	67.7	74.9	79.2	84.3	86.8
	6,500	22.9	28.7	34.5	40.4	48.6	52.6	58.2	61	69.2	74	79.2	81.4
	7,000	19.9	25.7	31.6	37.5	46.2	50.2	56	59.1	67.5	72.2	77.3	79.4
	7,500	18.2	24.1	30	35.8	44.4	48.2	54.1	57.3	66.2	71.1	76	78.2
	8,000	16.3	22	27.7	33.4	42.1	46.4	52.7	55.9	64.6	69.5	75	77.2
	9,000	9.6	14.5	19.7	25.7	35.2	40.4	47.2	50.7	60.2	65.3	71.1	73.5
	10,000	4.6	8.9	13.4	18.9	27.7	33.7	41.4	45.6	55.7	61.7	68.3	70.8
	11,000	2.8	6.8	10.9	15.7	24.3	29.5	37.4	42	52.8	58.7	65.1	67.7
	12,000		3.1	6.3	10.4	18.9	25.1	33.9	38.9	50.3	56.5	63	65.7
	13,000			5.4	5.4	12.7	19.7	29.1	36.4	48	54.6	61.2	64.1
	14,000				3	9.5	15.6	25.1	32.3	44.5	51.7	58.3	61.5
	15,000					5	10.9	20.7	29.5	42.1	49.3	55.8	58.8
	17,000						4.8	13.4	20.8	34.1	42.5	49.7	53
	19,000							7.3	13.3	26.4	35.7	43.1	46.6
	21,000								6.8	20	29.2	36.3	39.9
	23,000									13.5	20.5	26.9	31.2
	25,000										4	9.3	14.6
	27,000											3.9	9.2
	29,000												5.1

Table 11B-19. Percent Redd Dewatered Look-up Table for CCV Steelhead with ACID Dam Boards In (the percent of redds dewatered are looked up at the intersection of the "Spawning Flow" columns and "Dewatering Flow" rows)

	Spawning Flow																
Dewatering Flow	3,500	3,750	4,000	4,250	4,500	4,750	5,000	5,250	5,500	6,000	6,500	7,000	7,500	8,000	9,000	10,000	11,000
3,250	1.1	2.3	3.3	4.7	6.5	8.7	11	13.6	16	20.3	23.9	26.9	29.3	31.8	37.6	42.3	46.7
3,500		1.4	2.2	3.2	4.6	6.4	8.4	10.8	13	17.1	20.6	23.7	26.1	28.6	34.5	39.2	43.5
3,750			0.6	1.3	2.6	4.1	5.9	8.1	10	13.6	17	20	22.5	25.1	31.2	35.9	40.3
4,000				0.9	2.1	3.3	4.7	6.7	8.3	11.6	14.6	17.4	19.7	22.2	28.3	33.3	37.8
4,250					1.3	2.6	4	5.8	7.2	10.3	13.2	15.9	18.1	20.5	26.5	31.3	35.7
4,500						1.4	2.7	4.2	5.5	8.2	10.8	13.3	15.4	17.6	23.6	28.4	32.7
4,750							1.5	2.9	3.8	6.2	8.5	11	12.9	15.1	20.9	25.7	30
5,000								1.7	2.4	4.4	6.5	8.8	10.6	12.6	18.3	23.1	27.5
5,250									1.1	2.6	4.6	6.5	8	9.6	15	19.7	24
5,500										1.5	3.2	4.8	6.2	7.7	12.8	17.5	21.6
6,000											1.3	2.7	3.8	5.1	9.9	14.3	18.3
6,500												2.7	1.4	2.5	6.9	10.8	14.8
7,000													0.5	1.3	4.9	8.4	12.2
7,500														0.7	4	7.3	10.8
8,000															3	5.9	9.2
9,000																2.2	4.4
10,000																	1.6
11,000																	
12,000																	
13,000																	
14,000																	
15,000																	
17,000																	
19,000																	
21,000																	
23,000																	
25,000																	
27,000																	
29,000																	

Table 11B-19 (cont.)

		Spawning Flow											
		12,000	13,000	14,000	15,000	17,000	19,000	21,000	23,000	25,000	27,000	29,000	31,000
Dewatering Flow	3,250	50.5	53.5	55.6	56.3	54.1	49.5	46.8	42.3	39.1	38.3	37.7	39.2
	3,500	47.4	50.6	52.9	54.1	52.3	48.1	45.6	41.3	38.2	37.6	37	38.5
	3,750	44.2	47.4	49.9	51.4	50.6	46.3	44.4	40.4	37.6	37	36.5	38.1
	4,000	41.7	45.1	47.7	49.4	48.3	44.8	43.2	39.4	37	36.5	36.2	37.8
	4,250	36.5	42.8	45.5	47.3	46.6	43.2	41.7	38.2	36	35.6	35.4	37.1
	4,500	36.6	39.8	42.6	44.6	44.5	41.5	40.1	36.5	34.2	34	34	35.8
	4,750	33.7	37	39.7	41.8	42.1	39.4	38.2	34.8	32.9	32.8	33	34.8
	5,000	31.2	34.4	37.2	39.4	39.8	37.2	36.2	32.8	31.1	31.1	31.1	32.8
	5,250	27.9	31.1	33.8	36.2	36.9	34.8	33.8	30.3	28.2	28.4	28.9	30.4
	5,500	25.3	28.4	31.1	33.5	34.5	32.8	32.3	28.9	26.8	27	27.3	28.8
	6,000	21.9	25.1	27.8	30.2	31.3	29.7	29.4	26.3	24.3	24.5	24.8	26
	6,500	18.7	22.1	27.8	27.1	28.1	26.2	25.9	22.9	21.2	21.5	21.7	22.8
	7,000	16.2	19.6	22.5	24.9	26.4	24.7	24.5	21.7	19.9	20.2	20.4	21.4
	7,500	14.8	18.3	21.2	23.7	25.2	23.5	23.5	20.7	19.1	19.3	19.4	20.4
	8,000	13.1	16.6	19.5	21.9	23.7	22.2	22.5	19.7	18	18.1	18.5	19.5
	9,000	7.6	10.8	13.6	16.6	19.4	18.7	19.3	16.8	15.2	15.4	15.9	17
	10,000	3.6	6.6	9.2	12.1	15.1	15.3	16.4	14.5	12.9	13.4	14.3	15.5
	11,000	2.3	5	7.5	10.1	13.1	13.1	14.5	12.8	11.5	11.9	12.8	14.1
	12,000		2.2	4.3	6.7	10.1	10.9	12.9	11.4	10.4	10.9	11.9	13.2
	13,000			3.7	3.6	6.8	8.3	10.7	10.5	9.6	10.3	11.3	12.7
	14,000				2.1	5.1	6.6	9.1	9	8.3	9.2	10.3	11.9
	15,000					2.6	4.2	7.2	7.9	7.4	8.3	9.4	10.9
	17,000						1.9	5.1	5.8	5.6	6.8	8.3	10
	19,000							3	3.7	3.8	5.1	6.7	8.4
	21,000								1.4	1.8	2.9	4.4	6.3
	23,000									0.9	2.2	3.8	5.7
	25,000										1.7	3.4	5.4
	27,000											1.8	3.8
	29,000												2.2

11B.3.2. Feather River

Spring-run, fall-run, and steelhead spawn in both the upper Feather River between the Fish Barrier Dam and Thermalito Afterbay Outlet (Low Flow Channel or LFC) and the lower river downstream of the Thermalito Afterbay Outlet (High Flow Channel or HFC). Results of escapement surveys conducted since 2002 (Kindopp pers. comm. 2021a) show that the LFC is preferred for spawning over the HFC and that this preference has increased over time (Figure 11B-11). However, Alternatives 1–3 would have no effect on flow in the LFC, so differences in redd dewatering between the alternatives and the NAA were estimated only for the HFC.

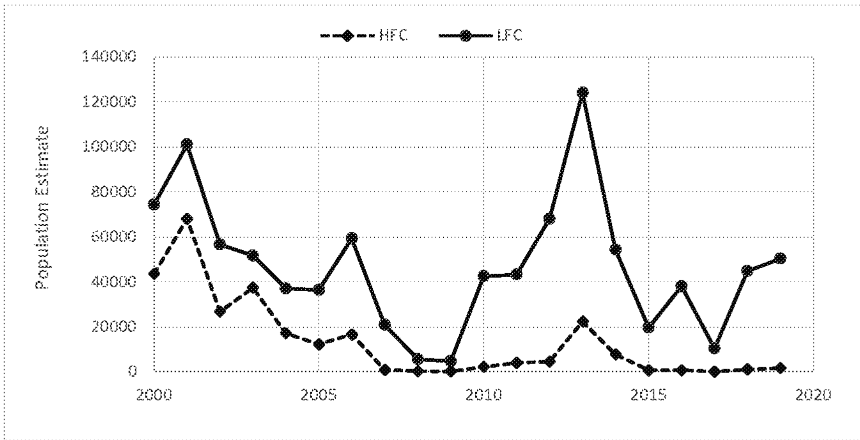

Figure 11B-11. Escapement Population Estimates for Fall-run Chinook Salmon in the Low Flow Channel (LFC) and High Flow Channel (HFC) of the Feather River from 2000 through 2019, from Escapement Surveys of CDWR.

No redd dewatering field data similar to that used for the Sacramento River (USFWS 2006) or the American River (see below) are available for salmon or steelhead in the Feather River; therefore, the reduction in flow from the spawning to the dewatering flow was used directly as a proxy for redd dewatering. The spawning and dewatering flows downstream of the Thermalito Afterbay outlet for each month of spring-run, fall-run, and steelhead spawning, as estimated by CALSIM II, were used to compute the reduction in flow under Alternatives 1–3 and the NAA. Larger reductions are assumed to increase the percent of redds dewatered and, therefore, to have a potentially negative effect on the species' populations. As previously noted, the use of monthly time-step flow estimates like those obtained from CALSIM II modeling likely underestimates redd dewatering rates. This potential bias is expected to equally affect the NAA and Alternatives 1–3.

11B.3.3. American River

The redd dewatering analysis for the lower American River used relationships between flow, river stage, and redd depth distribution developed by Bratovich et al. (2017). A composite redd depth frequency distribution was developed by combining results from several redd surveys conducted between 1996 and 2016. The stage vs. flow relationship for the river was developed from a combination of field measurements and modeling. CALSIM II flow estimates at the Nimbus Dam location were used to compute stage at the spawning and dewatering flows, and the redd depth frequency distribution was queried to determine the percentage of the redds that occur between those two stages and would therefore be dewatered. The analyses were conducted for fall-run and steelhead spawning and incubation periods for each year of the CALSIM period of record. Based on ranges provided in Bratovich et al. 2017, fall-run and steelhead were estimated to have three-month and two-month incubation periods, respectively. The analysis compared CALSIM II flow estimates below Nimbus Dam for each spawning month with the minimum flow during 2 or 3 months following the spawning month to estimate the percentage of redds dewatered. Absolute differences between Alternatives 1–3 and the NAA in the percentage of redds dewatered were used to compare the alternatives and the NAA. As noted above, the use of monthly time-step flow estimates like those obtained from CALSIM II modeling likely underestimates redd dewatering rates. This potential bias is expected to affect all Project scenarios equally.

11B.4 Redd Scour/Entombment

Loss of redds to scouring or entombment occurs when flows are high enough to mobilize sediments, destroying redds and their incubating eggs and alevins, or entombing the redds when sediments are redeposited. Estimates of redd losses resulting from scouring flows in the Sacramento and American Rivers were based on estimates from various sources of the minimum flows required to mobilize sediments and the frequency of occurrence of those flows. Frequency of scouring flows was not estimated for the Feather River because information on minimum flows required to mobilize sediments could not be located for the Feather River.

The probability of flows occurring that would be high enough to mobilize sediments and scour or entomb Chinook salmon and steelhead redds was estimated for the Sacramento and American Rivers. The amount of flow needed to mobilize sediments in these rivers has been little studied (Kondolf et al. 2000; Ayres 2001), but the information available suggests that a minimum of roughly 40,000 cubic feet per second (cfs) of flow is required in both rivers for significant bed movement (scour flow threshold) (Table 11B-20). It should be noted that 40,000 cfs is likely to be a conservative estimate for redd scour because, due to the areas of a streambed that salmonids typically select for redd construction, the flows needed to scour redds may be significantly greater than those that initiate bed mobility (May et al. 2009). A search of the literature found no corresponding estimate of scouring flow for the Feather River.

Table 11B-20. Estimated Bed Mobility Flows for the Sacramento and American Rivers

River	Approximate flow ranges to initiate mobility (cfs)	References
Sacramento River	24,000–50,000	Kondolf et al. 2000; Cain and Monohan 2008
American River	26,500–50,000	Ayres Associates 2001; Fairman 2007

For the Sacramento River, the frequency of flows exceeding 40,000 cfs for Alternatives 1–3 and the NAA during the spawning and egg incubation periods of winter-run, spring-run, fall-run and late fall–run Chinook salmon and steelhead were estimated from USRDOM estimates of daily flows.

No estimated daily flows for the American River under Alternatives 1–3 and the NAA are available; only CALSIM II estimates are available. Redd scour can occur at a very small temporal scale (minutes to hours), whereas CALSIM II provides mean monthly flow estimates. In an attempt to overcome this discrepancy in temporal scales, historical monthly and daily flow data during December through April (when scour is most likely to occur) were plotted to determine whether the probability of occurrence of daily flows above the scour flow threshold could be predicted with monthly flow data. The purpose was to find the minimum monthly flow value at which the maximum daily flow in that month would always be greater than the 40,000-cfs scour flow threshold. The actual monthly and daily flow data used in the analysis are from gauge records at Hazel Avenue, and the CALSIM II estimates used to compare probabilities of redd scour for Alternatives 1–3 and the NAA are for the Nimbus Dam location. The Nimbus Dam location is immediately upstream of the Hazel Avenue gauge location. The analysis of the Hazel Avenue gauge data shows that for months with a mean monthly flow of at least 19,350 cfs, the maximum daily flow in that month is always at least 40,000 cfs (Figure 11B-12). Therefore, redd scour probabilities for Alternatives 1–3 and the NAA were evaluated by comparing frequencies of CALSIM II flows greater than 19,350 cfs at Nimbus Dam during the fall-run and steelhead spawning and incubation periods.

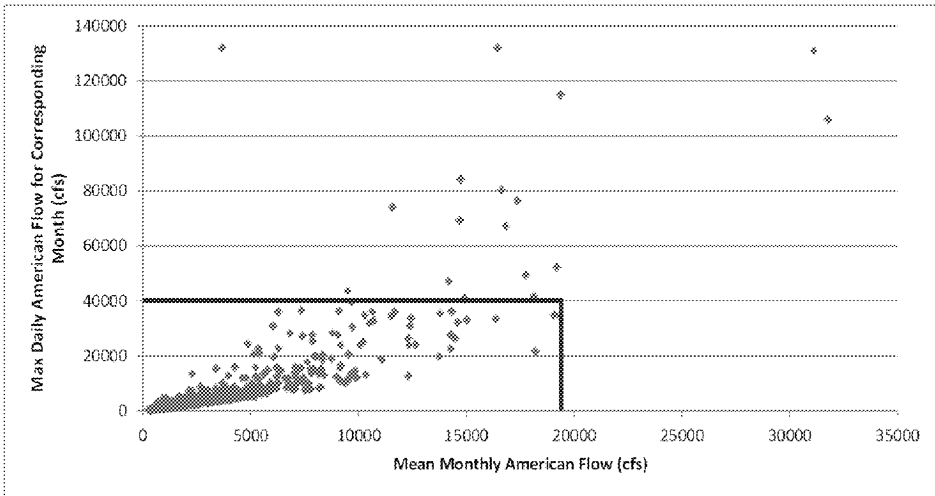

Figure 11B-12. Relationship between Mean Monthly Flows and Maximum Daily Flows during December through April, American River Downstream of Hazel Avenue, 1950–2015. Minimum monthly flow is identified in red.

11B.5 SALMOD

The SALMOD model was used to evaluate flow- and temperature-related mortality of early life stages and overall production of each race of Chinook salmon in the Sacramento River. Appendix 11H, *Salmonid Population Modeling (SALMOD)*, provides details and outputs of the model and Chapter 11, *Aquatic Biological Resources*, Impacts FISH-2, FISH-3, and FISH-4 include interpretation of model outputs.

11B.6 Rearing Habitat Weighted Usable Area

The availability of rearing habitat was estimated using WUA curves obtained from the literature (U.S. Fish and Wildlife Service 2005b). WUA is an index of the surface area of physical habitat available, weighted by the suitability of that habitat. WUA curves are normally developed as part of instream flow incremental methodology (IFIM) studies. Rearing habitat WUA was estimated only for the Sacramento River because no adequate flow versus rearing WUA curves located for the Feather or American River. The available flow versus rearing WUA information for these rivers is old, limited, and potentially unreliable (Thomas R. Payne & Associates 2002).

11B.6.1. Sacramento River

The rearing habitat WUA curves used for Chinook salmon rearing habitat in the Sacramento River were obtained from a U.S. Fish and Wildlife Service report (U.S. Fish and Wildlife Service 2005b). As noted above for spawning habitat, WUA is computed as the surface area of physical habitat available weighted by its suitability. Modeling assumptions used to derive rearing WUA curves include that the suitability of physical habitat for salmon and steelhead rearing is largely a function of water depth, flow velocity, and the availability and type of cover. The race- or species-specific suitability of the habitat with respect to these variables is determined by observing the fish and is used to develop HSC for each race or species. Hydraulic modeling is then used to estimate the amount of rearing habitat available for different HSC levels at different river flows, and the results are used to develop rearing habitat WUA curves and tables (Bovee et al. 1998). These curves and tables are used to look up the amount of rearing WUA available at different flows.

U.S. Fish and Wildlife Service (2005b) provides WUA curves and tables for rearing winter-run, fall-run, and late fall–run Chinook salmon for three segments of the Sacramento River encompassing the reach from Keswick Dam to Battle Creek (Figure 11B-1). Separate curves were developed for fry and juveniles, with fry defined as fish less than 60 millimeters and juveniles defined as greater than 60 millimeters. No WUA curves were developed for spring-run Chinook salmon or steelhead, but as discussed later, the fall-run curves were used to quantify spring-run rearing habitat and the late fall–run curves were used for steelhead. Figure 11B-13 through Figure 11B-18 show the flow versus rearing WUA results for fry and juvenile winter-run, fall-run, and late fall–run Chinook salmon in the three river segments (Segment 6 = Keswick to ACID Dam, Segment 5 = ACID Dam to Cow Creek, and Segment 4 = Cow Creek to Battle Creek) as provided in U.S. Fish and Wildlife Service (2006). Note that for Segment 6, separate WUA curves were developed for periods when the ACID Dam boards are installed (April through October) and for when the boards are out because installation of the boards affects water depths and velocities for some of the sampling transects used to develop the curves. All rearing WUA analyses were limited to juveniles less than a year old.

Because tributaries enter the Sacramento River between Keswick Dam and Battle Creek, flows are generally different among the three segments. For the U.S. Fish and Wildlife Service studies, flows were measured directly at the sampling transects and were estimated as the sum of Keswick flow releases and tributary gage readings upstream of the transects. To estimate WUA for the effects analysis, the segment flows were estimated using Sacramento River CALSIM II flows at Keswick Dam, the Clear Creek confluence, and Battle Creek for Segments 6, 5, and 4, respectively. Keswick Dam flows were used for Segment 5 upstream of the Clear Creek confluence. For Segment 6, the WUA curves for the months when the ACID Dam boards are installed (April through October) were used with the flows for those months and the WUA curves for the months when the ACID Dam boards are out were used with the flows for the rest of the year.

Although fall-run rearing WUA curves were used as surrogates for spring-run rearing, CALSIM II flows for the months of spring-run rearing, not those of fall-run rearing, were used to compute the spring-run WUA results. This caveat applies as well to the use of the late fall–run rearing WUA curves to compute steelhead WUA results.

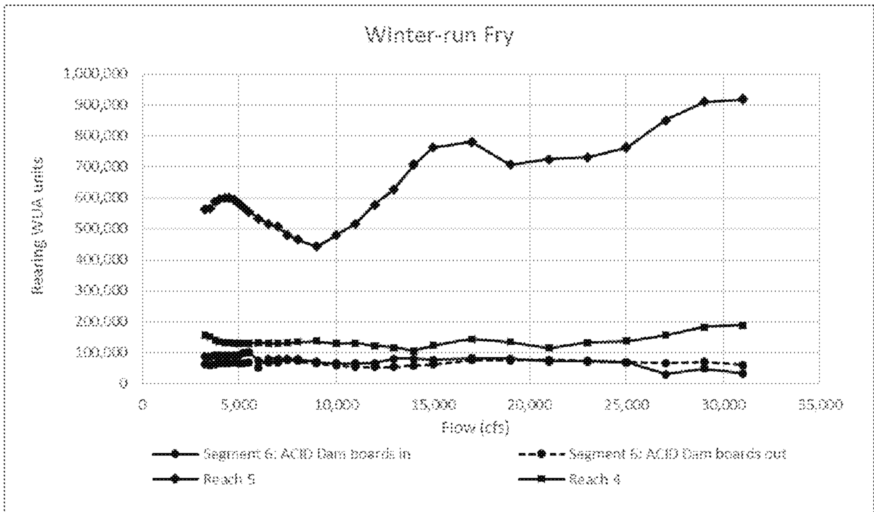

Figure 11B-13. Rearing WUA curves for Winter-Run Chinook Salmon Fry in the Sacramento River, Segments 4 to 6. ACID = Anderson-Cottonwood Irrigation District.

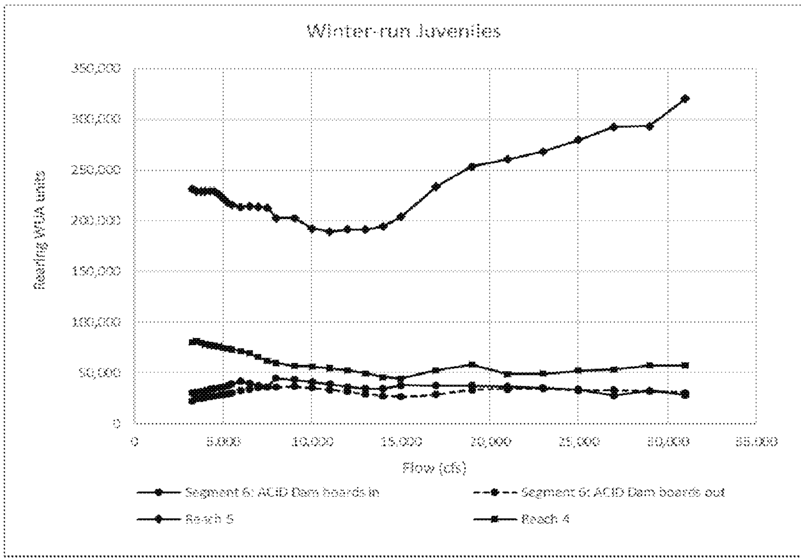

Figure 11B-14. Rearing WUA curves for Winter-Run Chinook Salmon Juveniles in the Sacramento River, Segments 4 to 6. ACID = Anderson-Cottonwood Irrigation District.

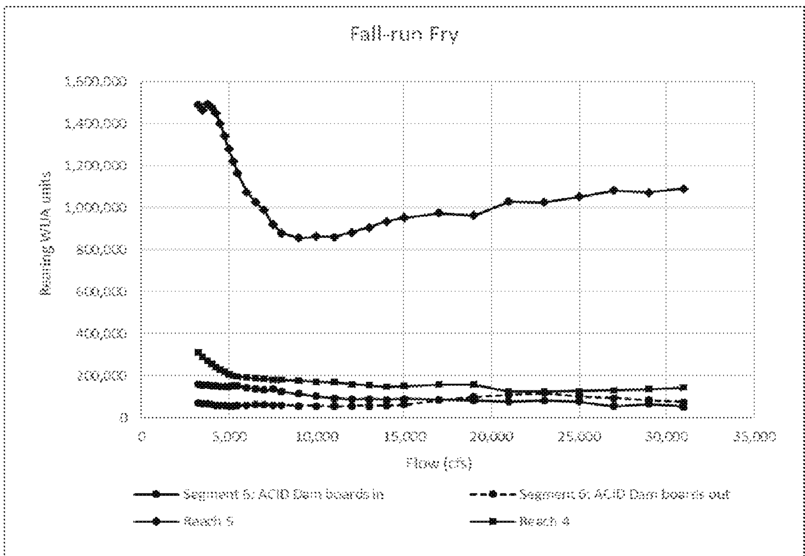

Figure 11B-15. Rearing WUA Curves for Fall-Run Chinook Salmon Fry in the Sacramento River, Segments 4 to 6. (The fall-run curves were used to quantify spring-run Chinook salmon WUA, as discussed in the text.) ACID = Anderson-Cottonwood Irrigation District.

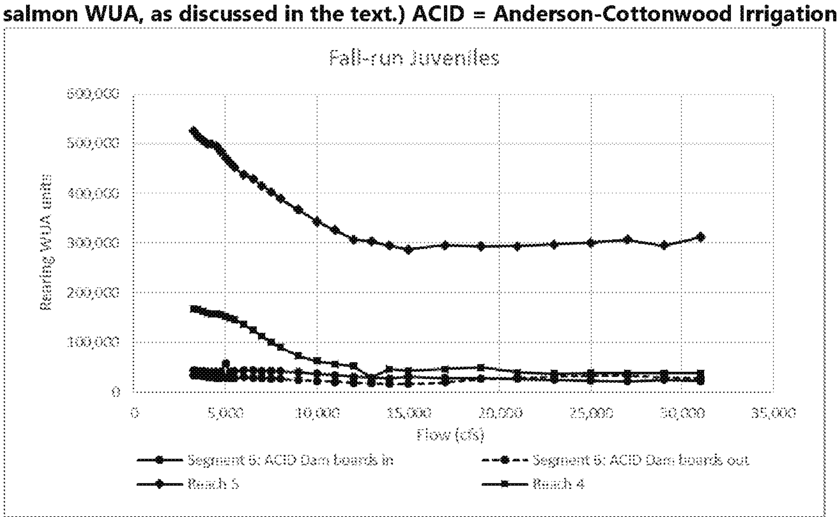

Figure 11B-16. Rearing WUA Curves for Fall-Run Chinook Salmon Juveniles in the Sacramento River, Segments 4 to 6. (The fall-run curves were used to quantify spring-run Chinook salmon WUA, as discussed in the text.) ACID = Anderson-Cottonwood Irrigation District.

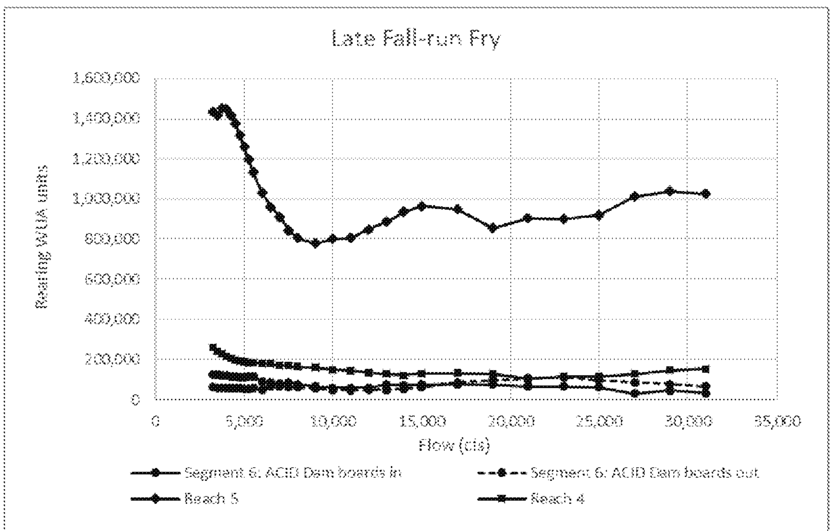

Figure 11B-17. Rearing WUA Curves for Late Fall–Run Chinook Salmon Fry in the Sacramento River, Segments 4 to 6. (The late fall–run rearing curves were used to quantify steelhead rearing WUA, as discussed in the text.) ACID = Anderson-Cottonwood Irrigation District.

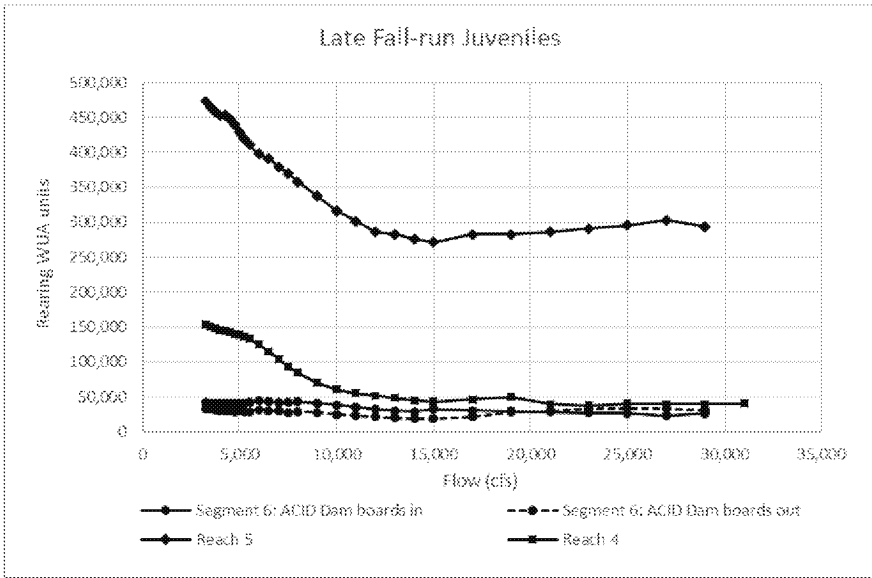

Figure 11B-18. Rearing WUA Curves for Late Fall–Run Chinook Salmon Juveniles in the Sacramento River, Segments 4 to 6. (The late fall–run rearing curves were used to quantify steelhead rearing WUA, as discussed in the text.) ACID = Anderson-Cottonwood Irrigation District.

As noted above, there are no spring-run or steelhead rearing WUA curves in the U.S. Fish and Wildlife Service documentation, so the fall-run and late fall–run Chinook salmon rearing WUA curves were used as surrogates to model rearing habitat for spring-run and steelhead, respectively. Mark Gard, who led the U.S. Fish and Wildlife Service studies that produced the Sacramento River WUA curves, has endorsed this practice for both spring-run Chinook salmon and steelhead (Gard pers. comm.). The use of these substitutions has been adopted in subsequent studies. For instance, the SacEFT model, which produces spawning and rearing WUA outputs for CV spring-run Chinook salmon and steelhead, derives the spring-run spawning and rearing WUA results using the fall-run WUA curves as surrogates and the steelhead rearing WUA results using the late fall–run WUA curves as surrogates (ESSA 2011; Robinson pers. comm.). It should be noted that this practice introduces additional uncertainty to the spring-run and steelhead results.

A potential limitation of the WUA curves presented above, as of all such habitat-based studies, is that they assume the channel characteristics of the river during the time of field data collection by U.S. Fish and Wildlife Service (1995–1999), such as proportions of mesohabitat types, have remained in dynamic equilibrium to the present time and would continue to do so through the life of the Project. If the channel characteristics substantially change, the shape of the curves may no longer be applicable. A further limitation is that the curves were developed for the Sacramento River upstream of Battle Creek, but all races of Chinook salmon and steelhead spend time rearing downstream of this part of the river.

Differences in the mean rearing WUA under Alternatives 1–3 and the NAA were examined for the months of the fry and juvenile rearing period under each water year type and all water year types combined. Differences in mean rearing WUA of greater than 5% were flagged in the results tables to highlight results with the largest differences.

11B.7 Juvenile Stranding

Commented [CC2]: Juvenile and adult stranding occurs in flood bypasses and areas along the river south of Red Bluff. Fish in the flood bypasses tend to get stranded during brief flood events and the tail end of long events. How might the project influence juvenile or adult stranding at the flood weirs and within the flood bypasses? There are many rearing enhancement projects along the lower Sacramento River and lower tributaries like the Cosumnes River, how will the project change access to salmonid rearing restoration sites through the lower river?

Juvenile stranding occurs when water level drops and the juveniles become isolated from suitable habitat. Juvenile salmon typically rest in shallow slow-moving water between feeding forays into swifter water, which makes them particularly susceptible to stranding during rapid reductions in flow (Jarrett and Killam 2015).

A juvenile stranding analysis for the Sacramento River was developed using a functional relationship developed in field studies by USFWS (2006). The juvenile stranding analysis is conceptually similar to the redd dewatering analysis in that both compare water elevation at an initial flow with that at the minimum flow during the following period. A period of 3 months is used for the juvenile stranding analysis in this report because the juveniles are presumed to be most vulnerable to stranding during their first 3 months (i.e., fry stage). The juvenile stranding analysis (USFWS 2006) computes the area of salmonid rearing habitat inundated at the initial flow that is dewatered at the minimum (stranding) flow and converts this area to number of stranded juveniles using estimates of habitat capacity based on field study observations. The estimates of area of rearing habitat available at different flows are based on a combination of field observations and modeling (USFWS 2006).

Commented [CC3]: Stranded juvenile salmonids greater than 3 months old have been observed in natural and modified areas south of red bluff.

Juvenile stranding is computed using USRDOM daily flow estimates for Alternatives 1–3 and the NAA at three locations in the upper Sacramento River: Keswick Dam, Clear Creek, and Battle Creek. Separate tables for converting initial and stranding flows to number of juveniles stranded were developed for periods when the ACID Dam boards are in and when they are out (Table 11B-21 and Table 11B-22). Both tables are used for all the salmonid species and races.

Table 11B-21. Juvenile Stranding Look-up Table for Chinook Salmon and Steelhead in the Sacramento River with ACID Dam Boards Out (numbers of juveniles stranded are looked up at the intersection of the "Initial Flow" columns and "Stranding Flow" rows)

	Initial Flow											
Stranding Fl		3,500	3,750	4,000	4,250	4,500	4,750	5,000	5,250	5,500	6,000	6,500
	3,250	1,097	11,227	11,895	13,095	14,598	16,654	16,819	16,939	17,494	20,250	20,860
	3,500		10,130	10,798	11,998	13,501	15,557	15,722	15,842	16,397	19,153	19,763
	3,750			668	1,868	3,371	5,427	5,592	5,712	6,267	9,023	9,633

		Initial Flow										
	4,000				1,200	2,703	4,759	4,925	5,044	5,599	8,355	8,965
	4,250					1,503	3,559	3,725	3,844	4,399	7,155	7,765
	4,500						2,056	2,222	2,341	2,896	5,652	6,262
	4,750							185	304	859	3,615	4,225
	5,000								139	694	3,450	4,060
	5,250									574	3,330	3,940
	5,500										2,775	3,385
	6,000											629
	6,500											
	7,000											
	7,500											
	8,000											
	9,000											
	10,000											
	11,000											
	12,000											
	13,000											
	14,000											

Table 11B-21 (cont.)

		Initial Flow									
		7,000	7,500	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000
Stranding Flow	3,250	20,954	21,024	21,953	22,764	23,084	23,193	23,230	23,239	23,253	23,420
	3,500	19,857	19,927	20,856	21,668	21,987	22,096	22,133	22,142	22,156	22,323
	3,750	9,727	9,797	10,726	11,538	11,857	11,966	12,003	12,012	12,026	12,193
	4,000	9,059	9,129	10,059	10,870	11,189	11,298	11,335	11,344	11,358	11,525
	4,250	7,859	7,929	8,858	9,670	9,989	10,098	10,135	10,144	10,158	10,325
	4,500	6,356	6,426	7,355	8,167	8,486	8,595	8,632	8,641	8,655	8,822
	4,750	4,319	4,389	5,319	6,130	6,449	6,558	6,595	6,604	6,618	6,785
	5,000	4,154	4,224	5,153	5,964	6,284	6,393	6,430	6,439	6,453	6,620
	5,250	4,034	4,104	5,033	5,845	6,164	6,273	6,310	6,319	6,333	6,500
	5,500	3,479	3,549	4,479	5,290	5,609	5,718	5,755	5,764	5,778	5,945
	6,000	723	793	1,723	2,534	2,853	2,962	2,999	3,008	3,022	3,189
	6,500	114	183	1,113	1,924	2,243	2,353	2,390	2,399	2,413	2,579
	7,000		89	1,018	1,830	2,149	2,258	2,295	2,304	2,318	2,485
	7,500			949	1,760	2,079	2,188	2,226	2,234	2,249	2,415
	8,000				811	1,131	1,240	1,277	1,286	1,300	1,466
	9,000					319	428	466	474	489	655
	10,000						109	146	155	169	336
	11,000							37	46	60	227
	12,000								9	23	190
	13,000									14	181
	14,000										167

Table 11B-22. Juvenile Stranding Look-up Table for Chinook Salmon and Steelhead in the Sacramento River with ACID Dam Boards In (numbers of juveniles stranded are looked up at the intersection of the "Initial Flow" columns and "Stranding Flow" rows)

	Initial Flow										
Stranding Flow	3,500	3,750	4,000	4,250	4,500	4,750	5,000	5,250	5,500	6,000	6,500
3,250	1,097	11,227	11,895	13,095	14,598	16,671	17,441	17,847	18,402	21,158	21,768
3,500		10,130	10,798	11,998	13,501	15,574	16,344	16,750	17,305	20,061	20,671
3,750			668	1,868	3,371	5,444	6,214	6,620	7,175	9,931	10,541
4,000				1,200	2,703	4,776	5,546	5,953	6,507	9,264	9,873
4,250					1,503	3,576	4,346	4,753	5,307	8,063	8,673
4,500						2,073	2,843	3,249	3,804	6,560	7,170
4,750							789	1,196	1,751	4,507	5,116
5,000								426	981	3,737	4,346
5,250									574	3,330	3,940
5,500										2,775	3,385
6,000											629
6,500											
7,000											
7,500											
8,000											
9,000											
10,000											
11,000											
12,000											
13,000											
14,000											

Table 11B-22 (cont.)

	Initial Flow									
Stranding Flow	7,000	7,500	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000
3,250	21,893	21,932	22,861	23,823	23,602	23,711	23,753	23,757	23,771	23,938
3,500	20,796	20,835	21,765	22,186	22,505	22,614	22,656	22,660	22,675	22,841
3,750	10,666	10,705	11,635	12,056	12,375	12,485	12,526	12,531	12,545	12,711
4,000	9,998	10,037	10,967	11,388	11,708	11,817	11,858	11,863	11,877	12,044
4,250	8,798	8,837	9,767	10,188	10,508	10,617	10,658	10,663	10,677	10,843
4,500	7,295	7,334	8,264	8,685	9,004	9,114	9,155	9,160	9,174	9,340
4,750	5,241	5,281	6,210	6,631	6,951	7,060	7,101	7,106	7,120	7,287
5,000	4,471	4,510	5,440	5,861	6,181	6,290	6,331	6,336	6,350	6,517
5,250	4,065	4,104	5,033	5,455	5,774	5,883	5,925	5,929	5,943	6,110
5,500	3,510	3,549	4,479	4,900	5,219	5,329	5,370	5,375	5,389	5,555
6,000	754	793	1,723	2,144	2,463	2,572	2,614	2,618	2,633	2,799
6,500	144	183	1,113	1,534	1,854	1,963	2,004	2,009	2,023	2,190
7,000		58	988	1,409	1,729	1,838	1,879	1,884	1,898	2,065
7,500			949	1,370	1,690	1,799	1,840	1,845	1,859	2,025
8,000				421	741	850	891	896	910	1,077

		Initial Flow									
	9,000					319	428	470	474	489	655
	10,000						109	151	155	169	336
	11,000							41	46	60	227
	12,000								5	19	185
	13,000									14	181
	14,000										167

As noted above, fry are likely the most vulnerable juveniles to the stranding flows and, therefore, stranding flows are assumed to cause the greatest mortality to the salmon runs or steelhead during the months that the fry are present. The seasonal presence of fry and early juveniles of each of the salmonid races and species was estimated from information on the spawning, incubation, and fry emergence periods in Appendix 11A, *Aquatic Species Life Histories*, and results of the USFWS RBDD Rotary Screw Trap and Sacramento River Beach Seine sampling efforts. The estimated fry and early juvenile rearing periods are: (1) July through October for winter-run, (2) November through February for spring-run, (3) December through March for fall-run, (4) March to June for late fall–run, and (5) February through May for steelhead).

Commented [CC4]: Proportionally juveniles may be the most vulnerable, but all life stages are vulnerable to modified flow regimes. Adults of five different salmonid races are essentially present in the river year around. Will flow modifications influence adult stranding in areas of low flow in the Sacramento River south of Red Bluff?

Commented [CC5R4]: CDFW recommends that there be analysis of adult standing in areas of low flow in the Sacramento River downstream of Red Bluff.

11B.8 Upstream Migration of Salmon and Sturgeon Adults

Most potential effects of flow on upstream migrating anadromous fish were not analyzed because adequate analysis procedures were unavailable. The only exception is effects of very low flow that may result in passage barriers, which is discussed below. Other flow effects on adult salmon migrations are primarily related to flow velocities in the river channel and the bioenergetics of the fish (Enders et al. 2003; Liao 2007; Martin et al. 2015). While effects of uniform flow velocities on adult salmon bioenergetics are reasonably well understood (Enders et al. 2003), many natural settings, such as the river channel of the upstream reaches of the lower Sacramento, Feather and American Rivers, have turbulent flow with complex flow velocity fields. These velocity fields vary greatly with discharge. Research has demonstrated that upstream migrating salmon intersperse periods of rest in flow velocity refuges, including complex flow vortices, with spurts of high energy expenditure through channel sections with higher flow velocities (Liao 2007). The bioenergetics of the salmon, which are highly complex, depend on the path through the flow velocity fields selected by the salmon, which change with the amount of flow in the river (Liao 2007; Martin et al. 2015). Adding to the complexity, the effects of temperature on the salmon bioenergetics interact with those of the flow velocities (Martin et al. 2015). Ultimately, what is needed to assess the effects of different flows on upstream migrating salmon is a model that integrates river channel hydraulics, water temperatures, migratory behaviors of the salmon, and their bioenergetics for different combinations of flow and temperature. No such model is currently available.

Commented [CC6]: What about attraction signals? Several endemics rely on Sacramento river flows entering the north side of the delta to be attracted to the river during inland migration.
It is reasonable to suspect that any increase in releases from the project to the Colusa Basin Drain will increase anadromous fish entrainment in the Ridge Cut Canal, and decrease attraction to the Sacramento River.

Commented [CC7R6]: CDFW recommends adding information to address attraction signals to this discussion.

Effects on upstream migrating adult salmon or sturgeon may occur if reduced flows result in inadequate water depth or flow over barriers for passage of adult fish. Note that if periods of low flow last only a few days and are not very frequent, they probably have little effect on the fish because the fish can wait in deeper water until passage conditions improve. The specific flow level at which passage difficulties for migrating adults first appear is not known for the Sacramento, Feather, or American Rivers. Therefore, threshold flows were selected based on the

Commented [CC8]: This idea needs to be further explained and supported; fish will not be aware of, or predict project operations during their migration.

expert judgment of biologists who have long experience from observing fish in these rivers at many different flows.

The required minimum flow release from Keswick Dam is 3,250 CFS (NCWA 2019). This flow was selected as the threshold for potential obstruction of upstream passage for the Sacramento River because the river's flow rarely drops below this level and salmonid adults have not been observed experiencing any passage difficulties at flows approaching this level (Killam pers. comm.). As such, it represents a conservative minimum flow above which fish do not experience migration difficulties. However, there have not been opportunities to observe whether fish experience passage difficulties below this level. A 1,000 cfs flow threshold was selected for the American River in this analysis because this is the approximate flow at which adult fall-run Chinook salmon have been first observed to delay upstream movement to spawning grounds (Kundargi pers. comm.).

Commented [CC9]: There are adult fish passage considerations in other areas in the river than Red Bluff, suggest including information for the rest of the river.

A threshold flow for upstream passage in the lower Feather River was more difficult to determine. The primary Feather River passage obstruction is a boulder weir at the Sunset Pumps in the Feather River at Live Oak (Thom 2017; Seesholtz pers. comm). This weir creates a partial barrier to the only confirmed spawning location of green sturgeon in the Feather River (Seesholtz et al. 2014). USFWS (2016) indicates that the boulder weir is a barrier to upstream passage of green sturgeon when Feather River flow is less than 6,000 cfs. Given the absence of information indicating passage at lower flows, 6,000 cfs flow was selected as the threshold flow for upstream passage of sturgeon in the Feather River. Adult salmonids are able to pass above the Sunset Pumps weir at 1,500 cfs or less (Kindopp pers. comm. 2021), so 1,500 cfs was selected as the threshold flow for upstream passage of salmonids. The recovery plan for the southern DPS of green sturgeon lists removal or modification of the Sunset Pumps boulder weir as a high priority recovery action (Thom 2017), but it is not clear when such measures would be implemented (Seesholtz pers. comm.).

Three locations in the Sacramento River (Keswick Dam, RBDD, and Wilkins Slough), one location in the Feather River (below Thermalito Afterbay outlet), and one location in the American River (below Nimbus Dam) were selected for this analysis of low flows. For the Sacramento River, USRDOM daily flow estimates at Keswick Dam and the RBDD and CALSIM II monthly flow estimates at Wilkins Slough were used. CALSIM II monthly flow estimates were also used for the locations on the Feather and American Rivers. For each species and location, the percent of days (Keswick Dam and RBDD) or months (other locations) during the adult immigration period that modeled flows were lower than the minimum flow thresholds were calculated for Alternatives 1–3 and the NAA, and the differences in these percentages between Alternatives 1–3 and the NAA were determined.

11B.9 References

Yellow = Missing full reference

11B.9.1. Printed References

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11B.9.2. Personal Communications

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Kindopp pers comm

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Chapter 31 Cumulative Impacts

Commented [CC1]: Please resubmit this document when the impact analysis is completed for the pending sections.

31.1 Regulatory Requirements for Analysis

Both CEQA and NEPA require the assessment of cumulative impacts as part of the environmental review process. Under CEQA, "cumulative impacts refer to two or more effects that when considered together are considerable or which compound or increase other environmental impacts" (State CEQA Guidelines, Section 15355). The State CEQA Guidelines go on to state that the types of projects that should be considered in a cumulative impact analysis are "closely related past, present, or reasonably foreseeable probable future projects" (State CEQA Guidelines, Section 15355; see also Section 15130, subd. (b)(1)(A)). The state lead agencies need not provide a discussion of the cumulative impacts at the same level of detail as provided for the impacts attributable to the project alone (State CEQA Guidelines, Section 15130, subd.(b)).

NEPA also provides guidance regarding treatment of cumulative impacts and how to determine the types of projects that should be considered in the impact analysis. The NEPA regulations adopted by the Council on Environmental Quality (CEQ) indicate that a cumulative impact is an impact on the environment that results from the incremental impact of a particular action when added to other past, present, or reasonably foreseeable future actions, regardless of the entity undertaking such an action (CEQ NEPA Regulations Part 1508, Section 1508.7). Additional guidance is provided by the Reclamation NEPA handbook which, similar to CEQA, indicates that past, present, and reasonably foreseeable projects should be included, although an exhaustive analysis of past projects is not required (U.S. Bureau of Reclamation 2012). The Reclamation NEPA handbook also indicates that how the cumulative impact assessment is incorporated into the NEPA document is at the lead agency's discretion (U.S. Bureau of Reclamation 2012).

The purpose of the cumulative impact analysis is to assess the impacts of a proposed action in combination with a group of actions or projects with similar or overlapping impacts.

31.2 Cumulative Project Selection and Approach

The cumulative impact analysis is generally based on a project list approach, considering projects identified in Table 31-1. The criteria for considering whether a project was reasonably foreseeable and probable for inclusion on the cumulative project list are:

- whether a project has been defined in adequate detail based upon publicly available environmental analysis documenting the potential environmental impacts of the project, because CEQA and NEPA do not require speculation related to future projects.
- whether a project would result in impacts on the same environmental resources that would be affected by the implementation of Alternatives 1, 2, and 3 (collectively referred to as the Project); projects that would not affect the same resources were considered outside the scope of the cumulative impact analysis. For example, the Project would not change the environment within Solano County; therefore, this cumulative impact analysis did not consider changes that would occur under the Solano County Multi-Species Habitat Conservation Plan (HCP).
- whether a project would result in similar impacts to those identified as potentially resulting from the Project and evaluated in Chapters 5 through 30 (i.e., resource chapters).

The projects identified as having no impact nexus with the Project are not considered in the cumulative analysis because they are not expected to have impacts that could combine with those of the Project. This determination is based on one or both of the factors below.

- The projects are located outside of the area where the Project would be constructed and thus would not cause impacts that would combine with effects of the Project.
- The project is of a type that would not produce impacts that could combine with impacts of the Project.

The cumulative impact analysis also considers past, current, and reasonably certain projects and programs included in the assumptions for existing conditions (CEQA resources) or affected environment (NEPA-only resources) descriptions. These projects and programs are generally described in Appendix *5A, Surface Water Resources Modeling of Alternatives*, and Appendix 5B, *Water Resources System Modeling, (Operations to confirm)*, throughout Chapters 5 through 30, and in Appendix 4A, *Regulatory Requirements*. Appendix 4A describes ongoing policies, programs, or regulations. Appendix 5A describes the hydrologic modeled representation of those ongoing policies, programs, or regulations.

Commented [C2]: Not provided to CDFW.

Plans and policies that are expected to continue and are described in Appendix 4A include:

- Central Valley Flood Protection Plan
- Colusa County General Plan
- County of Yolo 2030 Countywide General Plan
- FloodSAFE California
- Glenn County General Plan
- Glenn County General Plan Update, 2020 Existing Conditions Report

- National Marine Fisheries Service Recovery Plan for Sacramento River Winter-run Chinook Salmon, Central Valley Spring-run Salmon, and Central Valley Steelhead
- Tehama County General Plan
- U.S. Fish and Wildlife Service Giant Garter Snake Recovery Plan
- U.S. Fish and Wildlife Service Recovery Plan for Sacramento–San Joaquin Delta Native Fishes
- Yolo County HCP/Natural Community Conservation Plan (NCCP)
- Yolo Bypass Wildlife Area Land Management Plan (Yolo Bypass Wildlife Area LMP)
- Yolo County Storm Water Management Program

The cumulative analysis is primarily qualitative. For many of the projects in Table 31-1 it would be speculative to define multiple parameters and assumptions within a numerical modeling effort. However, the qualitative analysis is informed by quantitative modeling results describing the environmental setting for the existing conditions and appropriately applies those conditions to the action alternatives. The hydrologic modeling results are cumulative in nature because the model input must make allowances for the use of water outside the footprint of the alternatives. The model uses an 82-year historical hydrologic sequence to simulate a wide range of hydrologic conditions that could occur in the future, including extended wet periods and dry/critically dry periods. In addition, the model includes assumptions about population growth conditions that could occur in the future with or without the Project. In the case of the CALSIM modeling, this includes increased demand based on the level of buildout. This method of incorporating increased water demand into the CALSIM II modeling meets Reclamation's guidance on how to incorporate the cumulative analysis into the NEPA documentation. Therefore, the elements of the various impact assessments (e.g., surface water quality, aquatic biological resources, recreation) that relied on the hydrologic impact assessment for their respective analyses are also cumulative in nature. Projects that are represented by the modeling, and therefore also included in the cumulative impact analysis, are identified in Table 5A-XXX CAL SIM II Assumptions.

Commented [CC3]: Please, elaborate on what portions of the cumulative analysis are primarily qualitative. CDFW has highlighted our concerns, regarding Sites' modeling. These concerns when combined with the fact that much of the cumulative impact analysis seems to be qualitative, suggests that the analysis of cumulative impacts is insufficient to assess actual impacts from the project. While much of this chapter is still incomplete, the analysis provided in the completed sections, seems to be largely superficial and lacking in supporting documentation. A project of this size has the potential to have significant cumulative impacts, and all aspects of project operations should be analyzed in detail, in order to provide confidence that all cumulative impacts have been identified and realistically assessed.

Table 31-1 Cumulative Project List

Project	Primary Agencies	Status	Description	References
Flood Control Projects				
CALFED Levee System Integrity Program	California Department of Water Resources, California Department of Fish and Wildlife, U.S. Army Corps of Engineers	Ongoing	The CALFED Record of Decision requires that the Levee System Integrity Program be managed to provide for long-term protection for Delta resources through maintenance and improvement of the Delta levee system. Goals are to protect life, infrastructure, and properties; and reduce the risk to land use and associated economic activities, water supply, infrastructure, and ecosystem from catastrophic breaching of Delta levees. The primary focus is on the legal Delta as defined in Section 12220 of the California water Code. Protection and maintenance of a total of 1,300 miles of project and non-project levees has taken place since the inception of the CALFED Program in 2000. Other major undertakings include restoration of native vegetation and reuse of dredge material to bolster levee stability. Major activities include levee maintenance, levee improvement, environmental mitigation, emergency response functions, and other components carried out using local funds, with additional funds provided by the state and federal governments. However, uncertainty in program funding has required that some goals be revised, and schedules be extended. Proposition 50 provided $70 million for Delta Levees.	University of California (CaliSphere) website. Accessed October 12, 2020. http://s3-us-west-2.amazonaws.com/ucldc-nuxeo-ref-media/677f7439-2b07-4494-a627-4a96260226fa
Delta Levees Flood Protection Program	California Department of Water Resources	Ongoing	The Bay-Delta Levees Branch of DWR administers the Delta Levees Flood Protection Program as authorized by the California Water Code, Sections 12300 thru 12318 and 12980 thru 12995. This is a grants program that works with more than 60 reclamation districts in the Delta and Suisun Marsh to maintain and improve the flood control system and provide protection to public and private investments in the Delta including water supply, habitat, and wildlife. The program, through its two major components (Delta Levees Maintenance Subventions Program and Delta Levees Special Flood Control Projects), works with the local agencies to maintain, plan, and complete levee rehabilitation projects. The Delta Levees Maintenance Subventions Program provides financial assistance to local levee maintaining agencies for the maintenance and rehabilitation of non-project levees in the Delta. It has been in effect since passage of the Way Bill in 1973, which has been modified periodically by legislation. The program is under the authority of the Central Valley Flood Protection Board (Board) and is managed by DWR. Water Code Section 12987 calls on DWR to prioritize the islands for receipt of grant funds through the program and recommend the prioritization to the Board. The Board reviews and approves the Department's recommendation and enters into an agreement with reclamation districts to reimburse eligible costs. The Delta Levees Special Flood Control Projects provides financial assistance to local levee maintaining agencies for rehabilitation of levees in the Delta. The program was established by the California Legislature under SB 34, SB 1065, and AB 360. Since the inception of the program, more than $100 million have been provided to local agencies in the Delta for flood control and related habitat projects. The program presently focuses on flood control projects and related habitat projects for eight western Delta Islands (Bethel, Bradford, Holland, Hotchkiss, Jersey, Sherman, Twitchell and Webb Islands) and for the towns of Thornton and Walnut Grove.	California Department of Water Resources website. Access October 8, 2020 https://water.ca.gov/Work-With-Us/Grants-And-Loans/Delta-Levees-Maintenance-Subventions California Department of Water Resources website. Access October 8, 2020. https://water.ca.gov/Work-With-Us/Grants-And-Loans/Delta-Levees-Special-Flood-Control-Projects#:~:text=The%20Delta%20Levees%20Special%20Flood,cultural%20resources%20in%20the%20Delta
Delta Risk Management Strategy	California Department of Water Resources	Completed	The 2000 CALFED Record of Decision presented a Preferred Program Alternative that described actions, studies, and conditional decisions to help the Delta. The Preferred Program Alternative for Stage 1 implementation included the completion of a Delta Risk Management Strategy (DRMS) that would examine the sustainability of the Delta and would assess major risks to Delta resources for projections ranging from 50 to 200 years. The first phase of DRMS analyzes the risks and consequences of levee failure in the Delta region. The analysis considers current and future risks of levee failures from earthquakes, high water conditions (storms and tides), climate change, subsidence, dry-weather events, and a combination of these factors. The analysis also estimates the consequences of levee failures to the local and state economy, public health and safety and the environment. The DRMS Phase 1 report findings will be used to help develop a set of strategies to manage levee failure risks in the Delta and to improve the management of state funding that supports levee maintenance and improvement. Various scenarios to reduce the risks and consequences of levee failure are considered in Phase 2 of the DRMS Project.	Delta Revision website. Accessed 10/11/20. https://deltarevision.com/2011_docs/drms-again/DRMS_Phase2_Foreword_Executive_Summary.pdf
DWR Small Communities Flood Risk Reduction Program	DWR, Yolo County	Ongoing	In 2017, Yolo County received a grant from the California Department of Water Resources (DWR) Small Community Flood Risk Reduction Program to complete a feasibility study with a primary goal of identifying a preferred plan to reduce flood risk to Knights Landing. Based on the preliminary and final screening in the Feasibility Study, Alternative 12 was selected as the Preferred Alternative that accomplishes the goals of this Study. The Preferred Structural Alternative includes the following:	California Department of Water Resources website. Accessed April 2, 2021. https://water.ca.gov/Work-With-Us/Grants-And-Loans/Small-

Commented [CC4]: The Glenn-Colusa Irrigation District (GCID) has a long term Routine Maintenance Agreement to remove gravel from the canal. Please include this Project in the analysis. The Project's permits with CDFW are:

LSAA: 1600-2017-0088-R2
ITP: 2081-2020-002-02

Commented [CC5]: Please include the methodologies used to populate this project list.

Project	Primary Agencies	Status	Description	References
			Six different levee improvement locations along the Right Bank of Sacramento River between levee mile 0.86 and 5.4 to address underseepage, through seepage, and landslide stability concerns adjacent to community. Applicable freeboard/geometry repairs levee improvements along the Left Bank of Knights Landing Ridge Cut to improve stability and protection against erosion from levee mile 4.9 to 5.8 New cross levee just easterly of Knights Landing between the Sacramento River and the KLRC.	Communities-Flood-Risk-Reduction I have a copy of the Feasibility Study, but I don't believe it is online.
Folsom Dam Safety and Flood Damage Reduction Joint Federal Project	U.S. Department of the Interior, U.S. Army Corps of Engineers	Completed	The Folsom Dam was built by the U.S. Army Corps of Engineers and transferred to the U.S. Bureau of Reclamation in 1956. The Folsom Dam Safety and Flood Damage Reduction Project (Folsom DS/FDR) was developed to coordinate Reclamation's and Corps' multiple authorized projects at the Folsom Facility. A FONSI and Final Supplemental EA was signed in April 2008. Phase II was completed by the Bureau of Reclamation in 2011 and handed off to the US Army Corps of Engineers to construct Phase III, a control structure, which is currently underway.	U.S. Bureau of Reclamation website. Accessed October 12, 2020. https://www.usbr.gov/mp/jfp/index.html
Folsom Dam Safety and Flood Damage Reduction Project	U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, Sacramento Area Flood Control Agency, and Central Valley Flood Protection Board	Ongoing	The project represents a coordinated effort among the U.S. Bureau of Reclamation and U.S. Army Corps of Engineers to address dam safety and enhanced flood control at Folsom Dam. The project includes the Joint Federal Project Auxiliary Spillway, seismic improvements to the Main Concrete Dam and Mormon Island Auxiliary Dam (MIAD), static improvements to earthen structures, security upgrades, replacement of the Main Concrete Dam spillway gates, and a 3.5-foot (ft) raise to all Folsom Facility structures. Construction on the auxiliary spillway began in 2008 and is expected to be completed in 2015. The modifications to the dam would allow for the release of water sooner than is now possible, with the potential for higher releases should the downstream levees be improved to accommodate the increased flows. These larger, earlier releases from Folsom Reservoir would create and conserve flood storage space based on projected reservoir inflows resulting from a major storm impacting the upper American River watershed. However, the modifications would be operated using existing criteria until the completion of a revised Folsom Water Control manual and supporting supplemental environmental compliance documentation. The manual would be completed one year prior to completion of proposed structural modifications at Folsom Dam and Reservoir, at which time the full potential benefits of the proposed modifications would be realized.	Bureau of Reclamation website. Accessed October 8, 2020. https://www.usbr.gov/mp/nepa/nepa_project_details.php?Project_ID=1808
Levee Repair-Levee Evaluation Program	California Department of Water Resources	Ongoing	On February 24, 2006, Governor Arnold Schwarzenegger declared a State of Emergency for California's levee system, commissioning up to $500 million of state funds to repair and evaluate state/federal project levees. Following the emergency declaration, the Governor directed DWR to secure the necessary means to fast-track repairs of critical erosion sites. Hundreds of levee sites have been identified for immediate repair throughout the Central Valley. These repairs are necessary to maintain the functionality of flood control systems that have deteriorated over time and/or do not meet current design standards. While many of the most urgent repairs have been completed or are near completion, other sites of lower priority are still in progress, and still more are in the process of being identified, planned, and prioritized. In general, repairs to state/federal project levees are being conducted under three main programs: the Critical Erosion Repairs Program, the Sacramento River Bank Protection Project, and the PL84-99 Rehabilitation Program. A fourth program to repair critically damaged levees on the San Joaquin Flood Control System is under development by DWR. DWR is conducting geotechnical exploration, testing, and analysis of state and federal levees that protect the highly populated urban areas of greater Sacramento, Stockton/Lathrop, and Marysville/Yuba City. This program is being implemented simultaneously with the various urgent levee repairs. To expedite efforts to protect these communities, levee evaluations are being conducted in a fast-track manner over a two- to three-year period. During this time, technical specialists are reviewing existing levee historical data; mapping near-surface geology; conducting field explorations; performing engineering, stability and seepage analyses; and preparing preliminary design and construction estimates for repairing and upgrading the levees, where needed.	California Natural Resources Agency website. Accessed October 8, 2020. https://bondaccountability.resources.ca.gov/Program.aspx?ProgramPK=86&Program=Levee%20Evaluations%20Program&PropositionPK=5
Lower Cache Creek/Woodland Flood Risk Management Project	City of Woodland, USACE, DWR, CVFPB	Ongoing	The Final EIR and Final EIS evaluates impacts associated with a proposed flood risk reduction project on Lower Cache Creek. As a part of the overall effort, USACE is also preparing a project feasibility study. Similarly, the City of Woodland is partnering with DWR through its Urban Flood Risk Reduction Program to identify and implement the flood risk reduction project to meet the State's urban level of protection requirements in a cost-effective manner that would be compatible with and supportive of elements of the Integrated Watershed Monitoring Program. Project components include secondary earthen levees and a diversion channel to redirect overland	City of Woodland website. Accessed April 2, 2021. https://www.cityofwoodland.org/1196/Lower-Cache-Creek-Feasibility-Study-LCCF

Project	Primary Agencies	Status	Description	References
			flood flows into the Yolo Bypass, modification of the Cache Creek Settling Basin to allow conveyance of flood flows into the Yolo Bypass, and various bridge and/or culvert improvements to facilitate conveyance of flood flows in the diversion channel.	City of Woodland website. Accessed April 2, 2021. https://www.cityofwoodland.org/DocumentCenter/View/6628/Woodland_FRMP_Final_EIR_January2021_WEB
Oroville Facilities Relicensing	California Department of Water Resources	Completed	The Oroville Facilities, as part of State Water Project, are also operated for flood management, power generation, water quality improvement in the Sacramento-San Joaquin Delta, recreation, and fish and wildlife enhancement. The objective of the relicensing process was to continue operation and maintenance of the Oroville Facilities for electric power generation, along with implementation of any terms and conditions to be considered for inclusion in a new FERC hydroelectric license. The initial FERC license for the Oroville Facilities, issued on February 11, 1957, expired on January 31, 2007. DWR published the Final Environmental Report in June 2008.	California Department of Water Resources website. Accessed October 11, 2020. https://water.ca.gov/Programs/State-Water-Project/SWP-Facilities/Oroville/HLPCO-Oroville-Facilities-Project-2100
Sacramento River Bank Protection Project (SRBPP)	U.S. Army Corps of Engineers, CVFPB, SAFCA, WSAFCA, TRILA	Ongoing	The SRBPP is a continuing construction project authorized by Section 203 of the Flood Control Act of 1960. The purpose of the project is to provide erosion protection to the existing levee and flood management facilities of the SRFCP. To date, project work has been carried out in two phases, and a total of approximately 840,000 feet of riverbank has been stabilized. Phase I consisted of 435,000 feet, and Phase II's original authorization was for 405,000 feet. An additional 80,000 feet (a supplement to Phase II) has been authorized under the Water Resources Development Act of 2007 and is being supported by a Post Authorization Change Report, Engineering Documentation Report, and EIS/EIR. The authorization would be applied by USACE to the Sacramento River and other sites within the SRFCP that are identified as critical levee erosion sites.	U.S. Army Corps of Engineers website. Accessed April 2, 2021. https://www.spk.usace.army.mil/Missions/Civil-Works/Sacramento-River-Bank-Protection/
Sacramento River Flood Control System Evaluation, Phase III Mid-Valley Sites	USACE, DWR, KLRCDD, RD 108, Yolo County	Ongoing	The project proposes to repair levees at 13 sites northwest of the City of Sacramento which have required flood fighting or experienced seepage and boils during previous flood events. The repair of levees in Area 3 as part of Phase III will nearly triple the level of flood protection afforded the town of Knights Landing and the adjacent agricultural areas. Area 3 levee reconstruction involves 3.4 miles of levee repair along the Knights Landing Ridge Cut and 1.3 miles of levee repair along the west bank of the Sacramento River. Mid-Valley Sites 9, 10, and 11 are being evaluated further by Yolo County through the DWR Small Communities Flood Risk Reduction Program. Funding for construction of sites 9, 10, and 11 is not allotted yet but is anticipated.	U.S. Army Corps of Engineers website. Accessed April 2, 2021. https://www.spk.usace.army.mil/Portals/12/documents/usace_project_public_notices/MidValley_FINALEAIS.pdf
System Reoperation Program	California Department of Water Resources	Completed	The Department of Water Resources is conducting a system reoperation study (SRS) to identify potential reoperation strategies for the statewide flood protection and water supply systems. The SRS includes four phases. Phase 1, Plan of Study, was completed in 2011. Phase 2, Strategy Formulation and Refinements, was completed in 2014. Phase 3, Preliminary Assessments of Strategies, is scheduled to be completed in 2015. Phase 4, Reconnaissance Level Assessments of Strategies, is scheduled to be completed in 2016.	California Department of Water Resources website. Accessed October 11, 2020. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/California-Water-Plan/Docs/RMS/2016/06_System_Reoperation_July2016.pdf
Restoration Projects				
American Basin Fish Screen and Habitat Improvement Project	U.S. Bureau of Reclamation, California Department of Fish and Wildlife, and Natomas Central Mutual Water Company	Ongoing	The U.S. Bureau of Reclamation and the California Department of Fish and Wildlife propose to authorize and provide funds to the Natomas Central Mutual Water Company (Natomas Mutual) to construct and operate the American Basin Fish Screen and Habitat Improvement Project. The purpose of the project is: (1) to avoid or minimize potentially adverse effects to fish, particularly anadromous juvenile fish, due to water diversions from the Sacramento River and Natomas Cross Canal by Natomas Mutual and other small pumps operated by individual landowners for diversion of water into the Natomas Basin created by the operation of the Natomas Mutual's water distribution facilities. The project would result in modifications of Natomas Mutual's water diversion and distribution system adjacent to the Sacramento River and Natomas Cross Canal in Sacramento and Sutter counties, California. The modifications include the construction and operation of one or two positive-barrier fish screen diversion facilities; decommissioning and removing the Verona Diversion Dam and lift pumps;	Bureau of Reclamation website. Accessed October 9, 2020. https://www.usbr.gov/mp/nepa/nepa_project_details.php?Project_ID=783

Project	Primary Agencies	Status	Description	References
			removing five pumping plants and one small private diversion; and modifying the distribution system. The project is anticipated to be implemented in three phases.	
Anadromous Fish Screen Program	U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service	Ongoing	The primary objective of the Anadromous Fish Screen Program (AFSP) is to protect juvenile Chinook salmon (all runs), steelhead, green and white sturgeon, striped bass and American shad from entrainment at priority diversions throughout the Central Valley. Section 3406 (b)(21) of the Central Valley Project Improvement Act (CVPIA) requires the Secretary of the Interior to assist the State of California in developing and implementing measures to avoid losses of juvenile anadromous fish resulting from unscreened or inadequately screened diversions on the Sacramento and San Joaquin rivers, their tributaries, the Delta, and the Suisun Marsh. Additionally, all AFSP projects meet Goal 3 of the CALFED Ecosystem Restoration Program's (ERP) Draft Stage 1 Implementation Plan.	U.S. Fish and Wildlife Service website. Accessed 10/8/20 https://www.fws.gov/cno/fisheries/cvpia/AnadromFishScreen.cfm
Cache Slough Complex Restoration	California Department of Water Resources, California Department of Fish and Wildlife	Ongoing	The Cache Slough Complex is located in the northern Delta where Cache Slough and the southern Yolo Bypass meet. It currently includes Liberty Island, Little Holland Tract, Prospect Island, Little Egbert Tract and the surrounding waterways. Levee height on these tracts is restricted and designed to allow overtopping in large flow events to convey water from the upper Yolo Bypass. Since 1983 and 1998 respectively, Little Holland Tract and Liberty Island have remained breached. Restoration is occurring naturally on the islands. Restoration in the Cache Slough Complex was identified as an Interim Delta Action by Governor Schwarzenegger in July 2007. The Cache Slough Complex has potential for restoration success because of its relatively high tidal range, historic dendritic channel network, minimal subsidence, and remnant riparian and vernal pool habitat. Restoration efforts would support native species, including delta smelt, longfin smelt, Sacramento splittail, and Chinook salmon, by creating or enhancing natural habitats and improving the food web fish require. Surrounding lands that are at elevations that would function as floodplain or marsh if not separated by levees could also be included in the Cache Slough Area. This broader area includes roughly 45,000 acres of existing and potential open water, marsh, floodplain, and riparian habitat. The goals of restoration in the Cache Slough Complex are to (1) re-establish natural ecological processes and habitats to benefit native species, (2) contribute to scientific understanding of restoration ecology, and (3) maintain or improve flood safety. Three restoration actions are being considered in the Cache Slough Complex, including restoration actions at Calhoun Cut, Little Holland Tract, and Prospect Island.	California Department of Fish and Wildlife website. Accessed October 7, 2020. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=149819&inline
Central Valley Joint Venture Program	Central Valley Joint Venture	Ongoing	The Central Valley Joint Venture (CVJV) is a self-directed coalition consisting of 22 state and federal agencies and private conservation organizations. The partnership directs their efforts toward the common goal of providing for the habitat needs of migrating and resident birds in the Central Valley of California. The CVJV was established in 1988 as a regional partnership focused on the conservation of waterfowl and wetlands under the North American Waterfowl Management Plan. It has since broadened its focus to the conservation of habitats for other birds, consistent with major national and international bird conservation plans and the North American Bird Conservation Initiative. The CVJV provides guidance and facilitates grant funding to accomplish its habitat goals and objectives. Integrated bird conservation objectives for wetland habitats in the Central Valley identified in the 2006 Implementation Plan include restoration of 19,170 acres of seasonal wetland, enhancement of 2,118 acres of seasonal wetland annually, restoration of 1,208 acres of semi-permanent wetland, and restoration of 1,500 acres of riparian habitat.	Central Valley Joint Venture web site. Site accessed October 8, 2020. http://www.centralvalleyj ointventure.org/
Contra Costa Cana Fish Screen Project	Contra Costa Water District	Completed	Contra Costa Water District diversion of water from the Sacramento-San Joaquin Delta at Rock Slough serves as a major component of its water supply. Between 120,000 and 130,000 acre-feet of water per year is diverted by the canal for irrigation and municipal and industrial uses. The diversion at Rock Slough is one of the largest unscreened Delta sites. The project would install fish screens at the Rock Slough diversion to minimize the entrainment losses of sensitive fish species. It includes flow control and transition structures necessary to reduce tidal influences and maintain flow rates. This will help the screen perform properly and allow fish to pass by it easily. Improvements at the diversion site also would reduce potential predation on target species, fulfill legal requirements of the U.S. Fish and Wildlife Service's 2008 Biological Opinion for the threatened Delta smelt, complete the mitigation for the Los Vaqueros Biological Opinion, and complete CVPIA requirements in Section 3406(b)(5). Construction is estimated to be complete in 2011.	U.S. Bureau of Reclamation website. Accessed October 12, 2020. https://www.usbr.gov/tsc/techreferences/hydraulics_lab/pubs/PAP/PAP-1067.pdf
Cypress Avenue Bridge North	Glenn-Colusa Irrigation District and Sacramento River Forum	Completed	Side Channel Habitat Restoration and Enhancement Project – Restored a side-channel to create salmon rearing habitat along 1/3 mile stretch of the Sacramento River upstream of the east end of the Cypress Avenue Bridge in Redding.	NCWA website. Accessed March 29, 2021 https://norcalwater.org/wp-content/uploads/SacValleySalmonRecoveryProgram.fulloct2018.pdf

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Ecosystem Restoration Program Conservation Strategy	California Department of Fish and Wildlife	Ongoing	The Ecosystem Restoration Program (ERP) is a multi-agency effort aimed at improving and increasing aquatic and terrestrial habitats and ecological function in the Delta and its tributaries. The ERP Focus Area (JPG) includes the Sacramento-San Joaquin Delta, Suisun Bay, the Sacramento River below Shasta Dam, the San Joaquin River below the confluence with the Merced River, and their major tributary watersheds directly connected to the Bay-Delta system below major dams and reservoirs. Principal participants overseeing the ERP are CDFW, the U. S. Fish and Wildlife Service (USFWS), and the NOAA's National Marine Fisheries Service (NMFS), collectively known as the ERP Implementing Agencies. The ERP implements restoration projects through grants administered by the ERP Grants Program. The vast majority of these projects focus on fish passage issues, species assessment, ecological processes, environmental water quality, or habitat restoration. The ERP is guided by the following six strategic goals: • Recover endangered and other at-risk species and native biotic communities; • Rehabilitate ecological processes; • Maintain or enhance harvested species populations; • Protect and restore habitats; • Prevent the establishment of and reduce impacts from non-native invasive species; and • Improve or maintain water and sediment quality.	Department of Fish and Wildlife. Ecosystem Restoration Program website. Site accessed October 8, 2020. http://www.dfg.ca.gov/ERP/
Franks Tract Project	California Department of Water Resources, Bureau of Reclamation	Ongoing	DWR and Reclamation are conducting studies to evaluate the feasibility of modifying the hydrodynamic conditions near Franks Tract to improve Delta water quality and enhance the aquatic ecosystem. The results of these studies have indicated that modifying the hydrodynamic conditions near Franks Tract may substantially reduce salinity in the Delta and protect fishery resources, including populations of delta smelt, a federally listed and State-listed species that is endemic to the Delta. As a result, DWR and Reclamation propose to implement the Franks Tract Project to improve water quality and fisheries conditions in the Delta. DWR and Reclamation are evaluating the installation of operable gates to control the flow of water at key locations (Threemile Slough and/or West False River) to reduce sea water intrusion, and to positively influence movement of fish species of concern to areas that provide favorable habitat conditions. The project gates would be operated seasonally and during certain hours of the day, depending on fisheries and tidal conditions. Boat passage facilities would be included to allow for passing of watercraft when the gates are in operation. The Franks Tract Project is consistent with ongoing planning efforts for the Delta to help balance competing uses and create a more sustainable system for the future. By protecting fish resources, this project also could improve operational reliability of the SWP and CVP because curtailments in water exports (pumping restrictions) are likely to be less frequent. Franks Tract was previously evaluated as part of DWR's Flooded Island Pre-Feasibility Study Report (DWR, 2007).	United States Bureau of Reclamation website. Accessed October 8, 2020. https://www.usbr.gov/mp/frankstract/
Fremont Weir Adult Fish Passage Modification Project	California Department of Water Resources	Completed	The existing fish ladder at Fremont Weir was widened and deepened and upstream and downstream adjoining channels were reconfigured to enhance flow through the structure and migratory fish passage. In addition, one agricultural road crossings along the Tule Canal that delayed migration was replaced, and another removed.	Bureau of Reclamation website. Accessed March 29, 2021 https://www.usbr.gov/mp/bdo/fremont-weir.html
Hamilton City Flood Damage Reduction and Ecosystem Restoration Project	U.S. Army Corps of Engineers	Phase 1 Levee Construction Complete	The Hamilton City Levee Construction and Revegetation Project is a dual-purpose flood risk management and ecosystem restoration project, which will construct approximately 6.8 miles of levee for improved flood protection and about 1,500 acres of native habitat. The new setback levee will provide improved levels of flood risk management and levee stability. The restoration work will benefit the recovery and stability of numerous federal and state-listed species and provide a more natural river function, contributing significantly to aquatic ecosystem restoration along this reach of the Sacramento River.	USACE website. Accessed March 29. 2021 https://www.spk.usace.army.mil/Missions/Civil-Works/Hamilton-City/ Sacramento River Forum website. Accessed March 29, 2021 https://www.sacramentoriver.org/forum/index.php?id=hamilton_city
Klamath Basin Restoration	California Department of Fish and Wildlife, California Natural Resources Agency	Ongoing	The Department of Fish and Wildlife and the Natural Resources Agency will continue to work with diverse stakeholders to implement the Klamath Basin restoration and settlement agreements. Those agreements include measures to improve water quality in the Klamath River, restore anadromous fish runs, including Chinook and Coho salmon, and improve water reliability for agricultural and other uses by providing a drought planning mechanism for low water years. The administration will work with Congress to secure the necessary federal	Bureau of Reclamation website. Accessed October 8, 2020. https://www.usbr.gov/mp/nepa/nepa_project_details.php?Project_ID=11710

Project	Primary Agencies	Status	Description	References
			authorizations for the agreements and secure the necessary funding for removal of four hydroelectric dams on the Klamath River and funding for the necessary basin restoration.	
Knights Landing Outfall Gates (KLOG) Fish Barrier Project	Reclamation District 108 and California Natural Resources Agency	Completed	The project installed a positive fish barrier on the downstream side of the existing Knights Landing Outfall Gates to eliminate adult salmon straying off of the Sacramento River. Rehabilitate the outfall gates by repairing known structural deficiencies (including scouring found at the inlet and outlet gates), replacing worn out appurtenances, construct a trash barrier system to protect the gates and ease debris collection, and upgrading the electrical and communication system to include backup capability to meet current USACE O&M standards This project has been identified as one of the projects that will be implemented under California EcoRestore.	NCWA website. Accessed March 29, 2021 https://norcalwater.org/wp-content/uploads/SacValleySalmonRecoveryProgram.fulloct2018.pdf U.S. Bureau of Reclamation website. Accessed March 29, 2021 https://www.usbr.gov/newsroom/newsroomold/newsrelease/detail.cfm?RecordID=50440 California Department of Natural Resources website. Accessed October 12, 2020. https://resources.ca.gov/CNRALegacyFiles/docs/ecorestore/projects/Knights_Landing_Outfall_Gate.pdf
Lake California Side Channel Reconnection Project	Reclamation District 108 and Sacramento River Forum	Completed	The project removed accumulated gravel at the inlet and reconnect and existing side channel to the Sacramento River during the low flows of late fall and early winter between river mile 269 and 270 to create rearing habitat for juvenile salmon	NCWA website. Accessed March 29, 2021 https://norcalwater.org/wp-content/uploads/SacValleySalmonRecoveryProgram.fulloct2018.pdf
Liberty Island Conservation Bank	Reclamation District 2093	Completed	This project received permits and approvals in 2009 to create a conservation bank on the northern tip of Liberty Island that would preserve, create, restore, and enhance habitat for native Delta fish species, including Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, delta smelt, and Central Valley fall- and late fall-run Chinook salmon. The project consists of creating tidal channels, perennial marsh, riparian habitat, and occasionally flooded uplands on the site. The project also includes the breaching of the northernmost east-west levee, and preservation and restoration of shaded riverine aquatic habitat along the levee shorelines of the tidal sloughs. The island's private levees failed in the 1997 flood and were not recovered, leaving all but the upper 1,000 acres and the adjacent levees permanently flooded. These upper acres encompass the proposed bank. The lower nearly 4,000 acres will remain, at least for the near future, predominantly open water and subtidal because tidal elevations are too great for marsh or riparian habitat.	Wildlands website. Accessed October 12, 2020. https://www.wildlandsinc.com/banks/liberty-island-conservation-bank-salm/
Lower American River Modified Flow Management Standard	Sacramento Water Forum	Completed	The Modified Flow Management Standard for the lower American River has the goals of protecting anadromous salmonids and avoiding catastrophic water shortages in the basin. Flows are currently released on the American River to achieve these goals.	Sacramento Water Forum website. Accessed April 2, 2021. http://www.waterforum.org/wp-content/uploads/2017/08/WF-Modified-FMS-10_8_final_Single.pdf
Lower Yolo Restoration Project	State and Federal Contractors Water Agency, California Department of Water Resources and MOA Partners	On hold	The project is located in the lower Yolo Bypass and is a tidal and seasonal salmon habitat project restoring tidal flux to about 1,100 acres of existing pastureland. The project site includes the Yolo Ranch, also known as McCormack Ranch, which was purchased in 2007 by the Westlands Water District (WWD). The goal of this project is to provide important new sources of food and shelter for a variety of native fish species at the appropriate scale in strategic locations in addition to ensuring continued or enhanced flood protection. The Lower Yolo wetlands restoration project is part of an adaptive management approach in the Delta to learn the relative benefits of different fish habitats, quantify the production and transport of food and understand how fish species take advantage of new habitat.	California Natural Resources Agency website. Accessed on October 8, 2020. https://resources.ca.gov/CNRALegacyFiles/docs/ecorestore/projects/Lower_Yolo_Restoration.pdf
Yolo Bypass Salmonid Habitat	USBR, DWR	Ongoing	This project would comply with the NMFS Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and the State Water Project (2009 Biological Opinion) Reasonable and Prudent Actions (RPAs) 1.6.1 and 1.7. RPA Action	U.S. Bureau of Reclamation website. Accessed April 2, 2021.

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Restoration and Fish Passage Project			1.6.1 requires significantly increased seasonal floodplain rearing habitat availability with biologically appropriate frequency and duration from December through April in the lower Sacramento River Basin. RPA Action 1.7 requires improved fish passage throughout the Yolo Bypass. The alternative currently being pursued would construct and operate one or more gated and/or passive diversion channels to improve the connection between the Yolo Bypass and the Sacramento River at the Fremont Weir, and including passage improvements to the Tule Canal. A draft EIR/EIS was prepared to evaluate alternatives to meet the 2009 Biological Opinion requirements. Wallace Weir, described separately, is also intended to partially satisfy RPA Action 1.7.	https://www.usbr.gov/mp/bdo/yolo-bypass.html California Department of Water Resources website. Accessed April 2, 2021. https://water.ca.gov/Programs/Environmental-Services/Restoration-Mitigation-Compliance/Yolo-Bypass-Projects
North Delta Flood Control and Ecosystem Restoration Project	California Department of Water Resources	Ongoing	The North Delta Flood Control and Ecosystem Restoration Project is proposed near the confluence of the Cosumnes and Mokelumne rivers by DWR and encompasses approximately 197 square miles. The project is intended to improve flood management and provide ecosystem benefits in the North Delta area through actions such as construction of setback levees and configuration of flood bypass areas to create quality habitat for species of concern. These actions are focused on McCormack-Williamson Tract and Staten Island. The project would implement flood control improvements in a manner that benefits aquatic and terrestrial habitats, species, and ecological processes. Flood control improvements are needed to reduce damage to land uses, infrastructure, and the Bay-Delta ecosystem resulting from overflows caused by insufficient channel capacities and catastrophic levee failures in the 197 square-mile project study area. The Project as described in the Final EIR included levee modifications to allow controlled flow across McCormack-Williamson Tract and to mitigate hydraulic impacts; channel dredging to increase flood conveyance capacity; an off-channel detention basin on Staten Island; ecosystem restoration where floodplain forests and marshes would be developed at McCormack-Williamson Tract and the Grizzly Slough property; setback levee on Staten Island to expand the floodway conveyance; opening up the southern portion of McCormack-Williamson Tract to boating; improving the Delta Meadows property; providing access and interpretive kiosks for wildlife viewing; and providing restroom, circulation, parking, and signage infrastructure to support such uses (DWR, 2010).	California Department of Water Resources website. Accessed October 7, 2020. https://water.ca.gov/Programs/Flood-Management/Delta-Conveyance-And-Flood-Protection/North-Delta-Program California Natural Resources Agency website. Accessed October 8, 2020. https://bondaccountability.resources.ca.gov/Project.aspx?ProjectPK=8461&PropositionPK=5
Painter's Riffle Anadromous Fish Habitat Enhancement Project	Glenn-Colusa Irrigation District	Completed	The project reopened Painter's Riffle, a historic Sacramento River salmonid spawning side channel in Redding by moving more than 8,000 cubic yards of gravel.	NCWA website. Accessed March 29, 2021 https://norcalwater.org/wp-content/uploads/SacValleySalmonRecoveryProgram.fulloct2018.pdf Glenn-Colusa Irrigation District website. Accessed March 29, 2021 https://www.gcid.net/painters-riffle-project
Red Bluff Diversion Dam Fish Passage Project	U.S. Bureau of Reclamation and Tehama Colusa Canal Authority	Completed	The project modifies the Red Bluff Diversion Dam to reduce or minimize impacts on migration of anadromous fish and improve the reliability of agricultural water supply in the Tehama-Colusa and Corning Canal systems. The project includes a new pumping plant and fish screen with a pumping capacity of 2,500 cubic feet per second (cfs). The initial installed pumping capacity is 2,000 cfs. There is no increase in water diversions above 2,500 cfs. The original diversion dam is currently in the decommissioning process.	Tehama Colusa Canal Authority website. Accessed October 12, 2020. https://www.tccanal.com/RBDD-Bro-Spring2013_pages.pdf
Restoring Ecosystem Integrity in the Northwest Delta	California Department of Fish and Wildlife	Completed	This project proposes to acquire conservation easements within the Cache Slough complex, along the Barker, Lindsey and Calhoun Sloughs, north Delta tidal channels located west of the Yolo Bypass. Acquisition of conservation easements will be on 1,100 acres of existing riparian, wetland and/or agricultural lands. Currently in the process of acquiring an agricultural easement on 292 acres. Manage and restore up to 1,300 acres of perennial grassland/vernal pool complex in Solano County, CA, and develop a management plan for the Pembco property or other acquisition within the Jepson Prairie Preserve Island Corridor.	EcoAtlas website. Accessed 10/11/20 https://www.ecoatlas.org/regions/adminregion/delta/projects/5876
Upper Sacramento River Anadromous Fish Habitat Restoration Project(s)-	California Bureau of Reclamation, Glenn-Colusa Irrigation District	Completed	The Upper Sacramento River Anadromous Fish Habitat Restoration Project is located at multiple sites along the Sacramento River, including: Market Street, Gravel Placement Project, Turtle Bay Side Channel Project, Sand Slough Side Channel Enhancement Project, Anderson River Park Side Channels Project, Reading Island Side Channel Project, Lake California Side Channel Project, and Keswick Gravel Injections. Between 2012 and 2021, restoration projects have been conducted and include the addition of 20,000 tons of spawning gravel to the river just below Keswick Dam, the construction of constructing up to four additional perennial side channels on the island with associated placement of instream habitat structure to provide juvenile salmonid rearing and spawning habitat, the	Sacramento River Forum website. Accessed March 29, 2021 https://www.sacramentoriver.org/forum/index.php?id=channels U.S. Bureau of Reclamation website. Accessed March 29. 2021/

Project	Primary Agencies	Status	Description	References
			enhancement of an existing constructed side channel to improve its performance as juvenile salmonid rearing habitat, the modification of an existing side channel to provide suitable flows for juvenile salmon throughout the year, the creation of 11,500 linear feet of suitable perennial habitat for salmon of all age classes (including endangered winter-run Chinook), steelhead and trout, and the establishment of .95 miles of perennially flowing side channels along the Sacramento River to provide rearing habitat for juvenile Chinook salmon.	https://www.usbr.gov/mp/nepa/nepa_project_details.php?Project_ID=23758 Reclamation District 108 website. Accessed March 29, 2021 https://www.rd108.org/market-street-gravel-project/ Sacramento Valley Ecological Restoration website. Accessed March 29, 2021. http://www.saverfoundation.org/sand-slough/#:~:text=The%20Sand%20Slough%20Side%20Channel,River%20in%20Tehama%20County%2C%20California. NCWA website. Accessed March 29, 2021 https://norcalwater.org/wp-content/uploads/SacValleySalmonRecoveryProgram.fulloct2018.pdf
Upper Sacramento River Salmon Rearing Habitat Project	River Garden Farms	Completed	Installed 25 juvenile salmon shelter structures, consisting of tree trunks and root wads bolted to limestone boulders installed in the Sacramento River near Redding.	Sacramento River Forum website. Accessed April 2, 2021. https://www.sacramentoriver.org/forum/index.php?id=channels
Wallace Weir Fish Rescue Facility Project	Reclamation District 108	Completed	Constructed a permanent weir with a positive fish barrier and fish collection facility in the Yolo Bypass to prevent adult salmon from straying into the Colusa Basin Drain and to facilitate relocation of adult salmon that have strayed into the Yolo Bypass.	California Eco Restore website. Accessed April 2, 2021. https://resources.ca.gov/CNRALegacyFiles/docs/ecorestore/projects/Wallace_Weir_Modification.pdf
Infrastructure and Development Projects				
Alternative Intake Project	Contra Costa Water District, U.S. Bureau of Reclamation and California Department of Water Resources	Completed	The Alternative Intake Project was completed in 2010. The project located a new drinking water intake at Victoria Canal, about 2.5 miles east of Contra Costa Water District's (CCWD) existing intake on the Old River, which allows CCWD to divert higher quality water when it is available. The new screened intake includes a 2.5-mile pipeline extension and a new pumping plant that ties into CCWD's existing conveyance system. The new intake has the same capacity and similar design as the existing Old River intake (250 cubic feet of water per second).	U.S. Bureau of Reclamation website. Accessed October 12, 2020. https://www.usbr.gov/mp/nepa/nepa_project_details.php?Project_ID=1818.
Colusa Generating Station	California Energy Commission	Ongoing	The CGS is fueled by natural gas delivered to the site via an 8 inch, 1,500-foot pipeline owned and operated by PG&E. Water for the project is provided by the Glenn-Colusa Irrigation District (GCID) via the Tehama-Colusa Canal (TCC), which is located to the west of the project site. The project uses a Zero Liquid Discharge wastewater system. Air emissions from the facility are controlled using Best Available Control Technology with air pollution credits obtained from the Colusa County Air Pollution Control District. The facility is interconnected to the nearby existing electrical infrastructure owned by PG&E. The electrical switchyard and transmission facilities allow delivery of the power plant's output to PG&E's existing Cottonwood to Vaca-Dixon 230-kilovolt (kV) transmission corridor located approximately 1,800 feet east of the project site.	California Energy Commission website. Accessed March 29, 2021. https://ww2.energy.ca.gov/sitingcases/colusa/
Contra Costa Canal Replacement Project	Contra Costa Water District	Ongoing	Contra Costa Water District's Canal Replacement Project will replace the canal with a pipeline along a portion of the 48-mile Contra Costa Canal near Oakley. The first phase was initiated in 2009. The project would encase a 1,900-foot portion of the Contra Costa Canal	California Natural Resources Agency website. Accessed October 8, 2020. http://bondaccountability.resources.ca.go

Project	Primary Agencies	Status	Description	References
			to reduce salinity and water quality impacts of groundwater seepage from adjacent agricultural areas, as well as to increase public safety and flood protection. Contra Costa Water District will be initiating plans for the remaining sections.	v/Project.aspx?ProjectPK=9461&PropositionPK=4
Davis-Woodland Water Supply Project	Davis, Woodland, and University of California, Davis	Completed	The Davis-Woodland Water Supply Project would divert up to about 46,100 acre-feet per year of surface water from the Sacramento River and convey it for treatment and subsequent use in Davis and Woodland and on the University of California, Davis campus. The purposes of the project are to provide a reliable water supply to meet existing and future needs, improve water quality for drinking supply purposes, and improve treated wastewater effluent quality through 2040. Project activities would include construction and operation of a water intake/diversion, conveyance, and water treatment facilities. Surface water supplies would be acquired through new water rights and water rights transfers from senior water rights holders. The Project would be located in the east-central portion of Yolo County, between and within the cities of Woodland and Davis, the University of California, Davis campus, and west of the Sacramento River. The new water diversion facility would be constructed on the Sacramento River near the Interstate 5 crossing at the location of the existing Reclamation District 2035 diversion. The water treatment plant to treat the surface water diverted from the Sacramento River would have an ultimate capacity of up to 106 millions of gallons per day (MGD). Water diversions under the project would be made in compliance with Standard Water Right Permit Term 91, which prohibits surface water diversions when water is being released from CVP or SWP storage reservoirs to meet in-basin entitlements, including water quality and environmental standards for protection of the Sacramento-San Joaquin Delta. Water supply needs during periods applicable to Term 91 would be satisfied by entering into water supply transfer agreements with senior water rights holders within the Sacramento River watershed.	Woodland-Davis Clean Water Agency website. Accessed October 12, 2020. https://www.wdcwa.com/project-overview
Delta Conveyance	California Department of Water Resources and U.S. Army Corps of Engineers	Ongoing	Delta conveyance refers to State Water Project (SWP) infrastructure in the vast network of waterways comprising the Sacramento-San Joaquin Delta (Delta) that collects and moves fresh affordable water to homes, farms and businesses throughout major regions of the state from the Bay Area to southern California. The Department of Water Resources (DWR) is the owner and operator of the SWP and is responsible for all associated upgrades and maintenance, including the proposed Delta Conveyance Project that will modernize SWP conveyance. The Project would add new diversions in the north Delta to promote a more resilient and flexible SWP in the face of unstable future conditions.	Department of Water Resources Website. Access October 8, 2020. https://water.ca.gov/deltaconveyance
El Dorado Supplemental Water Rights Project	El Dorado Water & Power Authority	Ongoing	The El Dorado Water & Power Authority (EDWPA) proposes to establish permitted water rights allowing diversion of water from the American River basin to meet planned future water demands in the El Dorado Irrigation District (EID) and Georgetown Divide Public Utility District service areas, and other areas located within El Dorado County that are outside of these service areas. The EDWPA filed petitions for partial assignment of each of State Filed Applications 5644 and 5645, and accompanying applications allowing for the total withdrawal for use of 40,000 acre-feet per year, consistent with the diversion and storage locations allowed under the El Dorado-Sacramento Municipal Utility District Cooperation Agreement with the SWRCB, Division of Water Rights.	CEQA Net website. Accessed October 7, 2020. https://ceqanet.opr.ca.gov/2008102090
Folsom Lake Temperature Control Device	El Dorado Irrigation District, Bureau of Reclamation	Ongoing	The EID, in collaboration with Reclamation, proposes to construct facilities on the bank of Folsom Lake to withdraw water from the warm upper reaches of the lake while preserving the cold water pool at the bottom of the lake to protect downstream aquatic species. The facilities will include a large diameter concrete-lined vertical shaft and five lined horizontal adits extending from the shaft. This structure, known as a Temperature Control Device, will replace EID's five existing raw pump casings that currently extract water from Folsom Lake. The new facility will be sized to accommodate over twice the current capacity.	El Dorado Irrigation District website. Access October 7, 2020. https://www.eid.org/about-us/project-updates/folsom-lake-intake-project
Lake Natoma Lower American River Temperature Reduction Project (formerly known as the Lake Natoma Temperature Curtains Pilot Project)	USFWS, Bureau of Reclamation, Sacramento Water Forum	Unknown	The USFWS, Reclamation, and Sacramento Water Forum are proposing the Lower American River Temperature Reduction Modeling Project. The objective of the project is to develop predictive tools that will (1) reduce uncertainties in the performance of identified temperature control actions that could be implemented to improve the management of cold water resources in the Folsom/Natoma reservoir system and the lower American River, and (2) be available for daily operations, planning, and salmon and steelhead habitat studies by other project operators and other stakeholders. The project adapted, calibrated, and verified existing thermodynamic and hydrologic mathematical models for application at Folsom Reservoir, Lake Natoma and the lower American River. The models were used to assess the effectiveness of the identified actions individually and in combination and develop a recommendation for development and implementation of one or more actions for the purpose of reducing temperatures in the lower American River. The actions identified to improve transport of cold water through Lake	Bureau of Reclamation website. Accessed October 7, 2020. https://www.flow3d.com/wp-content/uploads/2014/08/Temperature-Modeling-of-Folsom-Lake-Lake-Natoma-and-the-Lower-American-River.pdf

Project	Primary Agencies	Status	Description	References
			Natoma and reduce the temperature of the lower American River included a Nimbus Dam curtain, a Lake Natoma plunge zone curtain, Nimbus power plant debris wall removal, dredging Lake Natoma, and modifying Folsom Power plant peak loading operation.	
Los Vaqueros Reservoir Expansion Phase II	Bureau of Reclamation	Ongoing	Los Vaqueros Reservoir is an off-stream reservoir in the Kellogg Creek watershed to the west of the Delta. The Los Vaqueros Reservoir initial construction was completed in 1997 as a 100,000 acre-foot off- stream storage reservoir owned and operated by Contra Costa Water District (CCWD) to improve delivered water quality and emergency storage reliability for CCWD's customers. In 2012, the Los Vaqueros Reservoir was expanded to a total storage capacity of 160,000 acre-feet (Phase 1) to provide additional water quality and supply reliability benefits, and to adjust the timing of its Delta water diversions to accommodate the life cycles of Delta aquatic species, thus reducing species impact and providing a net benefit to the Delta environment. An additional expansion up to 275,000 acre-feet. (Phase 2) is being evaluated by CCWD. The alternatives considered in the evaluation also consider methods to convey water from Los Vaqueros Reservoir to the South Bay Aqueduct to provide water to Zone 7 Water Agency, Alameda County Water District, and Santa Clara Valley Water District (Reclamation et. al., 2010).	Contra Costa Water District website. Accessed October 7, 2020. https://www.ccwater.com/993/Project-Documents Bureau of Reclamation website. Accessed October 7, 2020. https://www.usbr.gov/newsroom/newsrelease/detail.cfm?RecordID=69643
Maxwell Intertie Project	U.S. Department of Agriculture and Sites Project Authority	Approved	The overall purpose of the proposed Project is to increase the efficiency and reliability of water management in the western Sacramento Valley by adding to or improving existing facilities to facilitate greater flexibility in water conveyance, which would increase the drought resistance of rural communities. Rural development in California has frequently been limited by the availability and reliability of water to support the existing economic engines and the people of rural California. While rural water supplies appear to be plentiful, they are reliant on aging single-purpose water management facilities and winter storm precipitation. Water shortages during droughts and regulatory constraints on the operations of the Tehama-Colusa (TC) Canal and the Glenn Colusa Irrigation District (GCID) Main Canal have decreased the reliability of the water supplies to rural agencies in the Sacramento Valley and affected Central Valley Project deliveries. Some individual Tehama Colusa Canal Authority (TCCA) member districts have independently explored potential conveyance points between the GCID canal system and individual TCCA landowners and/or individual TCCA district facilities. The proposed Project comprehensively addresses this need and facilitates the flexibility of water conveyance to improve the resiliency of participants during dry years. The Maxwell Water Intertie (MWI) pipeline would connect existing canal systems west of the Sacramento River (the GCID Main Canal and the TC Canal) to achieve this flexibility. The proposed project is comprised of a set of new project features or facilities that would allow for the efficient bi-directional exchange of water from two existing, large water management systems in the western portion of the Sacramento Valley of California. The project features included: A 1,200-acre-foot capacity Terminal Regulating Reservoir (TRR) covering 130 acres with a spillway to the local irrigation ditch system and bottom drain, both of which ultimately connect to Funks Creek; TRR Pumping Plant with a 900-cfs maximum pumping capacity, a 1-acre Electrical Switchyard adjacent to the plant, and a 3.5-mile power line; a GCID Main Canal Connection to TRR including a gated inlet control structure, short inlet channel, and concrete canal lining in the GCID Main Canal immediately upstream and downstream of the TRR connection; a 3.5-mile MWI pipeline sized for 900 cfs pumped capacity and 900 cfs gravity flow capacity, private access bridge over the GCID Main Canal for construction access and maintenance of the pipelines, and a 2.7-mile gravel access road that would run most of the length of the MWI pipeline alignment. The approved project included the granting of a loan from the USDA to assist in the financing of the Maxwell Water Intertie Project.	
North Bay Aqueduct Alternative Intake	Solano County Water Agency	On hold	DWR issued a Notice of Preparation on December 2, 2009 to construct and operate an alternative intake on the Sacramento River, generally upstream of the Sacramento Regional Wastewater Treatment Plant, and connect it to the existing North Bay Aqueduct system by a new segment of pipe. The proposed alternative intake would be operated in conjunction with the existing North Bay Aqueduct Alternative Intake at Barker Slough. The project would be designed to improve water quality and to provide reliable deliveries of SWP supplies to its contractors, the Solano County Water Agency, and the Napa County Flood Control and Water Conservation District (DWR, 2011).	Sonoma County Water Agency website. Accessed October 7, 2020. https://www.scwa2.com/wp-content/uploads/2020/01/NBA-Funding-Flyer.pdf Delta Stewardship Council website. Accessed October 7, 2020. https://viewperformance.deltacouncil.ca.gov/pm/north-bay-aqueduct#:~:text=The%20North%20Bay%20Aqueduct%20Alternate%20Intake%20Pr

Project	Primary Agencies	Status	Description	References
				oject%20(NBA%20AIP)%20will,Slough%20 (existing%20intake%20location).
North Delta Flow Action	California Department of Water Resources, U.S. Bureau of Reclamation	Ongoing	In fall 2019 agricultural flows will be directed into Yolo Bypass for up to a month. The action is designed to generate a modest, seasonal positive flow pulse (e.g., 24 TAF) through the Yolo Bypass, but will be well below levels that would result in local flooding. The goal of the action is to support the Delta food web in downstream areas. By routing agricultural drain water through Yolo Bypass instead of the Sacramento River, DWR scientists predicted that a flush of plankton-rich water would provide a "seed" for the downstream Delta, enhancing food resources for Delta Smelt.	Bay Delta Live website. Accessed October 8, 2020. https://www.baydeltalive.com/assets/5c92b61032e1bfd2c6a30d4ee74773aa/application/pdf/North_Delta_Food_Web_Study_Fact_Sheet_06272019.pdf
Pacheco Reservoir /San Luis Reservoir Low Point Improvement Project	Bureau of Reclamation, Santa Clara Valley Water District, San Luis and Delta Mendota Water Authority	Ongoing	Reclamation and DWR jointly manage San Luis Reservoir for the purpose of storing and reregulating CVP and SWP water from the Sacramento-San Joaquin Delta. San Luis Reservoir is an offstream water storage facility that stores water for both projects. The San Luis Reservoir Low Point Improvement Project is proposed by Reclamation, the Santa Clara Valley Water District, and the San Luis and Delta Mendota Water Authority. The project is designed to address water supply reliability issues in San Luis Reservoir that result when water levels fall below 369 feet above sea level (corresponding to a reservoir capacity of 300,000 acre-feet) and create water quality degradation that has the potential to interrupt a portion of the San Felipe Division's water supply. The term "low point" refers to a range of minimum pool elevations in San Luis Reservoir. During the late summer months if the reservoir elevation drops below 369 feet above sea level, the conditions in San Luis Reservoir promote the growth of algae in the reservoir. The water quality during the algal blooms is not suitable for agricultural water users with drip irrigation systems in San Benito County or municipal and industrial water users relying on existing water treatment facilities in Santa Clara County. The low point issue increases progressively as the reservoir continues to drop below elevation 369 feet. The comprehensive plan would involve increasing groundwater recharge and recovery capacity, implementing desalination measures, re-operating Santa Clara Valley Water District's raw- and treated- water systems, and implementing institutional measures. If Pacheco Reservoir were to be enlarged, the reservoir would be filled with Delta water; thus, additional impacts on Delta aquatic species (e.g., juvenile salmonids and delta smelt) could result from an increase in Delta exports.	United States Bureau of Reclamation website. Accessed October 7, 2020. https://www.usbr.gov/mp/sllpp/
B.F. Sisk Dam Raise and Reservoir Expansion Project/San Luis Reservoir Expansion (includes dam safety modifications)	U.S. Bureau of Reclamation and San Luis & Delta-Mendota Water Authority	Ongoing	Reclamation and DWR jointly manage San Luis Reservoir for the purpose of storing and reregulating CVP and SWP water from the Sacramento-San Joaquin Delta. San Luis Reservoir is an offstream water storage facility that stores water for both projects. This project would add 10-feet to the crest of B.F. Sisk Dam while implementing dam safety modifications. The additional space would be used to store water that could be delivered to south-of-Delta water contractors and wildlife refuges. This water would be used to meet existing contractual obligations and not serve any new demands. The additional 10 feet of dam embankment could add approximately 130,000 AF of water storage to San Luis reservoir. Final EIR/EIS was released in December 2020. If Pacheco Reservoir were to be enlarged (see project above), the reservoir would be filled with Delta water; thus, additional impacts on Delta aquatic species (e.g., juvenile salmonids and delta smelt) could result from an increase in Delta exports.	Bureau of Reclamation website. Accessed October 9, 2020. https://www.usbr.gov/mp/sllpp/docs/2013-11-19-draft-san-luis-expansion-appraisal-report.pdf And https://www.usbr.gov/newsroom/newsroomold/newsrelease/detail.cfm?RecordID=73366 Accessed April 13, 2021 And Final EIR/EIS: https://www.usbr.gov/mp/nepa/nepa_project_details.php?Project_ID=44425 Accessed April 13, 2021
Shasta Lake Water Resources Investigation	Bureau of Reclamation	Ongoing	The Shasta Lake Water Resources Investigation is currently being conducted by Reclamation to determine the type and extent of federal interest in a multiple purpose plan to modify Shasta Dam and Reservoir to increase the survival of anadromous fish populations in the upper Sacramento River and increase water supplies and water supply reliability for agricultural, municipal, industrial, and environmental purposes. To the extent possible through meeting these objectives, alternatives include features to benefit other identified water and related resource needs including ecosystem conservation and enhancement, improved hydropower generation capability, flood damage reduction, increased recreation opportunities, and improved water quality conditions in the Sacramento River and the Delta. Anticipated	United States Bureau of Reclamation website. Accessed October 7, 2020. https://www.usbr.gov/mp/ncao/shasta-lake.html U.S. Bureau of Reclamation website. Accessed 10/11/20.

Project	Primary Agencies	Status	Description	References
			alternatives for expansion of Shasta Lake include, among other features, raising the dam from 6.5 to 18.5 feet above current elevation, which would result in additional storage capacity of 256,000 to 634,000 acre-feet, respectively. The increased capacity is expected to improve water supply reliability and increase the cold water pool, which would provide improved water temperature conditions for anadromous fish in the Sacramento River downstream of the dam. The final EIS and Feasibility Study for the project were completed in July/August 2015	https://www.usbr.gov/mp/nepa/nepa_project_details.php?Project_ID=1915
South Delta Temporary Barriers Project	California Department of Water Resources	Ongoing	The South Delta Temporary Barriers Project, initiated as a test project in 1991, was developed partially in response to a 1982 lawsuit filed by the South Delta Water Agency. The South Delta Temporary Barriers Project consists of four rock barriers across South Delta channels. The objectives of the project are to increase water levels, improve water circulation patterns and water quality in the southern Delta for local agricultural diversions, and improve operational flexibility of the State Water Project to help reduce fishery impacts and improve fishery conditions. Of the four rock barriers, the barrier at the head of Old River serves as a fish barrier (intended to primarily benefit migrating San Joaquin River Chinook salmon) and is installed and operated in April-May and again in September-November. The remaining three barriers (Old River at Tracy, Grant Line Canal, Middle River) serve as agricultural barriers (intended to primarily benefit agricultural water users in the south Delta) and are installed and operated between April 15 and November 30 of each season. In 2008, a court order designed to protect delta smelt prohibited the installation of the spring Head of Old River (HOR) barrier pending fishery agency actions or further order of the court. The remaining three barriers serve as agricultural barriers and are installed between April 15 and September 30 of each season. An experimental underwater, non-physical barrier was installed in 2009. The channel will be open to navigation.	California Department of Water Resources website. Accessed October 8, 2020. https://water.ca.gov/Programs/Bay-Delta/Water-Quality-And-Supply/South-Delta-Temporary-Barriers-Project CEQA Net website. Accessed October 9, 2020. https://ceqanet.opr.ca.gov/2000112054/12
South Willows Residential Development	City of Willows	Ongoing	The 143.4-acre project site is located in the southern portion of the City of Willows, Glen County, California, south of the Glenn-Colusa Irrigation Canal (GCIC), east of Interstate 5 and west of California State Route 99 (Tehama Street). The site is bounded on the south by agricultural land that is currently approved for commercial uses (South Willows Commercial Industrial Center). The Project would subdivide the 143.4-acre subject property into 419 single-family residential lots, one multiple-family lot, a neighborhood park site, several "open space" parcels, and a pedestrian-only bridge over the GCIC. Residential lots would range in size from 6,000 square feet to 15,117 square feet; the multiple-family lot would occupy an 8.1-acre parcel, arranged around the 3.7-acre neighborhood park and set back from Interstate 5, Tehama Street, and the California Northern Railroad transportation corridors and the South Willows Commercial Industrial development to the south. The open space parcels would be graded to accommodate storm and nuisance water runoff. An eight-foot tall, 3,125-foot long sound wall would be constructed along the western boundary of the residential subdivision to shield residences from Interstate-generated noise. Construction is anticipated to occur between 2021 and 2028.	City of Willows website. Accessed May 28, 2021. https://www.cityofwillows.org/assets/resources/South-Willows-Residential-2020-Initial-Study-FINAL-dec-1-2020-BASIN-Amended-Project.pdf
Wal-Mart	City of Willows	Completed	The project built a Walmart Supercenter at 470 N. Airport Road, Willows. The Supercenter contains a grocery component of about 45,951 square feet, and a Tire and Lube Express, as well as a garden center of approximately 14,479 square feet (including 9,581 square feet of hard-fenced outdoor garden center). The use also includes outdoor sales as well as a seasonal sales area in a portion of the parking lot. Along the front of the Supercenter will be series of small internal "shops" occupying a total floor area of approximately 10,499 square feet. Some of these spaces will be occupied by Wal-Mart services such as optical and pharmacy, while others will be leased to non-Wal-Mart vendors and service providers (e.g., bank, hair salon, dry cleaners, etc.), although vendors have not been identified. The Supercenter will also include sales of alcohol (for off-site consumption). The new Supercenter will be open 24 hours per day, seven days per week. Through a lot line adjustment, two separate parcels or "pad sites" will be configured along Wood Street (State Route 162) at the very front of the Supercenter site. These two parcels are designed to provide for a single fast-food restaurant with drive-through window, and a fuel station. The fuel station will have 12 fueling positions located in the southwest corner of the site near the Wood Street/North Airport Avenue intersection. The fuel station is anticipated to be constructed concurrently with, or very shortly after, the Wal-Mart. The entire project site is zoned "CG General Commercial with a PD Overlay.	City of Willows Website. Accessed May 28, 2021. ttps://www.cityofwillows.org/assets/resources/Willows-Walmart-Project-FEIR-Final-Environmental-Impact-Report.pdf CEQAnet Website. Accessed May 28, 2021. https://ceqanet.opr.ca.gov/2004062128/4
Upper San Joaquin River Basin Storage Investigation (Formerly	Bureau of Reclamation	Ongoing	The Upper San Joaquin River Basin Storage Investigation (Formerly Temperance Flat Dam and the Bay-Delta Conservation Plan, formerly the Peripheral Canal) is being conducted by Reclamation and DWR to evaluate alternative plans to increase Upper San Joaquin River Storage to enhance the San Joaquin River restoration efforts and improve water supply reliability for agricultural, municipal and industrial, and environmental uses in the Friant Division, the San Joaquin Valley, and other regions of the state. The investigation will also	United States Bureau of Reclamation website. Accessed October 7, 2020. https://www.usbr.gov/mp/sccao/storage/

Project	Primary Agencies	Status	Description	References
Temperance Flat Dam)			evaluate integration of conjunctive management and water transfer concepts into project formulations. Additional storage is also expected to provide incidental flood damage reduction benefits. Reclamation is analyzing alternatives for a new dam and a 1.26 million acre-foot reservoir at San Joaquin River Mile 274, in an area known as Temperance Flat. Primary planning objectives are to (1) increase water supply reliability, and (2) enhance flow and temperature conditions to support the San Joaquin River Restoration Program. To the extent possible, the investigation will explore opportunities to provide other benefits that could include hydropower, flood control, and recreation. Operation variables include reservoir carryover, new or shifting water supply beneficiaries, and alternative conveyance routes. Operations alternatives evaluated in the draft Feasibility Report will be selected from combinations that most economically accomplish the planning objectives.	
San Joaquin River Restoration Project	U.S. Bureau of Reclamation and California Department of Water Resources	Completed	The U.S. Bureau of Reclamation (Reclamation) is temporarily changing Friant Dam operations in Water Year 2010 to release Water Year 2010 Interim Flows from Friant Dam into the San Joaquin River and potentially downstream as far as the Sacramento-San Joaquin River Delta (Delta), as specified in the Stipulation of Settlement (Settlement) in NRDC et al. v. Kirk Rodgers et al., and as part of the San Joaquin River Restoration Project. The Water Year 2010 releases could be recaptured by existing water diversion facilities along the San Joaquin River and/or in the Delta. Interim Flows would be constrained by existing channel capacity, anticipated seepage, future agreements with downstream agencies, entities, and landowners, and the capacity of diversions, as well as water supply demand at the possible diversion locations. The purpose of the Water Year 2010 Interim Flows Project is to implement provisions of the Settlement related to Interim Flows and to collect relevant data to guide future releases of Interim Flows and Restoration Flows under the SJRRP. The full restoration flow schedule will be implemented no later than January 2014. See description of San Joaquin River Restoration Program.	U.S. Bureau of Reclamation website. Accessed October 12, 2020. https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=4403
Other Projects				
Bay-Delta Water Quality Control Plan Update	State Water Resources Control Board	Ongoing	The State Water Board is updating the 2006 Bay-Delta Water Quality Control Plan (Bay-Delta Plan). The Bay-Delta Plan is being updated through two separate processes (Plan amendments). First, on December 12, 2018, through State Water Board Resolution No. 2018-0059, the State Water Board adopted the Plan amendments and Final SED establishing the Lower San Joaquin River flow objectives and revised southern Delta salinity objectives. On February 25, 2019, the Office of Administrative Law approved the Plan amendments, which are now in effect. Second, the State Water Board is also considering Plan amendments focused on the Sacramento River and its tributaries, Delta eastside tributaries (including the Calaveras, Cosumnes, and Mokelumne rivers), Delta outflows, and interior Delta flows.	California Water Boards website. Accessed October 8, 2020. https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/
Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project Biological Opinion	U.S. Bureau of Reclamation	Ongoing	This Record of Decision (ROD or Decision) approves Reclamation's preferred alternative, Alternative 1, to better integrate ESA compliance actions and water supply operations through an operational plan that improves Reclamation's flexibility to manage the CVP, and best meets the authorized Project purposes. Reclamation's Decision includes a significant commitment to improved coordinated operations with DWR to meet ESA requirements for Delta Smelt, North American green sturgeon, California Central Valley steelhead, Central Valley spring-run Chinook salmon and Sacramento winter-run Chinook salmon and their habitat (collectively, "listed species"), as well as other fish and wildlife species in the project area. This Decision is expected to modernize Reclamation's operations by integrating real-time monitoring and real-time operations to enhance operations. It better reflects the complexity of the Projects where Reclamation operators must address multi-purpose uses, multi-species' needs, and multi-year actions, while complying with federal and state obligations, including coordination with DWR. Reclamation's sound, scientifically-based approach should benefit both ecosystem needs and water supply, including commitments to ESA compliance actions to meet the needs of threatened and endangered species. Based on prior spending by Reclamation, DWR and water users, these measures entail an estimated $1.5 billion expenditure, with an anticipated $15 million annually for real-time monitoring.	Bureau of Reclamation website. Accessed October 27, 2020. https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=42324
Incidental Take Permit for Long-Term Operation of the State Water Project in the	California Department of Water Resources	Ongoing	The California Department of Fish and Wildlife (CDFW) issued an Incidental Take Permit (ITP) to the Department of Water Resources (DWR) for long-term operations of the State Water Project (SWP). The permit covers four species protected under the California Endangered Species Act: Delta smelt, longfin smelt, winter-run Chinook salmon and spring-run Chinook salmon.	CDFW web site. Accessed: May 27, 2021. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/State-Water-Project/Files/ITP-for-Long-Term-SWP-Operations.pdf?la=en&hash=AE5FF28E0CB9

Project	Primary Agencies	Status	Description	References
Sacramento-San Joaquin Delta				FA5DC67EF1D6367C66C5FF1B8B55

31.3 Cumulative Impacts Analysis by Resource

The potential for Project implementation to result in a cumulatively considerable incremental contribution was determined for each resource based on the associated thresholds of significance (or evaluation criteria for NEPA-only resources), as described in Chapters 5 through 30. To reduce any cumulatively considerable incremental contributions from the Project, feasible mitigation measures are proposed for all potentially substantial adverse direct and indirect effects. In some cases, no feasible mitigation could be applied to reduce effects and the cumulative effects are considered to be significant and unavoidable.

Not all of the projects included in Table 31-1 may have been considered within the cumulative assessment for each resource analyzed below. The projects were first reviewed to determine if they could have an impact on a specific resource being evaluated. If so, these projects were considered in the cumulative analysis for a particular resource. As such, the cumulative impact analysis varies between resources and by geographic area. For example, the list of cumulative projects identified for the cultural resources assessment may be different than the list developed for the water quality assessment, as each of the projects selected have common impact mechanisms that would result in an impact on cultural resources or water quality, but not both. Each resource below identifies the projects in Table 31-1 that are relevant to the resource-specific cumulative analysis.

31.3.1. Surface Water Resources and Water Quality

To Be Completed After Group 3 Deliverable and/or Authority and Reclamation Review of Chapter Received– Discussion Is Only Related to Flooding

The cumulative geographic scope for flood control and management resources includes local drainages associated with the Sites Reservoir (e.g., Funks, Stone Corral, and Hunters Creeks), as well as downstream waterbodies such as the Sacramento River, Yolo Bypass, and Delta. Engineered drainage canals (i.e., TC Canal, GCID Main Canal, and CBD) are also included. These areas are included for potential construction and operation impacts described for these in Chapter 5. Projects from Table 31-1 that are included in the geographic scope include flood control projects (e.g., CALFED Levee System Integrity Program, Delta Levees Flood Protection Program, Sacramento River Bank Protection Project [SRBPP]) and restoration projects (e.g., Ecosystem Restoration Program [ERP], Hamilton City Flood Damage Reduction and Ecosystem Restoration Project) that have the potential to affect flood control and management resources in local drainages, along the Sacramento River, and in the Delta. As described in Chapter 5, other watercourses and flood storage facilities associated with northern California's water delivery and flood management infrastructure are not considered with respect to flooding. Based on the various modeling results available for the Project, these areas are unlikely to include substantial increases in flow or storage that would increase likelihood of flooding.

31.3.1.1. *Alternatives 1, 2, and 3 - Flooding*

Construction and operation would not result in an incremental contribution on flood control and management resources because effects would be minimal when considered in the broader flood control regime. Construction and operation of Alternative 1, 2, or 3 would not substantially increase the rate or amount of surface runoff in a manner which would result in onsite or offsite flooding. Streamflow present in Funks or Stone Corral Creeks would be contained behind coffer dams and localized flooding in these creeks would be avoided during construction. Streamflow in the channels associated with construction of the South Road (under Alternative 2 only) would be contained in a similar manner. Equipment used during construction activities in mapped 100-year floodplains would not increase the rate or amount of surface runoff in a manner which would result in onsite or offsite flooding. Project facility design and BMPs would identify design flows and incorporate measures to provide for drainage feature stability; incorporate appropriate relocation plans (for canals, ditches, wells, and other existing infrastructure); and incorporate other modifications to localized runoff amounts and/or patterns. Any necessary site features or procedures to remediate Project-induced drainage problems identified in the drainage evaluations would be installed before the Project was completed or as part of Alternative 1, 2 or 3, depending on site-specific conditions.

Commented [CC6]: Would there be bypass of the flow into Funks and Stone Corral Creeks or how exactly would flooding be avoided if the flow is contained behind coffer dams? Doesn't damming of the flow imply flooding?

Operation of Alternative 1, 2, or 3 would not significantly change the overall volume of water in the Sacramento River, and would therefore not contribute to onsite or offsite flooding. A flood protection benefit would also be provided for the areas downstream of Sites Reservoir in the Stone Corral Creek and Funks Creek watersheds (including the community of Maxwell) by reducing the size of the floodplain in the region.

Construction and operation of Alternative 1, 2, or 3 would not impede or redirect flood flows. The main and saddle dams would be designed and constructed pursuant to required guidelines and criteria designed to prevent dam failure. The designs would incorporate multiple lines of defense or design redundancy as required to meet design standards. In addition, an Emergency Action Plan would be prepared and submitted to the Governor's Office of Emergency Services for Project construction and operation.

With respect to emergency releases, Sites Reservoir would be designed to release flows into downstream waterbodies (i.e., Hunters Creek, Stone Corral Creek, and Funks Creek). Emergency releases would have the potential to occur only during years of very heavy precipitation when the Sites Reservoir is already at capacity and a localized storm in the Sites Reservoir watershed creates a significant rise in the reservoir's water surface. The risk of an event requiring such an emergency release remains very small because inflow is controlled through pumping. Water diversions to Sites Reservoir would not occur once the reservoir reaches a certain stage and additional precipitation events are forecasted to occur. Further, should water diversions continue in a highly unlikely scenario, the Authority would be able to prepare for any necessary flood warnings to the public downstream of the reservoir per the Emergency Action Plan.

Commented [CC7]: Specifically, what is the probability? What is the analysis showing?

Reservoir releases to the CBD would be controlled by operations and would not inundate existing agricultural fields adjacent to the CBD through overtopping, seepage, or reverse flows.

No flooding in the CBD area is anticipated as a result of Project operation. Reservoir releases potentially could be directed to the Yolo Bypass instead of the Sacramento River from August through October.

The types of projects that could result in cumulative impacts related to flood control and management resources are those that involve large-scale modifications to existing drainages. Most projects in Table 31-1 have not resulted in cumulatively considerable impacts on flood control and management resources because many have served to reduce the existing flood risk. Localized onsite or offsite stormwater runoff may have occurred or could occur during construction of projects that require soil disturbance. Implementation of standard BMPs (e.g., SWPPP) for other projects would reduce these types of localized effects. Furthermore, localized effects would be separated both spatially (e.g., projects would not always abut one another) and temporally (e.g., projects would have different construction periods).

Commented [CC8]: Analysis is needed to assess potential flood risk caused by releasing water through the Yolo Bypass considering rice field drainage needs and conveyance capacity.

Alternative 1, 2, or 3 would not result in a cumulative contribution to flood control and management resources. Therefore, Alternative 1, 2, or 3 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on this resource. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.1.2. Alternatives 1, 2, and 3 – Water Supply

Discussion to be completed

31.3.1.3. Alternatives 1, 2 and 3 – Water Quality

Discussion to be completed.

31.3.2. Fluvial Geomorphology

The cumulative geographic scope for fluvial geomorphologic resources includes local drainages associated with the Sites Reservoir (e.g., Funks, Stone Corral, and Hunters Creeks), as well as downstream waterbodies of the larger Sacramento River Watershed, such as the Sacramento River, Yolo Bypass, and Delta. Engineered drainage canals (i.e., TC Canal, GCID Main Canal, and CBD) are also included. These areas are included for potential construction and operation impacts described in Chapter 7. Projects from Table 31-1 that are included in this study area include flood control projects (e.g., CALFED Levee System Integrity Program, Delta Levees Flood Protection Program, SRBPP) and restoration projects (e.g., ERP, Hamilton City Flood Damage Reduction and Ecosystem Restoration Project) that have the potential to affect fluvial geomorphology.

31.3.2.1. Alternatives 1 and 3

Construction and operation would not result in an incremental contribution on fluvial geomorphology because most effects would be limited to the Project footprint, other similar projects do not occur in the vicinity, or effects would be minimal when considered in the broader fluvial geomorphologic regime of the drainages.

Construction and operation of Alternative 1 or 3 would not substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river or through the addition of impervious surfaces, in a manner which would result in a substantial increase or decrease in onsite or offsite erosion or siltation. Where appropriate (i.e., depending on slope, soil type) the implementation of BMPs for erosion and sediment control would prevent increased soil erosion and sedimentation rates. The addition of impervious surfaces would not substantially alter the existing drainage patterns of a site or area because of the limited area of impervious surfaces and the ability of the surrounding open area to infiltrate precipitation.

Construction and operation of Alternative 1 or 3 would not substantially alter natural river geomorphic processes on the Sacramento River or substantially alter geomorphic processes upstream or downstream of the dam structures on Funks and Stone Corral Creeks. The overall volume of water available and the pattern of water diversion in the Sacramento River (and therefore in the canals, Yolo Bypass, and Delta) would generally be similar to the amount and pattern of water diversion under existing conditions.

Commented [C9]: Please, cite the documentation that supports this statement. See, CDFW's comments in chapter 7, regarding Sites' assessment of project fluvial geomorphic impacts.

The types of projects that could result in cumulative impacts related to fluvial geomorphology are those that involve large-scale modifications to existing drainages. Most projects in Table 31-1 have not resulted in cumulatively considerable impacts on fluvial geomorphology because many have served to reduce the existing flood risk and to restore geomorphic processes (i.e., excessive scour) and associated channel and floodplain habitat. Furthermore, these projects may result in localized changes to channel processes in the immediate proximity of the Project; however, they have limited ability to result in substantial changes to the overall Sacramento River system over its entire geography or over time.

Commented [C10]: Supporting documentation is needed to support these statements. Fluvial geomorphic impacts occur over periods of years and many of the projects listed in Table 31-1 are either ongoing or have yet to start. It is inaccurate to state that these projects will have a limited ability to result in substantial changes, when there is not enough evidence yet to make that determination. Additionally, there is no analysis provided in this document that supports the conclusions made in this section.

Alternative 1 or 3 would not result in a cumulative contribution to fluvial geomorphology. Therefore, Alternative 1 or 3 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on this resource. Impacts would not be cumulatively considerable and impacts would be less than significant.

Commented [C11]: There does not appear to be any analysis quantitative or qualitative that supports this conclusion. The project appears to be just simply stating that there will be no cumulative impacts to fluvial geomorphology, without providing any supporting argument.

31.3.2.2. Alternative 2

The cumulative impacts associated with the construction and operation of Alternative 2 would be the same as those described above for Alternative 1 or 3 because the new facilities and construction footprints would be located in the same study area, would generally be the same size, and would generally affect the same drainages.

The Sacramento River discharge and the South Road, which are part of Alternative 2 only, would not result in an incremental contribution on fluvial geomorphology. The Sacramento River discharge would be located in an area on the river that has no current evidence of historical meandering. This area is also closely bordered by levees with extensive revetment and its lateral channel evolution is limited. The South Road would be located across multiple drainages in steep areas and would be more prone to accelerated erosion and sedimentation. BMPs would address potential increased erosion and siltation rates as a result of drainage pattern manipulation.

Alternative 2 would not result in a cumulative contribution to fluvial geomorphology. Therefore, Alternative 2 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on this resource. Impacts would not be cumulatively considerable and impacts would be less than significant.

Commented [C12]: CDFW's comments above, for Alternatives 1 and 3, also apply here to Alternative 2.

31.3.3. Groundwater Resources

Commented [C13]: Please, review CDFW's comments in chapter 8.

The cumulative geographic scope for groundwater resources consists of the groundwater basins and subbasins that could be directly affected by construction and operation of Project facilities: Funks Creek groundwater basin; Antelope Creek groundwater basin; and the Red Bluff, Colusa, and Yolo Subbasins of the Sacramento Valley Groundwater Basin. Projects from Table 31-1 that could affect these groundwater basins include the Davis-Woodland Water Supply Project to reduce reliance on groundwater. In addition, current and continuing plans identified in Appendix 4A, such as general plans and groundwater management plans (GWMPs), could affect groundwater basins in the geographic scope by either using groundwater or replenishing groundwater basins.

31.3.3.1. Alternatives 1 and 3

Alternative 1 or 3 would not result in an incremental contribution on groundwater resources because during construction and operation the groundwater quality would be maintained and not degraded. Groundwater degradation from contaminants during dewatering and other construction activities would be unlikely due to depth to the groundwater aquifer in the study area and the implementation of BMPs. Groundwater degradation would not occur as a result of operations because Sacramento River fresh water be used to fill the reservoir. In addition, due to the saline density of the Salt Pond, saline water would stay near the bottom of the reservoir where it would mix with fresh water close to the Golden Gate Dam. This fresh water would dilute the saline water column and improve water quality.

Alternative 1 or 3 would not result in an incremental contribution on groundwater resources because during construction and operation the groundwater levels would either be maintained or not substantially reduced. Construction groundwater use would be less than 15% of the 2018 groundwater pumped for total groundwater use within Antelope and Funks Creek Basins (Table 8-2). Over time, the water used during construction would be replaced through groundwater recharge. Modeling has shown little to no effect on existing groundwater recharge due to diversions. Inundation in previously unsaturated areas would result in higher groundwater in the shallow aquifer along the western margins of the Colusa Subbasin (in the immediate vicinity of the Sites Reservoir). Groundwater levels and recharge potential would slightly increase under Alternatives 1 and 3. Overall, Alternative 1 or 3 would not result in a measurable change in the availability of groundwater resources.

Alternative 1 or 3 would not result in an incremental contribution on groundwater resources because neither would conflict with or obstruct implementation of a sustainable groundwater management plan. Operations would not affect groundwater levels, flows, or water quality so they would not impede or conflict with the overarching Sustainable Groundwater Management Act goals. Operation would improve water supply and reliability by creating additional surface water storage to be used by SWP and CVP contractors. This increased water storage aligns with existing county Groundwater Management Plans and Basin Management Objectives, and with likely goals in counties' future Groundwater Sustainability Plans; it would lower dependency on groundwater pumping for crop irrigation in the Sacramento Valley and the San Joaquin Valley.

Sacramento Valley groundwater subbasins have experienced historical groundwater level declines and recoveries as a result of past hydrologic conditions (e.g., droughts and wet years), urban and municipal development and agricultural cultivation. Currently, the Colusa Subbasin and Yolo Subbasin are identified as high priority basins for water quality or groundwater levels (Appendix 8A, *Groundwater Resources Basin Setting*). Projects in Table 31-1 and plans identified in Appendix 4A would both continue to use groundwater supplies and would also reverse some of the groundwater quality and quantity reduction that has occurred in the Sacramento Valley.

Alternative 1 or 3 would not result in a cumulative contribution to groundwater resources because they would not result in a substantial measurable change in the availability of groundwater resources. Therefore, Alternative 1 or 3 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on groundwater resources. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.3.2. Alternative 2

The cumulative impacts associated with the construction and operation of Alternative 2 would be the same as those described above for Alternative 1 or 3 because the new facilities and construction footprints would be located in the same study area and would affect the same groundwater subbasins. Alternative 2 would not result in a cumulative contribution to groundwater. Therefore, Alternative 2 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on groundwater. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.4. Vegetation and Wetland Resources

To Be Completed After Group 3 Deliverable and/or Authority and Reclamation Review of Chapter Received

31.3.5. Wildlife Resources

To Be Completed After Group 3 Deliverable and/or Authority and Reclamation Review of Chapter Received

31.3.6. Aquatic Biological Resources

To Be Completed After Group 3 Deliverable and/or Authority and Reclamation Review of Chapter Received

31.3.7. Geology and Soils

The cumulative geographic scope for geology and soils consists of the Project footprint and adjacent areas that could be directly affected by construction and operation of Project facilities. These areas are included for potential construction and operation impacts. Projects from Table 31-1 that are included in this study area are those that involve large-scale excavation or construction of structures and have the potential to be affected by seismic events, ground failure, or soil issues or that could affect paleontological resources. These projects include the Maxwell Intertie Project and the Folsom Dam Safety and Flood Damage Reduction Joint Federal Project because they would require large-scale excavation and would build structures that could fail during a seismic event. The types of projects that could result in a cumulative impact related to geologic and soils hazards are those that involve large-scale excavation or construction of structures. Projects from Table 31-1 that could contribute to a cumulative geologic impact include infrastructure and development projects such as the Davis-Woodland Water Supply Project, the Delta Conveyance Project, and the B.F. Sisk Dam Raise and Reservoir Expansion Project/San Luis Reservoir Expansion. The types of projects that could result in a cumulative impact related to paleontological resources are those that involve large-scale excavation. Projects from Table 31-1 that could contribute to a cumulative impact on paleontological resources include flood control projects, such as the SRBPP; restoration projects, such as the Hamilton City Flood Damage Reduction and Ecosystem Restoration Project and the North Delta Flood Control and Ecosystem Restoration Project; and infrastructure and development projects, such as the Contra Costa Canal Replacement Project, and the Delta Conveyance Project.

31.3.7.1. Alternatives 1 and 3

Alternatives 1 and 3 facilities would be constructed in a seismically active region and in areas of steep terrain. These facilities could be subject to surface fault rupture, strong ground motion, ground failure, landsliding, reservoir-triggered seismicity (RTS), and soils issues. The Project would be designed to address these geologic conditions (e.g., per the California Building Standards Code and the seismic design criteria of Reclamation and/or DSOD), and therefore impacts related to geology and soils would be less than significant.

In some locations, excavation has the potential to disturb paleontological resources, and therefore Mitigation Measures GEO 7.1–GEO-7.5 have been developed to reduce impacts on paleontological resources to a less-than-significant level for most locations. However, for TRR East, where cement deep soil mixing would occur, the impact would remain significant and unavoidable.

Alternative 1 or 3 would not result in an incremental contribution related to geology and soils because most effects would be limited to the construction footprint or other similar projects do not occur in the vicinity. Alternative 1 or 3 would not result in an incremental contribution on paleontological resources because impacts would be limited to the construction footprint and mitigation measures would be in place to preserve discovered fossils. Most seismic and ground failure hazards, such as landslides and liquefaction, would affect the construction footprint and a limited area around the footprint and other projects would not overlap in location. Soil impacts caused by erosion and expansive soils and paleontological resource impacts would also be limited to the construction footprint. Therefore, these impacts would not contribute to a cumulative impact. Where seismic hazards could result in the failure or overtopping of a feature, such as dams and pipelines, other similar projects do not occur in the vicinity and therefore the failure would not combine with other projects to contribute to a cumulative impact.

Alternative 1 or 3 would not result in a cumulative contribution to geology, soils, or paleontological resources. Therefore, Alternative 1 or 3 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on these resources. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.7.2. Alternative 2

The cumulative impacts associated with the construction and operation of Alternative 2 would be the same as those described above for Alternative 1 or 3 because most new facilities and construction footprints would be mostly located in the same study area and would generally be the same size. The South Road, TRR West, and Sacramento River discharge would also be in the same general location and seismic and geologic setting. Alternative 2 would not result in a cumulative contribution to geology, soils, or paleontological resources. Therefore, Alternative 2 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on these resources. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.8. Minerals

The cumulative geographic scope for mineral resources consists of the mineral resources available for construction and operation of Project facilities in Tehama, Glenn, Colusa, Yolo, and Sutter Counties and where facilities would be located in Tehama, Glenn, Colusa, and Yolo Counties. Mineral resources include natural gas, aggregate (i.e., gravel and sand), and borrow (i.e., mixture of sand, silt, and clay). Projects from Table 31-1 that could affect mineral resources include all projects that involve constructing residential and commercial development, public facilities, or infrastructure that would require aggregate or borrow, including: Maxwell Intertie Project, South Willows Residential Development, Wal-Mart in the city of Willows, and Delta Conveyance Project. In addition, current and continuing plans identified in Appendix 4A, such as general plans that plan for urban development that may require aggregate or borrow during construction, could affect mineral resources.

31.3.8.1. Alternatives 1 and 3

Construction and operation of Alternative 1 or 3 would not result in an incremental contribution on mineral resources. Most effects would be limited to the construction footprint where there are a lack of natural gas fields, natural gas wells, or other mineral sources. In addition, if natural gas was found in the affected area it would not be permanently lost as a result of construction or operation of Alternative 1 or 3 because the natural gas fields would be accessible from the immediately adjacent area. There are sufficient aggregate resources in the region to support the construction and operation of Alternative 1 or 3 without affecting aggregate availability for other projects in the geographic scope (Table 13-2).

Projects identified in Table 31-1 and in Appendix 4A may use mineral resources as a result of constructing infrastructure or be located in an area that might preclude the future development of mineral resources. The different timing of the construction of various projects would relate to when the projects might affect mineral resources. Even if affected on other project sites, natural gas wells can be relocated and natural gas fields can be accessed from a considerable distance by directional drilling, thereby avoiding or reducing any potential impact. Known aggregate resources in the region are sufficient to meet demands for many decades and can provide materials for the projects identified in Table 31-1 (Table 13-2; Clinkenbeard and Gius 2018). County general plans also address natural gas and aggregate mineral resources and access to them, as well as their management and use. The goals and policies generally preserve access to and use of these known natural gas and mineral resources to the extent possible while balancing other environmental, economic, and development needs. The timing of construction, location of the other projects relative to existing mineral resources, and type of facilities to be installed that would require the use of mineral resource have not resulted in a cumulatively considerable condition for mineral resources.

Alternative 1 or 3 would not result in a cumulative contribution to mineral resources. Therefore, Alternative 1 or 3 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on this resource. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.8.2. Alternative 2

The cumulative impacts associated with the construction and operation of Alternative 2 would be the same as those described above for Alternative 1 or 3 because the new facilities and construction footprints would be located in the same study area, would generally be the same size, and would generally require the same type of mineral resources. Alternative 2 would not result in a cumulative contribution to mineral resources. Therefore, Alternative 2 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on mineral resources. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.9. Land Use

The cumulative geographic scope for land use consists of the three counties where new Project facilities would be constructed: Colusa, Glenn, and Yolo Counties. Projects in Table 31-1 that are part of this study area are Colusa Generating Station and the Maxwell Intertie Project. Land use planning documents (e.g., county general plans) identified in Appendix 4A are also included in this cumulative impact analysis.

31.3.9.1. Alternatives 1 and 3

Construction and operation of Alternative 1 or 3 would not result in an incremental contribution on land use or divide an established community. Construction and operation of Alternative 1 or 3 would not conflict with the Yolo County or Glenn County land use plans, policies, or regulations adopted for the purpose of avoiding or mitigating an environmental effect because there are none relevant to the facilities located in these particular counties. Construction and operation of

Alternative 1 or 3 would be consistent with Colusa County land use plans, policies, and regulations adopted for the purpose of supporting the construction and operation of Sites Reservoir. The Authority would work with the Counties of Glenn and Colusa to modify or amend general plans and/or zoning ordinances to bring lands into consistency with designated land uses and zoning. Privately owned parcels surround the inundation area in Glenn and Colusa Counties and are mainly designated as foothill agriculture with supporting zoning. These parcels are primarily rural residential development, grazing, non-developed foothill space. Surrounding land uses are not expected to conflict with Alternative 1 or 3 because surrounding land uses would continue to exist as they currently do with implementation of these alternatives. Through the existing zoning and land use designations any future development would be highly restricted and would ultimately require zoning or land use designation changes reviewed and approved by local governments. If any future change to surrounding land uses occurred, they would be evaluated at that time by local governments to determine if conflicts would occur.

Projects identified in Table 31-1 and in Appendix 4A have resulted in or would potentially result in land use designation or zoning changes consistent with various plans and policies of local jurisdictions. The local jurisdiction would be responsible for determining consistency and amending general plans or zoning to allow for the project. The Maxwell Intertie Project included facilities that are the same as Alternative 1 or 3 and therefore would not result in additional impacts beyond those already disclosed for Alternative 1 or 3.

Alternative 1 or 3 would not result in a cumulative contribution to land use. Therefore, Alternative 1 or 3 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on this resource. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.9.2. Alternative 2

Construction and operation of Alternative 2 with respect to land use would be similar to Alternatives 1 and 3 but would result in the physical division of established communities. There would be a physical division for the community of Lodoga, even though the South Road would be constructed under Alternative 2 and would connect Lodoga to Maxwell. This would result in an incremental contribution related to the division of an established community. There are no projects in Table 31-1 or plans in Appendix 4A that would result in dividing an established community in the Antelope Valley or immediate proximity. Therefore, there is not a cumulatively considerable contribution.

Alternative 2 would result in a cumulative contribution by dividing an established community. Alternative 2 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on this resource because there are no other cumulative projects that would result in this type of impact. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.10. Agriculture and Forestry

To Be Completed After Group 3 Deliverable and/or Authority and Reclamation Review of Chapter Received

31.3.11. Recreation Resources

The cumulative geographic scope for recreation resources includes the Project inundation area and construction footprint of the associated facilities. The study area also encompasses the following areas where recreation resources could be affected by Project operation:

- regional SWP and CVP reservoirs (i.e., Shasta Lake, Lake Oroville, Folsom Lake, San Luis Reservoir)
- rivers downstream of SWP and CVP reservoirs
- recreational facilities or areas in the region, such as the Sutter and Yolo Bypasses or wildlife areas and wildlife refuges, that receive water from SWP or CVP facilities

Projects in Table 31-1 located in the study area include those infrastructure or restoration projects along rivers used for recreation (e.g., Sacramento River) and those projects that have developed recreational amenities for the public, including:

- Oroville Facilities Relicensing
- Cache Slough Complex Restoration
- Central Valley Joint Venture Program,
- Ecosystem Restoration Program
- Davis-Woodland Water Supply Project
- Delta Conveyance Project
- Los Vaqueros Reservoir Expansion Phase II
- Maxwell Intertie Project
- Pacheco Reservoir/San Luis Reservoir Low Point Improvement Project
- B.F. Sisk Dam Raise and Reservoir Expansion Project/San Luis Reservoir Expansion
- Shasta Lake Water Resources Investigation
- Bay-Delta Water Quality Control Plan Update
- Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project Biological Opinion
- Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and the State Water Project Incidental Take Permit

31.3.11.1. Alternatives 1 and 3

Construction and operation of Alternative 1 or 3 would not result in an incremental contribution to cumulative impacts on recreation resources because either recreational resources are lacking or changes would be imperceptible to recreational users. Construction of Alternative 1 or 3 would not increase use of existing neighborhood and regional parks or other recreational facilities that would result in new or accelerated substantial physical deterioration of those facilities. Construction would primarily occur in areas that are not used for recreation. Operation of Alternative 1 or 3 is anticipated to result in operational changes at the regional SWP and CVP reservoirs and the rivers below them. These changes are not expected to be perceptible to recreational users and would not increase recreationist use of these reservoirs or increase use at recreational facilities (e.g., boat ramps, campgrounds) associated with these reservoirs and rivers because the hydrologic changes attributable to the operation of the Project are small. These changes, when combined with other projects, are not expected to be of the scale or duration which would adversely affected recreation opportunities within the cumulative impact study area.

The past construction and current operation of multiple projects in Table 31-1 have provided reservoir and river recreational amenities to the public. Construction of future infrastructure and restoration projects (e.g., Delta Conveyance Project, Los Vaqueros Reservoir Expansion Phase II, B.F. Sisk Dam Raise and Reservoir Expansion Project/San Luis Reservoir Expansion) would occur in different geographies of the river and reservoir system of California and in different timeframes for variable durations. Potentially recreational resources or amenities could be affected in a highly localized manner that would generally cease when construction is complete. The Maxwell Intertie Project included facilities that are the same as Alternative 1 or 3 and therefore would not result in an additional impact beyond those already disclosed for Alternative 1 or 3.

Alternative 1 or 3 would not result in a cumulative contribution to recreation. Therefore, Alternative 1 or 3 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on recreation resources. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.11.2. Alternative 2

The cumulative impacts associated with the construction and operation of Alternative 2 would be the same as those described above for Alternative 1 or 3 because the new facilities and construction footprints would be located in the same study area and would generally be the same size. The South Road and the Sacramento River discharge, which are part of Alternative 2 only, would not result in an incremental contribution on recreation resources. The South Road is located in an area with no public recreational amenities. The Sacramento River discharge would temporarily construction a coffer dam in the river that would not prohibit the use of the river by recreationists. Alternative 2 would not result in a cumulative contribution to recreation. Therefore, Alternative 2 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on this resource. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.12. Energy

To Be Completed After Group 3 Deliverable and/or Authority and Reclamation Review of Chapter Received

31.3.13. Navigation, Transportation and Traffic

To Be Completed After Group 3 Deliverable and/or Authority and Reclamation Review of Chapter Received

31.3.14. Noise

The cumulative geographic scope for noise consists of the locations in Tehama, Glenn, Colusa, and Yolo Counties where Project construction and operations would occur. Projects in Table 31-1 that are within the study area and in proximity to Project facilities include Colusa Generating Station, Maxwell Intertie Project, South Willows Residential Development, Wal-Mart in the city of Willows, and Hamilton City Flood Damage Reduction and Ecosystem Restoration Project.

31.3.14.1. Alternatives 1 and 3

Noise levels from construction activities for Alternative 1 or 3 are unlikely to coincide with noise from heavy equipment used for other projects because the study area consists primarily of agricultural use and undeveloped areas where no future use is planned. Levee and flood control projects and development projects could include use of haul trucks and earthmoving equipment in the vicinity of Alternatives 1 and 3, but those projects are either complete (i.e., temporary disturbance is done), or noise levels from the associated equipment are unlikely to combine except potentially for a brief amount of time. The Maxwell Intertie Project included facilities that are the same as Alternative 1 or 3 and therefore would not result in an additional impact beyond those already disclosed for Alternative 1 or 3. The South Willows Residential Development could overlap with GCID Main Canal improvements at the railroad siphon location if construction occurs between 2021 and 2028. However, the South Willows Residential Development and the GCID Main Canal improvements would follow required noise controlling measures, including construction during appropriate times. As such, there would be no incremental contribution from Alternative 1 or 3 and no cumulative impact.

With regard to the potential for cumulative vibration-related impacts, impacts from ground-borne vibration are generally determined by the individual piece of equipment generating the highest vibration levels. Vibration is only noticeable within a localized area around the vibration-generating equipment. Because of the localized effects of vibration, instantaneous peak vibration levels would not cumulatively combine to a level higher than the maximum peak particle velocity level from Alternative 1 or 3. As described in Chapter 19, according to modeling, vibration from the project would not be noticeable at the nearest receptors.

Alternative 1 or 3 would not result in a cumulative effect regarding noise or vibration. Therefore, Alternative 1 or 3 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on this resource. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.14.2. Alternative 2

The cumulative impacts associated with the construction and operation of Alternative 2 would be the same as those described above for Alternative 1 or 3 because the project facilities and footprints would be located in the same study area and would generally be the same size. The South Road and Sacramento River discharge, which are part of Alternative 2 only, would not result in an incremental contribution. The South Road is located in an area with limited or no sensitive noise receptors. The Sacramento River discharge would include construction of a temporary coffer dam in the Sacramento River that would produce noise and vibration above ambient levels for a limited amount of time, but this would not combine with other projects. Alternative 2 would not result in a cumulative contribution to noise. Therefore, Alternative 2 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on this resource. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.15. Air Quality

To Be Completed After Group 3 Deliverable and/or Authority and Reclamation Review of Chapter Received

31.3.16. Greenhouse Gas Emissions

To Be Completed After Group 3 Deliverable and/or Authority and Reclamation Review of Chapter Received

31.3.17. Cultural Resources

To Be Completed After Group 3 Deliverable and/or Authority and Reclamation Review of Chapter Received

31.3.18. Tribal Cultural Resources

The cumulative geographic scope for tribal cultural resources consists of areas of Colusa, Glenn, Tehama, and Yolo Counties, including waterbodies, that could be affected by Project construction or operations. The projects from Table 31-1 that occur in the cumulative analysis study area are not identified as affecting related tribal cultural resources or are not in proximity to the facilities.

31.3.18.1. Alternatives 1, 2, and 3

Construction of the reservoir and new facilities under Alternatives 1, 2, and 3 would result in disturbance or destruction of tribal cultural resources, but modifications to existing Sacramento River diversion facilities and conveyances to regulating reservoirs would have no impact because these facilities are already in place. Although there would significant and unavoidable impacts under Alternatives 1, 2, and 3, because there are no projects identified in Table 31-1 as affecting related tribal cultural resources, there would be no cumulatively considerable impact and impacts would be less than significant.

31.3.19. Visual Resources

The cumulative geographic scope for visual resources consists of Colusa, Glenn, and Yolo Counties because aboveground Project facilities would be located in these counties. Tehama County is not included because the sole Project activity occurring in that county is the installation of two new pumps in an existing facility, which would not affect visual resources. Projects in Table 31-1 would not be located in the same vicinity as aboveground facilities at the Sites Reservoir and conveyance complex and therefore could not be seen together with aboveground facilities. The South Willows Residential Development in Glenn County would be in proximity to GCID system upgrades and is considered. Restoration and flood control projects along the Sacramento River are also considered because the Sacramento River discharge would be constructed and operated under Alternative 2.

31.3.19.1. Alternatives 1 and 3

The construction of Alternatives 1 and 3 would result in a significant and unavoidable impact to the visual character and quality of Antelope Valley as a result of the inundation of the valley. This effect would be highly localized to the valley itself. Once the reservoir is operational it would create new visual character and quality associated with a surface reservoir in a rural foothill setting. The views would be typical of other California reservoirs, with surface water meeting land surface and the presence of "bath tub rings" of exposed soil when the reservoir is drawn down. Projects identified Table 31-1 would not be located in the same vicinity as Antelope Valley and therefore would have no ability to contribute to a cumulative effect. Although there would be significant and unavoidable impacts under Alternatives 1 and 3, because there are no projects identified in Table 31-1 as affecting related visual resources, there would be no cumulatively considerable impact on visual character and quality and impacts would be less than significant. Similarly, there are no projects in Table 31-1 in the vicinity of Antelope Valley that would contribute to light and glare. Therefore, Alternatives 1 and 3 would not result in a cumulatively considerable impact as a result of creating light and glare and impacts would be less than significant.

Alternatives 1 and 3 would result in less than significant impacts on the visual character and quality of existing areas around the GCID system upgrades in Glenn County. These upgrades would occur in the GCID Main Canal and would result in temporary disturbance of agricultural areas around the canal due to construction laydown areas and bypasses. Once construction is over, temporary areas would be restored. The GCID system upgrades, specifically those at the railroad siphon, would occur both temporally and spatially close to the South Willows Residential Development. However, because the GCID system upgrades would take place in the existing canal and the visual effects associated with construction would be temporary, Alternatives 1 and 3, in conjunction with the South Willows Residential Development would not result in an incremental contribution on visual resources.

Alternative 1 or 3 would not result in a cumulative contribution to visual resources. Therefore, Alternative 1 or 3 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on visual resources. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.19.2. Alternative 2

The cumulative impacts associated with the construction and operation of all common facilities for Alternative 2, including those associated with the Sites Reservoir and conveyance complex and GCID system upgrades, would be the same as described above for Alternative 1 or 3.

The Sacramento River discharge would be located in the Colusa to Verona reach of the river between River Miles 100 and 101. This reach is mostly confined by levees and the location of the Sacramento River discharge shows no evidence of historical meandering. The river channel in this general area is closely bordered by levees with extensive revetment, and lateral channel evolution is limited. Related past, present, and reasonably foreseeable future flood and restoration projects along the Sacramento River have altered the visual character and quality of the river. Levee projects sometimes necessitate the removal of mature vegetation to construct projects and require that levee slopes be maintained free of woody vegetation in perpetuity, resulting in the loss of a highly valued regional aesthetic landscape component. The mature vegetation along the levees is characteristic of the region and is a striking, distinctive element in the landscape. The existing vegetation that is removed is most often be replaced with herbaceous vegetation. Maintaining the levees devoid of the characteristic riparian vegetation and mature landscaping and replacing it with grass and potentially rock would highly degrade the visual character and quality of the area and increase glare. Restoration projects (e.g., Restoring Ecosystem Integrity in the Northwest Delta, Upper Sacramento River Anadromous Fish Habitat Restoration Project[s]) and some levee projects (e.g., Hamilton City Flood Damage Reduction and Ecosystem Restoration Project) involve replanting trees, restoring habitat, and installing setback levees to return the Sacramento River to a more natural meander setting. These types of projects serve to reduce visual impacts of levee projects. Alternative 2 would result in significant impacts to the visual character and quality of the Sacramento River due to the Sacramento River discharge structure. This would not be an incremental contribution to a cumulative impact on the visual character and quality because this stretch of the river has not experienced historical meander and is primarily levees. In addition, much of the eastern levee does not have riparian vegetation and is currently vegetated with grasses. Therefore, the removal of riparian vegetation along this small segment along the western bank of the river would not appear out of context.

Alternative 2 would not result in a cumulative contribution to visual resources. Therefore, Alternative 2 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on this resource. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.20. Population and Housing

The cumulative geographic scope for population and housing consists of Colusa, Glenn, and Yolo Counties because Project facilities would be located in these counties. Tehama County is not included in the study area because the sole Project activity occurring in that county is the installation of two new pumps in an existing facility, which would not affect population or housing in that county. Projects from Table 31-1 that are included in the cumulative analysis study area are those that involve construction or development because they have the potential to bring additional workers into the counties and create a need for additional housing. These projects include flood control projects, such as the DWR Small Communities Flood Risk Reduction Program; restoration projects, such as Cypress Avenue Bridge North, Hamilton City Flood Damage Reduction and Ecosystem Restoration Project, and the Knights Landing Outfall Gates (KLOG) Fish Barrier Project; and infrastructure and development projects, such as the Colusa Generating Station, and South Willows Residential Development.

31.3.20.1. Alternatives 1 and 3

Construction and operation of Alternative 1 or 3 would not result in an incremental contribution to cumulative impacts on population and housing because construction and operation of Alternative 1 or 3 would not result in unplanned population growth. The estimated construction labor force would be relatively small because most workers are anticipated to commute from the surrounding areas and are not expected to permanently relocate to the study area. Operation of Alternative 1 or 3 would not result in substantial unplanned population growth because existing roads are being realigned to continue current connectivity. Similarly, the projects identified in Table 31-1 that would occur in the cumulative analysis study area would not increase its population because overall they would require a relatively small work force. Those projects would not cause unplanned population growth because they would not create new major roads or other infrastructure that would induce population growth, and the new residential development would help to meet existing housing needs.

Construction of the Sites Reservoir for Alternatives 1 and 3 would permanently displace the residents of the unincorporated community of Sites. The projects identified in Table 31-1 would not permanently displace the residents of Antelope Valley or any other location and therefore would not combine with Alternative 1 or 3 to contribute to a cumulative impact.

Alternative 1 or 3 would not result in a cumulative contribution to population and housing. Therefore, Alternative 1 or 3 when combined with other past, present, and reasonably foreseeable future projects, would not have a significant cumulative impact on population and housing. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.20.2. Alternative 2

Construction and operation impacts under Alternative 2 would be the same as described above for Alternatives 1 and 3. The number of construction workers would be approximately the same between Alternative 1 or 3 and Alternative 2, even considering construction and operation of TRR West in place of TRR East and the Huffmaster Road realignment/South Road alignment rather than construction of a new bridge across the reservoir.

Alternative 2 would not result in a cumulative contribution to population and housing. Therefore, Alternative 2 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on this resource. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.21. Public Services and Utilities

The cumulative geographic scope for public services and utilities consists of areas of Glenn and Colusa Counties that could be affected by Project construction or operations. Tehama and Yolo Counties are not included in the study area because the areas where Project construction and operation would occur lack existing public services and utilities (i.e., the Project is unlikely to affect them). Projects from Table 31-1 that are considered in the cumulative impact analysis include the Sacramento River Flood Control System Evaluation (Phase III Mid-Valley Sites), Cypress Avenue Bridge North, Hamilton City Flood Damage Reduction and Ecosystem Restoration Project, KLOG Fish Barrier Project, Colusa Generating Station, and South Willows Residential Development. General plan goals and policies identified in Appendix 4A could also affect public services and utilities in the cumulative geographic scope.

31.3.21.1. Alternatives 1 and 3

Construction and operation of Alternative 1 or 3 would not result in an incremental contribution to cumulative impacts on requiring the construction of new governmental facilities or on acceptable service ratios, response times, or other performance objectives for fire protection, police services, or schools. Emergency services and response times, as well as school bus routes, would be maintained during construction through the use of existing roads and BMPs (e.g., TMPs) and no new or altered governmental facilities would be required. Operation of Alternative 1 or 3 is expected to increase the need for emergency response services. The Authority would implement the Recreation Management Plan and coordinate with the county and local emergency service providers to ensure that appropriate resources (e.g., funding, equipment) are available to respond to the potential increase in demand. The projects in Table 31-1 would be required to adhere to the same regulations regarding emergency services and coordinate with the county and local emergency service providers. The residential development was found to have no impact or less than significant impact on all services except water mains to maintain adequate fire flows, for which mitigation measures were developed to reduce the impact to less than significant.

If permanent employees relocate to Maxwell and there is an increase in school-age children in the Maxwell Unified School District, the Authority would work with the Maxwell Unified School District to utilize classrooms at existing schools to accommodate an increase in school-age children. Most projects identified in Table 31-1 are primarily construction projects and would not affect schools. The residential development was found to have no impact or less than significant impact on all services and would not occur within the Maxwell School District.

Construction and operation of Alternatives 1 and 3 would not require or result in the relocation or construction of new or expanded water, wastewater treatment or stormwater drainage, electric power, natural gas, or telecommunications facilities. Potential issues with relocation of existing infrastructure would be resolved prior to the commencement of construction activities, and features such as Comm Road South would allow for the continued access to existing utilities. During operation and maintenance activities under Alternative 1 or 3, the collection of stormwater would be similar to that under existing conditions and it would be routed to existing receiving waters, as well as Sites Reservoir. Most projects identified in Table 31-1 would not require new infrastructure or the relocation of infrastructure. The residential development would require new connections to water lines, wastewater lines, and other utilities, as well as the installation of a new 500,000-gallon water tank south of the project site, but these facilities were not anticipated to result in significant environmental effects, and mitigation measures were developed to reduce the impacts of utility line excavation on cultural and tribal resources.

A reliable water supply would be required for both construction and operation of Alternatives 1 and 3. Sufficient water supplies would be available through existing groundwater and surface water sources to support the construction of Alternatives 1 and 3, although new groundwater wells would likely be required. There is sufficient groundwater to support the nominal amount of water needed for the operation of the administration and maintenance buildings, and the reservoir would provide sufficient water to meet the recreation area needs. Impacts on water supply availability from Alternatives 1 and 3 would be less than significant. Most projects identified in Table 31-1 are construction projects that would not require long-term water use or generate a long-term water demand. The residential development was found to have sufficient water supplies from Cal Water and there would be no impact.

Construction and operation of Alternatives 1 and 3 would not result in a determination by a wastewater treatment provider that it has inadequate capacity to serve projected demand. There would be no need for wastewater generated during construction to be trucked to offsite treatment plants and portable toilets serviced by an appropriate provider off site would be used at construction sites. Wastewater treatment agencies in Glenn and Colusa Counties have adequate capacity to treat wastewater generated during operations and no expansion of existing treatment facilities would be required. Impacts related to the adequacy of wastewater treatment would be less than significant. Most projects identified in Table 31-1 are construction projects that would not require long-term wastewater treatment use or generate long-term wastewater. The residential development would provide for adequate wastewater disposal and treatment.

Construction and operation of Alternatives 1 and 3 would not generate solid waste in excess of state or local standards, or in excess of the capacity of local infrastructure, or otherwise impair the attainment of solid waste reduction goals. Construction contractors would be required to dispose of construction waste in accordance with federal, state, and local regulations as a requirement of construction contract specifications for Alternatives 1 and 3. Solid waste generated during operation of Alternative 1 or 3 is not anticipated to be substantial. Solid waste-related impacts from the construction and operation of Alternatives 1 and 3 would be less than significant. The projects in Table 31-1 would conform to similar regulations.

Alternative 1 or 3 would not result in a cumulative contribution to public services and utilities. Therefore, Alternative 1 or 3 when combined with other past, present, and reasonably foreseeable future projects, would not have a significant cumulative impact on public services and utilities. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.21.2. Alternative 2

Similar to Alternatives 1 and 3, impacts on public services under Alternative 2 would be less than significant. Alternative 2 would not result in a cumulative contribution to public services and utilities. Therefore, Alternative 2 when combined with other past, present, and reasonably foreseeable future projects would not have a significant cumulative impact on this resource. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.22. Public Health and Environmental Hazards

To Be Completed After Group 3 Deliverable and/or Authority and Reclamation Review of Chapter Received

31.3.23. Climate Change

To Be Completed After Group 3 Deliverable and/or Authority and Reclamation Review of Chapter Received

31.3.24. Indian Trust Assets

The cumulative geographic scope for Indian Trust Assets consists of areas of Colusa, Glenn, Tehama, and Yolo Counties, including waterbodies, that could be affected by Project construction or operations. The projects from Table 31-1 that occur in the cumulative analysis study area are not identified as affecting related Indian Trust Assets or are not in proximity to the facilities.

31.3.24.1. Alternatives 1, 2, and 3

Construction of the reservoir and new facilities under Alternatives 1, 2, and 3 would not result in effects on Indian Trust Assets due to the lack of Indian Trust Assets in proximity to areas where construction would occur. Furthermore, operation of the Project would not result in substantial modifications to existing river systems (i.e., flow) and therefore no adverse effects would occur. As a result of the lack of Indian Trust Assets or substantial modifications to existing river systems there would be no incremental contribution to a cumulative effect as a result of construction or operation of Alternatives 1, 2, and 3. Therefore, Alternatives 1, 2, and 3 would not result in a cumulative effect regarding Indian Trust Assts. Impacts would not be cumulatively considerable and impacts would be less than significant.

31.3.25. Environmental Justice and Socioeconomics

To Be Completed After Group 3 Deliverable and/or Authority and Reclamation Review of Chapter Received

31.4 References

To Be Completed

31.4.1. Printed References

31.4.2. Personal Communications

Chapter 28 Climate Change

Commented [CC1]: This section lacks enough detail for the reader to formulate their own opinions. Many of the tables lack enough description for the reader to understand what data are being presented. A thorough review of the discussion could not be completed because of this.

28.1 Introduction

This chapter describes the affected environment, methods of analysis, effects of climate change and sea level rise on the Project, and climate change effects that would potentially result from the operation of the Project, with a focus on water resources and related systems.

Climate change is defined as changes in the state of the climate that can be identified by changes in the mean and variability of its properties over an extended period of time. While climate change can occur naturally, change has accelerated due to human activity that alters the composition of the global atmosphere (Intergovernmental Panel on Climate Change 2018). The study area for climate change consists of the Sacramento Valley region.

This chapter gives a comparison of flow and volume indicators of Project performance under scenarios with and without climate change. The indicators analyzed include water supply, water quality, and aquatic biological resources. This chapter then describes how the Project could mitigate anticipated climate change impacts based on evaluation of the same indicators and describes other benefits from the Project. Finally, this chapter describes key climate impacts on study area resources and discusses how the Project could help mitigate those impacts. Construction is not considered in the assessment of climate change impacts as the focus is instead on the relationship between climate change effects and their long-term interactions with project operations and the resilience of the study area.

Table 28-1 summarizes the NEPA conclusions for project operational impacts with climate change by alternative.

Table 28-1. Summary of Project Operation Effects on Climate Change by Alternative

Alternative	NEPA Conclusion	Rationale
No Project	AE	**Results show overall reduced performance for storage, flow, and Sites Reservoir operations, especially during summer months and Critically Dry Water Years.** • Storage—Results show an overall decrease in expected storage under climate change during Critically Dry Water Years. • Flow—Results are variable but generally show increases in flow during winter months and decreases in flow in summer months. • Sites Reservoir operations—Results show overall slight decreases in operations capacity indicators during Critically Dry Water Years and significant variation during Wet Water Years.
1A	NE	**If Alt 1A is constructed, results show small changes in storage, reduced flow for Critically Dry Water Years, and small decreases for Sites Reservoir operations. This would not greatly affect performance.** • Storage—Results show small increases in winter during Critically Dry Water Years; SWP and CVP storage unchanged. • Flow—Results show variable change, and some large decreases in downstream flow for Critically Dry Water Years. • Sites Reservoir operations—Results are variable, with one particularly large decrease in diversions in March.
1B	NE, B	**If Alt 1B is constructed, results show small changes in storage and Sites Reservoir operations and reduced flow for Critically Dry Water Years. This would not greatly affect performance.** • Storage—Results show small changes in winter months, no change in Wet Water Years, and no change in SWP and CVP storage. • Flow—Results show high variability, with large Dry Water Year decreases in flow, and Wet Water Years mostly unchanged. • Sites Reservoir operations—Results show overall slight decreases in operations capacity indicators during Critically Dry Water Years and significant variation during Wet Water Years.

Commented [CC2]: Please define if this is flow into Sites reservoir or river flow throughout this section.

Alternative	NEPA Conclusion	Rationale
2	NE	**If Alt 2 is constructed, results show small Critically Dry Water Year increases in storage and Sites Reservoir operations and large variability for flow in both Critically Dry and Wet Water Years. This would not greatly affect performance.** • Storage—Results show little to no change during Wet Water Years and small increases during Dry Water Years. • Flow—Results show high variability and moderate decreases during Critically Dry Water Years and decreases in Wet Water Years. • Sites Reservoir operations—Results show little change, with slight increases for Sites releases.
3	NA, B	**If Alt 3 is constructed, results show, for Critically Dry Water Years, small increases in storage, high variability in flow, and decreases for Sites Reservoir operations. This would not greatly affect performance.** • Storage—Results show small year-round increases for Critically Dry Water Years, largest in October–December, a beneficial change. • Flow—Results show high variability, with some large changes in Dry Water Years. • Sites Reservoir operations—Results show slight decreases, with large decreases in diversions during Dry Water Years.

Note: Storage, flow, and Sites Reservoir operations are variables analyzed in the climate change scenarios modeled using CalSim III and analyzed in this chapter.
Alt = Alternative
NEPA = National Environmental Policy Act.
B = NEPA conclusion of beneficial effects
NE = NEPA conclusion of no effect or no adverse effect
AE = NEPA conclusion of adverse effect
SA = NEPA conclusion of substantial adverse effect

28.2 Affected Environment

28.2.1. Climate

Climate in the Sacramento Valley is Mediterranean, with cool, wet winters and hot, dry summers. The rainy season primarily occurs between November and April, with less precipitation between May and October. The valley region receives less precipitation than coastal regions to the west and mountains to the east due to the topography of the mountains. The valley also experiences more temperature extremes than its surroundings; during winter, the valley is colder than the coast, while in summer it is much hotter (Huber-Lee et al. 2003).

Interannual climate fluctuations occur in the Sacramento Valley due to the El Niño—Southern Oscillation. During El Niño, the rainy season tends to be longer, and strong storms occur during winter. During La Niña, the dry season becomes longer, and fewer storms occur in winter. However, these trends may not hold every year (Huber-Lee et al. 2003).

Table 28-2 shows baseline climate conditions for counties where the Project would be located.

Table 28-2. Baseline Climate Conditions in Glenn, Colusa, Sutter, Tehama, and Yolo Counties (Historical Modeled Baseline from 1961–1990)

Climate Variable	Glenn County	Colusa County
Annual Average Minimum Temperature	43.2°F–43.7°F	44.3°F–44.8°F
Annual Average Maximum Temperature	71.3°F–71.8°F	72.6°F–73.1°F
Annual Precipitation	23.9 - 28.6 inches	20.8–24.6 inches
	Sutter County	**Tehama County**
Annual Average Minimum Temperature	48.3 - 49.0 °F	41.1 - 41.7 °F
Annual Average Maximum Temperature	75.0 - 75.5 °F	68.3 - 68.8 °F
Annual Precipitation	18.4 - 21.4 inches	34.9 - 41.0 inches
	Yolo County	
Annual Average Minimum Temperature	46.2 - 46.9 °F	
Annual Average Maximum Temperature	73.8 - 74.3 °F	
Annual Precipitation	18.7 - 22.3 inches	

Source: Observed historical data derived from Gridded Observed Meteorological Data. Details are described in Livneh et al., 2015. Accessed via: Cal-Adapt

28.2.2. Global Climate Trends

Climate change has increased global temperatures in recent years and will continue to do so in the future. From 2006–2015, the observed global mean surface temperature was 0.87°C (1.6°F) higher than the historical (1850–1900) baseline. Warming is not equal everywhere—temperatures increase at two or three times the rate in the Arctic, and warming is usually higher over land than over the ocean. The global mean surface temperature continues to rise at about 0.2°C (0.4°F) per decade and may reach 1.5°C (2.7°F) above the historical baseline between 2030 and 2052 at the current rate. If there are no global reductions of greenhouse gas (GHG) emissions, the global mean surface temperature could potentially reach a 2°C (3.6°F) increase by 2050, which would result in much greater impacts on natural and human systems (Intergovernmental Panel on Climate Change 2018).

As global mean surface temperature rises, there will be an increase in extreme heat events. This may result in higher record-breaking temperatures, longer and more intense heat waves, and fewer cold days and nights that allow for recovery from extreme heat. Impacts from climate change may also include an increase in the intensity and frequency of precipitation extremes, such as heavier rainfall days, tropical cyclones and hurricanes, precipitation-induced flooding, and drought. Climate change may also result in changing seasonal patterns of temperature and precipitation, such as shortened rainy seasons and earlier snowmelt (Intergovernmental Panel on Climate Change 2018).

By 2100, global sea level rise may range from 0.26 to 0.77 meter under 1.5°C global warming (compared to 1985–2005 levels). Sea level rise can be especially impactful for small islands and low-lying coastal areas and deltas. Impacts include saltwater intrusion and flooding damage to coastal infrastructure (Intergovernmental Panel on Climate Change 2018).

Climate change could also result in indirect impacts. These include increases in risks from wildfires, vector-borne diseases, and ecosystem impacts like invasive species and pests. These impacts are likely to have effects on human health, agriculture, energy and water systems, and urban and rural life (Intergovernmental Panel on Climate Change 2018).

28.2.3. Climate Change Effects on California

Climate change is already affecting California. Since the start of the twentieth century, peak runoff in the Sacramento River now occurs nearly a month earlier, and glaciers in the Sierra Nevada have lost about 70% of their area. The state has gone through major recent climate events, including a drought in 2012–2016 followed by an extremely wet winter in 2016–2017 (Bedsworth et al. 2018).

These impacts are likely to continue and worsen in the future under climate change. California expects to see temperature increases of up to 5.8°F by 2050 and up to 8.8°F by 2100 under Representative Concentration Pathway (RCP) 8.5, a GHG concentration trajectory adopted by the Intergovernmental Panel on Climate Change. The state's precipitation patterns consist of dry and wet periods, which are driven by winter storms and atmospheric river events. These atmospheric rivers are projected to increase in strength under climate change, with northern California experiencing more wet extremes while southern California becomes drier. Increases in frequency and intensity of drought are likely to occur across the state as warmer temperatures and decreases in precipitation exacerbate dryness. Warmer temperatures will also reduce the fraction of precipitation falling as snow; since the 1950s, April 1 snow water storage across the western United States has declined 10%, and continued snowpack decline poses significant issues for water supply as spring snowpack can hold as much as 70% of the water for the state's engineered reservoirs (Bedsworth et al. 2018).

The Sacramento Valley is likely to see these changes as well. Warmer temperatures and increases in extreme heat will occur, with July through September increases of 2.7°F to 10.8°F. Heat waves are expected to become longer and more spread out geographically, with higher daytime and nighttime temperatures and fewer cooling days, which allow for recovery (Houlton and Lund 2018).

While average precipitation may not change significantly, there will be a change in precipitation patterns and extremes. On the wet extreme, the Sacramento Valley will likely see rainier winter storms, more extreme floods, and greater floodplain vulnerability. On the dry extreme, the region will see increased dryness in dry years and more extreme droughts. Precipitation whiplash, which is an abrupt transition from one extreme to another, may also increase by 25% in northern California (Houlton and Lund 2018).

Precipitation timing and its effect on snowpack also have implications for water management in California, particularly the Sacramento Valley. The northern Sierra Nevada, which provides the primary source for water in the region, will see more years with low snowpack and may have almost no annual snowpack by 2100. Precipitation will also fall more often as rain rather than snow due to high temperatures, which may shift timing of streamflow into the region from spring to winter, affecting inputs into rivers and reservoirs (Houlton and Lund 2018).

While the Sacramento Valley is not located on the coast, sea level rise is likely to affect the Delta by increasing flood potential and causing saltwater intrusion into the Delta's fresh waters (Houlton and Lund 2018).

28.2.4. Water Management and Climate

In normal water years, about 40% of California's water supply comes from groundwater, while the rest comes mostly from surface water; groundwater allocations increase to about half during Dry Water Years. Because northern California receives much more surface water flows than southern California, water conveyance infrastructure delivers water from the Delta to central and southern California and relies heavily on snowpack for seasonal water storage (Bedsworth et al. 2018).

Naturally, surface flows from runoff reach their peak in spring due to snowmelt. However, the release of a large amount of water in a short time period can result in flooding and remove storage (in the form of snowpack) that could provide water during drier periods. Releasing flows from reservoirs depending on seasonal needs can address this issue. Peak flows tend to occur in early winter as water is released from reservoirs to prepare for spring, the main runoff season. During spring, reservoir flows are reduced as they capture spring runoff inflows for later release. In summer, reservoir flows are higher than they would be naturally more flows are released to meet downstream irrigation needs (Huber-Lee et al. 2003).

Commented [CC3]: In general this section could benefit from more specifics and references- for example, not all surface flows from runoff reach their peak in the spring in CA so which ones are you talking about -Sacramento River?- data/references used? Also 'the release of a large amount of water...' are we now talking about reservoir releases, or releases as in snowmelt? Peak flows are listed as occurring in both spring naturally and early winter- what is the section trying to get at- reservoirs can be used beneficially to alter natural flow regimes to shift the hydrograph in favor of storage? If so follow that logic in the section. If not, clarify the point.

Climate change is likely to alter hydrologic patterns and will thus require changes in water management. More extreme flooding and precipitation will result in increased runoff and less groundwater recharge. Increased drought and potentially greater water demand may also put pressure on increasing water supply. As precipitation falls more often as rain rather than snow, streamflow timing will shift from spring to winter in Sacramento Valley (Houlton and Lund 2018). These impacts may result in reduced Delta exports and reservoir carryover storage, or the amount of water in reservoirs before the start of the wet season in October; carryover in Shasta Lake and Lake Oroville is projected to decline by one-third over the century, removing needed water supplies for dry years. The state will also face challenges related to drought resilience, such as flexibility and response time, particularly in the face of longer, more frequent, and more intense droughts (Bedsworth et al. 2018).

Commented [CC4]: data/references being used?

Commented [CC5]: references?

The state has recently emerged with regulations and plans related to planning for climate resilience in the water sector including: Sustainable Groundwater Management Act (SGMA) (2014), Executive Order B-30-15: Establishing 2030 CA Emissions Target, Adaptation Initiatives (2015), Executive Order B-30-15: Establishing 2030 CA Emissions Target, Adaptation Initiatives (2015), Senate Bill 246 (2015), Executive Order N-10-19 (2019), California Department of Water Resources California Water Plan Update (2018), and California Natural Resources Agency California Climate Change Adaptation Strategy and Safeguarding California Plan Update (2018). Together, these regulations and plans provide a policy framework for understanding and addressing climate-related risks to water resources. Additional information regarding each of these can be found in Appendix 4A, Regulatory Requirements.

28.3 Methods of Analysis

The Council on Environmental Quality released the Final Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in National Environmental Policy Act Reviews on August 5, 2016 (Council on Environmental Quality 2016), though it was withdrawn in 2017. The 2016 guidance suggests that NEPA analyses should consider whether climate change would result in beneficial or adverse effects on environmental or human resources under the action alternatives as compared to the No Action Alternative (with climate change assumption) in a different manner than would occur without consideration of climate change.

In Section 28.4, *Effects of Climate Change and Sea Level Rise on the Project*, the potential for climate change to impact key performance metrics of the Project is described, with insights on whether certain alternatives perform better than others in the 2035 Central Tendency (CT 2035) near-term climate hydrology. This analysis is based on comparison of flow and volume indicators of Project performance under no climate change using Chapter 5, *Surface Water Resources*, assessment of Project effects on surface water resources and the same indicators under climate change, using CT 2035 results.

Commented [CC6]: Just confirming the project will be fully operational in 14 years- if this is not likely perhaps consider using a later projection, or including both the near-term and a later projection in the analysis.

Section 28.4, *Effects of Climate Change and Sea Level Rise on the Project*, also identifies how and whether the Project would help to ameliorate the anticipated impacts of climate change, including impacts on water supply, water quality, and aquatic biological resources. This is based on evaluation of the same indicators and assessment of whether there are any improvements to indicators associated with these three impact areas under the modeled climate change scenario. This section also describes any other benefits from the Project (with climate change) compared to the No Project Alternative under climate change, drawing from both CALSIM III modeling and literature.

Section 28.5, *Potential Project-Related Climate Change Effects*, describes the key climate impacts on study area resources under the climate scenarios evaluated (i.e., CT 2035), including impacts on water supply, water quality, and aquatic biological resources. This assessment is based on both literature review and evaluation of the alternatives under the climate scenario.

28.3.1. Evaluation Criteria

Indicators evaluated for this assessment include indicators for benefits to aquatic biological resources, water quality, and water supply. The indicators for benefits to aquatic biological resources assessed are preservation of cold-water pools; meeting fish flow, habitat, and food supply ranges; and meeting salmonid temperature requirements, especially temperature requirements for winter-run spawning. The indicators of water quality benefits assessed are maintaining storage in Sites Reservoir at a high enough level that releases do not need to come from the surface of the reservoir; meeting water temperature requirements; peak flow attenuation and the maintenance of minimum flows; and meeting Delta outflow, salinity, and water quality standards. The indicators of water supply assessed are maintaining dry season yields; providing total water supply benefit; meeting supply demands of CVP and SWP south-of-Delta contractors; and meeting water provision requirements of Sites Reservoir Storage Partners.

Modeling results were assessed for locations listed in Table 28-3 and variables were categorized into three subcategories: storage, flow, and Sites Reservoir Operations. Table 28-3 summarizes these analyzed variables. Table 28-4 indicates linkage between the variables and benefits.

Table 28-3. Variables Analyzed in Climate Change Model

Variable Type	Variable Analyzed
Storage	Shasta storage
	Oroville storage
	Folsom storage
	Total San Luis storage
	Total CVP and SWP storage (includes Trinity, Shasta, Oroville, Folsom, and total San Luis)
Flow	Sacramento River flow at Bend Bridge
	Sacramento River flow below RBDD
	Sacramento River flow near Wilkins Slough
	Feather River flow at mouth
	American River flow at H Street
	Sacramento River at Freeport
	Yolo Bypass flow
	Delta outflow
	Total CVP and SWP Delta exports
Sites Reservoir Operations	RBDD
	Hamilton City Pump Station
	Sites Reservoir storage
	Sites Reservoir release
	Sites Reservoir release to Yolo Bypass for habitat
	Sites Reservoir release to Dunnigan Pipeline
	Sites Reservoir release to Sacramento River (Dunnigan Pipeline release minus Yolo Bypass release)
	Sites Reservoir release for local use (total release minus Dunnigan Pipeline release)

Note: CVP = Central Valley Project; GCID = Glenn-Colusa Irrigation District; RBDD = Red Bluff Diversion Dam; SWP =

State Water Project.

Table 28-4. Benefit Criteria for Climate Change Model Variables

Variable Type	Location of Benefit Criteria Variable	Benefit Criteria Variable
Storage	Sites Reservoir total storage	Maintenance of storage above 120 TAF in all months to avoid discharge of water from near the surface
Sites Reservoir Operations	Hamilton City Pump Station, RBDD	Total diversion for all months
Sites Reservoir Operations	Sites Reservoir releases (total and to Sacramento River)	Increased deliveries and flow (cfs) in all months
Storage (Volume)	Total SWP and CVP exports	Increased delivery volume (TAF) in all months
Storage	Folsom storage	Increased volume (TAF) in all months
Flow	American River (at Watt)	Increased flow (cfs) in select months
Storage	Oroville storage	Increased storage (TAF) during summer months (June–October) for preservation of cold-water pool.
Flow	Feather River flow at mouth	Increased flow during all months
Flow	Delta outflow (total)	Increased outflow (cfs) during all months
Storage	Shasta storage	Increased outflow (cfs) during all months
Flow	Yolo Bypass habitat flow i.e., "Yolo Bypass habitat through CBD/ridge cut"	Increased flow (cfs) from August through October
Flow	Yolo Bypass winter–early spring flows	Number of months with bypass inundation during winter and early spring as indicated by flow over Freemont Weir (the Project would cause a small decrease in winter inundation)

Note: CBD = Colusa Basin Drain; cfs = cubic feet per second; RBDD = Red Bluff Diversion Dam;
TAF = thousand acre-feet.
Reservoir storages must follow U.S. Army Corps of Engineer flood control rules and releases.

28.4 Effects of Climate Change and Sea Level Rise on the Project

A multitude of literature and datasets exist to showcase the potential effects of climate change on both local and national levels (Intergovernmental Panel on Climate Change 2018, Bedsworth et al. 2018). Project operations by alternative were simulated in the CT 2035 modeling. This section qualitatively and quantitatively addresses key effects of climate change observed through CT 2035 model results categorized by alternative: No Project Alternative (no structural changes), Alternative 1A, Alternative 1B, Alternative 2, and Alternative 3. The regions/variables analyzed for this study were identified by subject matter experts as the areas of greatest concern when considering alternatives and overall Project operations. The variables are broken down into three separate categories: storage/volume, flow, and Sites Reservoir operations. The variables were analyzed to better understand cascading effects that may exist under climate change and the Project. Average results for Wet and Critically Dry Water Years were analyzed to represent the full range of hydrologic conditions that would be observed under the modeled climate change.

Commented [CC7]: If not included already, please include a list of all subject matter experts consulted.

Commented [CC8]: Are water quality impacts/benefits assessed within one of these categories? Specifically, water temperatures in the reservoir, harmful alga bloom occurrence, temperature impacts within the Sacramento River near diversion intakes and release locations, etc?

The summarized results in the following sections should be compared and understood separately. Section 28.4.1, *No Project*, showcases solely the effects of climate change from CT 2035 model results. Section 28.4.2, *Alternative 1A*, through Section 28.4.5, *Alternative 3*, showcase differences between climate change and no climate change when compared to the No Project Alternative. For example, if total San Luis storage for Alternative 1B changed by 6% when compared to the No Project Alternative with no climate change and then by 9% with climate change when compared to its No Project Alternative baseline, this represents a 3% increase. Thus, it is understood that, with climate change, Alternative 1B would provide a 3% benefit in terms of water storage at San Luis Reservoir.

In the Alternatives discussion below (for 1A, 1B, 2 and 3), there are a number of instances where there are increases in Oroville and Folsom storage as compared to the NAA. Increased storage at Oroville and Folsom during key months for listed salmonids can have benefits to downstream temperature targets, particularly if these increases are in Dry or Critically Dry Water Years. As an example, per the NMFS 2019 BiOp there are key steelhead egg-to-fry temperature targets for December through May (temperatures below 54°F) and steelhead juveniles for May 15 through October (temperatures below 68°F).

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Sites Reservoir Operations

The last variable analyzed within this study, Sites Reservoir operations, showed—with few notable exceptions, see Section 28.4.1, *No Project*, to Section 28.4.5, *Alternative 3*—relatively consistent results for all alternatives. Thus, those results are summarized here. Unlike the results for storage and flow, comparisons between alternatives for this variable were analyzed by change in cubic feet per second (cfs) and not percentage change. Also, unlike the other two variables, the Sites Reservoir operations variables were most sensitive to Wet Water Year changes under climate change. While many results from storage and flow showed relatively small changes for Wet Water Years, Sites Reservoir operations variations were much larger.

For the Critically Dry Water Years, except for March, diversions at RBDD saw moderate increases (10–91 cfs) in every month, with larger magnitudes in the winter months (except for Alternative 3; see Section 28.4.5, *Alternative 3*). All alternatives experienced their largest increase (approximately 160 cfs) in December. The Wet Water Years saw moderate decreases (averaging around 50 cfs) in the summer months and moderate to large increases in winter months (January and February). The one exception to this trend was in November, in which all alternatives saw large (greater than 100 cfs) decreases. The increases during winter months

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indicate increased diversions of high flows for storage to Sites Reservoir. The decrease in flow during summer months represent a decrease in water supply for agriculture due to climate change. Similar effects occurred at the Hamilton City diversion.

Diversions at Hamilton City Pump Station had large month-to-month variability in the Critically Dry Water Years. Results showed large increases (greater than 100 cfs) in May. Summer months saw moderate (averaging around 60 cfs) decreases. For the Wet Water Years, all alternatives showed increases in the winter months, the largest in January and February, which averaged approximately 150 cfs. The summer months showed consistent moderate (approximately 50 cfs) decreases.

Sites Reservoir storage showed relatively small decreases for the Critically Dry Water Years for all months, except for May through July, in which most alternatives saw small increases. For the Wet Water Years, all months saw moderate decreases across alternatives, averaging approximately 40 cfs.

Sites Reservoir release for the Critically Dry Water Years also showed varying results, with late spring/early summer months (April–June) decreasing, with the largest decrease in May, and some alternatives decreasing more than 200 cfs. See subsequent sections for specifics for this variable by alternative. The Wet Water Years for this variable were much more consistent. All alternatives saw moderate increases (approximately 20 cfs) in the summer months and in November (approximately 50 cfs). Small decreases were observed in the winter months.

Sites Reservoir release to Yolo Bypass for habitat saw no changes across all alternatives for both Critically Dry and Wet Water Years. The one exception was seen from August through October, in which all alternatives saw moderate (averaging around 50 cfs) decreases in both Critically Dry and Wet Water Years.

Sites Reservoir release to Dunnigan Pipeline showed varied changes for Critically Dry Water Years. April and May both show moderate (averaging around 40 cfs) decreases, followed by similar magnitude increases in June and July across alternatives. For Wet Water Years, results showed no change between April and July, then small (approximately 15 cfs) decreases between August and October. All alternatives saw moderate (approximately 50 cfs) increases in November.

Sites Reservoir release to the Sacramento River showed moderate to large increases in all months (except May), with the largest increases in October, for Critically Dry Water Years. In May, all alternatives saw moderate (averaging around 50 cfs) decreases. The Wet Water Years showed more consistency in their response to climate change, as all months between April and October showed no change. November saw a moderate increase (approximately 50 cfs) across all alternatives.

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Finally, the Sites Reservoir release to GCID Main Canal showed consistency across alternatives. In the winter months, for both Critically Dry and Wet Water Years, this variable showed very little change. For Critically Dry Water Years, the summer months saw consistent moderate decreases, with May exhibiting the largest decreases (between 100 and 200 cfs across alternatives). Conversely, for Wet Water Years, the summer months saw moderate (approximately 30 cfs) increases.

28.4.1. No Project Alternative

Unlike the following four sections, the No Project Alternative analyzes the differences between the current water measurements and effects of climate change from the model outputs. Even without any Project adjustments, changes are to be expected with a changing climate.

For consistency and a more complete spectrum of future climate scenarios, the two extremes of Critically Dry and Wet Water Years are analyzed for this No Project Alternative baseline. These years are also analyzed in the comparisons between the alternatives under current conditions and climate change (see Section 28.4.2, *Alternative 1A*, to Section 28.4.5, *Alternative 3*). This section is meant to provide an understanding of overall changes under climate change simulations from the CalSim III model. The static infrastructure of this No Project Alternative comparison highlights the changes that could occur solely under climate change. The quantitative analyses includes raw value changes and/or percent changes, with the no climate change values as the baseline.

Storage

Due to California's interannual variability in precipitation under a changing climate, it is often of great consequence to study the driest years within California's records. The scientific literature shows that extended periods of drought and/or dry spells in California are expected to increase over the next century (CA 4th Assessment). For the storage values within this Project, results show an overall decrease in expected storage under climate change.

The one exception appears at Oroville storage in which results show a slight increase (less than 10%) throughout the Critically Dry Water Years (Table 28-5). Concurrently, the Wet Water Years analyzed also show an overall decrease in storage for all regions analyzed. It is important to note that overall variability throughout the year is greater for winter months, but the magnitude of these Wet Water Year decreases is smaller than the magnitudes seen in Critically Dry Water Years. The largest decrease in storage in Wet Water Years appears at San Luis, in which the latter months of the year (July through December) see approximately 20% decreases on average compared to the baseline (Table 28-6).

Table 28-5. Modeled Oroville Storage under Climate Change Scenario—Critically Dry Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Critically Dry Baseline Raw Change (TAF)	38	37	88	33	58	87	73	51	16	37	52	55
Critically Dry Baseline % Change	4.43	4.30	9.64	2.32	3.78	5.18	4.29	3.12	1.16	3.26	5.36	6.04

Note: TAF = thousand acre-feet.

Table 28-6. Modeled San Luis Storage under Climate Change Scenario—Wet Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Wet Baseline Raw Change (TAF)	-258	-265	-302	-56	-15	19	20	23	-17	-148	-125	-168
Wet Baseline % Change	-28.69	-22.45	-19.83	-3.79	-0.87	1.06	1.12	1.36	-1.31	-14.50	-16.60	-20.76

Note: TAF = thousand acre-feet.

Flow

The flow variable observed in this study does not present an overall change attributable to all sites. The variability of flow, both increases and decreases, shows larger magnitude changes when compared to storage. For the Critically Dry Water Years analyzed, results show slight increases at American River flow at H Street (Table 28-7) and the Delta outflow (Table 28-8). The other variables analyzed, such as Sacramento flow near Wilkins Slough, showed moderate vacillation for Critically Dry Water Years, with slight to moderate increases followed by slight to moderate decreases for each half of the year (Table 28-9). This type of vacillation was more present in the Wet Water Years, that is, with greater variability. There were many regions, such as American River flow at H Street, Yolo Bypass flow, and the total CVP and SWP Delta exports that showed moderate increases in flow in the winter months with similar magnitude decreases in the summer months.

Table 28-7. Modeled American River Flow at H Street under Climate Change Scenario—Critically Dry Water Years

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Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Critically Dry Baseline Raw Change (cfs)	125	28	62	214	177	-58	239	144	73	-177	-243	37
Critically Dry Baseline % Change	18.90	5.38	11.45	22.03	14.89	-7.18	22.71	16.28	8.84	-17.99	-23.97	5.46

Note: cfs = cubic feet per second.

Table 28-8. Modeled Delta Outflow under Climate Change Scenario—Critically Dry and Wet Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Critically Dry Baseline Raw Change (cfs)	-381	204	1,812	891	1,452	577	105	194	517	107	58	-53
Critically Dry	-9.33	5.23	21.33	8.40	10.63	5.20	1.10	3.41	9.63	2.66	1.71	-1.70

Baseline % Change												
Wet Baseline Raw Change (cfs)	113	-595	5,494	16,460	14,671	9,588	640	-9,536	-10,134	-1,402	-933	-1,108
Wet Baseline % Change	1.42	-5.10	20.90	19.33	14.68	11.97	1.17	-25.11	-43.33	-11.92	-12.95	-8.84

Note: cfs = cubic feet per second.

Table 28-9. Modeled Sacramento River Flow near Wilkins Slough under Climate Change Scenario—Critically Dry and Wet Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Critically Dry Baseline Raw Change (cfs)	-166	-247	637	82	828	657	-190	54	4	-91	-1,188	46
Critically Dry Baseline % Change	-3.26	-4.52	7.96	1.01	9.86	7.53	-3.42	1.22	0.07	-1.91	-24.50	1.16
Wet Baseline Raw Change (cfs)	-1,336	-158	1,001	566	419	77	-737	-2,571	-691	808	-850	-1,897
Wet Baseline % Change	-16.78	-1.76	8.02	2.70	1.92	0.39	-4.52	-24.32	-10.18	11.41	-13.98	-18.79

Note: cfs = cubic feet per second.

Sites Reservoir Operations

In line with overall results from the storage observations, the RBDD and Hamilton City Pump Station slightly decrease during the Critically Dry Water Years under climate change. In addition, during the Wet Water Years these two variables exhibit similar behaviors to the storage analysis. There is more variability, with many months increasing and decreasing slightly under the Wet Water Years. The RBDD shows a larger (but still relatively small) decrease for the summer months during both Wet and Critically Dry Water Years (Table 28-10).

Table 28-10. Modeled RBDD under Climate Change Scenario—Critically Dry and Wet Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Critically Dry Baseline Raw Change (cfs)	-4	-1	0	0	0	-4	-31	-52	-63	-76	-60	-25
Critically Dry Baseline % Change	-5.88	-6.18	0	0	-3.75	-15.40	-32.22	-41.13	-37.22	-39.30	-39.62	-45.32
Wet Baseline	-12	0	0	0	0	-1	21	-59	-55	-77	-59	-31

Raw Change (cfs)												
Wet Baseline % Change	-7.49	1.13	0	0	0	-6.12	11.42	-8.86	-4.92	-5.96	-5.78	-12.00

Note: cfs = cubic feet per second.

28.4.2. Alternative 1A

Storage

The storage variable for each of the sites analyzed showed relatively small changes for Alternative 1A under the effects of climate change. Overall, a few sites including Oroville, Folsom (Table 28-11), and San Luis (Table 28-12) saw small (less than 5%) increases in the winter months during Critically Dry Water Years. The Wet Water Years for these locations saw no change under this alternative. The total CVP and SWP storage remained unchanged in both Wet and Critically Dry Water Years.

Table 28-11. Folsom Storage: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 1A with Climate Change to Percent Change in Effect of Alternative 1A without Climate Change—Critically Dry Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (TAF)	-54	-55	-29	-35	-20	17	-13	-50	-76	-65	-47	-47
Alt 1A % change	4	3	4	3	1	2	1	0	0	0	1	1

Note: Alt = alternative; TAF = thousand acre-feet.

Table 28-12. Total San Luis Storage: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 1A with Climate Change to Percent Change in Effect of Alternative 1A without Climate Change—Critically Dry Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (TAF)	-24	-55	-94	-140	-117	-82	-74	-55	-26	-17	-83	-62
Alt 1A % change	2	2	3	2	2	1	1	1	1	0	3	1

Note: Alt = alternative; TAF = thousand acre-feet.

Flow

Flow during the Critically Dry Water Years shows the highest variability for this alternative. Most sites, including Sacramento River flow at Bend Bridge, Sacramento River flow below RBDD, and Delta Outflow (Table 28-13), show small decreases (less than 5%) in most months, with only slight increases in May, August, and November. Sacramento River at Freeport shows the most variability with this specific trend, with all months decreasing slightly but with an 11%

increase in August, which is the largest increase amongst all alternatives (Table 28-14). The greatest variability among all the variables (regardless of trend) is seen at Yolo Bypass flow, which shows large decreases in August through October—the largest decrease of 75% (Table 28-15). But there is still a large increase relative to baseline (Chapter 5). Also, at Yolo Bypass during the Critically Dry Water Years, there are no changes to flow for January through July. The Wet Water Years for all variables show no significant change, with the one exception being Yolo Bypass. During these Wet Water Years, August and September decrease by about 20%.

Table 28-13. Delta Outflow: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 1A with Climate Change to Percent Change in Effect of Alternative 1A without Climate Change—Critically Dry Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (cfs)	-381	204	1,812	891	1,452	577	105	194	517	107	58	-53
Alt 1A % change	-6	6	-3	0	0	1	-1	2	0	-3	4	1

Note: Alt = alternative; cfs = cubic feet per second.

Table 28-14. Sacramento River Flow at Freeport: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 1A with Climate Change to Percent Change in Effect of Alternative 1A without Climate Change—Critically Dry Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (cfs)	-76	-328	608	482	1,374	884	157	254	505	-342	-1,420	126
Alt 1A % change	-2	1	-1	-1	1	0	0	2	0	-2	11	-3

Note: Alt = alternative; cfs = cubic feet per second.

Table 28-15. Yolo Bypass Flow: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 1A with Climate Change to Percent Change in Effect of Alternative 1A without Climate Change—Critically Dry Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (cfs)	0	0	157	39	56	7	0	0	0	0	0	-11
Alt 1A % change	-75	14	-4	-1	0	1	0	0	0	0	-69	-16

Note: Alt = alternative; cfs = cubic feet per second.

Sites Reservoir Operations

As stated previously, most alternatives within the Sites Reservoir operations category followed the same trajectory, regardless of alternative; however, there are some results that stand out for Alternative 1A. For the Critically Dry Water Years, RBDD saw the largest decrease in March of 132 cfs, very different from other alternatives, which saw either smaller decreases or even increases in March (Table 28-16). For Sites Reservoir storage, all months in Critically Dry Water Years saw slight decreases, except December, which had a very small increase. Sites Reservoir release to Dunnigan Pipeline showed moderate increases in all months, except April and May, which showed small and moderate increases, respectively (Table 28-17).

Table 28-16. RBDD: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 1A with Climate Change to Percent Change in Effect of Alternative 1A without Climate Change—Critically Dry Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (cfs)	-4	-1	0	0	0	-4	-31	-52	-63	-76	-60	-25
Alt 1A % change	4	1	164	28	81	-132	12	11	24	21	42	12

Note: Alt = alternative; cfs = cubic feet per second.

Table 28-17. Sites Reservoir Release to Dunnigan Pipeline: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 1A with Climate Change to Percent Change in Effect of Alternative 1A without Climate Change—Critically Dry Water Years

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (cfs)	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A % change	18	27	0	0	36	17	-7	-86	35	31	5	5

Note: Alt = alternative; cfs = cubic feet per second.

28.4.3. Alternative 1B

Storage

Like Alternative 1A, the storage variable for each of the sites analyzed showed relatively small changes for Alternative 1B under the effects of climate change. For the Critically Dry Water Years, Shasta and Folsom (Table 28-18) storage saw small (less than 5%) decreases within the winter months, while Oroville and San Luis (Table 28-19) storage showed small (less than 5%) increases in the winter months. The Wet Water Years saw no change under this alternative. The total CVP and SWP storage remained unchanged in both Wet and Critically Dry Water Years.

Table 28-18. Folsom Storage: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 1B with Climate Change to Percent Change in Effect of Alternative 1B without Climate Change—Critically Dry Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (TAF)	-54	-55	-29	-35	-20	17	-13	-50	-76	-65	-47	-47
Alt 1B % change	-2	-1	0	1	1	1	0	0	-1	-2	-3	-4

Note: Alt = alternative; TAF = thousand acre-feet.

Table 28-19. Total San Luis Storage: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 1B with Climate Change to Percent Change in Effect of Alternative 1B without Climate Change—Critically Dry Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (TAF)	-24	-55	-94	-140	-117	-82	-74	-55	-26	-17	-83	-62
Alt 1B % change	3	3	3	3	2	0	0	1	0	0	3	4

Note: Alt = alternative; TAF = thousand acre-feet.

Flow

Flow during the Critically Dry Water Years shows the highest variability for this alternative. Most sites, including Sacramento River flow at Bend Bridge, Sacramento River flow below RBDD, and Sacramento River flow near Wilkins Slough, show small decreases (less than 5%) in most months, with only slight increases in May, August, and November. American River flow at H Street showed moderate decreases (around 10%) in the latter half of the year (between August and December) during Critically Dry Water Years (Table 28-20). Like Alternative 1A, Yolo Bypass flow shows the largest variability of any variable analyzed *in any alternative*. Critically Dry Water Years show large decreases between August and October, the largest of 100%. This means that without climate change, Alternative 1B would have a 100% increase in flow, while under climate change, Yolo Bypass flow for Alternative 1B does not change flow at all (Table 28-21). As seen in previous sections, the winter months seem to be most affected for Yolo Bypass, and the Wet Water Years for all variables show no significant change, with the one exception of Yolo Bypass. During these Wet Water Years, August through October decrease by about 15%.

Table 28-20. American River Flow at H Street: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 1B with Climate Change to Percent Change in Effect of Alternative 1B without Climate Change—Critically Dry Water Years

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Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline	125	28	62	214	177	-58	239	144	73	-177	-243	37

(cfs)												
Alt 1B % change	-11	-10	-10	0	1	-4	10	2	3	6	6	0

Note: Alt = alternative; cfs = cubic foot per second.

Table 28-21. Yolo Bypass Flow: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 1B with Climate Change to Percent Change in Effect of Alternative 1B without Climate Change—Critically Dry Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (cfs)	0	0	157	39	56	7	0	0	0	0	0	-11
Alt 1B % change	-100	15	-2	0	-1	0	0	0	0	0	-37	-78

Note: Alt = alternative; cfs = cubic foot per second.

28.4.4. Alternative 2

Storage

Like the previous two alternatives, results show very little to no change for the Wet Water Years for flow under Alternative 2. The Critically Dry Water Years show a small increase (approximately 5%) for the winter months at Oroville and San Luis storage (Table 28-22). Overall, this alternative appears to be the most stable for the storage variable.

Table 28-22. Total San Luis Storage: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 2 with Climate Change to Percent Change in Effect of Alternative 2 without Climate Change—Critically Dry Water Years

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (TAF)	-24	-55	-94	-140	-117	-82	-74	-55	-26	-17	-83	-62
Alt 2 % change	2	1	3	2	2	0	0	1	0	0	2	1

Note: Alt = alternative; TAF = thousand acre-feet.

Flow

Like the previous two alternatives, flow during the Critically Dry Water Years shows the highest variability for this alternative. This alternative is most similar to Alternative 1B in that Sacramento River flow at Bend Bridge, Sacramento River flow below RBDD, and Sacramento River flow near Wilkins Slough also show small decreases (less than 5%) in most months with only slight increases in May, August, and November (Table 28-23). This alternative also mirrors Alternative 1B at American River flow at H Street with moderate decreases (around 15%) in the latter half of the year (between August and December) during Critically Dry Water Years (Table

28-24). Once again, Yolo Bypass flow shows the largest variability of any variable analyzed. However, this alternative now mirrors Alternative 1A for Yolo Bypass flow, which shows the same large decreases in August through October, with the largest decrease of 75%. Also, at Yolo Bypass during the Critically Dry Water Years, there are no changes to flow for January through July. The Wet Water Years for all variables show no significant change, with the one exception being Yolo Bypass. This alternative shows the largest decrease of all alternatives for Yolo Bypass flow during Wet Water Years, with September decreasing by 45% (Table 28-25).

Table 28-23. Sacramento River Flow at Bend Bridge: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 2 with Climate Change to Percent Change in Effect of Alternative 2 without Climate Change—Critically Dry Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (cfs)	-79	-261	392	-137	619	649	-26	159	31	-150	-1,229	-10
Alt 2 % change	-1	2	0	0	-1	-3	-2	4	0	0	2	-1

Note: Alt = alternative; cfs = cubic foot per second.

Table 28-24. American River flow at H Street: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 2 with Climate Change to Percent Change in Effect of Alternative 2 without Climate Change—Critically Dry Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (cfs)	125	28	62	214	177	-58	239	144	73	-177	-243	37
Alt 2 % change	-13	-12	-5	2	-1	-5	8	2	2	1	6	0

Note: Alt = alternative; cfs = cubic foot per second.

Table 28-25. Yolo Bypass Flow: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 2 with Climate Change to Percent Change in Effect of Alternative 2 without Climate Change—Wet Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (cfs)	-2	-32	1,387	8,024	6,641	4,365	352	-474	-61	0	3	0
Alt 2 % change	14	0	0	0	0	0	0	1	0	0	-24	-45

Note: Alt = alternative; cfs = cubic foot per second.

Sites Reservoir Operations

As stated, most alternatives within the Sites Reservoir operations category followed the same trajectory, regardless of alternative; however, there are some results that stand out for Alternative 2. During the Wet Water Years, the sole—but still small, 10 cfs—increase for the Sites Reservoir release variable in October occurs for this alternative (Table 28-26). All other alternatives slightly decrease.

Table 28-26. Sites Reservoir Release: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 2 with Climate Change to Percent Change in Effect of Alternative 2 without Climate Change—Wet Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (cfs)	0	0	0	0	0	0	0	0	0	0	0	0
Alt 2 % change	10	57	-8	0	3	0	19	29	39	43	21	-26

Note: Alt = alternative; cfs = cubic foot per second.

28.4.5. Alternative 3

Storage

Similar to the other alternatives, results show very little to no change for the Wet Water Years for flow under Alternative 3. The Critically Dry Water Years show a small increase (approximately 5%) for the winter months at Oroville and San Luis storage (Table 28-27). This change is also seen in Alternative 2 for this variable. Unlike the other alternatives, for Folsom storage during Critically Dry Water Years under Alternative 3, there are small year-round increases (Table 28-28). The largest increases are seen in October, November, and December, which result in 7%, 9%, and 6%, respectively. All other alternatives for Folsom storage during the Critically Dry Water Years show very little (less than 3%) change.

Table 28-27. Total San Luis Storage: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 3 with Climate Change to Percent Change in Effect of Alternative 3 without Climate Change—Critically Dry Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (TAF)	-24	-55	-94	-140	-117	-82	-74	-55	-26	-17	-83	-62
Alt 3 % change	5	5	4	3	2	1	1	2	2	2	1	3

Note: Alt = alternative; TAF = thousand acre-feet.

Table 28-28. Folsom Storage: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 3 with Climate Change to Percent Change in Effect of Alternative 3 without Climate Change—Critically Dry Water Years

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (TAF)	-54	-55	-29	-35	-20	17	-13	-50	-76	-65	-47	-47
Alt 3 % change	7	9	6	5	1	1	1	1	1	1	3	3

Note: Alt = alternative; TAF = thousand acre-feet.

Flow

Flow during the Critically Dry Water Years shows the highest variability for this alternative. This alternative is similar to Alternatives 1B and 2 in that Sacramento River flow at Bend Bridge, Sacramento River flow below RBDD, and Sacramento River flow near Wilkins Slough also show small decreases (less than 5%) in most months, with only slight increases in May and/or August (Table 28-29). During Critically Dry Water Years, the Feather River flow at mouth increases by 16% during October (Table 28-30). This is by far the largest increase among the alternatives, as the others only increase 1%–2% for this same variable. American River flow at H Street during the Critically Dry Water Years has largest variability among the alternatives. The largest increase at this location is 25% in February, and the largest decrease is 30% in November. Once again, Yolo Bypass flow shows the largest variability of any variable analyzed. This alternative mirrors Alternatives 1A and 2 for Yolo Bypass flow, which shows the same large decreases in August through October, with the largest decrease of 75% (Table 28-31). Also, at Yolo Bypass during the Critically Dry Water Years, there are no changes to flow for December through August. Alternative 3 for Yolo Bypass shows no change in August, while the other alternatives show moderate (36%–69%) decreases. The Wet Water Years for all variables show no significant change, with the one exception being Yolo Bypass, which shows the same changes as Alternative 1A and Alternative 2.

Table 28-29. Sacramento River Flow near Wilkins Slough: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 3 with Climate Change to Percent Change in Effect of Alternative 3 without Climate Change—Critically Dry Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (cfs)	-166	-247	637	82	828	657	-190	54	4	-91	-1,188	46
Alt 3 % change	3	4	-3	1	-3	-1	0	2	0	-3	8	1

Note: Alt = alternative; cfs = cubic foot per second.

Table 28-30. Feather River Flow at Mouth: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 3 with Climate Change to Percent Change in Effect of Alternative 3 without Climate Change—Critically Dry Water Years

Results	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (cfs)	-46	-102	-67	143	253	246	88	137	412	-58	-7	31
Alt 3 % change	16	-4	0	0	0	0	0	1	2	-4	7	-8

Note: Alt = alternative; cfs = cubic foot per second.

Table 28-31. Yolo Bypass Flow: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternative 3 with Climate Change to Percent Change in Effect of Alternative 3 without Climate Change—Critically Dry Water Years

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP

Baseline (cfs)	0	0	157	39	56	7	0	0	0	0	0	-11
Alt 1A % change	-75	14	-4	-1	0	1	0	0	0	0	-69	-16
Alt 1B % change	-101	15	-2	0	-1	0	0	0	0	0	-37	-78
Alt 2 % change	-75	14	-5	-1	0	0	0	0	0	0	-60	-31
Alt 3 % change	-75	14	-1	1	-1	1	0	0	0	0	0	-34

Note: Alt = alternative; cfs = cubic foot per second.

Sites Reservoir Operations

Most alternatives within the Sites Reservoir operations category followed the same trajectory, regardless of alternative; however, there are some results that stand out for Alternative 3. During Critically Dry Water Years, the RBDD slightly decreases (10–25 cfs) from June through September, all other alternatives moderately increase (Table 28-32). For the Critically Dry Water Years, RBDD saw a large decrease in March of 75 cfs, very different from Alternatives 1B and 2, which saw moderate increases in March, but similar to Alternative 1A, which saw a larger decrease of 132 cfs in March.

Table 28-32. RBDD: Comparison of Baseline with Climate Change to Without Climate Change and Percent Change in Effect of Alternatives with Climate Change to Percent Change in Effect of Alternatives without Climate Change—Critically Dry Water Years

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Baseline (cfs)	-4	-1	0	0	0	-4	-31	-52	-63	-76	-60	-25
Alt 1A % change	4	1	164	28	81	-132	12	11	24	21	42	12
Alt 1B % change	10	10	164	20	91	32	11	36	30	30	50	15
Alt 2 % change	6	10	163	31	81	31	12	11	24	17	21	16
Alt 3 % change	-3	15	155	28	91	-75	7	8	-21	-25	-20	-10

Note: Alt = alternative; cfs = cubic foot per second.

28.5 Potential Project-Related Climate Change Effects

This section qualitatively describes the following Project-related climate change effects based on a literature review and other chapters in the RDEIR/SDEIS:

- How will operations of the Project have an impact on these resource areas?
- How will climate change exacerbate the impacts that the Project would have on these resource areas?
- How could the Project potentially mitigate anticipated impacts due to climate change?

28.5.1. Surface Water Resources and Fluvial Geomorphology

The Project would result in exchanges of water between Sites Reservoir, the Sacramento River, and other nearby storage reservoirs (Shasta Lake, Lake Oroville, Folsom Lake) due to diversions to and releases from Sites Reservoir. The Project is expected to result in reduced flows in Sacramento River below RBDD for some alternatives due to increases in winter diversions to Sites Reservoir and potential increases in flow during September and October of Critically Dry Water Years due to increased releases from Shasta Lake. Sites Reservoir releases to the Sacramento River would happen most often during dry conditions, while releases to the Yolo Bypass would occur more during Wet Water Years. The alternatives could also increase flow at the downstream end of Sacramento River during July through October of Critically Dry Water Years. Regarding storage, Shasta Lake's storage is expected to increase slightly, with more increases in Critically Dry Water Years than Wet Water Years. There could be smaller effects on Lake Oroville and Folsom Lake.

In the Delta, the combined effects of diversions to Sites Reservoir, releases from Sites Reservoir to the Sacramento River and Yolo Bypass, and operational changes for the three reservoirs would result in small reductions in Delta outflow during wetter months and increases in Delta outflow during dryer months, particularly during Dry Water Years. Overall, the Project would increase water supply to downstream users, and Delta exports are expected to increase, especially during summers of Critically Dry Water Years.

These effects are expected to help mitigate impacts of climate change. Increases in precipitation extremes, such as flooding during the wet season and drought during the dry season, are expected to occur more frequently in the future. Timed diversions and releases of the Sites Reservoir can help reduce these flooding risks and provide increased water storage capacity during drought.

Commented [CC15]: Show or reference the analysis done to support this/demonstrate the magnitude and/or frequency of impact?

The Sites Reservoir faces the risk of dam failure or reservoir emergency flows, both of which could result in flooding to downstream regions, particularly during years of heavy precipitation. Climate change could increase the frequency and intensity of extreme precipitation events, thus increasing the risk of dam failure or need to conduct reservoir emergency flows.

The risks and potential mitigation described above also apply to climate change impacts on fluvial geomorphology. The Project is not expected to have significant impacts on factors related to fluvial geomorphology. These include potential changes to drainage patterns that would result in increased erosion and sedimentation; altering of river geomorphic processes and characteristics; and altering of instream woody material, boulders, aquatic habitat, and spawning gravel.

28.5.2. Surface Water Quality

Climate change could exacerbate existing water quality effects. Heat and drought can result in evaporation that could reduce water levels, thus increasing concentrations of pollutants in reservoirs and rivers. On the wet extreme, increases in extreme precipitation could result in more flooding and runoff that washes pollutants into surface waters and results in sedimentation.

Increases in wildfires could have similar effects by burning vegetation that stabilizes soil and creating conditions conducive to flash flooding and debris flows, both of which could worsen water quality. Increased temperatures could result in chemical reactions in water, creating algal blooms. In the Delta, sea level rise could result in increased salinity (Bedsworth et al. 2018).

The Project could mitigate some of these climate change impacts on water quality. Regulated flows, consisting of diversions to and releases from Sites Reservoir, could reduce flooding in Wet Water Years and increase water supply in Dry Water Years.

28.5.3. Groundwater Resources

The Project is expected to have no adverse effects on groundwater resources. During operations some seepage would occur resulting in a potential increase in groundwater levels, but this is not anticipated to adversely affect recharge or groundwater quality.

Climate change could have effects on groundwater resources. Drought and high temperatures could increase water demand, causing water users to draw more on groundwater. During the wet season, higher extreme precipitation could result in more surface runoff and less groundwater recharge, decreasing future groundwater supplies. Sea level rise could also result in saltwater intrusion of groundwater resources (Houlton and Lund 2018).

The Project would help mitigate these effects by regulating flow. Flows would generally be released during Dry and Critically Dry Water Years and flows would be reduced during Wet Water Years on the Sacramento River. In addition, flows on Funks and Stone Corral Creeks would be captured by Sites Reservoir in Wet Water Years and this capture would reduce flood risk downstream. This could provide more surface water resources for water users during drought, reduce groundwater withdrawal, and support infiltration for groundwater recharge.

28.5.4. Wildlife and Vegetation Resources

The Project is likely to result in effects on wildlife and vegetation resources, both substantially adverse and not adverse after mitigation is incorporated. Affected species and vegetation include aquatic and terrestrial invertebrates, reptiles and amphibians, birds, mammals, and various terrestrial and aquatic habitat types. Both construction and operation of the Project may result in species displacement, death or damage of species from construction, impacts on health due to pollution, and disruption of habitats and species activities, such as foraging, nesting, breeding, and dispersal. These impacts are also likely to block existing migration corridors. For vegetation resources, construction of the Project may result in habitat loss, hydrological disruptions, and increased erosion and sedimentation. The full list of impacts and species affected are described in Chapter 9, *Vegetation and Wetland Resources*, and Chapter 10, *Wildlife Resources*.

A variety of mitigation measures to reduce the severity of these effects would be implemented. These include conducting wildlife and plant surveys and suitability assessments for wildlife connectivity, seeking alternative suitable habitats and relocating species, replacing lost habitat, protecting nearby habitats that do not need to be displaced, adjusting the temporal and spatial boundaries of construction as necessary, and purchasing mitigation credits from conservation banks. With the implementation of these mitigation measures, the Project is not expected to conflict with local policies and ordinances protecting wildlife.

Climate change impacts in the Sacramento Valley region could exacerbate impacts on wildlife and vegetation resources or reduce the effectiveness of mitigation measures. Changes to temperature and precipitation patterns and extremes could change habitat and species compositions as some vegetation and wildlife species become unable to survive in the new conditions. Increased wildfire risk may also result in more acres of vegetation being burned. Increases in extreme precipitation and drought may result in more flooding and evaporation, exacerbating existing erosion and water quality problems. These climate impacts may increase the number of species and wildlife that need to migrate to other suitable habitats, thus increasing the need to find solutions for wildlife connectivity (Houlton and Lund 2018).

The Project may mitigate some of the effects exacerbated by climate change, given anticipated regulation of flows that can help to maintain habitat required by some species.

28.5.5. Aquatic Biological Resources

The Sacramento River and its tributaries support listed salmon runs, steelhead, and green sturgeon and other native species, some of which are state and/or federally listed as endangered or threatened. The Sacramento Valley region contains the highest number of California endemic fish, and 82% of native fish may become extinct by 2100 (Houlton and Lund 2018).

The Delta supports a wide variety of aquatic species that the Project must consider. These species include the Chinook salmon, California Central Valley steelhead, green sturgeon, white sturgeon, delta smelt, longfin smelt, lampreys, native minnows, starry flounder, northern anchovy, striped bass, American shad, threadfin shad, black bass, and California Bay shrimp.

The indicators for benefits to aquatic biological resources assessed are preservation of cold-water pools; meeting fish flow, habitat, and food supply ranges; and meeting salmonid temperature requirements and temperature requirements for winter-run spawning. These factors and the climate change impacts on them are listed below.

- **Flows**: Regulators have set rules for watersheds in California to determine how much water should be left in a natural channel to support aquatic and riparian wildlife and habitat. Climate change may increase precipitation extremes, such as increased frequency and intensity of drought and extreme precipitation events, which may affect these flows (California Natural Resources Agency et al. 2020).
- **Temperature**: Fish species in the Delta are adapted to certain ranges of temperatures. Higher temperatures may result in waters becoming too warm to support many of these species. Warmer water temperatures may also favor nonnative and invasive species of fish that can then outcompete native species (Houlton and Lund 2018). Management of cold water in reservoirs also relates to fish species; if storage in these reservoirs is too low at the end of April, there may not be enough cold water to adjust water temperatures in the Sacramento River during warm months. Thus, increased drought and temperatures

can result in decreased storage and increased evaporation, further affecting temperatures important to salmon species (U.S. Department of the Interior, Bureau of Reclamation 2014).

- **Water quality and nutrients**: Excessive nutrients and high concentration of pollutants can be harmful to aquatic life. Both increased drought and increased extreme precipitation can worsen water quality, as drought can reduce water levels (thus increasing concentrations of pollutants), and heavy rainfall can cause more surface runoff to wash nutrients and pollutants into surface waters (Houlton and Lund 2018).
- **Salinity**: Fish species in the Delta are adapted to certain ranges of salinity. Sea level rise may cause salt water to intrude into the Delta, increasing salinity levels (Houlton and Lund 2018). This could limit available habitat for some species of fish.
- **Turbidity**: An overload of sediments can increase the turbidity of water, decreasing the amount of light that can aid in primary productivity to feed fish. High turbidity may also decrease visibility that allows predators to catch prey and allows prey to escape. Increasing extreme precipitation may cause more sedimentation in rivers, increasing turbidity levels (Houlton and Lund 2018).

The Project may help mitigate some of these climate impacts. Reducing flows during heavy precipitation events and increasing flows during dry periods would reduce impacts related to those hazards. Under climate change, flows at Yolo Bypass from August to October would normally decrease; all Project alternatives would help keep these flows stable, providing benefits for fish food supply in the north Delta/Cache Slough complex. Furthermore, Alternative 3 also increases flows to Feather River at the mouth compared to no project under climate change; this would also help keep flows stable, supporting salmonid temperature requirements.

Commented [CC16]: I would like to see climate change reservoir/river temperature model results to support this. Warmer air temperatures and warmer reservoir inflows will lead to higher equilibrium temperatures further upstream than we've seen historically. This means that projects will have less control over stream temperature, which will diminish the benefit of cold water conservation that may occur with Sites operation.

28.5.6. Public Health, Environmental Hazards, Environmental Justice, and Socioeconomics

The Project is not expected to have substantial adverse effects on public health and environmental hazards. This includes exposure to hazardous materials, impairment of emergency response plans, or exposure to high wildfire risk, flooding, landslides, algal blooms, and vector-borne diseases. While the Project is not likely to increase the risk of these hazards, climate change may increase the frequency, severity, and geographic extent of wildfires and flooding in the future, and extreme precipitation occurring after wildfires may also trigger more landslides. Increased heat may also cause more algal blooms to form in water bodies, as well as expand the range of mosquitos, potentially increasing the risk of vector-borne diseases.

The Project would have some substantially adverse effects on environmental justice, since the Project could have a disproportionate impact on air quality, GHG emissions, agriculture, and visual resources for minority and low-income populations for Alternatives 1 and 3. For Alternative 2, these effects would also occur, in addition to disproportionate effects on land use and transportation and traffic for minority and low-income populations. Effects on regional, local, agricultural, municipal, and industrial economics are not expected to be adverse and would be beneficial.

Climate change is also expected to have disproportionate impacts on minority and low-income populations and may thus exacerbate any impacts on these populations from the Project. Minority and low-income populations already experience disproportionate environmental pollution, which may have affected their health in the long term as a result, potentially making them more sensitive to climate hazards such as decreased air quality. These populations may also have less adaptive capacity to respond to natural hazards due to socioeconomic and political constraints. Thus, they may lack access to adaptation strategies such as using more air conditioning during heat waves, migrating to other locations in extreme events, or paying healthcare bills resulting from climate-related injuries (Bedsworth et al. 2018).

28.5.7. Energy, Air Quality, and Greenhouse Gas Emissions

The Project is not expected to substantially adversely affect energy consumption, nor conflict with renewable energy and energy efficiency plans or require increased regional capacity. A GHG reduction plan and purchase of carbon offsets would be implemented to offset GHG emissions.

Climate change could increase impacts related to energy, air quality, and greenhouse gas emissions. Extreme heat could result in a need for increased air conditioning use and cooling in facilities associated with the reservoir, which could then result in increased energy and GHG emissions. Increased heat and drought could also increase water demand from downstream users, thus increasing the need to increase water releases.

Regarding air quality, the Project is not expected to conflict with air quality plans or expose sensitive receptors to some substantial pollutants, such as asbestos, lead-based paint, and spores that cause valley fever. During construction, there would be a net increase in pollutants resulting from concentration, such as nitrogen oxides, reactive organic gas, and particulate matter smaller than or equal to 10 microns in diameter, which could exceed applicable thresholds without mitigation.

Climate change could exacerbate these air quality impacts. Potential increase in wildfires could increase the concentration of PM_{10} in the air during wildfire events. An increase in drought could potentially increase the spread of valley fever spores. Climate change could also increase the concentration of other air pollutants, such as ozone, particulates, and respiratory allergens, which may have impacts on sensitive populations (Houlton and Lund 2018).

28.5.8. Other

28.5.8.1. Geology, Soils, and Minerals

The Project was not found to have substantial adverse effects or adverse effects on geology, soils, and minerals. Climate change is not expected to effect seismicity or minerals. Climate change may effect soil. Increases in extreme precipitation events and wildfire risk may result in more soil erosion and topsoil loss, as wildfire can burn vegetation that holds soil in place, while heavy rainfall may increase surface runoff that erodes soil. Heavy precipitation following wildfire may also result in a cascading hazard that triggers landslides. As the Project is built on gentle slopes and has design requirements including the Initial Reservoir Fill Plan, substantial adverse effects from landslides are unlikely to occur. The Project may mitigate some of these climate effects. Reducing flows during heavy precipitation events could reduce erosion and landslide risk.

28.5.8.2. Land Use, Population, and Housing

The Project is expected to have some impacts on land use, population, and housing. Alternative 2 would result in physical division of an established community, resulting in a substantial adverse effect with no feasible mitigation. The Project would not result in unplanned population growth but would displace members of an existing community; this is not expected to be a significant impact, as surrounding areas are expected to absorb the displaced community.

Climate change could also result in effects on land use, population, and housing. Increased frequency and severity of extreme heat, wildfire, and flooding events could damage homes and drive migration to other communities less at risk. Expanding floodplains and potential increases in insurance can especially stress finances for people in local communities, causing them to leave (Houlton and Lund 2018).

Given that climate change is already impacting land use and housing, the project impacts to land use and housing could slightly exacerbate this harm.

28.5.8.3. Agriculture and Forestry Resources

The Project would result in conversion of some farmland designations to permanent nonagricultural use, resulting in a substantial adverse effect despite mitigation measures.

Climate change will have numerous impacts on agriculture, potentially exacerbating the Project's impacts on agriculture resources. Changing heat and precipitation patterns and extremes will likely alter the types of crops that can be grown and change crop productivity. For example, field crops, orchards, grains, grapes, corn, and truck crops are likely to decline 1.9% to 11% in productivity, while cotton, alfalfa, citrus, rice, tomato, and pasture may increase in productivity by 0% to 5%. Some wildlife species in the Sacramento Valley also depend on agricultural or grazed lands; these species include burrowing owl, Swainson's hawk, giant garter snake, and waterfowl and shorebirds that use croplands flooded during winter. The combination of climate change and agricultural land conversion may exacerbate effects on these species (Houlton and Lund 2018).

The Project could reduce some of these climate change effects. The reservoir provides a reliable water supply that nearby farmers could use during drought or dry periods, increasing their resilience to climate change. This could reduce the impact of the Project and climate change reducing acres available for agriculture. The Project could also support crops that require inundation.

28.5.8.4. Recreation Resources

The Project is expected to have no substantial adverse effects on recreation resources. Recreational facilities and water-based recreational resources (such as rivers and reservoirs) are not expected to see significant changes under the Project. Climate change could potentially result in impacts on recreation resources if increases in extreme heat, wildfire, and heavy precipitation and flooding events degrade water-based recreation resources or dissuade activities. Changes to precipitation extremes, such as increased heavy precipitation or increased drought, may also alter water levels or water quality in rivers and reservoirs, potentially changing long-term recreational potential in these waters. The Project could favorably increase water levels in rivers and reservoirs to increase recreational opportunities.

28.5.8.5. Navigation, Transportation, and Traffic

Alternatives 1 and 3 would not have substantial adverse effects on navigation, transportation, and traffic. Alternatives 1 and 3 are not expected to result in increased roadway hazards or affect emergency, school bus, and recreational and commercial navigation. Alternative 2 would result in a substantial adverse effect that cannot be reduced on school bus routes.

Climate change effects could result in roadway degradation and traffic disruptions. Increased average and extreme temperatures increase the incidence of rail buckling and pavement warping. Roads, railways, and sidewalks are all vulnerable to flooding and wildfire, which can cause direct damage to infrastructure, block access to areas, and result in increased traffic (Bedsworth et al. 2018). The Project is not anticipated to increase or decrease climate effects on navigation, transportation, and traffic.

28.5.8.6. Noise and Visual Resources

Inundation from Alternatives 1, 2 and 3 can affect nighttime glare and Alternative 2 would clear vegetation and install riprap along the Sacramento River, which would have significant visual impacts without mitigation measures. Climate change is not expected to worsen these effects.

28.5.8.7. Cultural Resources and Indian Trust Assets

Various climate change hazards, including extreme heat, wildfire, and flooding could result in damage or increased degradation to cultural and archaeological resources. Climate change is also altering historic temperature, precipitation, flooding, and wildfire patterns, threatening traditional ecological knowledge that developed from knowing the land for centuries (Goode et al. 2018).

The Project would provide neither benefits from nor adverse effects to climate impacts on cultural resources.

28.5.8.8. Public Services and Utilities

The Project would not have a substantial adverse effect on public services and utilities. The Project is not expected to call for extra fire or police protection or require additional water and wastewater treatment, stormwater drainage, electric power, natural gas, or telecommunications.

Climate change could exacerbate the need for reliable water. Increased heat and drought could put more strain on groundwater and surface water resources, while increased extreme precipitation could decrease groundwater recharge, preventing this water source from fully replenishing in the future. Climate change hazards may also result in a variety of effects on water and wastewater treatment, stormwater drainage, energy, and telecommunications, including direct damage to infrastructure, increase in demand of services, and disrupted operations (Bedsworth et al. 2018). However, the Project is anticipated to support regulation of flows through diversion during high flows and releases during low flows; this would help decrease flooding and decrease drought risks by providing more steady water volumes in the Sacramento River and the Delta during times of increased wetness or dryness.

28.6 References

28.6.1. Printed References

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28.6.2. Personal Communications

5.1 Introduction

This chapter describes the environmental setting, methods of analysis, general hydrologic modeling results and impact analysis for surface water resources that would potentially be affected by the construction and operation of the Project. Surface water resources generally include reservoirs, rivers, and diversions and this chapter addresses surface hydrology, water supply (diversions) and flooding.

The study area for surface water resources consists of those areas with greatest potential to be affected by the Project and associated changes in operations. This area includes drainages in the Sites Reservoir footprint, conveyance and storage facilities for moving water to and from Sites Reservoir, Shasta Lake and the Sacramento River, Lake Oroville and the Feather River, Folsom Lake and the American River, Yolo Bypass, and the Delta. Water supply service areas and the delivery system of the CVP, including San Luis Reservoir, as well as the SWP, are also discussed. Trinity River operations would not be affected by the Project and are not discussed in this chapter (Appendix 5B, *Water Resources System Modeling*).

The study area for flood control and management facilities includes the local drainages in the inundation area and downstream, as well as the larger flood management system along the Sacramento River and the Yolo Bypass. Other watercourses and flood storage facilities associated with northern California's flood management infrastructure, such as the Trinity River (i.e., Trinity Lake, Lewiston Lake,), the Feather River (i.e., Lake Oroville and the Thermalito Complex), the American River (i.e., Folsom Dam and Lake Natoma), and San Luis Reservoir are not analyzed with respect to flooding. This is because various modeling results indicate negligible increases in flow or storage at these facilities that would result in no measurable increase in the likelihood or risk of flooding (Appendix 5B, *Water Resources System Modeling*).

Tables 5-1a and 5-1b summarize the CEQA determinations and NEPA conclusions for construction and operation impacts, respectively, between alternatives.

Table 5-1a. Summary of Construction Impacts and Mitigation Measures for Surface Water Resources

Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
Impact HYDRO-1: Reduce water supply for other water users			
No Project	NI/NE	–	NI/NE
Alternative 1	LTS/NE	–	LTS/NE
Alternative 2	LTS/NE	–	LTS/NE
Alternative 3	LTS/NE	–	LTS/NE

Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
Impact HYDRO-2: Substantial increase in the rate or amount of surface runoff in a manner which would result in flooding onsite or offsite			
No Project	NI/NE	–	NI/NE
Alternative 1	LTS/NE	–	LTS/NE
Alternative 2	LTS/NE	–	LTS/NE
Alternative 3	LTS/NE	–	LTS/NE
Impact HYDRO-3: Impede or redirect flood flows			
No Project	NI/NE	–	NI/NE
Alternative 1	LTS/NE	–	LTS/NE
Alternative 2	LTS/NE	–	LTS/NE
Alternative 3	LTS/NE	–	LTS/NE

Notes:
NI = CEQA determination of no impact
LTS = CEQA determination of less-than-significant impact
LTSM = CEQA determination of less than significant with mitigation
S = CEQA determination of significant impact
B = NEPA conclusion of beneficial effects
NE = NEPA conclusion of no effect or no adverse effect
AE = NEPA conclusion of adverse effect
SA = NEPA conclusion of substantial adverse effect

Table 5-1b. Summary of Operation Impacts and Mitigation Measures for Surface Water Resources

Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
Impact HYDRO-1: Reduce water supply for other water users			
No Project	NI/NE	–	NI/NE
Alternative 1	LTS/NE	–	LTS/NE
Alternative 2	LTS/NE	–	LTS/NE
Alternative 3	LTS/NE	–	LTS/NE
Impact HYDRO-2: Substantial increase in the rate or amount of surface runoff in a manner which would result in flooding onsite or offsite			
No Project	NI/NE	-	NI/NE
Alternative 1	LTS/NE	-	LTS/NE
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE
Impact HYDRO-3: Impede or redirect flood flows			
No Project	NI/NE	-	NI/NE
Alternative 1	LTS/NE	-	LTS/NE

Alternative	Level of Significance Before Mitigation	Mitigation Measures	Level of Significance After Mitigation
Alternative 2	LTS/NE	-	LTS/NE
Alternative 3	LTS/NE	-	LTS/NE

Notes:
NI = CEQA determination of no impact
LTS = CEQA determination of less-than-significant impact
LTSM = CEQA determination of less than significant with mitigation
S = CEQA determination of significant impact
B = NEPA conclusion of beneficial effects
NE = NEPA conclusion of no effect or no adverse effect
AE = NEPA conclusion of adverse effect
SA = NEPA conclusion of substantial adverse effect

5.2 Environmental Setting

The environmental setting focuses on surface water resources in the study area and considers the broader context for these resources in California. Variability and uncertainty are the dominant characteristics of California's water resources. Precipitation is the primary source of California's water supply (California Department of Water Resources 2019: 1-14); however, it varies greatly on an annual and seasonal basis and by region. Most of the precipitation falls in northern California. The total volume of water the state receives can vary dramatically between Critically Dry and Wet Water Years. For example, during Water Year 2013, a Critically Dry Water Year, California received 103 MAF of water and during 2011, a Wet Water Year, California received than 248 MAF of water (California Department of Water Resources 2019: 1-4). The majority of California's precipitation occurs between November and April and most of the demand for water is during the summer months. The annual, seasonal, and regional hydrologic variability necessitates that water from precipitation in the winter and spring must be stored for use in the summer and fall. Federal, state, and local agencies and private entities have constructed reservoirs, aqueducts, pipelines, and water diversion facilities to capture and use the rainfall and snowmelt.

5.2.1. River and Hydrologic Systems

The river and hydrologic systems in the study area are composed of natural and artificial waterbodies. This section provides a general description of the hydrologic conditions for the natural drainages near and in the inundation area (Figure 1-3); Project conveyance systems (Figure 1-2); and waterbodies associated with SWP and CVP where operational changes may occur as a result of Project implementation (Figure 1-1).

5.2.1.1. Local Drainages

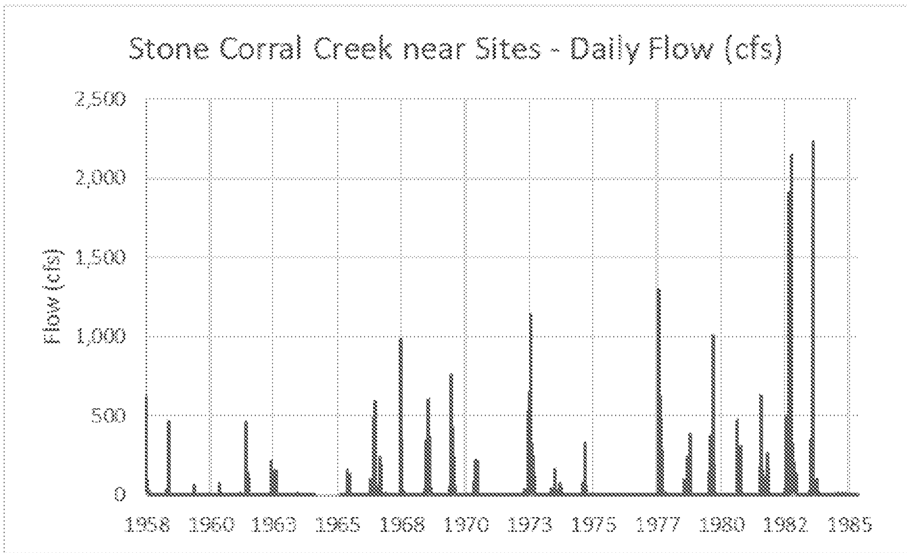
Multiple small creeks are in the vicinity of the Sites Reservoir, either within the inundation area or near the inundation area. These local creeks originate in the eastside foothills of the Coast Range and drain west towards the Sacramento Valley subregion of the Central Valley. In general, these creeks are ephemeral (within and upslope of Antelope Valley) transitioning to intermittent or perennial streams that frequently experience low to no flows in the summer. The creek segments on the Sacramento Valley floor have been highly altered, primarily for water conveyance and agricultural purposes.

The creek located to the north of the inundation area is Hunters Creek and the primary drainages in the inundation area are Funks Creek and Stone Corral Creek. These creeks originate at elevations below the snow line of the Coast Range and consequently do not receive cold snowmelt water. Rather, they respond rapidly to significant rainfall events and flash flooding and substantial overland flow (U.S. Bureau of Reclamation and California Department of Water Resources 2013).

Stone Corral Creek

Stone Corral Creek has a drainage area of 38 square miles and crosses over a siphon in the TC Canal before traveling through agricultural lands. About 3 miles below the TC Canal siphon, Stone Corral Creek crosses the GCID Main Canal siphon. Although most of the water in the GCID Main Canal passes under Stone Corral Creek in the siphon, GCID can make releases to Stone Corral Creek for delivery to agricultural fields downstream. About 5.5 miles below the GCID Main Canal, Stone Corral Creek is joined by Funks Creek and then flows an additional 5.7 miles to the CBD. Antelope Creek is also tributary to Stone Corral Creek.

The U.S. Geological Survey (USGS) collected 27 years of discharge measurements in Stone Corral Creek near the community of Sites from 1958 through 1985 (Figure 5-1). The data demonstrate high variability of flow over the period of record. There were multiple years with minimal flow and two with zero flow (1976 and 1977). The maximum annual discharge during the period of record was 50.1 TAF in 1983. Based on the USGS data, the long-term annual average discharge through the creek is 6.7 TAF/year.



Source: U.S. Geological Survey stream gage 11390672

Figure 5-1. Daily Flow in Stone Corral Creek near Sites (cfs)

Funks Creek

Funks Creek has a drainage area of 43 square miles and drains into Funks Reservoir. Below Funks Dam, Funks Creek travels 3.9 miles through agricultural fields in a combination of natural and straightened channels to where it crosses the GCID Main Canal. While the GCID Main Canal passes under Funks Creek in a siphon, GCID releases water from the canal to Funks Creek, and like Stone Corral Creek, GCID uses the downstream portions of Funks Creek as part of its conveyance system to deliver water to agricultural fields. Approximately 2 miles northeast of Maxwell and 1 mile east of Interstate 5 (I-5), Funks Creek flows into Stone Corral Creek. Grapevine Creek is tributary to Funks Creek.

There is no measured flow record for Funks Creek, but given the comparable size, geology, and topography of the two watersheds and their proximity to each other, Funks Creek hydrology is likely similar to Stone Corral Creek in terms of amount and seasonality of flow. Because the Funks Creek drainage area (43 square miles) is 13% greater than the drainage area of Stone Corral Creek (38 square miles), runoff from the Funks Creek watershed is approximated here as 113 % of that for Stone Corral Creek runoff. Therefore, the estimated long-term annual volume of flow for Funks Creek is 7.6 TAF and the estimated maximum flow for 1983 is 56.7 TAF.

Hunters Creek

The headwaters forks of Hunters Creek, including its north fork, originate in the uplands to the north of Antelope Valley, flow east toward the Sacramento Valley, and converge northwest of the inundation area. Hunters Creek flows in a southeasterly direction for approximately 9.0 miles until it reaches the TC Canal. Hunters Creek continues past the GCID Main Canal, is joined by several additional creeks on the valley floor, passes under I-5, and terminates in the vicinity of the CBD. The three main contributing channels to Hunters Creek on the valley floor are downstream/downslope of the locations of Saddle Dams 3, 5, and 8B.

Flood Risk

The 100-year floodplain delineations for the drainages that are near and in the inundation area are shown on Figure 5-2. Funks, Stone Corral, and Hunters Creeks are mapped within the 100-year floodplain (with inundation spreading away from the channels the further eastward into the valley the creeks go), but no other flooding hazard exists elsewhere adjacent to these creeks.

The USGS flow data and 100-year discharge estimates indicate that Stone Corral Creek has a "flashy" hydrologic regime[1]. The maximum mean daily flow on record for Stone Corral Creek was 2,230 cubic feet per second (cfs) in 1983; the maximum instantaneous peak flow, 5,700 cfs, was also recorded that year (U.S. Geological Survey 2021a). The California Department of Water Resources (DWR) established the 100-year discharge for Stone Corral Creek as 7,870 cfs based on the 25 years of records (U.S. Bureau of Reclamation and California Department of Water Resources 2008:3-12). The USGS StreamStats estimate the 100-year discharge for Stone Corral Creek being slightly lower (6,590 cfs) with the mean daily discharge exceeding 215 cfs only 1% of the time and flows above 0 cfs 45% of the time (U.S. Geological Survey 2021b). Flooding occurred in the vicinity of the inundation area in February 2017 as a result of overtopping of Stone Corral Creek. The valley floor around the community of Maxwell flooded, and two sections of I-5 just north of the city of Williams were barely passable due to floodwater encroachment. Local roadways were also closed from flooding and mudslides, and some residents voluntarily evacuated. Boils were reported on the agricultural levees stretching from Colusa to Knights Landing. The Colusa County Sheriff's Department cited flooding of local creeks as a contributor (Kalb and Opshal 2017).

There are no stream discharge data for Funks Creek and Funks Creek hydrology is considered similar to that of Stone Corral Creek, as previously mentioned. Therefore, the peak flow recurrence intervals and mean daily flow durations for Funks Creek are regarded as comparable to Stone Corral Creek.

Flooding Types

The types of flooding most applicable to Funks, Stone Corral, Hunters, Grapevine, and Antelope Creeks, as well as nearby unnamed channels, are localized flooding and riverine flooding (albeit to a lesser extent). This is based on a review of the geology, topography, soils, and vegetation

[1] Flashy indicates a stream that experiences a rapid increase in flow shortly after onset of a precipitation event, and an equally rapid return to base conditions shortly after the end of the precipitation event.

associated with the drainages in the inundation area vicinity. Localized flooding is often caused by severe weather cycles or a significant and often prolonged rainfall event on a relatively small drainage area (e.g., Funks, Stone Corral, Hunters, Grapevine, and Antelope Creeks). The term "flash flood" describes localized floods of significant magnitude and short duration. Riverine flooding, sometimes referred to as "slow rise" flooding, occurs when a watercourse exceeds its bankfull capacity (i.e., overbank flow), and generally results from prolonged rainfall, or rainfall that is combined with already saturated soils from previous rain events. This type of flooding occurs in river systems whose tributaries may drain large geographic areas and include one or more independent river basins. The onset and duration of riverine floods may vary from a few hours to many days. The potential for riverine flooding in the inundation vicinity is limited to the lowest reaches of Funks, Stone Corral, Hunters, Grapevine, and Antelope Creeks, generally east of the GCID Main Canal near I-5.

5.2.1.2. Conveyance Systems

There are a number of conveyance systems in the study area that would be used to convey water from the Sacramento River to storage in Sites reservoir, and then then convey releases from Sites Reservoir to the CBD, Yolo Bypass and/or the Sacramento River. These conveyance systems are described in this section along with associated potential flood risks.

TCCA System

The TCCA operates the RBPP, TC Canal, Funks Reservoir, Corning Pumping Plant, Corning Canal, fish passage facilities, and settling basin. These facilities are held in title by Reclamation, which would retain title regardless of Project implementation. TCCA operates the TC Canal through a Joint Powers Authority composed of 17 water districts and delivers water to the service areas of those districts in Tehama, Glenn, Colusa, and northern Yolo Counties.

The RBPP was constructed on the Sacramento River adjacent to Reclamation's RBDD as part of the Fish Passage Improvement Project and includes a fish screen, canal, siphon, forebay, switchyard, and a bridge across Red Bank Creek. TCCA currently operates the four pumps in the RBPP at a total capacity of 2,000 cfs, which is in accordance with the biological opinions issued by U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) specifically for the pumping plant. The RBPP contains two additional pump bays designed for the future installation of two 250-cfs vertical axial-flow pumps, which would increase the total capacity to the maximum 2,500 cfs. The TC Canal and the Corning Canal convey Sacramento River water from the RBPP south to irrigate approximately 150,000 acres of cropland. The TC Canal also supplies water to 20,000 acres of wildlife refuges in the Sacramento Valley.

The TC Canal is a concrete-lined channel that extends approximately 111 miles from the RBPP in Tehama County to south of Dunnigan in Yolo County. There is a regulating reservoir (i.e., Funks Reservoir) at its midpoint approximately 66 canal miles downstream of the intake. The TC Canal terminates 4 miles west of the CBD The TC Canal has 26 automated check structures that are run by Supervisory Control and Data Acquisition (SCADA) and approximately 75 turnouts that are closed-piped systems (non-canal/ditch). The automated check structures control the water surface elevation (WSE) where the canal enters (i.e., Funks Dam) and exits Funks Reservoir (check structures 16 and 17, respectively).

Funks Reservoir was created by the installation of the Funks Dam in 1976. The dam regulates flows from TC Canal and Funks Creek, and its gates are opened during large storm events to pass flood waters through the reservoir and downstream to avoid compromising the capacity and operations of the TC Canal. The initial volume of Funks Reservoir was approximately 2,200 AF but sediment deposition that is predominately on the north and east sides has reduced the volume of usable storage in the reservoir's operating range to approximately 1,100 AF. The WSE in Funks Reservoir typically ranges from 200 to 205 feet.

The typical summer releases from Funks Reservoir to the lower portions of the TC Canal range from 500 cfs to 1,000 cfs. Total flows of 50 cfs to 200 cfs for off-peak limited agricultural releases are typically needed between November and February (occasionally March, depending on the weather) (California Department of Water Resources 2003). Since the TC Canal began operating, fall and winter diversions have increased due to higher water demands for rice straw decomposition purposes.

GCID System

The existing GCID facilities include the Hamilton City Pump Station and forebay, Main Canal, intake and bypass channels, fish screens, head gates, gradient facility, and three siphons on the Main Canal (i.e., Walker Creek, Willow Creek, and the railroad siphon). GCID's system of canals was largely constructed in the early 1900s and conveys water to approximately 140,000 acres of irrigated lands and 22,000 acres of wildlife refuges and private wetlands in the GCID service area (Glenn-Colusa Irrigation District ND).

The Hamilton City Pump Station is on the Sacramento River approximately 5 miles northwest of Hamilton City (River Mile [RM] 205) and pumps water into the GCID Main Canal intake. GCID operates 10 pumps at the Hamilton City Pump Station with a total capacity of 3,000 cfs diversion. The approximately 65-mile-long GCID Main Canal is an unlined, earthen channel that delivers water between the intake at the pump station and its terminus at the CBD to the southeast near the city of Williams. There is a 1,000-cfs, gravity-fed intertie connecting GCID Main Canal and TC Canal north of Funks Reservoir and a cross tie south of the city of Williams.

The GCID Main Canal's primary irrigation season is early April through September and there is currently little to no available capacity during this period. Several recent improvements along the GCID Main Canal allow year-round water delivery operations. Two major operational changes included a shift to year-round water delivery to convey water in fall and winter to the Sacramento, Colusa, and Delevan National Wildlife Refuges, as well as to meet increased fall and winter season water demands for rice straw decomposition purposes by growers in GCID's service area.

The GCID Main Canal is typically out of service each year between early January and late February for approximately 6 weeks for maintenance. Debris that enters the intake channel, such as large trees, can block flows to the channel, get entangled at the face of the fish screen, obstruct the water control structure, or cause other disruptions to operating conditions. The debris commonly builds up during winter flood flows and is removed at the beginning of the irrigation season in late March or early April.

CBD and Knights Landing Ridge Cut

The CBD is a human-made channel designed to convey agricultural return flows and storm runoff from the Colusa Basin to the Sacramento River or the Yolo Bypass, with direction of flow controlled by the Knights Landing Outfall Gates (KLOG) near the downstream end of the CBD (Gray and Pasternack 2016:12–13). When CBD water is discharged to the Sacramento River, it enters near RM 90 at Knights Landing. Construction of the CBD commenced in 1919, and the facility was expanded over the years until its current form was completed in 1958. The CBD is 70 miles long and crosses areas of Glenn, Colusa, and Yolo Counties; Colusa County contains the longest segment (Gray and Pasternack 2016:3). The CBD receives inflow from local creeks, including Funks and Stone Corral Creeks, and discharge and runoff from the agricultural lands in the Colusa Basin. The CBD typically conveys flood flows from November through April, and agricultural irrigation and drainage flows from May through October (Gray and Pasternack 2016:ii).

Under conditions of low water levels, CBD drains by gravity into the Sacramento River at Knights Landing; however, when the water levels in the Sacramento River at Knights Landing are too high for this gravity flow to occur or when CBD flow is too great, discharge from the CBD is routed directly to the Yolo Bypass through the Knights Landing Ridge Cut (KLRC) (Gray and Pasternack 2016 p13).

The rate of flow from the CBD into the Sacramento River through the KLOG is affected by the differential stage in the Sacramento River and in the CBD at the KLOG. The stage in the CBD at the KLOG depends on the operation of the KLOG (Gray and Pasternack 2016:12–13). In the irrigation season, KLOG gates are closed to facilitate irrigation withdrawal; keeping the gates closed creates an upstream ponding effect.

CBD discharge to the Sacramento River was measured from 1984 through 2012 at DWR Water Data Library Station A02945 (Sacramento River at Knights Landing) and is summarized in Table 5-2. CBD flows measured during the flood conveyance period from November through April do not always represent full flows. CBD flow during this period may be directed to the Yolo Bypass. Flows during the agricultural irrigation and drainage period from May through October likely represent the full CBD flow being directed to the Sacramento River. The peak CBD flow during the irrigation and drainage period occurred during August and September.

Commented [CC1]: A02945 is named "Colusa Basin Drain at Knights Landing"

Table 5-2. Summary of Daily Flow Measured in the CBD Discharging to the Sacramento River at Knights Landing between 1984 and 2012.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min	0	0	0	0	0	0	0	0	0	0	0	0

Avg	256	197	79	147	310	247	369	766	889	210	609	345
Max	1,673	1,573	908	1,327	1,817	1,546	1,390	1,900	2,225	897	1,900	1,705

Source: DWR Water Data Library Station A02945

Flood Risk

Funks Reservoir

The drainage area above Funks Dam is 43 square miles. The Funks Reservoir structural height is 80 ft and its normal operating depth at the dam is 36 ft. The reservoir's spillway capacity is 22,500 cfs at an elevation of 0 ft with a crest length of 1,460 ft. Reclamation is the original owner of the reservoir and does not list flood control as a design objective of Funks Dam (U.S. Bureau of Reclamation 2021a). The reservoir is exempt from the jurisdiction of DSOD. At the time of preparation of this RDEIR/SDEIS there were no records of flooding or structural failure at Funks Reservoir. There is no discharge record for Funks Creek on the California Data Exchange Center, which is administrated by DWR and compiles stream monitoring data from multiple sources (e.g., USGS). The 100-year floodplain delineations surrounding Funks Reservoir are shown on Figure 5-2. Funks Creek is mapped within the 100-year floodplain, but no other flooding hazard exists elsewhere adjacent to Funks Reservoir.

TC Canal and GCID Main Canal

The primary purpose of the TC Canal and GCID Main Canal is to provide irrigation and not flood control. The 100-year floodplain delineations for areas downstream of Sites Reservoir (including the canals) are shown on Figure 5-2 through Figure 5-5. As shown on Figure 5-2, the canals to the east of Sites Reservoir are intersected by various small drainages (e.g., Funks, Stone Corral, and Hunters Creeks as described above), but no other flooding hazard exists elsewhere adjacent to the canals. Areas with undetermined flood hazards include the national wildlife refuges, which are not subject to the Federal Emergency Management Agency (FEMA) National Flood Insurance Program regulations. As shown on Figure 5-4 and Figure 5-5 the Dunnigan Pipeline and the Walker and Willow Creek siphon replacements, would be within the 100-year floodplain.

CBD

The CBD has been designated as a floodway by the Central Valley Flood Protection Board (CVFPB). The CBD collects all drainage from the Colusa Basin watershed, which covers approximately 1,045,445 acres (1,635 square miles) (Colusa County Resource Conservation District 2012:1). The Colusa Basin encompasses the area between the Stony Creek watershed in the north and the Cache Creek watershed to the south, and that between the Sacramento River in the east and the inner Coast Range foothills to the west. Various ephemeral streams drain the Coast Range foothills, and have historically contributed to seasonal flooding in the Colusa Basin when combined with Sacramento River overflow (H. T. Harvey et al. 2008:1). The leveed capacity of the CBD is 20,000 cfs (California Department of Water Resources 2017a:3-3). However, even during summer conditions, some inundation of agricultural fields could occur at RM 8.9 if the WSE were to reach 25.3 feet as a result of seepage and backwater.

The KLOG are closed in the nonirrigation season during high Sacramento River events to prevent river water from flowing up the CBD. When CBD flows are high, waters are rerouted to the KLRC, which delivers overflow waters to the Yolo Bypass (Gray and Pasternack 2016:5). The CBD frequently floods in the winter (Gray and Pasternack 2016:13). While the lower drain flood waters are routed through the KLRC to the Yolo Bypass, upper drain flood waters in the shallow portion of the CBD overflow the banks. For example, the State Route 20 bridge overpass near Colusa experiences overbank flooding when discharge exceeds 2,100 cfs (Gray and Pasternack 2016:13). The highest discharge recorded at State Route 20 bridge overpass was 23,900 cfs (February 21st, 1958), while the highest discharge recorded in the lower reaches near the KLRC was over 8,500 cfs (January 17, 1978) (Gray and Pasternack 2016:13).

Knights Landing Ridge Cut

Streamflows in the KLRC are based on flow conditions caused by the slide gate and flap gate settings at the outfall relative to the head difference of: (1) the stage of the gage on the CBD, which is upstream of the gates; and (2) the stage of the gage on the Sacramento River at Knights Landing, which is downstream of the gates. The KLRC conveys CBD drainage and flood flows into the Yolo Bypass several miles downstream of Fremont Weir. In addition, flood flows in the KLRC can occasionally be diminished via backwatering of the Yolo Bypass when it is at maximum conveyance capacity.

The banks on each side of the KLRC are Sacramento River Flood Control Project (SRFCP) levees. The Knights Landing Ridge Drainage District maintains the south levee upstream of the Knights Landing Outfall, and Yolo County Service Area 6 maintains the south levee downstream of the Knights Landing Outfall. Reclamation District 787 maintains the north levee upstream of the Knights Landing Outfall, and the Sacramento River Westside Levee District maintains the north levee downstream of the Knights Landing Outfall. The leveed capacity of the KLRC is 20,000 cfs (California Department of Water Resources 2017a:3-3).

During the flood events of 1986, 1997, 2006, and 2011, the stage of the Sacramento River was consistently higher than the CBD at the peak of the flood wave, resulting in no stream flow through the Knights Landing Outfall structure. However, at the ends of the rising and/or receding limbs of the hydrographs, there are occasions where the CBD water levels are higher than the stage in Sacramento River, resulting in stream flow through the Knights Landing Outfall (up to 1,370 cfs during the four historic floods). Based on historic record, the maximum flow through the Knights Landing Outfall is 2,220 cfs. (cbec in preparation:1).

The 100-year floodplain delineations for the CBD and the KLRC are shown on Figure 5-3. Most of the topographically low-lying areas adjacent to the riverine areas are included within the 100-year floodplain (Figure 5-3). The KLRC is within a 100-year floodplain (Zone A) as designated by FEMA.

5.2.1.3. Sacramento River and Lake Shasta

Sites Reservoir would operate on conjunction with the operations of Lake Shasta and flows in the Sacramento River would be affected by Sites Reservoir diversions and releases. The

Sacramento River is the largest river in California. Runoff from the upper Sacramento River and its tributaries are regulated by Shasta Lake and Shasta Dam. Shasta Dam was constructed in 1945 by Reclamation and is part of the CVP. Shasta Lake has a storage capacity of approximately 4.55 MAF and captures runoff from the Sacramento, McCloud, and Pit rivers. It has a maximum flood control storage space of 1.3 MAF. Releases from Shasta Reservoir are managed for protection of fish and wildlife, flood control requirements, hydropower generation, and water supply demands of CVP contractors. (Reclamation 2014:1-3,6-6,6-20).

During normal operations (i.e., non-emergency spill releases) Shasta Dam releases are restricted to 79,000 cfs at the tailwater of Keswick Dam and by a flood stage of 27 feet at the Sacramento River near the Bend Bridge gage. This flood stage at Bend Bridge corresponds to a discharge of just under 100,000 cfs at Shasta Dam. Shasta Dam outlet works capacity is 81,800 cfs, while the emergency spillway capacity is 186,000 cfs at 1,065 ft elevation (U.S. Bureau of Reclamation 2021b). In 2017 and 1997, both Wet Years and during floods, it was reported Shasta Dam opened its top gates to release from 70,000 cfs to 79,000 cfs (Serna 2017). A FEMA report was stated to identify the 2017 flood had a 5-year recurrence interval, which corresponds to a 20% chance of occurring in any given year (Solis 2017). Flood stage at Bend Bridge was exceeded in both 2017 and 1997 floods, when discharge reached 100,000 cfs and 121,000 cfs respectively. The highest peak on record at Bend Bridge was 157,000 cfs in 1970 (National Ocean and Atmospheric Administration 2021).

A Temperature Control Device was installed at Shasta Dam between 1996 and 1998 to both minimize power losses and control the water temperature downstream of Shasta Lake to protect salmon. The Temperature Control Device has allowed for warmer water withdrawals in the spring/early summer, resulting in conservation of the deep cold-water pool for colder withdrawals in the late summer/early fall to meet downstream temperature requirements.

Keswick Reservoir was formed by the completion of Keswick Dam in 1950. It has a capacity of approximately 23.8 TAF and serves as an afterbay for releases from Shasta Dam and for discharges from the Spring Creek Power Plant.

The level of flow in the upper Sacramento River below Keswick Dam is controlled by releases from Shasta Lake and Keswick Reservoir, as well as transfers from the Trinity River and natural accretions. The releases and transfers are determined by a suite of laws, regulations, contracts, and agreements to address demands of water users, requirements for water quality, and needs of fish populations throughout the river and the Delta. Operations are regulated by State Water Resources Control Board (State Water Board) D-1641, which requires flow releases to meet Delta standards, and their WRO 90-5 decision, which requires cold water releases to meet temperature targets at compliance points in the upper Sacramento River. Dry hydrologic conditions often lead to inadequate storage in Shasta Lake for operators to provide suitable conditions for salmonids and other native fish species in the upper Sacramento River.

Downstream of Keswick Reservoir, the Sacramento River is influenced by tributary streams; diversions for agricultural, municipal, and industrial purposes; agricultural and municipal discharges; and a flood damage reduction system that includes levees, floodplains (including the Yolo, Sutter, and Colusa Bypasses), and weirs. The CVP is operated to meet the navigation flow requirement of 5,000 cfs at the Wilkins Slough gaging station when diversions are occurring downstream under all but the most critical water supply conditions. Flows measured at Wilkins Slough are summarized in Table 5-3. These data show that during very dry conditions, flow at Wilkins Slough may go as low as approximately 3,000 cfs. Generally, however, flows are often above what is required for this location, generally for the purpose of flood control, water quality (e.g., upstream temperatures or Delta salinity), Delta outflow, or Delta exports. The Feather River joins the Sacramento River at the community of Verona, and the American River joins at the city of Sacramento. The Sacramento River then flows south, joining with the San Joaquin River in the Delta, and out to the Pacific Ocean.

Table 5-3. Summary of Daily Flow Measured (cfs) in the Sacramento River below Wilkins Slough between 1985 and 2020.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min	3,290	3,780	3,870	2,860	2,720	2,900	2,950	3,050	3,980	3,050	3,390	3,460
Avg	13,583	14,698	14,791	11,022	8,650	8,017	7,584	7,080	7,099	5,572	5,746	10,316
Max	31,600	32,600	30,300	29,800	30,200	26,700	14,600	11,300	12,600	14,400	23,700	30,700

Source: U.S. Geological Survey 2021n.

Sacramento River Flood Control Project and Flood Management

Existing flood management facilities along the Sacramento River affect its flow and operation. These facilities include dams and reservoirs, levees, and weirs. Shasta Lake (described above). Shasta Lake collects flow in the upper Sacramento River, but many controlled and uncontrolled tributaries enter the Sacramento River downstream from this reservoir. In addition to dams and reservoirs, there are six weir structures and three flood relief structures that divert portions of flood flows to three overflow basins/bypasses: Butte Basin, Sutter Bypass, and Yolo Bypass. These weirs act as flood relief structures, allowing high flows from the Sacramento River to empty into the overflow basins and bypasses. The weirs were designed to function in a particular order (upstream to downstream), as follows: Moulton Weir, Colusa Weir, Tisdale Weir, Fremont Weir, Sacramento Weir, and Cache Creek Weir (California Department of Water Resources 2010:1). The 100-year floodplain delineations for the northern Sacramento River Valley are shown on Figure 5-3. Most of the topographically low-lying areas adjacent to the riverine areas are included within the 100-year floodplain (Figure 5-3).

Multiple facilities along the Sacramento River are part of the SRFCP (authorized by Congress in 1917). The SRFCP was the major project for flood control on the Sacramento River and its tributaries. It was sponsored by The Reclamation Board of the State of California (today reauthorized as the CVFPB) and was the first federal flood control project constructed outside the Mississippi River Valley (U.S. Army Corps of Engineers 2009). The SRFCP includes approximately 980 miles of levees, overflow weirs, pumping plants, and bypass channels that protect communities and agricultural lands in the Sacramento Valley and the Delta. Currently, the SRFCP extends from the Sacramento River's mouth near Collinsville in the Delta to near

Chico Landing in the northern Sacramento Valley. Approximately 980 miles of levees were constructed as part of the SRFCP, providing flood protection to thousands of acres of highly productive agricultural lands, and multiple cities in the Central Valley, including Sacramento and Marysville. A large area of this regulated system includes both state- and federally authorized projects as the CVFPB has provided assurances of state cooperation to the federal government. This portion of the flood protection system is known as the State Plan of Flood Control (SPFC). The current flood risk statuses of the Sacramento River and other river systems under the jurisdiction of the SPFC, as well as the statuses of levees and flood control structures in these areas, are fully described in DWR's *2017 Flood System Status Report* (California Department of Water Resources 2017b).

The SRFCP begins downstream from Ord Ferry (RM 184) and ends at the confluence with the Feather River at Verona (RM 80). Key information pertaining to flood control facilities within the SRFCP is summarized in Table 5-4:

Table 5-4. Summary Flood Control Facilities and Management of the SRFCP.

Reach	River Miles	Flood Control Facilities	Flood Characteristics
Red Bluff to Chico Landing	246 to 194	No levees present (U.S. Army Corps of Engineers 2002:20)	• Sacramento River naturally meanders through alluvium, and local tributaries contribute unregulated flows. • RBDD diverts water from the Sacramento River to the Corning Canal and the TC Canal at RM 243. • In-channel capacity of the river upstream of Chico Landing is 260,000 cfs. (California Department of Water Resources 2017a:3-3.)
Chico Landing to Colusa Reach	194 to 143	Constructed levees; (levees of the SRFCP begin in this reach, downstream from Ord Ferry on the west [RM 184] and downstream from RM 176 above Butte City on the east side of the river), natural overbank areas, and various flood relief structures leading into the Butte Basin.	• The Sacramento River meanders through alluvial deposits between widely spaced levees. • The largest tributary in this reach is Stony Creek; Black Butte Lake on Stony Creek is the only reservoir operated to manage flood flows in this reach. • Big Chico Creek and Mud Creek drain flood waters from the east side of the Sacramento Valley in the Chico area. • Floodwaters in the Sacramento River overbank to the east at three locations into what is referred to as the Butte Basin Overflow Area. These include the M&T (RM 190) and Three Bs flood relief structures (RM 186); Moulton Weir (RM 158); and the Colusa Weir (RM 146). • Several federal projects begin in this reach, including the SRFCP, Sacramento River Major and Minor Tributaries Project, and the Sacramento River Bank Protection Project (SRBPP). • The leveed capacity of the Sacramento River near Butte City (RM 169) is 160,000 cfs; 135,000 cfs at the Colusa Weir; and 65,000 cfs at the Butte Slough Outfall Gates at Colusa (RM

Reach	River Miles	Flood Control Facilities	Flood Characteristics
			143) (California Department of Water Resources 2017a:3-3)
Colusa to Verona Reach	143 to 79	A continuation of the constructed levees	• Feather River (the largest eastern tributary to the Sacramento River), has its confluence with the Sacramento River just above Verona (RM 80). • Flood management diversions occur at the Tisdale Weir at RM 119 (where floodwaters enter into the Tisdale Bypass, which then routes water into the Sutter Bypass), and the Fremont Weir at RM 71 (where floodwaters from the Sacramento River, Sutter Bypass, and Feather River combine and flow into the Yolo Bypass). • The leveed capacity of the Sacramento River upstream of the Tisdale Bypass (from Butte Slough Outfall Gates at RM 138 to Tisdale Weir) is 66,000 cfs (California Department of Water Resources 2017a:3-3). • The leveed capacity of the Sacramento River downstream of the Tisdale Bypass (from the Tisdale Weir to the Knights Landing Outfall structure at RM 90) is 30,000 cfs (California Department of Water Resources 2017a:3-3). • The leveed capacity of the Sacramento River between the Knights Landing Outfall structure and the Fremont Weir is also 30,000 cfs (California Department of Water Resources 2017a:3-3).
Verona and Collinsville	79 to 0	Levees, weirs and use of Bypass	• Sacramento River flows past the city of Sacramento to the Delta. • The Yolo Bypass parallels the river reach to the west. Flows enter the Sacramento River from the Natomas Cross Canal (approximately 1 mile downstream from the Feather River confluence at RM 80). • The American River (RM 60); and at RM 14 near Rio Vista where the flows in the Yolo Bypass reenter the river. • As the Sacramento River enters the Delta, the Georgiana Slough branches off from the mainstem Sacramento River, directing flows into the central Delta. • The one diversion point for flood management is at the Sacramento Weir (RM 63), where floodwaters are diverted from the Sacramento River through the Sacramento Bypass to the Yolo Bypass.

The capacity of the leveed Sacramento River between Verona and Collinsville is listed in Table 5-5.

Table 5-5. Lower Sacramento River Leveed Capacity.

Segment	River Miles	Flow (cfs)
Fremont Weir to Sacramento Weir	RM 71 - RM 63	107,000 cfs
Sacramento Weir to Sutter Slough	RM 63 - RM 34	128,000 cfs
Sutter Slough to Steamboat Slough	RM 34 - RM 32	85,000 cfs
Steamboat Slough to Georgiana Slough	RM 32 - RM 26	56,500 cfs
Georgiana Slough to Yolo Bypass Junction	RM 26 - RM 14	35,900 cfs
Yolo Bypass Junction to Threemile Slough	RM 14 - RM 9	579,000 cfs
Threemile Slough to Collinsville	RM 9 - RM 0	514,000 cfs

Source: California Department of Water Resources 2017a:3-3

Annual Exceedance Probability of Flows / Peak Flows

Table 5-6 summarizes the flood characteristics of the Sacramento River reaches from Red Bluff to Verona relative to each reach's design flood capacity. Included in the table are the USGS gage station name, the number of years maximum annual peak flows were recorded at the gage, the maximum peak and its date, the number of instances the annual peak flow exceeded the reach capacity, and the probability that a peak flow or a mean daily flow would exceed the capacity of the reach at that particular gage station site.

The probability that the annual peak flow would exceed the leveed capacity was calculated using the U.S. Army Corps of Engineers (USACE) Hydraulic Engineering Center's Statistical Software Package (HEC-SSP) software program for three stations: Sacramento River at Colusa, Sacramento River below Wilkins Slough, and Sacramento River at Verona. The estimation process used the B17B method and default program settings.

Table 5-6. Probability of Flows Exceeding Leveed Capacity, Sacramento River.

Reach	Leveed Capacity (cfs)	USGS Station	Years on Record (Peak flows)	Max Peak on Record (cfs)	Number of Years Peak Exceeded Capacity	Date	Probability that Peak Flow will Exceed Leveed Capacity in any Given Year	Probability that Daily Average Flow will Exceed Leveed Capacity in any Given Year
Red Bluff to Chico	260,000	Sacramento River near	87	291,000	2	February 28, 1940	<4%	<1%

Reach	Leveed Capacity (cfs)	USGS Station	Years on Record (Peak flows)	Max Peak on Record (cfs)	Number of Years Peak Exceeded Capacity	Date	Probability that Peak Flow will Exceed Leveed Capacity in any Given Year	Probability that Daily Average Flow will Exceed Leveed Capacity in any Given Year
Landing		Red Bluff						
Chico Landing to Colusa	65,000	Sacramento River at Colusa	79	51,300	0	March 4, 1983	<0.2%[a]	<1%
Colusa to Verona	30,000	Sacramento River below Wilkins Slough	81	32,700	10	February 2, 1986	<12.5%	<1%
Verona to Collinsville	107,000	Sacramento River at Verona	90	102,000	0	January 2, 1997	<0.2%[a]	<1%

Source: U.S. Geological Survey 2021c–2021j

[a] While it appears that the Annual Instantaneous Peak Flow probability is less likely to exceed the leveed capacity than the Mean Daily Flow Duration, this is merely an artifact of the calculated statistics range. The USGS StreamStats Flow Duration Statistics are produced for 99 % duration to 1 % duration, whereas the USACE Frequency Curves are produced for 95 % to 0.2 %. For Sacrament River at Colusa, the leveed capacity exceeds the highest computed flow for both Flow Duration and Flow Frequency. Therefore, the likelihood of flow exceeding leveed capacity is less than the smallest computed probability in both cases.

5.2.1.4. Feather and American Rivers

The Feather and American Rivers are described because they are part of the CVP and SWP and Project operations would be integrated with operations of reservoirs on these rivers.

Lake Oroville and the Feather River

The upper Feather River watershed, extending downstream to Lake Oroville, contains numerous reservoirs and power plant diversions. The mainstem of the Feather River is regulated by Oroville Dam. The dam and its two saddle dams were completed in 1968 and formed Lake Oroville, a 3.5-MAF capacity storage reservoir with a surface area of approximately 16,000 acres at its normal maximum operating level. Water released from Lake Oroville passes through the Edward Hyatt Pumping-Generating Plant and the Thermalito Power Canal into the Thermalito Diversion Pool. At the diversion pool, water can be released through the Thermalito Diversion Dam Powerplant to the low-flow channel (LFC) of the Feather River or diverted through the Thermalito Power Canal Forebay and into Thermalito Afterbay. Flows can be diverted from Thermalito Afterbay into agricultural canals to meet local Feather River service area requirements or released through the Thermalito Afterbay outlet back into the Feather River, where they combine with flows passing through the LFC to produce the high-flow channel (HFC).

Several local irrigation districts receive water from the Thermalito Afterbay during the May through August irrigation season. Major diversions on the Feather River downstream of the Thermalito Complex (which comprises Oroville Dam, Thermalito Diversion Dam, and Thermalito Afterbay outlet) include those into the Western Canal, Richvale Canal, the Pacific Gas and Electric Company Lateral, and the Sutter-Butte Canal. Feather River water is also diverted by holders of riparian water rights for agricultural and municipal uses within the Feather River and Butte Creek watersheds (U.S. Geological Survey 2010, Butte County Department of Water and Resource Conservation 2016: ES-8, 4-11, A-1, A-2).

Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversions, and water quality. Hydroelectric power production is scheduled within the boundaries specified by the water operations criteria. During the wintertime, the facilities are operated pursuant to flood control requirements specified by USACE. Pursuant to these requirements, Lake Oroville is operated to maintain up to 750,000 AF of storage space to allow for the capture of significant inflows.

DWR operations at the Thermalito Complex include planned weekly releases to accommodate water deliveries, meet Sacramento Valley in-basin demands such as Delta requirements, meet instream flow requirements in the Feather River, satisfy minimum flood management space requirements, and benefit cold water fisheries. DWR currently operates the Thermalito Complex consistent with the NMFS and USFWS biological opinions associated with relicensing of the Oroville Facilities Hydroelectric Project. Table 5-7 shows Feather River flow requirements in the LFC and the HFC as specified in the NMFS biological opinion (National Marine Fisheries Service 2016:371). In addition, water temperatures in the LFC and HFC are required to meet stringent standards for protection of all life stages of the anadromous salmonids (National Marine Fisheries Service 2016:370).

Table 5-7. Summary of Feather River Flow Requirements

Feather River Reach	Minimum Flow Requirement
Low-Flow Channel	–800 cfs from September 9–March 31 and 700 cfs the rest of the year –
High-Flow Channel (downstream of Thermalito Afterbay)	1,000 cfs to 1,700 cfs, with the highest flows required during October–March when unimpaired runoff for the preceding April through July was > =55% of normal. Flow requirements are reduced if water surface elevation in Lake Oroville is predicted to fall below 733 feet (approximately 1.5 MAF storage)

Source: National Marine Fisheries Service 2016:51, 371

Folsom Lake and the American River

Folsom Lake is the largest reservoir in the American River watershed and has a storage capacity of approximately 1 MAF. Reclamation owns and operates Folsom Lake (formed by Folsom Dam) and Lake Natoma (formed by Nimbus Dam) as part of the CVP. Construction of Folsom Dam was completed in 1956 (Reclamation 2021c). Releases from Folsom Lake are reregulated downstream at Lake Natoma, which has a storage capacity of 8,760 AF (U.S. Bureau of Reclamation 2011). The American River flows 23 miles between Nimbus Dam and the confluence with the Sacramento River (Reclamation 2021d).

Flood control requirements and regulating criteria are specified by USACE and described in the *Folsom Dam and Lake, American River, California Water Control Manual* (U.S. Army Corps of Engineers 1987). Since 1996, Reclamation has operated the facilities according to modified flood control criteria, which reserve 400,000 to 670,000 AF of flood control space in Folsom Lake and in a combination of three upstream reservoirs. This flood control plan, which provides additional protection for the lower American River, is implemented through an agreement between Reclamation and Sacramento Area Flood Control Agency.

Reclamation uses Folsom Lake releases to help meet Delta salinity objectives to improve fisheries and downstream water quality. In accordance with federal and state regulatory requirements, the CVP and SWP are frequently required to release water from upstream reservoirs to maintain Delta water quality. Folsom Lake is located closer to the Delta than Lake Oroville and Shasta Lake; therefore, the water generally is first released from Folsom Lake if an immediate change is needed. As water from Lake Oroville and Shasta Lake arrives in the Delta, Folsom Lake releases are reduced.

The minimum allowable flows in the lower American River are defined by SWRCB Water Right Decision 893 (D-893), which states that in the interest of fish conservation, releases should not ordinarily fall below 250 cfs between January 1 and September 15, or below 500 cfs during the rest of the calendar year. D-893 minimum flows are rarely the controlling objective of CVP operations at Nimbus Dam. Nimbus Dam releases are nearly always controlled during significant portions of a water year by flood control requirements or are coordinated with other CVP and SWP releases to meet CVP water supply and Delta operations objectives.

In July 2006, Reclamation, the Sacramento Area Water Forum, and other stakeholders agreed to a flow and temperature regime (known as the Lower American River Flow Management Standard) to improve conditions for fish in the lower American River. Minimum flow requirements during October, November, and December are primarily intended to address fall-run Chinook salmon spawning, and flow requirements during January and February address fall-run Chinook salmon egg incubation and steelhead spawning. From March through May, minimum flow requirements are mainly intended to facilitate steelhead spawning and egg incubation, as well as juvenile rearing and downstream movement of fall-run Chinook salmon and steelhead. The June through September flows are designed to address over-summer rearing by juvenile steelhead, although this period partially overlaps with adult fall-run Chinook salmon immigration.

The 2019 NMFS biological opinion requires water temperatures at Watt Avenue not to exceed 68°F from May 15 to October 31 for more than 7 consecutive days unless it is a Critically Dry Water Year based on the Sacramento Valley index or a year following one or more Critically Dry Water Years. In Critically Dry Water Years, and years immediately after a Critically Dry

Water Year, the temperature exceedance requirement is 68°F at Hazel Avenue. These requirements are met through operational modifications of temperature control shutters on Folsom Dam, and structural improvements on several intakes in Folsom Lake and Lake Natoma. The 2019 NMFS biological opinion also requires that flows are not to be higher than 50,000 cfs in the American River during January to May with the exception of flood control or emergency conditions. Seasonal operational decisions that affect water temperature and river flows are coordinated through the American River Group.

5.2.1.5. Yolo Bypass

The Yolo Bypass is an approximately 59,000-acre area that conveys Sacramento River floodwaters around Sacramento during times of high runoff. During high stages in the Sacramento River, water enters the Yolo Bypass (from the north over the Fremont Weir) and also from the east (via the Sacramento Weir and bypass). Diversion of the majority of the Sacramento River, Sutter Bypass, and Feather River floodwaters to the Yolo Bypass controls Sacramento River flood stages at Verona. The Yolo Basin was a natural overflow area to the west of the Sacramento River. The SRFCP modified the basin by confining the extent of overflow through a leveed bypass and allowing flood flows to enter the Yolo Bypass from the Sacramento River over the Fremont and Sacramento Weirs. Water in the bypass generally flows north to south and extends from Fremont Weir (RM 71) downstream to Liberty Island (RM 14) in the Delta. The Yolo Bypass conveys floodwaters around the Sacramento metropolitan area and reconnects them to the Sacramento River at Rio Vista. The capacity of the Yolo Bypass increases from 343,000 cfs at Fremont Weir to 500,000 cfs near the mouth of the bypass at Rio Vista (California Department of Water Resources 2017a:3-3).

As described above, during periods of high stage in the Sacramento River, flows from the CBD are also discharged through the KLRC into the Yolo Bypass. Additional flows enter the Yolo Bypass from the westside tributaries, including Cache Creek, Putah Creek, and the Willow Slough Bypass. In recent years, increased flow through the Yolo Bypass has been proposed as a means to improve fish populations through increased floodplain habitat or Delta food web enhancement.

During drier periods, when no water enters the bypass from the Sacramento River, flow through the bypass is greatly reduced and mostly contained in the Tule Canal in the northern part of the bypass and the Toe Drain in the southern part of the bypass. At a flow of 1,000 cfs, most of the water is retained within these drains. The area of inundation at this flow is 4,100 acres (Section 5.A.A.4.3.3.4 and Table 5.A.A.4-1 in California Department of Water Resources and U.S. Bureau of Reclamation 2016).

Daily average flow in the Yolo Bypass is extremely variable (Table 5-8), especially in the winter when flows have varied from less than 30 cfs of local drainage to 367,000 cfs of storm flow. During the July through October dry season, flow through the bypass has remained below 1,000 cfs and averaged 20–200 cfs.

Table 5-8. Summary of Daily Flow Measured (cfs) in the Yolo Bypass near Woodland between 1986 and 2020.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min	7	28	28	19	14	11	11	11	10	3	4	5
Avg	18,719	24,967	19,301	8,997	2,513	595	63	71	208	21	49	3,397
Max	299,000	367,000	215,000	106,000	65,500	18,900	621	636	750	63	1,150	93,100

Source: U.S. Geological Survey 2021n.

Yolo Bypass Inundation and Flood Risk

The Yolo Bypass floods approximately once every 3 years, generally during the winter months (U.S. Bureau of Reclamation and DWR 2019:4-6). The flood season can occasionally be longer, depending on the temporal hydrologic variability and extremes of the inflow sources. The 100-year floodplain delineations for the Yolo Bypass are shown on Figure 5-3. Most of the topographically low-lying areas adjacent to the riverine areas are included within the 100-year floodplain (Figure 5-3).

At the Fremont Weir, the likelihood of maximum annual instantaneous flows exceeding the Yolo Bypass capacity (343,000 cfs) is between 1% and 2% as computed through the Central Valley Flood Protection Plan by DWR in 2016 (Reclamation and DWR 2019:4-7). The maximum mean daily flow on record at Fremont Weir occurred in 1955 and was 256,000 cfs (U.S. Geological Survey 2021k). USGS stopped recording discharge at Fremont Weir in 1975. Near the city of Woodland, the USGS recorded 70 years of peak flows between 1942 and 2019. The maximum peak flow on record near Woodland is 374,000 cfs and occurred on February 20, 1986 (U.S. Geological Survey 2021l). The second highest peak flow was 357,000 cfs and occurred on January 3, 1997. The capacity of the Yolo Bypass at Woodland is likely between 343,000 cfs and 500,000 cfs. At the time of preparation of this RDEIR/SDEIS there were no reports of flooding and its capacity is likely greater than the maximum peak flow on record. According to USGS StreamStats, the mean daily flow at Yolo Bypass near Woodland exceeded 96,000 cfs 1% of the time on record (U.S. Geological Survey 2021m).

5.2.1.6. Delta and Suisun Marsh

The Delta, located east of San Francisco Bay, includes integrated channels and islands at the confluence of the Sacramento and San Joaquin Rivers. The Delta is a natural floodplain that covers 738,000 acres and drains approximately 40% of the state (California Department of Water Resources 1995: 1). Inflows to the Delta occur primarily from the Sacramento River system and Yolo Bypass, the San Joaquin River, and other eastside tributaries such as the Mokelumne, Calaveras, and Cosumnes Rivers. In most years, approximately 76% of water enters the Delta from the Sacramento River, approximately 15% enters from the San Joaquin River, and approximately 5% enters from the eastside tributaries, with the remainder coming from Delta precipitation (California Department of Water Resources 1995: 19). The Delta is tidally influenced; rise and fall varies from less than 1 foot in the eastern Delta to more than 5 feet in the western Delta (California Department of Water Resources 1995: 21).

There are multiple structures in the Delta that affect flow and water quality, and the main structures are the Suisun Marsh Salinity Control Gates, Delta Cross Channel, and the southern Delta temporary barriers. The Suisun Marsh Salinity Control Gates are used to reduce salinity in Suisun Marsh. The Delta Cross Channel allow relatively high quality Sacramento River water to enter the southern Delta when the Suisun Marsh Salinity Control Gates do not need to be closed for high flows and fish protection. The southern Delta temporary barriers raise water levels for agricultural diversions and reduce fish migration down Old River.

Water quality in the Delta is highly variable and strongly influenced by seawater intrusion into the western and central portions of the Delta during periods of low Delta outflow, which may be attributed to low Delta inflows and/or high volumes of export pumping at the CVP and SWP facilities. The position of "X2" is one indicator of the extent of seawater intrusion; it is defined as the distance from the Golden Gate Bridge up the axis of the Delta in kilometers to the location where near-bottom salinity is 2 parts per thousand. The location of X2 is important to both aquatic life and water supply beneficial uses. In addition to seawater intrusion, Delta water quality is also affected by the water quality and volume of river inflows, tidal flows, agricultural diversions, drainage flows, wastewater discharges, and groundwater accretions.

There are multiple regulations affecting flow through the Delta. For example, the State Water Board Bay-Delta Plan (2018) includes flow and water quality regulations to benefit fish and wildlife, municipal and industrial use, and agriculture. These include Delta export constraints and inflow, outflow, and salinity objectives (including February–June X2 requirements). The 2019 USFWS Biological Opinion and 2020 DWR Incidental Take Permit include additional operational regulations that affect Delta flows including management of reverse flow in Old and Middle Rivers toward the export pumps, modified operation of the Delta Cross Channel gates for fish protection, San Joaquin River inflow to export ratio requirements, fall X2 requirements, and additional Delta outflow. These regulations often limit Delta exports directly or indirectly as the SWP and CVP facilities are operated to comply with the requirements. To meet the Delta water quality requirements and water rights requirements of users located upstream of the Delta, the CVP and SWP are operated in a coordinated manner in accordance with the Coordinated Operation Agreement (Appendix 4A, *Regulatory Requirements*).

Delta Flood Risk

The present hydrogeomorphic regime of the Delta is a function of the intensity of water management in each of the tributary rivers, local farming practices, intra- and inter-Delta water transfers, and an extensive human-made levee system. Channel alignments are largely fixed by artificial levees and erosion control measures. Flooding, except when artificial levees break, no longer occurs on most islands and tracts (Northwest Hydraulic Consultants 2006:7). Instead, flow and sediment remain confined to the existing channel network. Upstream water diversions for municipalities and agriculture reduce the amount of flow entering the Delta and the amount of sediment transported to the Delta. In addition, conveyance of water within and out of the Delta alters flow directions and affects sedimentation, erosion rates, and erosion patterns. The levee system in the Delta restricts flow to a network of human-made and natural channels that reduce flood events and inhibit the accumulation of soils on the Delta islands.

5.2.1.7. *San Luis Reservoir*

The CVP and SWP can store Delta exports in San Luis Reservoir when there is no immediate demand for them. CVP water is conveyed via the Delta Mendota Canal and SWP water is conveyed via the California Aqueduct to the O'Neill Pumping Plant, which lifts the CVP water into the O'Neill Forebay. The William R. Gianelli Pumping-Generating Plant lifts water from O`Neill Forebay and discharges it into San Luis Reservoir. Total San Luis Reservoir capacity is approximately 2.03 MAF, with approximately 1.06 MAF used by the SWP and 0.97 MAF used by the CVP. Under wet conditions, Delta exports can be limited by San Luis Reservoir capacity.

Water generally is diverted into San Luis Reservoir from late fall through early spring when irrigation water demands of CVP and SWP water users are low. By April or May, demands from CVP and SWP water users located south of the Delta usually exceed the pumping rate at the CVP Jones Pumping Plant and the SWP Banks Pumping Plant in the southern Delta, and the stored water is released.

SWP water is released from San Luis Reservoir by gravity into the San Luis Canal for continued conveyance to the Dos Amigos Pumping Plant, where it is lifted more than 100 feet to permit gravity flow to the end of the San Luis Canal at Kettleman City. The SWP California Aqueduct continues downstream of Kettleman City to convey SWP water to the southern San Joaquin Valley, central coast, and southern California. SWP water from the California Aqueduct can also flow through O`Neill Forebay directly into the San Luis Canal instead of being pumped into San Luis Reservoir, especially during irrigation season when water demands are high.

CVP water from San Luis Reservoir can be moved south through either the San Luis Canal or through the Delta-Mendota Canal, which ends at the Mendota Pool. The CVP San Luis Reservoir water can also be diverted at the Pacheco Pumping Plant to be conveyed through the Pacheco Conduit westward into Santa Clara and San Benito Counties.

5.2.2. Water Supply and Service Areas

The CVP and SWP supply water to multiple users throughout the state. The water supplied by Sites Reservoir would serve various Storage Partners, including those who are also members of the CVP and SWP. This section describes the types of water recipients of the CVP, SWP and Sites Reservoir.

5.2.2.1. *CVP*

Reclamation provides CVP water to several types of water users in accordance with water rights issued by the State. Some CVP water supplies federal and state wildlife refuges that were defined under the Central Valley Project Improvement Act (CVPIA) under Public Law 102-575, Title 34. The main recipients of CVP water are water users who had preexisting water rights that were affected by construction of CVP facilities and water users who hold CVP contracts (Table 5-9).

Table 5-9. Types and Examples of CVP Water Recipients

Type	Examples
Water users who had water rights prior to construction of CVP facilities.	
Sacramento River settlement contractors	The largest Sacramento River settlement contractors include Anderson-Cottonwood Irrigation District, and GCID, Natomas Central Mutual Water Company, Reclamation District 108, Sutter Mutual Water Company
South of Delta exchange and settlement contractors	South of Delta exchange and settlement contractors divert water from the San Joaquin River, including Mendota Pool, with the largest contractor being Central California Irrigation District
CVP Contractors	
North of Delta	Contractors who receive water from Shasta Lake, the Trinity River, Black Butte Reservoir, CBD, Corning Canal, TC Canal, and American River municipal and industrial contracts.
Delta	Contra Costa Water District
South of Delta	Contractors who divert from the Delta-Mendota Canal, Mendota Pool, Cross Valley Canal, as well as the San Felipe Division, and the West San Joaquin Division, with Westlands Water District holding the largest contract. Friant Division and eastside water users are also south of the Delta, but they do not receive Delta exports.

Source: U.S. Bureau of Reclamation 2016

5.2.2.2. SWP

DWR provides several types of SWP water. The majority of SWP water is Table A water, which represents the maximum volume of water that is allocated and delivered for SWP water supply contracts. Other types of SWP water include Article 21, Article 56 (carryover), and turnback pool water. Article 21 water is offered to SWP contractors for short periods when there is excess water available for export that cannot be stored. Article 56 water is Table A water carried over to the next year. Turnback pool water is Table A water that exceeded a SWP contractor's needs and was sold to another SWP contractor. The volume of Article 21, Article 56, and turnback pool water available is small compared to Table A contract water (California Department of Water Resources 2020:17).

Average annual delivery of Table A water during 2009–2018 was estimated to be 1,871 TAF/yr, about 45% of the maximum Table A contract amount of 4,173 TAF/yr (California Department of Water Resources 2020:16-17). Total estimated SWP deliveries during this time (i.e., including Article 21 water, Article 56 water, and turnback pool water) averaged 1,963 TAF/yr. There are large fluctuations in SWP deliveries, with the total volume ranging from 477 TAF/yr to 3,410 TAF/yr during 2009–2018.

DWR also delivers water to settlement agreement users in the Feather River Service Area (FRSA) that had senior water rights prior to construction of the SWP facilities on the Feather River. This water is not part of the Table A contracts.

SWP Table A includes contracts with water users in the Feather River Area (separate from the settlement agreement users), San Francisco Bay area, San Joaquin Valley, central coast, and southern California. The largest Table A contract volumes belong to Kern County Water Agency (983 TAF) and Metropolitan Water District of Southern California (1,912 TAF) (California Department of Water Resources 2020:17).

5.2.2.3. Storage Partners

As of the writing of this RDEIR/SDEIS, the Sites Reservoir Storage Partners are listed in Table 5-10. Most of the Storage Partners receive either CVP or SWP water. Storage Partners that receive CVP water are almost all located north of the Delta and receive water via the TC Canal or are Sacramento River settlement contractors. Storage Partners that receive SWP water are mostly located in southern California, but also include the City of American Canyon (which receives water via the North Bay Aqueduct), Zone 7 Water Agency (which receives water via the South Bay Aqueduct), and the Santa Clara Valley Water District (which receives SWP water via the South Bay Aqueduct and CVP water from San Luis Reservoir). Some Storage Partners receive water indirectly from the SWP. For example, Irvine Ranch Water District receives water from the Municipal Water District of Orange County, which purchases water from the Metropolitan Water District of Southern California (Irvine Ranch Water District 2021).

Table 5-10. Storage Partner Summary Table

Storage Partner[a]	Location (relative to Delta, county)	CVP/SWP Contractor[b]	Service Area	Municipal and Industrial Provider?
City of American Canyon	North of the Delta (receives Delta Water), Napa County	SWP	30 square miles	Y
Antelope Valley-East Kern Water Agency	South of the Delta, Los Angeles, Kern, and Ventura Counties	SWP	2,400 square miles	Y
Carter Mutual Water Company	North of the Delta, Colusa County	CVP-Sacramento River Settlement	3 square miles	Y
Coachella Valley Water District	South of the Delta, Riverside, Imperial, and San Diego Counties	SWP	1,000 square miles	Y
Colusa County	North of the Delta, Colusa County	CVP-TC Canal	Unknown	Y
Colusa County Water District	North of the Delta, Colusa County	Unknown	72 square miles	Y
Cortina Water District	North of the Delta, Colusa County	CVP-TC Canal	1 square mile	N
Davis Water District	North of the Delta, Colusa County	CVP-TC Canal	3 square miles	Y
Desert Water Agency	South of the Delta, Riverside County	SWP	195 square miles	Y
Dunnigan Water	North of the Delta, Yolo County	CVP-TC Canal	15.6 square	Y

Storage Partner[a]	**Location (relative to Delta, county)**	**CVP/SWP Contractor[b]**	**Service Area**	**Municipal and Industrial Provider?**
District			miles	
Glenn-Colusa Irrigation District (GCID)	North of the Delta, Glenn and Colusa Counties	CVP-Sacramento River Settlement	273 square miles	N
Irvine Ranch Water District	South of the Delta, Orange County	SWP	181 square miles	Y
La Grande Water District	North of the Delta, Colusa County	CVP-TC Canal	2 square miles	Y
Metropolitan Water District of Southern California	South of the Delta, Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura Counties	SWP	5,200 square miles	Y
Reclamation District 108	North of the Delta, Yolo and Colusa Counties	CVP-Sacramento River Settlement	75 square miles	N
Rosedale Rio Bravo Water Storage District	South of the Delta, Kern County	SWP[c]	69 square miles	N
San Bernardino Valley Municipal Water District	South of the Delta, San Bernardino County	SWP	353 square miles	Y
San Gorgonio Pass Water Agency	South of the Delta, Riverside and San Bernardino Counties	SWP	225 square miles	Y
Santa Clara Valley Water District	South of the Delta, Santa Clara County	CVP and SWP	1,300 square miles	Y
Santa Clarita Valley Water District (formerly Castaic Lake)	South of the Delta, Los Angeles County	SWP	195 square miles	Y
Westside Water District	North of the Delta, Colusa County	CVP-TC Canal	24 square miles	Y
Wheeler Ridge-Maricopa Water Storage District	South of the Delta, Kern County	SWP[c]	230 square miles	N
Zone 7 Water Agency	West of the Delta, Alameda and Contra Costa Counties	SWP	Unknown	Y

Table Notes:

[a] These Storage Partners are Reservoir Committee members.

[b] California Department of Water Resources 2020:17 and U.S. Bureau of Reclamation 2016.

[c] Members of the Kern County Water Agency.

The CVP water districts served by the TC Canal include Kirkwood, Orland-Artois, Glide, Kanawha, Holthouse, 4-M, Glenn Valley, LaGrande, Davis, Westside, Myers-Marsh, Cortina, Colusa County, and Dunnigan Water Districts. GCID

also periodically takes water from the TC Canal.
GCID is a Sacramento River Settlement Contractor and diverts water from the Sacramento River under the conditions of the Settlement Contract with Reclamation.

5.3 Hydrologic Modeling Methods

Descriptions of changes in reservoir storage, stream flow downstream of the reservoirs, diversions, and Delta flows are presented to provide a basis for understanding changes in system hydrology. Hydrologic effects specific to particular environmental resources are addressed in the chapters associated with each resource. For example, changes in surface water storage in the CVP and SWP reservoirs could affect recreational opportunities under the action alternatives as compared to the No Action Alternative. Changes in surface water storage are presented in this chapter as part of the description of surface water resources, but evaluation of model results as they specifically pertain to the recreation analysis are presented in Chapter 16, *Recreation Resources*. This chapter utilizes CALSIM results to explain generally changes in system hydrology and for the evaluation of changes in water supply and flood risk.

CALSIM II is the primary model used to evaluate Project effects, with inputs including water demands, hydrology, facilities, water management, regulatory standards, and operational criteria assumptions. CALSIM simulates the operations of the SWP and CVP, resulting in output information including projected storage conditions, river flows, Delta inflows and outflows, and diversions including Delta exports. CALSIM II includes an 82-year modified historical hydrology (Water Years 1922–2003) developed jointly by DWR and Reclamation to account for hydrologic variability among water years.

CALSIM II is intended to be used in a comparative mode. The results from a project alternative simulation are compared to the results of a No Action Alternative simulation to determine the incremental effects of a project. The results from a single simulation do not necessarily represent the exact operations for a specific month or year but reflect long-term trends. Use of the model in a comparative manner helps reduce the effects monthly and other assumptions that are indicative of real-time operations, but do not specifically match real-time observations.

The operational decisions in CALSIM II (e.g., determining the flow needed to meet a salinity standard in the Delta) are on a monthly time-step which do not consider operational responses to changes that are on a sub-monthly timescale. Results for an individual parameter are either a monthly average or an end-of-month condition. Because CALSIM is a monthly model, it does not fully capture real-time operational decisions that may deviate from standard operations due to extreme conditions such as drought or decisions that are affected by variations in flow within a month. During storm events when peak flows, weir spills, and diversions may vary considerably during a month that the model cannot capture. To check and improve the accuracy of the CALSIM simulation of flows that depend on daily variations in flow and operational decisions, CALSIM was used in conjunction with the Upper Sacramento River Daily Operations Model (USRDOM) and associated tools.

USRDOM simulates daily flow and storage conditions in the Sacramento River from Shasta Lake to Knights Landing and CBD including the Project conveyance and storage features. USRDOM utilizes results from CALSIM II to evaluate the impacts of changing diversion, in-basin use and Delta operations under projected conditions. It couples the monthly operational decisions in CALSIM II to a simulation of the associated sub-monthly operational response at Shasta Lake depending on the inflows. USRDOM is particularly useful in verifying the CALSIM II simulated river conditions and the availability of excess flows to fill the Sites Reservoir under the capacity and operational constraints of the intakes at Red Bluff and Hamilton City.

CALSIM and USRDOM were used iteratively to develop a set of monthly CALSIM results that would be compatible with daily operations for Sites Reservoir diversions. Because USRDOM requires inputs on a daily timestep, the monthly inputs and outputs of the CALSIM II model are downscaled to a daily timestep for use in USRDOM. Due to the complexity in the Sites Reservoir intake operational rules, a spreadsheet tool was developed to implement the operational constraints using the daily results from the USRDOM. This spreadsheet tool incorporates restrictions on TC Canal and GCID Main Canal conveyance and maintenance, Sacramento River flow requirements, and pulse flow requirements for anadromous fish.

Commented [CC2]: Calsim II does not include inflow or outflow for Funks and Stone Corral Creeks. The USRDOM should include estimates for these, as well as "emergency spill" operations, minimum flows in the creeks, and channel maintenance pulses (if proposed). As the operational requirements are drafted and refined, a detailed operations model is needed that includes all inflows and outlets of the proposed Project.

CALSIM II output, as well as the ancillary USRDOM output, is also used by a variety of other assessment models as described throughout this document, and summarized in Appendix 1A, *Introduction to Appendices and Modeling Information*. With the information generated from these models, the water storage, deliveries, flows, water quality, geomorphology, and potential fish effects can be compared for the different alternatives.

CALSIM methods and results are described in detail in Appendix 5A, *Surface Water Resources Modeling of Alternatives*, and Appendix 5B. Appendix 5C, *Upper Sacramento River Daily River Flow and Operations Model*, contains a description of the model and summary of results.

Commented [CC3]: Only Appendix 5B (tables and figures) is available to review at this time. 5A and 5C, describing the detailed assumptions of the modeling, are not available.

5.4 Hydrologic Modeling Results

5.4.1. CALSIM

5.4.1.1. Summary of General Changes in Hydrology

CALSIM results were used to estimate changes in hydrology that would be associated with the Project. These modeled changes in hydrology were used to inform the impact evaluation for multiple resources. The CALSIM results were also used to generate model input for other models specific to particular resources. A concise description of general hydrologic effects simulated by CALSIM are described here.

Operation of Sites Reservoir would have direct effects on flow in the Sacramento River below the points of diversion (RBPP and GCID Main Canal upstream of Hamilton City) and below the points of Sites discharge (Sacramento River discharge for Alternative 2, CBD outlet for Alternatives 1 and 3, and downstream end of Yolo Bypass for all three alternatives). These direct effects include diversion to and release from Sites Reservoir storage for use by storage participants. Operation of Sites Reservoir could have indirect effects on storage in Shasta Lake, Lake Oroville, and Folsom Lake and the flows below these reservoirs including:

- Shasta Lake, Lake Oroville, and Folsom Lake Exchanges. Exchanges could occur when Sites Storage Partner water is temporarily stored in Shasta Lake, Lake Oroville, or Folsom Lake in order to increase storage in these reservoirs in the spring and early summer to help provide cold-water fish habitat. Sites Reservoir releases for south of Delta export only would occur during July–November. To initiate an exchange, Sites Reservoir water would be "pre-released" to meet CVP or SWP obligations, and in exchange, Sites participant water would be retained in Shasta Lake, Lake Oroville, or Folsom Lake for release later in the summer or fall. No exchanged water would be carried over from year to year. Although exchanges could occur at any one of these three reservoirs, for CALSIM modeling purposes, it was assumed no Sites exchanges would occur with Folsom Lake.
- CVP Operational Flexibility Water (Op Flex Water). CVP Op Flex water is CVP's Sites Reservoir account. The volume of Op Flex Water would depend on the level of Reclamation participation in the Project (7% for Alternative 1B and 25% for Alternative 3). Op Flex Water can be released from Sites Reservoir to augment CVP supply or to replace water that would have been released from Shasta or Folsom Lakes. Replacement of releases from Folsom Lake were not included in the CALSIM modeling.
- Operational Adjustments. The addition of Sites Reservoir and potential alteration of storage in some reservoirs may result in additional small adjustments in the coordinated operation of CVP and SWP facilities to meet demands and water quality criteria. Folsom Lake and the lower American River are the primary locations where these additional adjustments may be manifested.
- Real-Time Exchanges with Local Participants. These in-lieu exchanges between Sites Reservoir releases and flow in the Sacramento River would occur when Sites Reservoir releases are used to meet local participant demands (Sacramento River Settlement Contractors, Reclamation, or, most likely, GCID) that normally would be met through diversions from the Sacramento River. The water that is not diverted would remain in the Sacramento River for use by downstream Storage Partners.

Tables 5-11 through 5-29 below provide a summary of the changes in hydrology expected to occur as a result of the alternatives as evaluated by CALSIM. These results were selected to show generally what may be expected under a range of hydrologic conditions, average values for Critically Dry and Wet Water Years. Other metrics are used for some other resources to represent conditions specific to that resource (e.g., WSE for recreation). Most of the summary tables presented below show No Action Alternative (NAA) values followed by the % change associated with each of the alternatives. However, for those values associated with Sites Reservoir operations, the values shown for the alternatives are not presented in terms of % change, but rather in terms of either flow or storage. These tables follow a general hydrologic, north to south order, starting with Shasta Lake then heading down the Sacramento River, picking up Sites diversions and releases along the way, followed by the Feather and American Rivers, and then flow into and out of the Delta.

The Project could allow storage in Shasta Lake to increase slightly, with more increases expected during Critically Dry Water Years than Wet Water Years (Table 5-11). Releases from Shasta Lake are also not expected to be greatly affected by the alternatives; generally, some small decreases in flow may occur in the first part of the year, allowing for small increases in storage and fall releases during Critically Dry Water Years (Table 5-12). At Red Bluff, substantial increases in diversions at the RBPP are expected to occur with the alternatives, particularly during January–March of Wet Water Years (Table 5-13). Diversions under the NAA represent diversions for agriculture and increases in diversions associated with the alternatives indicate diversions for storage in Sites Reservoir. Downstream of Red Bluff, Sacramento River flows would be somewhat reduced due to the increase in winter diversions, but there may be increases in flow during September and October of Critically Dry Water Years due mostly to increased releases from Shasta Lake (Table 5-14). The diversion pattern at Hamilton City and flow effects downstream of Hamilton City near Wilkins Slough (Tables 5-15 and 5-16) are similar to what occurs due to the RBDD diversions except the winter diversions at Hamilton City are smaller and there are substantial increases in flow during July through October of Critically Dry Water Years. The increases in flow at Hamilton City are due to Sites water being used in-lieu of diversions into GCID Main Canal.

For all alternatives, storage levels in Sites Reservoir are expected to be greater than 1 MAF during wet conditions and could fall below 225 TAF during fall of Critically Dry Water Years (Table 5-17). Most releases from Sites Reservoir would be made during dry conditions (Table 5-18). Some trends are more apparent with the more detailed results presented for all water year types in Appendix 5B. Under Alternative 3 (and to a lesser degree under Alternative 1B), CVP Op Flex results in increased releases during Above Normal and Below Normal Water Years compared to the other alternatives. Under all alternatives, depleted reservoir storage causes Sites Reservoir releases to be lower on average during Critically Dry Water Years than Dry Water Years. This depletion is greatest for Alternative 3, since under Alternative 3, there is a tendency for reservoir storage to be used more actively resulting in lower storage during some Critically Dry Water Years.

Sites Reservoir releases to the Sacramento River (either through CBD or the Dunnigan Pipeline) are expected to be greatest during dry conditions, with average peak releases of approximately 350-600 cfs during June–August of Critically Dry Water Years (Table 5-19), with releases reaching a maximum of 1,000 cfs during some months (Appendix 5B). Releases would be somewhat higher during Dry Water Years than Critically Dry Water Years due to greater storage in Sites Reservoir, with average peak releases of approximately 530-970 cfs during June- August (Table 5-19).

Sites Reservoir releases to Yolo Bypass would be greater during Wet Water Years than during Critically Dry Water Years (Table 5-20), with releases reaching 350–440 cfs during August and September of Wet Water Years. Percent change in total Yolo Bypass flows is expected to be large during August–October because existing Yolo Bypass flows are generally low during these months (Table 5-21). Small % reductions in Yolo Bypass flows are expected during the rainy season as a result of the diversions to Sites Reservoir storage.

Commented [C4]: Please, reference or show the % reductions in Yolo Bypass flows.

Changes to storage in Lake Oroville are expected to be minimal, with small changes associated with Sites Reservoir exchanges (Table 5-22). The exchanges may enable reduction in SWP releases from Lake Oroville in June and July, thereby allowing water to be retained longer in Lake Oroville and resulting in more water released during the late summer and early fall as can be seen in the CALSIM results for Critically Dry Water Years (Table 5-23). Effects on Folsom Lake storage are expected to be small (Table 5-24), although some increases and decreases may occur in the American River flows (Table 5-25). The main effect of Alternatives 1, 2, and 3 on flow near the downstream end of the Sacramento River at Freeport is an increase in flow, sometimes 10 % or more, during July through October during Critically Dry Water Years (Table 5-26).

Commented [C5]: These exchanges seem uncertain and drawing conclusions about potential project impacts or a lack of impacts, based on the outcome of these exchanges casts doubts on the sufficiency of the project's impact analysis. The impacts assessed in this document should reflect project operations, absent any speculative benefits that might be derived from exchanges that may or may not occur. Alternatively, where Sites' operations are speculative, an assessment of project impacts should be included that assesses potential impacts in the absence of the speculative operations. For example, what would impacts from the Sites' operations look like if exchanges with the Shasta, Oroville, and Folsom do not occur.

In the Delta, the effects of diversions to Sites storage, Sites releases to the Sacramento River, Sites releases to the Yolo Bypass, and small operational changes for Shasta Lake, Lake Oroville, and Folsom Lake combine to produce small percentage reductions in Delta outflow during the wetter months, but allow increases in Delta outflow during drier months, particularly during Critically Dry Water Years and substantial increases in exports during the summer of Critically Dry Water Years (Table 5-27 and 5-28). Small changes in storage may occur in San Luis Reservoir storage (the main receiving reservoir for Delta exports), with the largest effect being a reduction in storage of less than 10% modeled to occur during October of Critically Dry Water Years (Table 5-29). Note that this reduction in San Luis Reservoir storage is associated with the largest increase in exports, so is likely a consequence of model algorithms and not a necessary consequence of Alternatives 1, 2, and 3.

Commented [C6]: Sites has no control over whether operational changes will be made for Shasta Lake, Lake Oroville, or Folsom Lake. This raises doubts about the accuracy of the analysis, when Sites' impacts, are potentially being offset by operations of other projects that are outside of its control.

Commented [C7]: Please, elaborate on how the project's operations increase Delta outflow. Is the increase in outflow coming from carriage water?

Table 5-11. Simulated Shasta Lake Storage: NAA (TAF) and % Change between Alternatives

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	1,714	1,667	1,806	2,548	2,718	2,914	2,987	2,813	2,486	2,143	1,882	1,831
Alt 1A	1	1	2	1	1	1	1	2	2	3	3	3
Alt 1B	2	2	2	1	1	1	1	3	3	4	4	3
Alt 2	0	1	1	1	1	0	0	2	2	2	3	2
Alt 3	4	4	4	2	2	2	2	4	5	5	6	5
Average for Wet Water Years												
NAA	3,183	3,168	3,256	3,451	3,604	3,855	4,349	4,490	4,376	3,942	3,568	3,304
Alt 1A	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1B	0	0	0	0	0	0	0	0	0	0	0	0
Alt 2	0	0	0	0	0	0	0	0	0	0	0	0
Alt 3	0	0	0	0	0	0	0	0	0	0	0	0

Table 5-12. Simulated Sacramento River Flow at Bend Bridge: NAA (cfs) and % Change between Alternatives

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	6,058	6,376	6,565	6,390	6,515	6,599	5,463	8,754	10,013	10,030	8,545	4,844
Alt 1A	8	0	-1	2	-1	1	0	-8	0	1	-1	4
Alt 1B	7	0	0	0	-1	0	0	-9	-1	0	1	5
Alt 2	7	0	0	0	-1	1	0	-8	0	0	0	4
Alt 3	6	0	0	-1	-1	0	-3	-9	0	0	0	4
Average for Wet Water Years												
NAA	8,722	9,466	13,051	28,508	31,283	24,660	14,483	12,724	10,822	13,475	11,605	10,811
Alt 1A	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1B	0	-1	0	0	0	0	0	0	0	0	0	0
Alt 2	0	0	0	0	0	0	0	0	0	0	0	0
Alt 3	0	-1	0	0	1	0	0	0	0	0	0	0

Table 5-13. Simulated Sacramento River Diversion at Red Bluff: NAA (cfs) and Change between Alternatives (Not % Change)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	69	17	0	0	7	25	96	128	169	195	153	55
Alt 1A	-12	1	465	283	153	342	-6	0	-7	-13	-23	-25
Alt 1B	-18	2	465	283	153	343	-7	-37	-13	-30	-26	-25
Alt 2	-16	2	466	283	153	343	-5	0	-7	-14	-29	-29
Alt 3	-1	2	472	282	152	297	0	-3	32	34	26	4
Average for Wet Water Years												
NAA	154	15	0	0	0	20	184	668	1,121	1,289	1,020	261
Alt 1A	1	341	37	1,065	1,052	804	382	134	45	21	44	0
Alt 1B	1	325	37	1,188	1,179	829	414	194	45	21	45	0
Alt 2	1	338	37	1,026	971	675	318	134	45	21	9	0
Alt 3	2	325	37	1,205	1,179	1,047	531	244	85	21	44	0

Table 5-14. Simulated Sacramento River below Red Bluff Diversion: NAA (cfs) and % Change between Alternatives

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	5,996	6,386	6,676	6,476	6,605	6,646	5,407	8,637	9,847	9,836	8,392	4,790
Alt 1A	8	-1	-8	-3	-3	-4	0	-8	0	1	-1	5
Alt 1B	7	0	-7	-4	-3	-5	0	-8	-1	1	1	5
Alt 2	7	0	-7	-4	-3	-4	0	-8	0	0	1	5
Alt 3	7	-1	-7	-5	-3	-4	-3	-9	-1	0	0	4
Average for Wet Water Years												
NAA	8,577	9,514	13,245	29,134	31,811	24,953	14,501	12,102	9,714	12,188	10,586	10,552
Alt 1A	0	-4	-1	-4	-3	-3	-3	-1	-1	0	0	0
Alt 1B	0	-4	-1	-4	-3	-3	-3	-2	-1	0	0	0
Alt 2	0	-4	0	-3	-3	-3	-2	-1	-1	0	0	0
Alt 3	0	-4	0	-4	-3	-4	-4	-2	-1	0	0	0

Table 5-15. Simulated Hamilton City Diversion: NAA (cfs) and Change between Alternatives (Not % Change)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	484	616	170	89	64	62	512	2,133	2,412	2,243	1,745	517
Alt 1A	-89	-51	-20	-3	0	21	-22	-235	-14	-492	-326	-78
Alt 1B	-74	-32	-20	-7	0	21	-30	-250	-95	-488	-329	-64
Alt 2	-103	-40	-18	-3	0	21	-22	-227	-1	-453	-249	-58
Alt 3	-30	-29	-24	-4	-4	14	-20	-338	-72	-434	-215	-67
Average for Wet Water Years												
NAA	575	695	229	78	67	22	378	2,117	2,238	2,538	2,190	621
Alt 1A	165	-2	-4	239	392	324	501	117	129	41	46	34
Alt 1B	166	-2	-4	286	457	340	592	138	160	40	46	-1
Alt 2	163	-2	-4	238	378	231	446	114	125	40	45	-1
Alt 3	167	-2	-4	286	494	490	723	197	158	39	46	35

Table 5-16. Simulated Sacramento River Flow downstream of Hamilton City near Wilkins Slough: NAA (cfs) and % Change between Alternatives

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	5,102	5,450	8,000	8,126	8,394	8,727	5,560	4,378	4,755	4,761	4,847	4,000
Alt 1A	11	0	-6	-2	-2	-3	0	-11	2	11	4	8
Alt 1B	10	1	-5	-3	-2	-4	0	-11	1	11	8	8
Alt 2	10	0	-5	-3	-2	-3	0	-11	1	10	6	7
Alt 3	8	0	-5	-4	-2	-3	-3	-10	0	9	4	6

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Wet Water Years												
NAA	7,961	9,018	12,477	20,933	21,863	19,607	16,301	10,572	6,786	7,085	6,077	10,096
Alt 1A	-2	-4	0	-1	-1	-2	-3	-2	-3	0	-1	0
Alt 1B	-2	-4	0	-2	-1	-3	-3	-3	-4	0	-1	0
Alt 2	-2	-4	0	-1	-1	-2	-3	-2	-3	0	-1	0
Alt 3	-2	-4	0	-2	-1	-3	-3	-4	-4	0	-2	0

Table 5-17. Simulated Sites Reservoir Storage for All Alternatives (TAF)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A	225	216	244	551	559	577	551	490	436	353	289	248
Alt 1B	193	185	213	512	521	538	512	451	395	312	250	212
Alt 2	189	180	209	485	493	512	486	427	378	300	242	209
Alt 3	169	162	190	446	453	464	438	375	326	249	202	180
Average for Wet Water Years												
NAA	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A	1,306	1,326	1,329	1,175	1,257	1,325	1,373	1,381	1,382	1,374	1,347	1,318
Alt 1B	1,289	1,303	1,301	1,132	1,224	1,295	1,350	1,363	1,365	1,358	1,331	1,300
Alt 2	1,110	1,129	1,132	1,008	1,084	1,139	1,180	1,188	1,189	1,182	1,153	1,120
Alt 3	1,267	1,282	1,280	1,057	1,152	1,245	1,315	1,333	1,338	1,330	1,304	1,276

Table 5-18. Simulated Sites Reservoir Release for All Alternatives (cfs)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A	350	155	17	0	1	53	397	932	837	1,253	980	649
Alt 1B	297	132	24	20	1	68	407	936	866	1,255	961	597
Alt 2	303	148	17	0	0	38	397	899	750	1,188	889	517
Alt 3	182	116	24	24	27	126	408	962	760	1,171	710	332
Average for Dry Water Years												
NAA	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A	674	481	39	0	0	13	199	348	1,242	1,731	1,455	1,093
Alt 1B	644	420	49	0	18	30	351	533	1,230	1,663	1,461	995
Alt 2	621	296	43	0	0	13	199	348	1,164	1,724	1,433	990
Alt 3	533	242	22	0	0	52	317	774	1,433	1,829	1,263	803
Average of All Water Year Types												

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A	401	191	27	0	0	13	114	224	451	707	791	622
Alt 1B	373	203	59	7	7	20	154	315	590	744	796	562
Alt 2	383	158	29	0	0	11	114	219	418	695	781	603
Alt 3	339	147	53	4	9	33	146	384	778	1,052	831	498
Average for Wet Water Years												
NAA	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A	287	17	14	1	0	2	9	3	24	39	380	416
Alt 1B	284	93	102	1	3	7	9	3	24	39	379	403
Alt 2	273	15	17	1	0	2	9	3	24	39	380	450
Alt 3	239	81	102	0	4	6	9	3	24	39	380	395

Table 5-19. Simulated Sites Reservoir Release to Sacramento River (Release to Dunnigan Pipeline minus Release to Yolo Bypass) for All Alternatives (cfs)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A	204	99	3	0	0	0	108	432	529	615	416	428
Alt 1B	127	96	10	15	0	13	123	417	520	621	435	373
Alt 2	131	100	3	0	0	0	109	425	497	605	346	319
Alt 3	80	83	10	19	21	78	148	396	464	593	379	179
Average for Dry Water Years												
NAA	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A	325	364	23	0	0	0	58	111	794	970	609	572
Alt 1B	367	294	31	0	15	15	184	178	765	956	594	538
Alt 2	251	206	26	0	0	0	58	111	750	966	583	487
Alt 3	284	163	12	0	0	38	156	231	656	936	531	443
Average of All Water Year Types												
NAA	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A	113	130	11	0	0	0	28	88	271	391	276	218
Alt 1B	107	139	43	5	5	7	60	100	314	385	275	191
Alt 2	87	102	13	0	0	0	29	87	257	388	254	184
Alt 3	99	91	39	3	8	21	57	109	307	397	271	147
Average for Wet Water Years												
NAA	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A	0	17	14	0	0	1	0	0	0	0	0	0
Alt 1B	0	93	102	0	3	6	0	0	0	0	0	0

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Alt 2	0	15	17	0	0	1	0	0	0	0	0	0
Alt 3	0	81	102	0	4	5	0	0	0	0	0	0

Table 5-20. Simulated Sites Reservoir Release to Yolo Bypass for All Alternatives (cfs)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A	37	0	0	0	0	0	0	0	0	0	123	61
Alt 1B	54	0	0	0	0	0	0	0	0	0	103	77
Alt 2	37	0	0	0	0	0	0	0	0	0	150	37
Alt 3	37	0	0	0	0	0	0	0	0	0	37	39
Average for Wet Water Years												
NAA	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A	286	0	0	0	0	0	0	0	0	0	356	404
Alt 1B	284	0	0	0	0	0	0	0	0	0	356	391
Alt 2	272	0	0	0	0	0	0	0	0	0	356	437
Alt 3	239	0	0	0	0	0	0	0	0	0	356	382

Table 5-21. Simulated Total Yolo Bypass Flow: NAA (cfs) and % Change between NAA and Alternatives 1, 2, and 3

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	41	22	385	406	599	351	107	68	64	48	54	78
Alt 1A	75	0	0	-2	-4	-4	0	0	0	0	189	70
Alt 1B	101	0	-3	-2	-4	-4	0	0	0	0	148	87
Alt 2	75	0	0	-2	-4	-4	0	0	0	0	231	43
Alt 3	75	0	-4	-2	-4	-4	0	0	0	0	60	43
Average for Wet Water Years												
NAA	86	596	5,365	29,169	35,753	21,857	7,148	688	172	48	139	79
Alt 1A	269	-2	0	-3	-2	-3	-3	-11	0	0	218	399
Alt 1B	267	-2	1	-3	-3	-3	-4	-11	0	0	218	388
Alt 2	255	-2	0	-3	-2	-2	-3	-11	0	0	218	434
Alt 3	227	-2	1	-3	-3	-3	-7	-13	0	0	218	378

Table 5-22. Simulated Lake Oroville Storage: NAA (TAF) and % Change between NAA and Alternatives 1, 2, and 3

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	867	855	910	1,440	1,546	1,686	1,702	1,649	1,410	1,124	965	914
Alt 1A	-3	-3	-3	-1	-1	-1	-1	-1	1	2	1	0
Alt 1B	-3	-3	-3	-1	-1	-1	-1	-1	1	2	1	0
Alt 2	-3	-3	-3	-1	-1	-1	-1	-1	1	2	1	-1
Alt 3	-1	-1	-1	-1	-1	-1	-1	-1	1	2	1	-1
Average for Wet Water Years												
NAA	2,448	2,413	2,430	2,617	2,855	2,945	3,304	3,508	3,488	3,191	2,964	2,624
Alt 1A	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1B	0	0	0	0	0	0	0	0	0	0	0	0
Alt 2	0	0	0	0	0	0	0	0	0	0	0	0
Alt 3	0	0	0	0	0	0	0	0	0	0	0	0

Table 5-23. Simulated Feather River Flow at Mouth: NAA (cfs) and % Change between NAA and Alternatives 1, 2, and 3

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	1,327	1,290	1,785	3,212	2,954	2,814	3,129	2,534	3,780	3,388	2,148	1,826
Alt 1A	25	5	0	1	0	0	0	0	-14	-5	12	11
Alt 1B	23	5	0	0	0	0	0	0	-14	-4	10	13
Alt 2	20	5	0	0	0	0	0	0	-13	-5	11	12
Alt 3	6	5	0	0	0	0	0	0	-12	-3	12	12
Average for Wet Water Years												
NAA	4,220	3,653	7,992	22,107	25,897	24,147	16,441	14,487	10,477	7,380	5,680	8,460
Alt 1A	2	0	0	0	0	0	0	0	0	0	0	0
Alt 1B	2	0	0	0	0	0	0	0	0	0	0	0
Alt 2	2	0	1	0	0	0	0	0	0	0	0	0
Alt 3	2	0	0	0	0	0	0	0	0	0	0	0

Table 5-24. Simulated Folsom Reservoir Storage: NAA (TAF) and % Change between NAA and Alternatives 1, 2, and 3

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	314	338	415	427	426	482	509	524	496	426	362	334
Alt 1A	-4	-3	-4	-3	-1	-2	-1	-1	0	0	-2	-2

Alt 1B	0	1	-1	-1	-1	-1	0	0	0	1	2	2
Alt 2	-1	0	-1	-1	-1	-1	0	0	0	0	1	1
Alt 3	0	-2	-2	-1	1	1	0	1	1	1	-1	-2
Average for Wet Water Years												
NAA	648	544	541	567	567	751	897	966	951	864	746	691
Alt 1A	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1B	0	0	0	0	0	0	0	0	0	0	0	0
Alt 2	0	0	0	0	0	0	0	0	0	0	0	0
Alt 3	0	0	0	0	0	0	0	0	0	0	0	0

Table 5-25. Simulated American River Flow at H Street: NAA (cfs) and % Change between NAA and Alternatives 1, 2, and 3

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	662	517	538	974	1,187	803	1,054	888	827	986	1,014	682
Alt 1A	13	-9	18	0	-9	9	-8	-3	-4	-1	8	0
Alt 1B	13	-2	15	-3	1	5	-9	-1	-2	-3	-5	0
Alt 2	13	-2	11	0	1	4	-8	0	-2	-1	-6	0
Alt 3	-15	20	-2	0	-15	3	2	-7	-1	0	12	0
Average for Wet Water Years												
NAA	1,483	4,066	3,870	8,715	9,145	5,534	5,252	6,774	4,688	2,946	2,673	1,832
Alt 1A	0	1	0	0	0	0	0	0	0	0	0	0
Alt 1B	1	0	0	0	0	0	0	0	0	0	0	0
Alt 2	0	1	0	0	0	0	0	0	0	0	0	0
Alt 3	0	0	0	1	0	0	0	0	0	-1	0	0

Table 5-26. Simulated Sacramento River Flow at Freeport: NAA (cfs) and % Change between NAA and Alternatives 1, 2, and 3

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	7,362	7,896	12,607	13,993	16,897	13,976	11,337	8,738	10,378	10,010	9,036	6,986
Alt 1A	17	2	-3	-1	-2	-1	0	-1	0	10	10	14
Alt 1B	14	3	-3	-2	-1	-2	0	-1	0	10	10	13
Alt 2	14	2	-3	-2	-1	-2	0	-1	0	10	8	12
Alt 3	7	3	-3	-2	-2	-1	0	-1	0	9	11	9
Average for Wet Water Years												
NAA	14,276	18,111	25,645	48,304	56,161	48,925	40,279	33,406	24,000	19,624	16,478	21,465
Alt 1A	-1	-2	0	-1	-1	-1	-2	-1	-1	0	0	0

Alt 1B	-1	-2	0	-1	-1	-1	-2	-1	-1	0	0	0
Alt 2	-1	-2	0	-1	-1	-1	-1	-1	-1	0	0	0
Alt 3	0	-2	0	-1	-1	-2	-2	-1	-1	0	-1	0

Table 5-27. Simulated Delta Outflow: NAA (cfs) and % Change between NAA and Alternatives 1, 2, and 3

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	4,083	3,905	8,495	10,608	13,663	11,103	9,539	5,682	5,371	4,019	3,375	3,110
Alt 1A	24	-8	-5	-2	-2	-2	0	-1	0	1	5	0
Alt 1B	22	-6	-5	-2	-1	-3	0	-1	0	1	5	1
Alt 2	22	-7	-4	-2	-1	-3	0	-1	0	1	5	0
Alt 3	17	-4	-5	-2	-3	-2	0	-2	0	1	2	-1
Average for Wet Water Years												
NAA	7,958	11,658	26,283	85,174	99,942	80,070	54,824	37,979	23,391	11,761	7,207	12,538
Alt 1A	2	-3	0	-2	-1	-1	-2	-1	-1	0	3	2
Alt 1B	2	-3	0	-2	-2	-1	-2	-1	-1	0	3	3
Alt 2	2	-3	0	-1	-1	-1	-1	-1	-1	0	4	3
Alt 3	2	-3	0	-1	-1	-2	-2	-1	-1	0	3	2

Table 5-28. Simulated Delta Exports (Banks and Jones): NAA (cfs) and % Change between NAA and Alternatives 1, 2, and 3

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	3,890	4,735	5,917	5,856	6,080	4,146	1,551	2,237	1,921	2,240	3,707	3,577
Alt 1A	7	9	0	2	0	1	1	0	3	42	23	28
Alt 1B	5	10	1	0	0	2	1	-1	2	43	22	26
Alt 2	5	10	1	0	0	2	1	0	3	40	18	24
Alt 3	-5	9	0	-1	0	1	2	0	1	39	24	19
Average for Wet Water Years												
NAA	8,908	11,174	10,387	8,365	9,741	8,179	6,689	6,650	7,810	10,889	9,768	10,692
Alt 1A	-1	0	0	0	0	0	0	0	0	0	0	0
Alt 1B	0	0	0	0	0	0	0	0	0	0	0	0
Alt 2	0	0	0	0	0	0	0	0	0	0	0	0
Alt 3	0	0	1	0	0	0	0	-2	0	0	0	0

Table 5-29. Simulated San Luis Reservoir Storage: NAA (TAF) and % Change between Alternatives and NAA

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Average for Critically Dry Water Years												
NAA	386	549	791	1,196	1,399	1,497	1,403	1,265	961	615	427	362
Alt 1A	-7	-3	-2	-2	-2	-1	-1	-1	0	0	-3	-3
Alt 1B	-8	-4	-2	-1	-1	0	0	0	0	0	-4	-4
Alt 2	-7	-3	-2	-2	-1	-1	0	-1	0	0	-4	-3
Alt 3	-8	-4	-3	0	0	0	0	-1	-1	-2	-2	-1
Average for Wet Water Years												
NAA	901	1,181	1,523	1,472	1,688	1,832	1,825	1,673	1,323	1,019	753	807
Alt 1A	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1B	0	0	0	0	0	0	0	0	0	0	0	0
Alt 2	0	0	0	0	0	0	0	0	0	0	0	0
Alt 3	-1	-1	0	0	0	0	0	0	0	0	-1	-1

5.4.1.2. Summary of Water Supply Delivery Results

CALSIM results were used to estimate Sites water deliveries to Storage Partners participants as well as regular system deliveries to CVP and SWP contractors. Summaries of these water supply deliveries are provided in Tables 5-30 and 5-31. Results are shown for the average of all years in the 82-year simulation period as well as the average for all Dry and Critically Dry Water Years (Table 5-30). These metrics are informative for understanding overall average water supply as well as water supply during drier conditions when additional water supply is most beneficial. Water transfers in these tables are added to the deliveries received by the recipient, not the seller.

Overall total Sites deliveries are estimated to average between about 170 TAF/yr and 190 TAF/yr, with Dry and Critically Dry Water Year averages ranging between 320 TAF/yr and 370 TAF/yr, depending on alternative.

Table 5-30 shows how reservoir size and CVP participation affect deliveries. To evaluate the effect of reservoir size on water supply effects, Alternative 1A can be compared to Alternative 2 because neither of these alternatives includes CVP participation. Total authority deliveries are more affected by reservoir water supplies during Dry and Critically Dry Water Years, with the 1.5 MAF reservoir providing total authority deliveries that are about 25 TAF/yr greater than the 1.3 MAF reservoir (366 TAF versus 341 TAF/yr).

The effects of CVP participation in the Project can be seen by comparing Alternative 1A (no participation) to Alternative 1B (some CVP participation) and Alternative 3 (more CVP participation). Under Alternative 3, increases in CVP deliveries from Sites storage (CVP Operational Flexibility) cause some reduction in other Sites deliveries. In addition, CVP participation is associated with reduction in total authority deliveries, with greater reduction during Dry and Critically Dry Water Years and with greater CVP participation (Alternative 3). On average, CVP operational flexibility results in more active use of Sites Reservoir, particularly due to increased releases during Above Normal and Below Normal Water Years (Appendix 5B and Table 5-18), which sometimes decreases storage and water supply during Critically Dry Water Years, but on average increases yield (releases) from the Sites Reservoir. This increased yield helps contribute toward environmental objectives (e.g., storage in Shasta Lake) and is not apparent in Table 5-30, which focuses on deliveries.

Table 5-30. Simulated Sites Authority Water Supply Deliveries

Deliveries (TAF/year) (change from No Project Alternative conditions)	Alternative 1A 1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD)		Alternative 1B 1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD)		Alternative 2 1.27 MAF Reservoir Dunnigan Pipeline (outlet to Sacramento River)		Alternative 3 1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD)	
	All	**Dry and Critically Dry Water Years**	**All**	**Dry and Critically Dry Water Years**	**All**	**Dry and Critically Dry Water Years**	**All**	**Dry and Critically Dry Water Years**
Total Authority Deliveries to Storage Partners	128	307	119	286	117	277	96	230
North of Delta	31	64	29	60	29	62	25	52
South of Delta	97	243	91	226	87	215	71	178
CVP Operational Flexibility	0	0	8	19	0	0	24	46
Sub-Total Supplemental Deliveries for Water Supply	128	307	127	305	116	277	120	276
Refuge Water Supply	22	36	22	35	24	39	20	31
North of Delta	6	8	6	8	6	8	6	7
South of Delta	16	28	15	27	18	31	14	24
Yolo Bypass Habitat Water Supply	38	23	36	21	41	25	33	14
Total Authority Deliveries	189	366	185	361	181	341	173	321
% of Total Authority Deliveries								
Deliveries to Storage Partners - North of Delta	16%	17%	16%	17%	16%	18%	15%	16%
Deliveries to Storage Partners - South of Delta	52%	66%	49%	63%	48%	63%	41%	55%
CVP Deliveries - Operational Flexibility	0%	0%	4%	5%	0%	0%	14%	14%
Refuge Water Supply	12%	10%	12%	10%	13%	12%	12%	10%
Yolo Bypass Habitat Water Supply	20%	6%	19%	6%	23%	7%	19%	4%
Consideration of Incidental Change to CVP and SWP Deliveries								

Deliveries (TAF/year) (change from No Project Alternative conditions)	Alternative 1A 1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD)		Alternative 1B 1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD)		Alternative 2 1.27 MAF Reservoir Dunnigan Pipeline (outlet to Sacramento River)		Alternative 3 1.5 MAF Reservoir Dunnigan Pipeline (outlet to CBD)	
	All	Dry and Critically Dry Water Years	All	Dry and Critically Dry Water Years	All	Dry and Critically Dry Water Years	All	Dry and Critically Dry Water Years
Incidental Change to CVP and SWP Deliveries without CVP Operational Flexibility	2	8	1	11	3	8	15	19
Total Authority and Incidental Changes in CVP and SWP Deliveries	191	374	186	371	184	349	188	340

Table 5-31 provides more information about the incidental changes to CVP and SWP deliveries shown in Table 5-30. The values under existing conditions (i.e., NAA) are provided to put the incidental changes in context and the changes are broken down by north of Delta versus south of Delta and SWP versus CVP. The CVP values include increases due to CVP Op Flex Water. These SWP and CVP deliveries are further parsed into hydrologic regions and different types of CVP and SWP uses (e.g., settlement/exchange contractors, refuges, municipal, agricultural, FRSA) in Table *** in Appendix ***. All decreases in water supply are negligible relative to total deliveries and in consideration of model limitation. On average, total CVP and SWP deliveries would remain basically unchanged or increase with Alternatives 1, 2, and 3, with greater increases expected in association with CVP participation, particularly with Alternative 3.

Table 5-31. Simulated CVP and SWP Water Supply Deliveries: NAA (TAF) and Alternatives 1, 2, and 3 Minus NAA (TAF)

Alternative	North of Delta Total SWP	North of Delta Total CVP	South of Delta Total SWP	South of Delta Total CVP
Average of Dry and Critically Dry Water Years				
NAA	69	494	1,376	765
Alternative 1A	0	4	-2	8
Alternative 1B	0	7	1	24
Alternative 2	0	4	-1	8
Alternative 3	0	18	9	39
Average of All Years				
NAA	88	617	2,223	1,355
Alternative 1A	0	1	0	3
Alternative 1B	0	2	-2	10
Alternative 2	0	1	0	3
Alternative 3	0	7	6	21

Note: There are small differences in the calculation of CVP and SWP deliveries between the reports used to generate this table and Table 5-30. This table provides breakdown of CVP and SWP deliveries, but the calculated total CVP and SWP deliveries in Table 5-30 are slightly more accurate.

5.4.1.3. CALSIM Flood Metrics Comparison

Table 5-32 compares the CALSIM II modelled flood flows for each alternative, as well as the no action alternative, at key diversion and return locations across the affected area. The flood metrics are maximum monthly average and monthly average exceeded 10% of the time. Daily flows and peak flows were not modelled in CALSIM II. The design capacity for each reach is listed so that the reader may compare any increases in monthly flood flows to the flood capacity of the reach.

Table 5-32. CALSIM II Modeled Flood Flows

CALSIM II Model Station Sacramento River Flow at Bend Bridge	Location relative to Project Elements Between Shasta Lake outflow and first diversion to Sites (Red Bluff)	Capacity (cfs) 98,000 (approx.)	Flood Flows Metric	CALSIM II Modeled Flows (cfs)						Difference from NAA (cfs)			
				Month	NAA	Alt 1a	Alt 1b	Alt 2	Alt 3	Alt 1a	Alt 1b	Alt 2	Alt 3
Sacramento River Flow at Bend Bridge	Between Shasta Lake outflow and first diversion to Sites (Red Bluff)	98,000 (approx.)	Max Monthly Ave	Feb	84,426	84,427	84,428	84,427	84,429	1	2	1	3
			Monthly Ave Flow Exceeded 10% of the Time	Feb	43,713	43,952	43,714	43,952	43,953	239	1	239	240
Red Bluff Diversion	First diversion to Sites (serving TC Canal)	2,530	Max Monthly Ave	Jul	1,397	2,250	2,250	2,250	2,250	853	853	853	853
			Monthly Ave Flow Exceeded 10% of the Time	Jul	1,378	1,337	1,337	1,337	1,337	-41	-41	-41	-41
Sacramento River Flow below Red Bluff Diversion Dam	Between first diversion to Sites (Red Bluff) and second diversion to Sites (GCID Main Canal)	260,000	Max Monthly Ave	Feb	85,872	83,751	83,752	83,751	83,753	-2,121	-2,120	-2,121	-2,119
			Monthly Ave Flow Exceeded 10% of the Time	Feb	44,494	43,079	42,836	44,244	44,244	-1,415	-1,658	-250	-250
Hamilton City Diversion	Second diversion to Sites (GCID Main Canal)	3,000	Max Monthly Ave	Jun	2,715	3,000	3,000	3,000	3,000	285	285	285	285
			Monthly Ave Flow Exceeded 10% of the Time	Jun	2,710	2,708	2,708	2,710	2,698	-2	-2	0	-12
Sacramento River near Wilkins Slough	Between second diversion to Sites (GCID Main Canal) and Sites return (CBD)	30,000	Max Monthly Ave	Feb	27,805	27,800	27,799	27,800	27,799	-5	-6	-5	-6
			Monthly Ave Flow Exceeded 10% of the Time	Feb	26,418	26,290	26,257	26,403	26,270	-128	-161	-15	-148
Colusa Basin Drain above Dunnigan Pipeline	Between Sites return (TC Canal) and CBD return to Sacramento River	2,100	Max Monthly Ave	Jan	2,889	2,899	2,899	2,899	2,899	10	10	10	10
			Monthly Ave Flow Exceeded 10% of the Time	Feb	919	919	919	919	919	0	0	0	0

CALSIM II Model Station Sacramento River Flow at Bend Bridge	Location relative to Project Elements Between Shasta Lake outflow and first diversion to Sites (Red Bluff)	Capacity (cfs) 98,000 (approx.)	Flood Flows Metric	CALSIM II Modeled Flows (cfs)						Difference from NAA (cfs)			
				Month	NAA	Alt 1a	Alt 1b	Alt 2	Alt 3	Alt 1a	Alt 1b	Alt 2	Alt 3
Sacramento River below Colusa Basin Drain	Between CBD return and Yolo Bypass	30,000	Max Monthly Ave	Feb	27,804	27,835	27,834	27,835	27,834	31	30	31	30
			Monthly Ave Flow Exceeded 10% of the Time	Feb	26,452	26,324	26,291	26,438	26,304	-128	-161	-14	-148
Flow through Yolo Bypass	Below Fremont Weir	343,000	Max Monthly Ave	Feb	129,956	129,881	129,952	129,881	129,967	-75	-4	-75	11
			Monthly Ave Flow Exceeded 10% of the Time	Feb	48,623	46,583	46,145	47,686	46,311	-2,040	-2,478	-937	-2,312

5.4.2. CBD Hydraulic Modeling

A one-dimensional (1D) Hydrologic Engineering Center River Analysis System (HEC-RAS) model hydraulic model was used to simulate existing conditions in the CBD and assess changes to the WSE caused by a release of 1,000 cfs from the Dunnigan Pipeline into the CBD under Alternatives 1 and 3.

The model results indicate that for a low-flow condition in the CBD, KLOG causes backwater with a flat WSE (almost zero water surface slope) up to RM 25 near Balsdon Weir (Jacobs 2020:4, Figure E1). The 1,000 cfs Sites Reservoir release during these conditions increases CBD WSEs by a maximum of 1.54 feet. The WSE increases are highest upstream of the Sites release location to Balsdon Weir; and the WSE dissipates upstream of the weir. The WSE increases taper off downstream of Sites release location to KLOG; and the WSE converges at the KLOG.

The 1,000 cfs release during a high-flow condition of 1,700 cfs in CBD (Jacobs 2020:5, Figure E2) still has a maximum WSE increase of 1.54 feet but tapers off upstream at a faster rate because of the higher slope of the water surface. The lowest elevation along the toe of west berm profile at RM 8.9 was determined to be the lowest field elevation of 25.3 feet, NAVD 88. This elevation was considered critical in this analysis for assessing WSE effects because if the CBD WSE exceeds this elevation, flooding in this field can result because of seepage and backwater.

Using the simulated proposed conditions stage results, Jacobs (2020) identified the periods when WSEs exceed the critical elevation of 25.3 feet, NAVD 88 at RM 8.9, and computed the quantity and timing of when Sites Reservoir volumes can be conveyed to Sacramento River with a constant flow rate of 1,000 cfs. In brief, the 1,000 cfs Sites Reservoir release can be conveyed without causing WSE effects, primarily during the months of April through July, and October. In August and September, the CBD carries high flows, resulting from rice field agricultural drainage, and does not have capacity to convey reservoir releases of 1,000 cfs.

5.5 Methods of Analysis

The evaluation of environmental impacts on surface water resources is both quantitative (using and interpreting modeling results) and qualitative (using information about local hydrological conditions to establish context and impact mechanisms). The following sections outline the processes used in the determination of impacts on surface water resources associated with construction and operation of the Project.

5.5.1. Construction

Construction impacts are evaluated qualitatively based on the physical characteristics of the locations where construction would occur, including slope and soil type. Where appropriate, the impact analysis is combined for Alternatives 1, 2, and 3 depending on the impact being evaluated or the associated Project components. The BMPs described in Appendix 2D, *Best Management Practices*, are incorporated into the analysis of potential construction impacts on surface water resources, including the erosion and sediment control measures under the description of the Stormwater Pollution Prevention Plan(s) (SWPPP) under Stormwater Construction General Permit coverage, and drainage evaluations, design, and implementation. These BMPs minimize alterations to existing drainage infrastructure and patterns where needed.

The analysis of dam failure and emergency releases relies on the following information: previous studies conducted for the 2017 Draft EIR/EIS; design standards and design criteria described in Chapter 2, *Project Description and Alternatives*, and Appendix 2D; and the Emergency Action Plan described in Chapter 2. The impact analysis assumes the Project would be designed and constructed in accordance with the following standards, criteria, and regulations:

- As described in Section 2.5.3.1, *Geotechnical Investigations*, the Authority would conduct geotechnical studies (e.g., reservoir rim study, seismic fault study) to provide Project-specific recommendations for the engineering and final design of all facilities.
- All Project facilities would be designed to meet a wide variety of seismic design criteria, such as the California Building Standards Code regulations for structures and transmission lines, the International Building Code for structural design, the seismic design for railway structures, and the seismic provisions for structural steel buildings.
- The main dams, saddle dams, saddle dikes, I/O Works, and TRR East embankment or TRR West would be designed to conform with Project-specific geotechnical design recommendations and the seismic design criteria of the Reclamation and/or DSOD. TRR East would be designed to meet both DSOD and Reclamation design criteria because of its height of embankment, whereas TRR West would be designed to meet only Reclamation design criteria because it is constructed through excavation rather than an embankment.
- Roads and the bridge would be designed to meet national, state, and county standards. In addition, the bridge would be designed to meet California Department of Transportation (Caltrans) Seismic Design Criteria, including its no collapse criteria (California Department of Transportation 2020:3-1–3-4). The bridge's earthen fill prisms would be designed to meet Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications, Caltrans Seismic Design Criteria, and Caltrans California Amendments to the AASHTO LRFD Bridge Design Specifications.
- Buildings would be built to the seismic design standards of the California Building Standards Code.
- Consistent with California Water Code sections 6160, 6161, and 6002.5, an Emergency Action Plan would be prepared and submitted to the Governor's Office of Emergency Services (CalOES) for Project construction and operation. The Emergency Action Plan would comply with SB 92 and CalOES's Emergency Action Plan requirements. The Emergency Action Plan would include, but may not be limited to, emergency notification flowcharts, notification procedures, inundation maps, and a variety of other important

emergency response protocols for notifying downstream entities if an emergency release is anticipated.

5.5.2. Operation

Potential water supply effects associated with the Project were evaluated using results from CALSIM, which are described in Section 5.4, Hydrologic Modeling Results. Potential flooding effects were evaluated using CALSIM II results, which are described in Section 5.4., Hydrologic Modeling Results. Operational impacts of Alternatives 1, 2, and 3 on flooding were evaluated quantitatively and qualitatively using the modeled results, as described above.

5.5.3. Thresholds of Significance

An impact on surface water resources would be considered significant if the Project would do any of the following.

- Reduce water supply for other water users
- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river or through the addition of impervious surfaces, in a manner that would do either of the following.
  - Substantially increase the rate or amount of surface runoff in a manner which would result in flooding onsite or offsite.
  - Impede or redirect flood flows.

5.6 Impact Analysis and Mitigation Measures

Impact HYDRO-1: Reduce water supply for other water users

No Project

The No Project Alternative represents the continuation of the existing conditions within the study area. Under the No Project Alternative, the operations of the existing TC Canal, RBPP, and GCID Main Canal would continue, and Sites Reservoir would not be constructed or operated. Existing water supply would not be affected.

Significance Determination

The No Project Alternative would not reduce water supply for other water users because no new facilities would be constructed and operated. There would be no impact.

Alternatives 1, 2, and 3

Construction

The estimated volume of water needed for construction is estimated to be between 1.12 and 1.43 MGD for 4 years (Table 26-4, Chapter 26, *Public Services and Utilities*). This is approximately 1.3 to 1.6 TAF per year. This water would be obtained either through acquisition of property with wells or through acquisition of water from nearby local water purveyors (ditches, canals, and wells) and possibly local landowners (wells). As identified in Chapter 8, *Groundwater Resources*, there is sufficient groundwater supply to provide this water during the construction period. Furthermore, because of financial compensation, use of water during construction would not harm existing water right holders.

Operation

Under all alternatives, operations of Sites Reservoir would be integrated with existing CVP water operations and regulations. CVP and SWP water contractors with more junior water rights (i.e., not settlement, exchange, or FRSA contractors) are the most likely water users to be affected by changes in operations and changes in the movement of water through the Delta. However, the purpose of Sites Reservoir would be to increase water supply and movement of water from Sites Reservoir through the Delta would only be allowed if regulatory conditions permitted, CVP and SWP exports were already maximized, and other conditions (e.g., pumping and storage capacity) allowed increased exports. CALSIM results indicate the consequences of integrating Sites Reservoir operations with existing operations in the Central Valley (see Section 5.3, Hydrologic Modeling and Results).

The effect of the Project alternatives on CVP and SWP water supply as estimated by CALSIM are shown in Table 5-31 for north of Delta and south of Delta CVP and SWP water users under average and dry and critical year conditions. Further breakdown of these results is shown in appendix ***. All decreases in water supply modeled for the alternatives are negligible considering the magnitude of the changes relative to total deliveries and potential model limitations. On average, CVP and SWP deliveries are expected to increase with Alternatives 1, 2, and 3, with greater increases expected in association with CVP participation, particularly with Alternative 3.

Operation of Alternative 1, 2 or 3 would require new or modified water rights, water supply, and operating agreements to accommodate the supplies identified by the simulations. Implementation of Alternative 1, 2 or 3 would require authorization from the State Water Board's Division of Water Rights (Division) in the form of a permit to divert and store water that would eventually be perfected to a license. The Authority is currently coordinating with the State Water Board Division related to water rights filings to support the Sites Reservoir and operation. The filing would include submitting a petition for assignment, likely in the form of an application. Once filed, the State Water Board Division would notice the application which would provide an opportunity for public review. The process allows for the filing of protests based on perceived injury to legal users of water or based on environmental impacts. The Authority would be required to resolve all protests (which could result in a hearing to resolve concerns) prior to receiving authorization for Alternative 1, 2, or 3. Final authorization would require resolution of all concerns which would be included as terms and conditions in the water rights authorizing Alternative 1, 2, or 3. Given the above, any right(s) and agreement(s) as part of Alternative 1, 2, or 3 would be formulated to protect existing beneficial uses associated with existing water rights, and that the action to obtain new or modified water rights, water supply, and operating agreements would be evaluated pursuant to the State of California's water rights laws.

CEQA Significance Determination and Mitigation Measures

Project alternatives would not reduce water supply to other water users. This impact is considered less than significant.

NEPA Conclusion

Project effects would be the same as described above for CEQA. Water supply for other water users would not be adversely affected.

Impact HYDRO-2: Substantial increase in the rate or amount of surface runoff in a manner which would result in flooding onsite or offsite

No Project

The No Project Alternative represents the continuation of the existing conditions in the study area. Current flood control infrastructure, as well as existing routine operations and maintenance activities would continue, and there would be no change in the flood control regimes. Unimpeded flooding in the creeks in the vicinity of Sites Reservoir (i.e., Stone Corral Creek) would continue to pose a flood hazard to downstream reaches.

Significance Determination

The No Project Alternative would not result in substantial increases in the rate or amount of surface runoff in a manner which would result in flooding onsite or offsite because no new facilities would be constructed and operated. There would be no impact.

Alternatives 1, 2, and 3

Construction

Sites Reservoir, the Funks and TRR reservoirs and PGPs, administration and operation and maintenance buildings, Dunnigan Pipeline, Sacramento River discharge, and new roads, including the South Road (under Alternative 2 only) represent new facilities with the potential to alter existing drainage patterns and characteristics. The increase in impervious surfaces associated with construction activities is discussed under Impact FLV-1 in Chapter 7, *Fluvial*

Geomorphology. Streamflow present in Funks or Stone Corral Creeks would be contained behind coffer dams and localized flooding in these creeks would be avoided during construction. Streamflow in the channels associated with construction of the South Road (under Alternative 2 only) would be contained in a similar manner.

On Funks Creek at the Golden Gate Dam construction site, flow would be routed through a temporary pipe underneath the construction site and then re-enter the Funks Creek channel downstream. The coffer dam would provide enough residence time for settling of sediment to occur for typical flows in Funks Creek[2]. On Stone Corral Creek at the Sites Dam construction site, flow would be routed through a permanent tunnel underneath the construction site (which would later be used as the dam outlet pipe) and then re-enter the Stone Corral Creek channel downstream[3].

Various construction activities would occur in mapped 100-year floodplains. However, the equipment used during these construction activities would not increase in the rate or amount of surface runoff in a manner which would result in flooding onsite or offsite. Project facility design and BMPs would identify design flows and incorporate measures to provide for drainage feature stability; incorporate relocation plans (for canals, ditches, wells, and other existing infrastructure); and incorporate other modifications to localized runoff amounts and/or patterns. Any necessary site features or procedures to remediate Project-induced drainage problems identified in the drainage evaluations would be installed before the Project was completed or as part of Alternatives 1, 2 or 3, depending on site-specific conditions.

<u>Operation</u>

Based on the CALSIM II modeled flood flows, the differences in maximum monthly average and monthly average flow exceeded 10% of the time between the No Action Alternative and Alternatives 1 and 3 at the eight locations are shown in Table 5-32. Excluding the RBPP and GCID Main Canal at Hamilton City diversions (the first and second diversion points for Alternatives 1, 2, and 3), these values range from an increase of less than 1% to a decrease of less than 2.5% for the maximum monthly averages when compared to No Action Alternative, and an increase of less than 1% to a decrease of approximately 5% for the monthly average flows exceeded 10% of the time when compared to No Action Alternative, depending on the location (Table 5-33). Identified water discharge decreases would reduce in-channel flow and thus reduce any potential for flooding, while the identified water discharge percentage increases are minor. In brief, these percent differences are minor when considered in the context of the larger system

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[2] Note that the anticipated volume that would need to be stored for a 33-hour 100-year storm event on Funks Creek is approximately 5,900 AF.

[3] The anticipated volume that would need to be stored for a 33-hour 100-year storm event on Stone Corral Creek is 3,500 AF. Maximum flows for the outlet would be 2,500 cfs. Release capabilities of up to 2,500 cfs in combination with 1,940 AF of storage would be sufficient to prevent the coffer dam from overtopping. The outlet tunnel with two 84-inch-diameter fixed cone valves would accommodate these releases, and an energy dissipating chamber would reduce the velocity of the water released to approximately 33 feet per second.

and would not represent a substantial increase in the amount or rate of runoff that would result in flooding.

Table 5-33. % Change between the No Action Alternative and Alternatives 1, 2, and 3

CALSIM II Model Station	Flood Flows Metric	% Difference from NAA				
		Month	Alt 1a	Alt 1b	Alt 2	Alt 3
Sacramento River Flow at Bend Bridge	Max Monthly Ave	Feb	0.001184	0.002369	0.001184	0.003553
	Monthly Ave Flow Exceeded 10% of the Time	Feb	0.546748	0.002288	0.546748	0.549036
Sacramento River Flow below Red Bluff Diversion Dam	Max Monthly Ave	Feb	-2.46996	-2.46879	-2.46996	-2.46763
	Monthly Ave Flow Exceeded 10% of the Time	Feb	-3.1802	-3.72635	-0.56187	-0.56187
Sacramento River near Wilkins Slough	Max Monthly Ave	Feb	-0.01798	-0.02158	-0.01798	-0.02158
	Monthly Ave Flow Exceeded 10% of the Time	Feb	-0.48452	-0.60943	-0.05678	-0.56022
Colusa Basin Drain above Dunnigan Pipeline	Max Monthly Ave	Jan	0.346141	0.346141	0.346141	0.346141
	Monthly Ave Flow Exceeded 10% of the Time	Feb	0	0	0	0
Sacramento River below Colusa Basin Drain	Max Monthly Ave	Feb	0.111495	0.107898	0.111495	0.107898
	Monthly Ave Flow Exceeded 10% of the Time	Feb	-0.4839	-0.60865	-0.05293	-0.5595
Flow through Yolo Bypass	Max Monthly Ave	Feb	-0.05771	-0.00308	-0.05771	0.008464
	Monthly Ave Flow Exceeded 10% of the Time	Feb	-4.19555	-5.09635	-1.92707	-4.75495

Values in table based on CALSIM results as of 02-01-2021

As computed from Table 5-32 and as shown in Table 5-33, the average (system-wide) decrease in maximum monthly average flow between the No Action Alternative and Alternatives 1A, 1B, 2, and 3 is less than 1%. As shown in Table 5-33, the maximum monthly average flow would increase in three locations, where each instance represents a change of less than 1%. The biggest changes (decreases) would occur in the Sacramento River between RBPP and the GCID Main Canal at Hamilton City, but even these decreases are less than 2.5% compared to the No Action Alternative.

As computed from Table 5-32 and as shown in Table 5-33, the average (system-wide) decrease in monthly average flow exceeded 10% of the time between the No Action Alternative and Alternatives 1A is approximately 2%; the average (system-wide) decrease in monthly average flow exceeded 10% of the time between the No Action Alternative and Alternatives 1B is approximately 2.5%; the average (system-wide) decrease in monthly average flow exceeded 10% of the time between the No Action Alternative and Alternatives 2 is less than 1%; and the average (system-wide) decrease in monthly average flow exceeded 10% of the time between the No Action Alternative and Alternatives 3 is approximately 1.6%. As shown in Table 5-33, the monthly average flow exceeded 10% of the time would increase in one location, where a change of less than 1% would occur. The biggest change (decrease) would occur in the Sacramento River below the Fremont Weir, but even these decreases are generally less than 5% compared to the No Action Alternative.

Besides the minor decreases in flood flows on the Sacramento River as described in the preceding paragraphs, a flood protection benefit would also be provided for the areas downstream of Sites Reservoir (specifically on the floodplains of Stone Corral Creek where flooding has historically occurred). As described in the Water Storage Investment Program (WSIP) application (Sites Project Authority 2017), direct flood control benefits would be provided in the Stone Corral Creek and Funks Creek watersheds (including the town of Maxwell) by reducing the size of the floodplain within the region. It is estimated that the Project would reduce the 100-year floodplain by approximately 10,000 acres, representing a 9% reduction. In addition to increasing the level of protection in the Funks Creek and Stone Corral Creek watersheds, a 100-year level of protection would also be achieved for approximately 4,025 acres in the Colusa Basin located east of Interstate 5.

CEQA Significance Determination and Mitigation Measures

Construction of Alternative 1, 2, or 3 would not increase flooding onsite or offsite. Construction sequencing and use of coffer dams and bypass flow mechanisms, as well as drainage evaluations that would consider design flows (during and after construction), would ensure that localized flooding during construction would be avoided. Construction of Alternatives 1, 2 and 3 would not substantially increase the rate or amount of surface runoff in a manner that would result in flooding on or off site and impacts would be less than significant.

Diversions under Alternatives 1, 2 and 3 would only occur under higher flow regimes in the Sacramento River. Operational impacts on the flood control regime of the greater Sacramento River system are expected to be minimal and result in mostly decreases in monthly average flow and the existing flood volume. Alternatives 1, 2 and 3 would result in a direct reduction in runoff from the Stone Corral Creek and Funks Creek watersheds and associated historic flooding downstream, downstream including the town of Maxwell. Operation of Alternatives 1, 2 and 3 would not substantially increase the rate or amount of surface runoff in a manner that would result in flooding on or off site and impacts would be less than significant.

NEPA Conclusion

Construction and operation effects for Alternatives 1, 2, and 3 would be the same as those described above for CEQA and would not substantially increase flooding onsite or offsite. In addition, the Project would provide direct flood control benefits within the Stone Corral Creek and Funks Creek watersheds by reducing the size of the floodplain within the region. Construction effects of Alternatives 1, 2 and 3 would not be adverse and operation effects of Alternatives 1, 2, and 3 would be beneficial.

Impact HYDRO-3: Impede or redirect flood flows

No Project

The No Project Alternative represents the continuation of the existing conditions in the study area. Current flood control conditions, as well as existing routine operations and maintenance activities would continue, and there would be no change in the flood control regimes.

Significance Determination

The No Project Alternative would not result in the impediment or redirection of flood flows because no new facilities would be constructed and operated. There would be no impact.

Alternatives 1, 2, and 3

This section addresses potential impacts associated with impediment of redirection of flood flows as a result of operation of each alternative. Impact mechanisms related to redirection flood flows during construction and related impacts are similar to those discussed above under Impact HYDRO -2 and therefore are addressed under that impact.

Operation

Dam Failure

If surface fault rupture (or other means of structural compromise, including inadequate construction, acts of vandalism or terrorism, etc.) resulted in partial or complete dam failure, it could cause widespread flooding to property and people in the region downstream of the dams to the Sacramento River. Previous analysis indicated that the peak outflow from a breach of Sites Reservoir could be estimated at 2,078,000 cfs, and that the flood wave would move east through the foothills, fanning out to the relatively flat terrain of the Sacramento Valley before reaching the city of Maxwell and I-5. The estimated flow velocity at Maxwell and I-5 would be 4.5 feet per second (fps) and the maximum depth would be 10 feet. The flood wave would then continue approximately 13 miles east to the city of Colusa and the Sacramento River. The flood wave would then be impeded by the west levee of the Sacramento River, and the flood would reach a depth of 22 feet (upslope of the Sacramento River levee) (California Department of Water Resources 2005:4).

Under Alternatives 1, 2, and 3, Sites Reservoir dams would be designed and constructed pursuant to conservative guidelines and criteria designed to prevent failure. The designs would incorporate multiple lines of defense or design redundancy as required to meet design standards. The known faults, geologic structures, and seismic activity of the area would be considered in the final design of the main dams, saddle dams, and saddle dikes and would be designed to conform with all applicable design criteria. The main dams, saddle dams, and saddle dikes would also be designed to accommodate the maximum predicted fault offset (Chapter 12, *Geology and Soils*, Table 12-6). The dams would be designed to ensure the dam embankment is not impaired by extensive cracking, crest settlement, or excessive deformation in critical zones, and the design would limit seismic deformation to 5 feet. Furthermore, monitoring equipment and tools, including strong motion seismic detectors, piezometers, settlement points, and seepage weirs, would be permanently installed at each dam site, and strong motion seismic detectors would be installed at center crests, abutments, and toes of Golden Gate Dam and Sites Dam. These procedures would provide early warning signs of potential dam failure.

In addition, the I/O Works, tunnels, and pipelines in the Antelope Valley and foothills would be located near or on known faults, and surface fault rupture could damage these facilities. Damage to these facilities could cause flooding along Funks and Stone Corral Creeks. A seismic fault study would map the faults adjacent to the I/O Works and ensure that the location of the alignment would minimize fault crossings. As with the dams and dikes, these facilities would by designed to meet all applicable design criteria. Furthermore, the power and supervisory controls required to operate the I/O Works and other appurtenances would be designed to remain fully operable following a seismic event, which would enable operators to shut down facilities as needed.

Finally, consistent with California Water Code sections 6160, 6161, and 6002.5, an Emergency Action Plan would be prepared and submitted to the Governor's Office of Emergency Services (CalOES) for Project construction and operation. The Emergency Action Plan would comply with SB 92 and CalOES's Emergency Action Plan requirements. The Emergency Action Plan would include, but may not be limited to, emergency notification flowcharts, notification procedures, inundation maps, and a variety of other important emergency response protocols for notifying downstream entities if an emergency release is anticipated.

Reservoir Emergency Releases

Under Alternatives 1 and 3, the reservoir would be designed to release flows into Hunters Creek, Stone Corral Creek, and Funks Creek. Stone Corral Creek is the only creek in the vicinity of Sites Reservoir with stream gage data, but based on the size, geology, topography, and proximity of Funks Creek and the forks of Hunters Creek, these creeks are comparable to Stone Corral Creek. The hydrology of Funks Creek and Hunters Creek is likely similar to Stone Creek hydrology in terms of peak flow recurrence intervals and mean daily flow durations. The 100-year discharge for Stone Corral is established as 7,870 cfs[4] based on the 25 years of records (USBR and DWR 2008:3-12). The maximum mean daily flow on record from the USGS gage station 11390672 Stone Corral Creek, near Sites, was 2,230 cfs. This flow occurred in 1983 and the maximum instantaneous peak flow on record was 5,700 cfs also occurring in 1983. This flow event created downstream flooding in the town of Maxwell.

The potential emergency release flows in Hunters Creek Forks 3, 5, and 8B (1,000 cfs from Saddle Dam 3; 1,200 cfs from Saddle Dam 5; and the Probable Maximum Flood (PMF) event from Saddle Dam 8B) and Stone Corral Creek (2,500 cfs from Sites Dam) would be below the

[4] The USGS StreamStats estimate the 100-year discharge for Stone Corral slightly lower at 6,590 cfs with the mean daily discharge exceeding 215 cfs only 1% of the time and flows above 0 cfs 45% of the time.

100-year discharge. The emergency release flows in Hunters Creek (at least 2,200 cfs) would be slightly less than the volume of the maximum mean daily flow on record available, and the emergency release flows in Stone Corral Creek (approximately 2,500 cfs) would be slightly more than the volume of the maximum mean daily flow on record available. Both of these emergency release volumes would cause some amount of downstream flooding, the extent of which would be more amplified in the Stone Corral Creek watershed.

Emergency release flows would also be released into Funks Reservoir (9,000 cfs) and TRR East or TRR West (7,000 cfs) via the I/O works and pipelines, which would ultimately be discharged into Funks Creek. These emergency releases would cause some amount of downstream flooding in Funks Creek. TRR West (under Alternative 2) is not adjacent to Funks Creek; therefore, the area between TRR West and Funks Creek would be flooded (Rude pers. comm.)

Under Alternative 2, the reservoir would also be designed to release flows into Hunters Creek, Stone Corral Creek, and Funks Creek. However, Saddle Dams 3 and 5 would not be utilized and only the PMF event from Saddle Dam 8B would be released into Hunters Creek. While the volume of water associated with the PMF is unknown at this time, the volume would be less than under Alternatives 1 and 3.

As an offstream reservoir, Sites Reservoir would be filled by controlled diversions and would receive little inflow from the local creeks. In general, Sites Reservoir would fill to its highest operating levels by spring to early summer, and then drawn down during summer. By the time the rainy season begins in earnest (i.e., when a 100-year flood could occur), the reservoir would have more than enough capacity to handle typical storm events from the local creeks (presumably with discharges that range from 1 to 100 cfs), even at full operating capacity. Emergency releases would only have the potential to occur during years of very heavy precipitation when the Sites Reservoir is already at capacity and a localized storm in the Sites Reservoir watershed creates a significant rise in the reservoir's water surface. The risk of an event requiring such an emergency release remains very small because inflow is controlled through pumping. Water diversions to Sites Reservoir would not occur once the reservoir reaches a certain stage and additional precipitation events are forecasted to occur. Further, should water diversions continue in a highly unlikely scenario, the Authority would be able to prepare for any necessary flood warnings to the public downstream of the reservoir (see Emergency Action Plan above). Finally, the drainage area contributing to the Sites Reservoir is considered low elevation and therefore rarely contains accumulating snow during the winter. Thus, there is no potential for additional water volume from snowmelt or rain-on-snow hydrological events.

Commented [CC8]: By your own estimates, an average of ~14 TAF, with a maximum of ~107 TAF in 1983.

Commented [CC9]: In the Calsim II models, Sites Reservoir is full in January 1983. Heavy rains continued in January, February, and March so the inflow cannot be controlled through pumping if it's starting full and over 40 TAF of inflow needs to be released before the peak flow in March. Nearby Napa River shows peak flow on 12/31/2005 was over 70% higher than on 3/13/1983, and 10 other years with higher flows than 1983, so these conditions are not unique to this one year. Emergency releases WILL happen, especially with more intense flooding anticipated in our current and future climate.

CBD Flood Impacts

Reservoir releases to the CBD would be controlled by operations and would not inundate, as a result of overtopping, seepage, or reverse flows, existing agricultural fields adjacent to the CBD. No flooding in the CBD area is anticipated as a result of operation of Alternatives 1, 2, and 3. Reservoir releases potentially could be directed to the Yolo Bypass instead of the Sacramento River from August through October.

CEQA Significance Determination and Mitigation Measures

The probability of dam failure and subsequent impacts is very low as a result of incorporation of design criteria and construction practices, post-construction monitoring, and avoidance or minimizing of fault crossings. The probability of the emergency release event occurring is remote because inflow is controlled primarily through pumping for offstream storage reservoirs. The reservoir would be operated to avoid overtopping, seepage, or flooding into adjacent lands as a result of releases into the CBD. Accordingly, Alternatives 1, 2, and 3 would have a less-than-significant impact with regards to the impediment of redirection of flood flows.

Commented [CC10]: This assertion should be supported quantitively with some peak flow analysis and/or simulation. I'm looking roughly and I would estimate that emergency releases have a recurrence interval of about 10 years unless flood space is reserved in the winter.

NEPA Conclusion

Operation effects for Alternative 1, 2, or 3 would be the same as those described above for CEQA. The operation of Alternative 1, 2, or 3 would not have an adverse effect on the impediment or redirection of flood flows.

5.7 References

Yellow = citation found in text, with no matching reference in this section.

Gray = no citation found in the text for this reference.

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5.7.2. Personal Communications

Rude, Pete. Civil Engineer. Jacobs. April 23, 2021—Smartsheet response re: TRR West emergency releases to Nicole Williams, Project Manager, ICF, Sacramento, CA.

Appendix 2D Best Management Practices

Outstanding issues [yellow=info needed for completion from ICF or Integration; blue=QA/QC globals for ICF Editing]
Integration/Authority: Please review gray comment bubbles in Table 2D-1 and fill in information. We need to discuss the dewatering BMP with respect to private wells, particularly along the Dunnigan pipeline, in appendix 2D. We need to be able to have something around the BMP such as criteria/monitoring. This is also applicable to Chapter 8
Integration/Authority: Please add information to Section 2D.1 Initial Reservoir Fill Plan as needed.
Integration/Authority: Please add information to the Recreation Management Plan as needed; this will need a cross check with Chapter 26.
ICF: to add/review information about HABs in the Reservoir management plan section base on the fact that on 5/28/2021 EPA posted a Cyanotoxins Preparedness and Response Toolkit (CPRT) online. The CPRT will help EPA's state and tribal partners prepare for potential harmful algal blooms in freshwater bodies and respond to protect public health. Cyanobacterial Harmful Algal Blooms (CyanoHABs) can cause fouling of beaches and shorelines, economic and aesthetic losses, taste and odor problems in drinking water, and direct risks to human, fish, and animal health.
ICF: back check Section 2D.4 and 2D.5 with Chapter 11.

Appendix 2D Introduction

The Authority has incorporated numerous best management practices (BMPs) into the Project design as described in Chapter 2, *Project Description and Alternatives*. In addition, the Authority has incorporated different plans and studies that would be required as part of the Project, including the Initial Reservoir Fill Plan, Reservoir Management Plan, Land Management Plan, Cultural Resources Management Plan, and Recreation Management Plan. This appendix describes the BMPs, management plans, and technical studies that are part of the Project and are integrated into the impact analyses in Chapters 5 through 30 as applicable.

2D.1 Best Management Practices

The Project BMPs include applicable design standards, criteria, and requirements; standard general practices required during construction, operations, and maintenance; and resource-specific on projects pursuant either to regulations or as a result of best management. Table 2D-1 contains the titles, key features, responsible party(ies), and timing of the BMPs.

Table 2D-1. Best Management Practices

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
Conform with Applicable Design Standards and Building Codes	The Authority will ensure that the standards, guidelines, and codes (the most current applicable version at the time of implementation), which establish minimum design criteria and construction requirements for levees, pipelines, excavations and shoring, pumping stations, dams, grading, foundations, bridges, access roads, structures, and other facilities, will be followed by the project engineers, where applicable, in the design of project facilities and will be included as minimum standards in the construction specifications. The project engineers will follow standards, guidelines, and code requirements that are legally mandated. Proposed design standards include, but may not be limited to the following: • **Reservoir Roads and Bridges** American Association of State Highway and Transportation Officials (AASHTO) "A Policy on Geometric Design of Highways and Streets" 2018, 7th edition AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications, 8th edition California Department of Transportation (Caltrans) California Amendments to the AASHTO LRFD Bridge Design Specifications) Caltrans' Seismic Design Criteria (SDC) 2.0. ARS curve Caltrans Seismic Design Criteria, Version 2.0. April 2019 Caltrans Highway Design Manual (HDM), 6th Edition Colusa and Glenn County Standards (described in Appendix 2C). • **Conveyance Pipelines and Manifold (HC Feasibility Study Report July 2020)** American Railway Engineering and Maintenance-of-Way Association Manual for Railway Engineering, Volume 2, Chapter 9, Seismic Design for Railway Structures, 2008. American Concrete Institute (ACI) 350 for hydraulic structures ACI 318 for miscellaneous, non-hydraulic, concrete structures, including building slabs and foundations American Water Works Association (AWWA) Concrete Pressure Pipe (M9) 3rd Edition. AWWA Steel Pipe Guide for Design and Installation (M11) 5th Edition. AWWA C200-05. AWWA M11 Chapters 6, 8, 9, 12, 13. AWWA C205, C207, C208, C214, 216, C217, C219, C222. AWWA M-51 American Society for Testing and Materials (ASTM) A1018/A1018M for specification of structural steel. ASTM A516/A516M for specification of structural steel. American Society of Civil Engineers (ASCE) 27-00, Standard Practice for Design of Precast Concrete Pipe for Jacking in Trenchless Construction. ASCE Steel Penstock Design (Manual of Practice (MOP) 79). American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC) Section VIII, Division 1, Part 2. ASME 16.5 and ASME 16.47. ASME BPVC, Section IX. American Welding Society D1.1 for field welds. CI/ASCE 36-01, Standard Construction Guidelines for Microtunneling.	• Authority • Design engineers • Construction contractors	• Prior to and during construction	• The Authority will review all project facility designs to ensure the standards, guidelines, and codes listed above are included where appropriate. The Authority will ensure that the identified design standards are treated as the minimum standard for design and construction, unless more stringent requirements are enacted or promulgated. • Project engineers will provide all draft and final project facility designs to the Authority for review. • A seismic monitoring array will be designed and implemented as part of the Project to monitor site seismic activity, including identifying any increase in seismicity rate that could be attributed to potential reservoir triggered seismicity (RTS)	• Department of Water Resources, Division of Safety of Dams • U.S. Army Corps of Engineers • Central Valley Flood Protection Board

Commented [WN1]: *Integration/HC – for GCID siphon upgrade?)*

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Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
	New & O'Reilly 1992 or an equivalent method for settlement predictions Underground Technology Research Council (UTRC) 1997 Geotechnical Baseline Reports for Underground Construction – Suggested Guidelines and Practices. Reston: American Society of Civil Engineers. UTRC 2006 Final Design Geotechnical Baseline Report • **Structures (non-hydraulic concrete, steel, and masonry structures)** current governing codes and standards applicable to the construction of buildings, structures, and appurtenances in the State of California (California Building Code, **YEAR** (Title 24 California Code of Regulations; California Code of Regulations, Title 8) The Masonry Society Building Code Requirements and Specifications for Masonry Structures (TMS 402) latest edition of the American National Standards Institute (ANSI) /American Institute of Steel Construction (AISC) Steel Construction Manual and the ANSI/AISC Specification for Structural Steel Buildings RCSC Specification for Structural Joints Using High Strength Bolts • **Electrical Supply** The point of interconnection, transmission, and substation design criteria, dependent on the point of interconnection option, will incorporate the following references: • California General Order 95, Rules for Overhead Electric Line Construction • Western Area Power Administration Service and Generation Interconnection Requirements • Pacific Gas and Electric Company (PG&E) Interconnection Requirements • PG&E Substation Design Criteria The latest edition and addenda of the following publications, as applicable, will be incorporated in the design specifications codes and standards sections. • ANSI • Institution of Electrical and Electronics Engineers, Inc. (IEEE) • Association of Edison Illuminating Companies (AEIC) • Transmission Interconnections Handbook (TIH) • North America Electric Reliability Corporation Standards (NERC) • National Fire Protection Agency (NFPA) 70 National Electric Code • National Electrical Safety Code (ANSI C2) • **Transmission Lines** In addition to the point of interconnection requirements, transmission lines will be designed in accordance with the latest edition and addenda of the following publications, as applicable which will be incorporated in the design specifications. • California Building Code 2016, Title 24 Vol. 2 • ASCE-113 Substation Structure Design Guide • ASCE/SEI 7-05 Minimum Design Loads for Buildings and Other Structures • ANSI/AISC 41-10 Seismic Provisions for Structural Steel Buildings • **Reservoir, Dam, and Inlet/Outlet Works** ASTM C33 (2018) for aggregate for filters and drains and aggregate use in structural concrete				

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
	California Department of Water Resources, Division of Safety of Dams Emergency Drawdown Criteria (DSOD) International Building Code (IBC) (2018). Chapter 16 Structural Design. U.S. Army Corps of Engineers (USACE) 1997 Tunnels and Shafts in Rocks, EM-2-1110-2901. USACE 2000 Roller Compacted Concrete, EM 1110-2-2006 USACE 2005 Stability Analysis of Concrete Structures, EM 1110-2-2100 USACE 2018 Hydrologic Engineering Center, HEC-HMS Hydrologic Modeling System, Version 4.3. Reclamation 1987 Design of Small Dams. Reclamation 1989 Flood Hydrology Manual, First Edition. Reclamation 2011 Design Standards No. 13, Embankment Dam Design Standards, Chapter 4: Static Stability Analysis Phase 4 (Final). Reclamation 2011 Design Standards, No. 13, Embankment Dam Design Standards, Chapter 5: Protective Filters Phase 4 (Final). Reclamation 2016 USBR Design Standards No. 6, Hydraulic and Mechanical Equipment, Chapter 12, Trashracks and Trashrack Cleaning Devices. • **Slope Protection** USACE 2002 Coastal Engineering Manual Reclamation 1989 Flood Hydrology Manual				
Siting of Recreational Structures	• The downslope portion of the recreation facilities within the recreation areas will be designed above the predicted wave run-up elevation. • The determination for location will be based on project design studies. • If the predicted seiche wave run-up level would extend into a recreation area and inundate a facility, the Authority would relocate the recreation facility accordingly during final design and not construct in that location.	• Authority	• Prior to Construction and during final design	• None	• County
Perform Geotechnical Evaluations and Prepare Geotechnical Data Reports	• Perform geotechnical laboratory testing on select samples to evaluate engineering and other properties of collected soils. • Prepare geotechnical data reports to document observations and findings of subsurface investigations and tests • Prepare geotechnical baseline and/or other reports to describe expected construction conditions and provide design and construction recommendations	• Geotechnical engineer	• Prior to construction and during final design	• The Authority will review and approve all geotechnical reports and implement subsequent measures as required based upon the results of these reports	• DSOD
Utility and Infrastructure Verification and/or Relocation	• Confirm utility/infrastructure locations through consultation with utility service providers, preconstruction field surveys, and services such as Underground Service Alert. • Determine exact location of underground utilities by safe and acceptable means, including use of hand and modern techniques as well as customary types of equipment. • Confirm the specific location of all high priority utilities (i.e., pipelines carrying petroleum products, oxygen, chlorine, toxic or flammable gases; natural gas in pipelines greater than 6 inches in diameter, or with normal operating measures, greater than 60 pounds per square inch gauge; and underground electric supply lines, conductors, or cables that have a potential to ground more than 300 volts that do not have effectively grounded sheaths) and such locations will be highlighted on all construction drawings • Identified size, color, and location of existing utilities will be included on all construction drawings and/or in health and safety officer materials	• Authority • Contractors • Construction Management Team; Contractor Monitor • Health and Safety Officer	• Identify all utilities/ infrastructure prior to start of construction activities associated with any and all facilities • During construction the construction contractors will implement measures to avoid utilities/ infrastructure that	• Contractor will consult with utility service providers and cross check preconstruction field surveys to confirm exact location of underground utilities/infrastructure • The Authority or construction contractor monitor will perform regular site inspections to verify contractor compliance and retain inspection records in the project file maintained by the Authority • Contractor-designated health and safety officer will provide written confirmation to the Authority that the utility lines/infrastructure have been adequately	• None

Commented [WN2]: *Integration/HR/HC – can you confirm? I think they might require this right? or you are preparing these reports to design to DSOD requirements?*

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
	• Stage utility line modifications and relocations in a manner that minimizes interruption of service • In places where utility lines would be relocated, existing corridors will be utilized to the greatest extent possible, in the following order of priority: (1) existing utility corridors; (2) highway and railroad corridors; (3) recreation trails, with limitations; and (4) new corridors. • New poles or towers will be erected and cable-pulled prior to being connected to existing systems. Natural gas pipeline relocation will be constructed by one of several methods including cut-and-cover, trenching, or placement on at-grade saddles. Active natural gas wells in the proposed water conveyance facilities area will be abandoned to a depth below construction excavation. • Relocate utilities and infrastructure in a way that avoids or minimizes any effect on worker and public health and safety by protecting, supporting, or removing underground utilities as necessary to safeguard employees and notifying local fire departments if a gas utility is damaged causing a leak or suspected leak, or if damage to a utility results in a threat to public safety. • Coordinate and provide design plans and construction phasing with railroad; establish communication protocol with railroad and/or have railroad staff person onsite during construction of facilities adjacent to or affecting the railroad line.		are not being relocated • Prior to construction relocate utilities/infrastructure if needed	located, and excavation will not start until this confirmation has been received by the Authority • The Authority and Contractor will coordinate with all appropriate utility providers and local agencies to determine which utility lines will be relocated and the location of the relocated utility lines • Construction contractors will monitor the construction site(s) daily to ensure no damage occurs to utilities and if a utility is damaged which causes a threat to worker and public health and safety, construction contractors will notify the Authority and the local fire departments immediately and document the damage for the project file to be maintained by the Authority.	
Natural Gas Well Decommissioning	• Follow California Department of Conservation, Division of Oil, Gas and Geothermal Resources (CalGEM) Guidelines, Statutes and Regulations (California Code of Regulations, April 2019), which include: Prior to plugging and abandoning any oil and gas well or any other well under CalGEM's jurisdiction, operators must submit a Notice of Intention (NOI) to CalGEM. CalGEM will provide plugging requirements to minimize the potential for subsurface contamination and hazardous surface conditions. Comply with applicable plugging guidelines (i.e., Coiled Tubing Plugging Guidelines, Bentonite Plugging Guidelines) (source: https://www.conservation.ca.gov/calgem/for_operators)	• Contractor	• Site preparation as part of clearing and grubbing	• Permit and procedures per regulatory agency.	• California Department of Conservation, Division of Oil, Gas and Geothermal Resources.
Water Wells Decommissioning	• Decommissioning of water wells shall consist of the complete filling of the well in accordance with applicable requirements set out by the County that contains the well. • Prior to decommissioning of a water well, investigations will be conducted to determine its condition, details of construction, and whether there are obstructions that will interfere with the process of filling and sealing. • Wells situated in unconsolidated material in an unconfirmed groundwater zone shall have the upper 20 feet of the well sealed with suitable sealing material and the remainder shall be filled with suitable fill or sealing material. • Fill material or sealing material placement will follow appropriate procedures as required by the applicable County.	• Contractor	• Site preparation as part of clearing and grubbing	• Authority to maintain files on the location condition and fill process for each well filled.	• Counties
Road abandonment	• *HR: insert standard abandonment proceedures*	• Contractor	• Site preparation as part of clearing and grubbing	• Insert	• None

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
Environmental Site Assessment	• Environmental site assessment procedures (due diligence) for future development on or near any potentially hazardous or contaminated sites. A Phase I environmental site assessment would be conducted as appropriate for property considered for purchase, transfer, retirement, or sale in fee or easement for the Project. • Preconstruction Surveys. The evaluation would assess the potential for hazardous substance contamination in accordance with all applicable federal, state, and local statutes and regulations. • Conduct soil and groundwater testing at known or suspected contaminated areas within the construction footprint and remediate and/or contain contamination. • Subsequent actions, such as Phase II environmental site assessment and Phase III environmental site assessment, would be taken as necessary and appropriate. • A Phase II environmental site assessment would involve sample collection and analysis to identify and characterize contamination as needed. • A Phase III environmental site assessment would provide a plan for design and implementation of mitigation or remediation (including, but not limited to, removal of underground storage tanks, drums, buried waste, or other items potentially associated with contamination) and would identify the proper storage, handling, transport, and disposal of designated and hazardous waste if so required. • Perform pre-demolition surveys for structures to be demolished within the construction footprint, characterize hazardous materials (including asbestos-containing material and lead-based paint), and dispose of them in accordance with applicable regulations.	• Authority • Hazardous waste contractors, as needed	• Prior to and during construction	• The Authority will establish procedures to ensure that concentrations of hazardous constituents, if present, have been identified and treated or removed as appropriate for their concentration and in compliance with applicable state and federal laws and regulations. • An Authority-appointed qualified monitor will monitor the preconstruction and pre-demolition investigations to ensure surveys and characterization and disposal of hazardous materials are conducted according to the established procedure. • The Authority will be responsible for the proper disposal and handling of hazardous materials. • The Authority will be responsible for coordination of monitoring data from the qualified monitor to determine areas which contain hazardous materials. If hazardous materials are encountered, the Authority will determine whether the area can be avoided, soil and/or groundwater removed from the contaminated area can be remediated and contained in compliance with applicable state and federal laws and regulations, or if consultation with the regional DTSC office is required. • The qualified monitor will be responsible for reporting monitoring data from the preconstruction surveys to the Authority. • In the event that a hazardous materials area cannot be avoided or removed and remediated and contained, the Authority will initiate consultation with the regional DTSC office to establish which permit and subsequent action will be required. • Site-specific asbestos abatement work would meet the requirements of both the federal Clean Air Act and California Division of Occupational Safety and Health (Cal-OSHA) (CCR Title 8, Subchapter 4, Article 4, Section 1529).	• State Water Resources Control Board (State Water Board) • Department of Toxic Substances Control (DTSC) • Air Quality Management Districts (AQMDs)

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
				• The applicable AQMD(s) will be notified 10 days prior to initiation of demolition activities of asbestos-containing materials.	
Onsite Wastewater Disposal Systems	• Soil testing at locations of habitable structures would occur as part of final design. • Final design of these structures would use an alternative wastewater disposal system, such as a mound system or pressure dose system, if needed, to overcome potential limiting soil and groundwater conditions at Funks Reservoir.	• Authority	• Prior to construction and during final design	• None	• County
Salvage, stockpile, and replace topsoil and prepare a topsoil storage and handling plan	• Depending on the thickness of the topsoil at a given construction site, topsoil may be salvaged from construction work areas, stockpiled, and then applied over the surface of spoil and borrow areas to the maximum extent practicable. Exceptions to this measure are the Sites Reservoir inundation area; the inundation area of the TRR; areas smaller than 0.1 acre; areas of nonnative soil material where the top layer of soil does not consist of native topsoil; where the soil would be detrimental to plant growth; and any other areas identified by the soil scientist in evaluating topsoil characteristics. • The detailed design of the proposed project-related construction activities will incorporate an evaluation, based on review of soil survey maps supplemented by field investigations and prepared by a qualified soil scientist that specifies the thickness of the topsoil that should be salvaged, and that identifies areas in which no topsoil should be salvaged. The soil scientist will use the exceptions listed above as the basis for identifying areas in which no topsoil should be salvaged. • A qualified soil scientist will also prepare topsoil stockpiling and handling plans for the individual project components, establishing such guidelines as the maximum allowable thickness of soil stockpiles, temporary stockpile stabilization/revegetation measures, and procedures for topsoil handling during salvaging and reapplication. • The plans will also specify that, where practicable, the topsoil be salvaged, transported, and applied to its destination area in one operation (i.e., without stockpiling) to minimize degradation of soil structure and the increase in bulk density as a result of excessive handling. • The stockpiling and handling plans will also specify maximum allowable stockpile sideslope gradients, seed mixes to control wind and water erosion, cover crop seed mixes to maintain soil organic matter and nutrient levels, and all other measures to avoid soil degradation and soil erosional losses caused by excavating, stockpiling, and transporting topsoil. • For staging areas and similar areas in which topsoil would not be excavated or overcovered, the stockpiling and handling plans will describe how the soil will be decompacted or otherwise remediated after demobilization.	• Authority • Contractors • Soil monitor	• Development of topsoil storage and handling plans will be completed before construction begins. • Salvaging, stockpiling, and reapplying of topsoil will occur throughput construction.	• The Authority will ensure that each plan is prepared by a qualified individual, that it adequately addresses all relevant activities and facilities, and that its specifications are properly executed during construction by the contractors. • The qualified soil scientist will monitor excavation sites daily to determine the correct amount of topsoil to be removed. Additionally, they will monitor stockpile health and oversee reapplication and revegetation. • Construction contractors will perform the salvaging, stockpiling, and replacing of topsoil during construction. • The Authority will perform regular site inspections to verify contractor compliance with topsoil storage and handling plans. • The Authority will incorporate reporting requirements into the topsoil storage and handling plans to be adhered to by the construction contractor. The qualified soil scientist will report results of excavation site and stockpile health monitoring to the Authority and report construction contractor adherence to storage and handling plans in a report delivered to Authority technical staff for analysis.	• None
Dredged Material Management	• Prior to dredging, a chemical evaluation of Funks Reservoir water and sediment will be conducted to determine contaminant concentrations. This will help evaluate the suitability of dredged material for beneficial use and determine compliance with water quality standards. • Based on the chemical characterization of Funks Reservoir sediment and water, onsite water treatment for contaminant removal may be required in the dredged material containment/dewatering areas. The type of treatment required would be specific to the characteristics of the dredged material and dredged material effluent	• Authority • Contractors	• Before, during and following dredging of Funks Reservoir	• The Authority will incorporate monitoring/management requirements for operating the upland confined disposal areas. • Effluent monitoring may be specified as a requirement under the Section 401 water quality certification.	• U.S. Army Corps of Engineers (USACE) Sacramento District • State Water Resources Control Board • Regional Water Quality Control Board

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
	• Following characterization of Funks Reservoir sediment and water quality, site investigations will be conducted to further inform the design and construction of the dredged material containment/dewatering areas (e.g., dike design) for containment of dredged material during dewatering and in storage areas, and evaluation of potential foundation settlement, groundwater levels, flow and direction, runoff patterns and adjacent drainage, will be considered in the investigations. • The following general best management practices (or equally effective measures) for dredged material containment/dewatering areas will be implemented to avoid adverse effects on water quality through the discharge of dredged material or dredged material effluent to surface waters or surface water drainage courses: ○ In siting the containment/dewatering facilities, sufficient surface area and dike/berm height with freeboard will be made available for retention of fine-grained material to maintain effluent water quality. The facilities will be designed with adequate volume to contain the total volume of sediment to be dredged, ○ Wet dredged material within the containment/dewatering areas will not exceed the elevation of the berms, dikes or similar containment feature of the dewatering area. ○ If dewatering basins are used, a containment berm will be placed around the basin to prevent runoff of dredged material. A silt fence will be installed around the perimeter of the berm to further contain any runoff. ○ Dredged material containment/dewatering areas will be returned to their pre-existing condition. ○ If dredged material effluent from dewatering or sedimentation basins is discharged back into Funks Reservoir, the effluent discharge will be monitored and analyzed for water quality constituents including, but not limited to, suspended solids, turbidity, dissolved oxygen, and temperature pursuant to 401 Water Quality Certification or Waste Discharge Requirements. • Dredged material will be screened prior to dewatering to remove debris and trash, which will be disposed of at an appropriate solid waste disposal facility. • Dredged material not suitable for reuse will be disposed of at a permitted land fill site.				
Develop and Implement Stormwater Pollution Prevention Plan(s) (SWPPP) and gain coverage under Stormwater Construction General Permit (storm water and non-storm water)	• For work areas that will be inundated or otherwise temporarily or permanently isolated from receiving waters, prepare and implement SWPPP(s) per State Water Board Stormwater Construction General Permit, which will include erosion control measures, sediment control measures, post-construction erosion control measures, waste management measures, and non-stormwater management measures as described below. • **Erosion Control Measures** (e.g., silt fencing, weed-free straw bale barriers, fiber rolls, storm drain inlet protection, hydraulic mulch, and stabilized construction entrances) No disturbed surfaces would be left without erosion control measures in place during the winter and spring months. Keep emergency erosion-control supplies onsite at all times during construction and have the contractor(s) use these emergency stockpiles as needed.	• Authority • Contractors	• Prior to any ground-disturbing activity • Before and during construction • Minimum of 5 years following completion of construction (for postconstruction stormwater management measures)	• The Authority and Contractors will prepare SWPPP(s) • During construction, Contractors will be responsible for implementation of the SWPPP(s). • Contractors will report to the Authority any deficiencies in compliance with the SWPPP(s) as well as any warnings or violations of the Construction General Permit received from the SWRCB. The Authority will evaluate these events as needed on a site-by-site basis to require the contractor to amend SWPPP(s) as	• State Water Board • Regional Water Quality Control Board (RWQCB)

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
	Divert runoff away from steep, denuded slopes, or other critical areas with barriers, berms, ditches, or other facilities. To the extent feasible, retain native trees and vegetation to help stabilize hillsides, retain moisture, and reduce erosion. Plastic monofilament netting or similar material will not be used for erosion control. Acceptable substitutes include coconut coir matting or tackified hydroseeding compounds. This limitation will be communicated to the contractor through specifications or special provisions included in the construction bid solicitation package.			needed to reduce the severity of and/or avoid the potentially significant impacts on the environment.	
	• **Sediment Control Measures** Sediment would be retained onsite by a system of sediment basins, traps, or other appropriate measures. Reduce runoff velocity on exposed slopes. Collect and direct surface run on and runoff at non-erosive velocities to controlled drainage courses. When ground disturbing activities are required adjacent to surface water, wetlands, or aquatic habitat, the use of sediment and turbidity barriers, soil stabilization and revegetation of disturbed surfaces. Reduce off-site sediment tracking by installing gravel on primary construction ingress/egress points, rumble plates, and/or truck tire washing. Deposit or store excavated soil materials and tunnel muck away from drainage courses and protect from erosion by constructing berms along the downslope perimeter if rain events are forecast within 48 hours. • **Management Measures for Construction Materials** Protect stockpiled construction materials that are not scheduled to be re-disturbed for at least 14 days or in advance of forecasted rain events by constructing berms along the downslope perimeter or by covering the stockpile. Store chemicals in watertight containers. Minimize exposure of construction materials to stormwater. Designate refueling and equipment inspection/maintenance locations per SPCCP (i.e., located 150 feet from surface waters and sensitive habitats such as wetlands). • **Waste Management Measures** Prevent off-site disposal or runoff of any rinse or wash waters. Implement concrete and truck washout facilities and appropriately sized storage, treatment, and disposal practices. Ensure the containment of sanitation facilities (e.g., portable toilets). Clean or replace sanitation facilities (as necessary) and inspect regularly for leaks/spills. Cover waste disposal containers during rain events and at end of every day. • **Non-Stormwater Management Measures** Control all non-stormwater discharges during construction. Wash vehicles in such a manner as to prevent non-stormwater discharges to surface waters. Clean streets in such a manner as to prevent non-stormwater discharges from reaching surface water. Discontinue the application of any erodible landscape material during rain, or within 2 days before a forecasted rain event.				

Commented [CC3]: Materials used for erosion and silt control such as fencing, coir logs, coir rolls, etc., should be monitored to ensure they do not pass downstream, and the materials composing the barriers should not pose an entanglement risk to fish or wildlife. Plastic monofilament or cross joints in the netting that are bound/stitched (such as found in straw wattles/fiber rolls and some erosion control blankets), which may cause entrapment of wildlife, should not be used.

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Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
	• **Post-construction Storm Water Management Measures** The Stormwater Construction General Permit requires that the SWPPP specify post-construction storm water management measures and runoff reduction measures that provide for a post-project time of runoff concentration that is equal or greater than pre-project time of concentration. The post-construction storm water management measures must specify that BMPs be implemented to reduce pollutants in storm water discharges that are reasonably foreseeable after all construction phases have been completed at the site. A long-term maintenance plan for the post-construction storm water management measures must be described in the SWPPP and implemented for a minimum of 5 years following completion of construction. The plan must describe the procedures to ensure that the post-construction storm water management measures are adequately maintained. During operations and maintenance, project facilities including, but not limited to, roads (including access roads), other paved and unpaved surfaces, structures, and equipment, will be properly maintained so as to avoid the potential for erosion and sediment/siltation into local waterbodies and in compliance with all applicable federal, state, and local regulations. Project operation and maintenance erosion and sediment control plans will be prepared and implemented as determined necessary, depending on the specific activity and potential for erosion or other impacts. • Drift and runoff from areas treated with herbicides, pesticides, and other chemicals that may be harmful to aquatic habitats will be controlled. • Sediment control measures will include retaining sediment onsite by a system of sediment basins, traps, or other appropriate measures; reducing runoff velocity on exposed slopes; and collecting and directing surface run-on and runoff at non-erosive velocities to controlled drainage courses. • Post-construction erosion control measures will be implemented (such as silt fencing, fiber rolls, hydraulic mulch/seeding, and vegetative plantings) and monitored to minimize effects on water quality. • Revegetation treatments will be integrated into grading plans to create favorable planting environments that will aid plant establishment and natural regeneration. To the extent feasible and practicable, local native plants that require little or no maintenance and do not create an extreme fire hazard will be used.				
Develop and Implement Spill Prevention and Hazardous Materials Management / Accidental Spill Prevention, Containment, and Countermeasure Plans (SPCCPs) and Response Measures.	• As part of the SWPPP, SPCCPs will be developed and implemented to minimize effects from spills of hazardous or petroleum substances during construction and operation/maintenance. • Multiple SPCCPs may be prepared for project construction activities, each taking into account site-specific conditions. • Spill prevention kits will always be in proximity when hazardous materials would be used (e.g., crew trucks and other logical locations). • Measures to ensure that hazardous materials will be properly handled by all reasonable means will be implemented when working in or near any waterway. • For all fueling of stationary equipment at the construction sites, containments will be provided to the degree that any spill would not enter the channel or damage wetland or riparian vegetation.	• Authority • Contractors	• Before, during, and throughout construction	• The Authority will monitor the development and implementation of the SPCCPs to minimize effects from spills of oil or oil-containing products during project construction and operation. • Colusa, Glenn, and Yolo Counties (reporting of unforeseen hazardous conditions) • As part of each SPCCP, an inspection program which includes regularly scheduled inspections, evaluations, and testing by qualified personnel will be	• RWQCB • Cal-OSHA

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
	• Refueling of construction equipment will occur only in designated areas that will be a minimum of 150 feet from surface waters and other sensitive habitats, such as wetlands. • Equipment used in direct contact with water will be inspected daily for oil, grease, and other petroleum products prior to use. All equipment will be cleaned of external petroleum products prior to beginning work where contact with water may occur in order to prevent the release of such products to surface waters. • Equipment will not be serviced within the ordinary high-water mark or immediate floodplain of existing waterways (e.g., Funks Creek, Stone Corral Creek), unless the equipment stationed in these locations could not be readily relocated (e.g., pumps and generators). • Store hazardous materials in double containment. • Dispose of all hazardous and nonhazardous products following instructions and Material Safety Data Sheets and if needed, placed in nonleaking sealed containers until transport to an appropriate disposal facility. • Monitor onsite vehicles for fluid leaks and regular maintenance to reduce the chance of leakage. • Provide containment (a prefabricated temporary containment mat, a temporary earthen berm, or other measure can provide containment) of bulk storage tanks having a capacity of more than 55 gallons. • The contractor will conduct sampling of runoff effluent when a leak, spill, or other discharge of non-visible pollutants is detected. • Provide equipment and materials necessary for cleanup of accidental spills onsite. • Clean up accidental spills and leaks immediately and dispose of properly. • All necessary personnel will be trained in emergency response and spill containment techniques and will also be made aware of the pollution control laws, rules, and regulations applicable to their work. • Petroleum products will be stored in nonleaking containers at impervious storage sites from which an accidental spill cannot escape. • Absorbent pads, pillows, socks, booms, and other spill containment materials will be stored and maintained at the hazardous materials storage sites for use in the event of an accidental spill. • Contaminated absorbent pads, pillows, socks, booms, and other spill containment materials will be placed in nonleaking sealed containers until transport to an appropriate disposal facility. • When transferring oil or other hazardous materials from trucks to storage containers, absorbent pads, pillows, socks, booms or other spill containment material will be placed under the transfer area. • Oil-absorbent booms will be used when equipment is used in or immediately adjacent to waters. • All reserve fuel supplies will be stored only within the confines of a designated staging area, to be located a minimum of 150 feet from surface waters and other sensitive habitats, such as wetlands. • Fuel transfers will take place a minimum of 150 feet from surface waters and other sensitive habitats, such as wetlands, and absorbent pads will be placed under the fuel transfer operation.			developed in accordance with USEPA's SPCC Guidance for Regional Inspectors. • The Authority will review and approve all SPCCPs to ensure the above measures and practices are included and the SPCCPs are prepared in accordance with 40 CFR Part 112. • During construction, the contractors will be responsible implementation of the SPCCP as well as conducting inspections, evaluation, and testing required in each site-specific SPCCP. • The inspection program personnel will report to the Authority any deficiencies in compliance with the SPCCP as well as any spills of gasoline, diesel fuel, oil, or other related substance. The Authority will evaluate these events as needed on a site-by-site basis to amend SPCCPs as needed to reduce the severity of and/or avoid the potentially significant impacts on the public and environment.	

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
	• Staging areas will be designed to contain contaminants such as oil, grease, fuel, and other petroleum products so that should an accidental spill occur, contaminants do not drain toward receiving waters or storm drain inlets. • All stationary equipment will be staged in appropriate staging areas and positioned over drip pans. • In the event of an accidental spill, personnel will identify and secure the source of the discharge and contain the discharge with sorbents, sandbags, or other material from spill kits and will contact appropriate regulatory authorities (e.g., National Response Center will be contacted if the spill threatens navigable waters of the United States or adjoining shorelines, as well as other appropriate response personnel).				
Comply with Requirements of RWQCB Order 5-00-175	• Groundwater pumped as part of construction-related dewatering will be contained onsite during construction within bermed areas adjacent to construction areas to avoid impacts to surface waters. • As necessary, the Authority will ensure that the water is pumped into Baker tanks or approved equivalent with either a filter or gel coagulant system or other containment to remove sediment as required. • Remaining water will be discharged to a designated receiving water body or via land application, in accordance with the requirements of RWQCB Order No. 5-00-175. • BMPs, as described in the SWPPP, will also be implemented to retain, treat, and dispose of groundwater. Measures will include, but are not limited to: Directly conveying pumped groundwater to a suitable land disposal area capable of percolating flows Retaining pumped groundwater in surface facilities to reduce turbidity and suspended sediment concentrations If contamination is suspected, testing water collected during dewatering for contamination prior to disposal Treating (i.e., flocculating) pumped groundwater to reduce turbidity and concentrations of suspended sediments if turbidity exceeds RWQCB effluent limitations as defined in General Order 5-00-175.	• Authority • Contractors	• Before and during construction	• None	• State Water Board • RWQCB
Groundwater/ Dewatering Water Supply	• An alternate water supply will be provided to the landowner during the construction dewatering period if adjacent existing well uses experience temporary, localized impacts to groundwater availability due to construction dewatering activities.	• Authority	• During construction	• None	• County
Drainage Evaluations, Design and Implementation	• During final project design, project engineers will coordinate with owners and operators of local drainage systems and landowners served by the systems to evaluate pre- and post-project drainage needs and design features to ensure local drainage infrastructure (e.g., ditches, pipes, culverts, wells, etc.). would not be disrupted, and to remediate any project-related alteration in runoff patterns that would increase the potential for localized erosion and sedimentation. • If disruption of a local drainage system and/or substantial alteration of runoff patterns could result from a project feature, a drainage evaluation will be prepared as part of final project design. The drainage evaluation will consider the design flows of any existing facilities that would be crossed by project features and develop appropriate plans for relocation or other modification of these facilities and construction of new	• Authority	• Before construction	• None	• Regional Water Quality Control Board (RWQCB)

Commented [WN4]: Integration: per comment in public services we should discuss this BMP so that we can be more specific about what it is actually covering and how it's being monitored (e.g., is groundwater elevations at wells going to be monitored during construction?)

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
	facilities, as needed, to ensure equivalent functioning of the system during and after construction. • If no drainage facilities would be affected, but project features would have a substantial adverse effect on runoff amounts and/or patterns, new drainage systems will be included in the design of project alternatives to ensure that the project would not result in new erosion and sedimentation. Any necessary features to remediate project-induced drainage problems will be installed before the project is completed or as part of the project, depending on site-specific conditions. • This applies to above ground facilities that would ultimately result in impervious surfaces, including, Funks and TRR PGPs, the administration building, the maintenance building, TRR and its PGP, the Dunnigan pipeline and its Sacramento River Discharge site, all roads (including the South Road) and impervious areas that might result due to Recreation area construction.				
Develop and Implement Construction Equipment, Truck, and Traffic Management Plan (TMP)	• Identify specific haul and access routes, as described in the alternatives description, with all contractors when multiple facility sites are under construction concurrently, so that Project-generated construction traffic is dispersed to the extent practicable and necessary. • Prohibit construction traffic in the community of Maxwell. • Install traffic control devices, as specified in Caltrans' Manual of Traffic Controls for Construction and Maintenance Work Zones, where needed to maintain safe driving conditions, including use of signage to alert motorists and bicyclists of construction activities, potential hazards, and travel detours, and use flaggers when appropriate. • During operations and maintenance, truck and other maintenance equipment will be maintained in good working condition and will be used in accordance with all applicable federal, state, and local regulations. • The Authority will develop the TMPs in coordination with the applicable jurisdictions, including local agencies for local roads, transit providers, and rail operators where applicable. • The Authority will modify TMPs as needed during and after construction. • Provide construction notification procedures for Glenn, Colusa, Yolo, and Tehama Counties' police, public works, fire departments, and other public service providers, and cycling organizations, bike shops, and schools. • Inform contractors and subcontractors of work hours, modes and locations of transportation, and parking for construction workers. • Describe the procedures for construction area evacuation in the case of an emergency declared by county or other local authorities. • Identification of emergency routes available and open for county and other public emergency personnel. • Designate areas where nighttime construction will occur. • Posted information for contact in case of emergency or complaint. • Other actions to be identified and developed as may be needed by the construction manager/resident engineer to ensure that temporary impacts on transportation facilities are minimized.	• Authority • Construction Management Team; Contractor construction monitor(s)	• Prior to, during, after construction	• The Authority will appoint a construction monitor to perform site inspections to verify contractor compliance with the TMP. • Contractor should ensure that all TMP requirements are addressed; contractor will ensure that inspectors monitor traffic conditions while work is being performed to avoid impacts in excess of what was identified in the TMP.	• Counties
Visual/Aesthetic Design, Construction,	• Use native trees and shrubs for screening at the project facilities that may substantially degrade the existing visual character of the site(s) in a manner that does not	• Authority • Contractors	• Before, during, and after construction	• Include in construction plans for review and approval by the Authority	• None

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and Operation Practices	compromise facility access or safety and does not conflict with existing safety requirements of agencies (e.g., DSOD). • Incorporate high-quality site design that does not detract from the rural nature of the surroundings. New structures will be painted in a shade that is visually cohesive with the general surrounding area. Color selection will be made for the coloring of the most prevalent season. If the color selection is between two or three colors, one of the darker shades be selected. This is because choosing a darker shade will allow the surface to recede and blend within the visual landscape, whereas lighter colors advance, or are more apparent, within the visual landscape. Choosing a darker color will also reduce the potential for glare. Therefore, coloring will be slightly darker unless aesthetic design treatments indicate another color selection is appropriate with the intent to specifically improve aesthetics. Paints will be of a dull, flat, or satin finish only. Appropriate paint type will be selected for the finished structures to ensure long-term durability of the painted surfaces. • If any concrete entrance signs, barriers, or landscape accents are to be located along public roadway, then such features will receive aesthetic treatments to ensure they enhance views associated with the Project. Aesthetic treatments may include mimicking natural material (e.g., stone or rock surfacing) and using integral color to reduce visibility, improve aesthetics, and to ensure that features blend with the landscape rather than creating a utilitarian-looking concrete element. • All required lighting during construction will be directional to minimize glare impacts to humans and wildlife. • All artificial outdoor lighting associated with project alternatives will be limited to safety and security requirements, designed using Illuminating Engineering Society's design guidelines and in compliance with International Dark-Sky Association approved fixtures. Light emitting diode (LED) lighting will avoid the use of blue-rich white light lamps and use a correlated color temperature that is no higher than 3,000 Kelvin. Wherever possible and pragmatic, the lighting designer will select fixtures and lighting control systems that conform to International Dark-Sky Association's Fixture Seal of Approval program. In addition, LED lights will use shielding to prevent nuisance glare and ensure that light spill does not affect sensitive residential viewers. Lights along perimeter roadways and pathways, as well as safety lighting at building entrances and loading areas, will employ shielding to minimize off-site light spill and glare and be screened and directed away from residences and adjacent uses to the highest degree possible. The use of nighttime lights along perimeter roadways and pathways will be minimized to the highest degree possible to ensure that spaces are not unnecessarily over lit, while still maintaining minimum adequate lighting to provide necessary visibility for security. For example, the amount of artificial light can be reduced by limiting the number of light posts in higher-use areas and by using hooded wall mounts on pathways that receive primarily pedestrian traffic. Technologies to reduce light pollution evolve over time and design measures that are currently available may help but may not be the most effective means of controlling light pollution once the proposed project is finalized. Therefore, all design measures used to reduce light pollution will employ the technologies available at the time of project design to allow for the highest potential reduction in light pollution.				

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
Fire Safety and Suppression / Develop and Implement a Fire Prevention and Control Plan	• Prepare a fire safety plan for Glenn, Colusa, and Yolo County review. This plan would include precautions to carry out during high-fire danger, a list of fire-suppression equipment and tools to have on hand, a description of available communications; procedures and policies for controlling any fires that are on the work site, and other related fire prevention and control procedures, specifications for the supply of water to have on hand, and descriptions of other actions that would reduce the risk of ignition and facilitate immediate control of an accidental fire. • Maintain fire-suppression equipment (e.g., fire extinguishers, fire blankets) at work locations. • If a fire should start, the appropriate fire protection agencies responsible will be contacted immediately. • Maintain a list of all major potential fire hazards, proper handling and storage procedures for hazardous materials, potential ignition sources and their control, and the type of fire protection equipment necessary to control each potential major hazard. • Smoking will be allowed only in areas designated for smoking. • Gasoline-powered construction equipment with catalytic converters will be equipped with shielding or other acceptable fire prevention features. Internal combustion engines will be equipped with spark arrestors. • Welding sites will include fire prevention provisions. • The contractor will maintain contact with local firefighting agencies throughout the fire season for updates on fire conditions, and such fire conditions will be communicated daily to the on-site employees of the contractor and subcontractors daily.	• Authority • Fire suppression agencies • Contractors	• Prior to and during construction	• Authority (monitoring) • Fire protection agencies (report to them in the event of a fire) • Contractors (report fire incidents to the Authority)	• State Fire Marshal • Local fire suppression agencies (Counties)
Worker Health and Safety	• The Authority and Contractors will follow all required federal, state, and local occupational health and safety laws on the construction site(s) at all times.	• Authority • Construction Contractors	• During construction	• Construction monitors for each site will monitor construction operations to ensure the California Occupational Safety and Health Act of 1973, as administered by Cal-OSHA, will be followed as a minimum standard to protect workers. • The construction monitors will report any deficiency in compliance by the construction contractor with the California Occupational Safety and Health Act of 1973 to the Authority immediately.	• Cal-OSHA
Worker Health and Safety Plan Blasting	Comply with all federal, state and local requirements for blasting, including handling, transport, and storage of explosive blasting materials. These include, but may not be limited to the following • A county explosive permit • California Highway Patrol (CHP) Hazardous Materials Transport License • County Sheriff or Police or fire department for site specific permits • U.S. Department of Transportation and California Department of Motor Vehicles (CA DMV) Motor Carry Permit • State of California Department of Justice Bureau of Firearms Licenses for each blaster • A Blast Plan will be prepared for every blast performed at the quarries; this plan will include: • Appropriate handling of blasting materials	• Contractor(s)	• Prior to construction • Implemented during construction	• Authority (Monitoring) • Contractors	• Bureau of Alcohol Tobacco, Firearms and Explosives • Counties • CA DMV • CHP • Cal-OSHA

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
	• Appropriate timing for clearing the quarry • Redundant communications • Distances for safely distancing from the blast location				
Mosquito and Vector Control During Construction	• Coordinate with Glenn County Mosquito and Vector Control District (MVCD) and the Colusa County Environmental Health Department (including the Colusa County Mosquito Abatement District) and Yolo County (Sacramento-Yolo Mosquito and Vector Control) related to implementation of standard local, state, and federal vector control requirements during construction of all facilities. Best management practices during construction include: Utilize water sources with mosquito predators for flooding Drain irrigation water into ditches or other water bodies with abundant mosquito predators Implement monitoring and sampling programs to detect early signs of mosquito population problems Use biological agents such as mosquito fish to limit larval mosquito populations Use larvicides and adulticides, as necessary. If larvicides and adulticides are required, the project proponent will evaluate the effects of the chemicals and, if required, prepare a monitoring program for review by fish and wildlife agencies to evaluate effects, if any, application would have on macroinvertebrate and associated covered fish species	• Authority • Contractors • Mosquito and Vector Control Districts	• Before and during construction	• Contractors (during construction) – Actions TBD	• Colusa County Environmental Health Department (including the Colusa County Mosquito Abatement District) • Glenn County MVCD • Yolo County (Sacramento-Yolo Mosquito and Vector Control)
Construction Noise	• Develop and implement a site-specific noise abatement plan to avoid or reduce construction-related noise impacts. This plan would incorporate the following types of measures: Employ noise-reducing construction practices during construction. Prior to construction, initiate a complaint/response tracking program. Prohibit gasoline or diesel engines from having unmuffled exhaust. Require that all construction equipment powered by gasoline or diesel engines have sound-control devices that are at least as effective as those originally provided by the manufacturer and that all equipment be operated and maintained to minimize noise generation. Prevent excessive noise by shutting down idle vehicles or equipment. Use noise-reducing enclosures around noise-generating equipment. Select haul routes that affect the fewest number of people and implement the TMP, which avoids the community of Maxwell. Construct barriers between noise sources and noise-sensitive land uses or take advantage of existing barrier features (e.g., terrain, structures) to block sound transmission to noise-sensitive land uses. The barriers shall be designed to obstruct the line of sight between the noise-sensitive land use and on-site construction equipment. Nighttime construction associated with reservoir facilities (e.g., Golden Gate Dam, Sites Dam, Saddle Dams, Saddle Dikes, Inlet/Outlet Works) would not be conducted between 10:00 p.m. and 7:00 a.m. within 1,000 feet of occupied residences. Construction activities are anticipated to occur between 7:00 a.m. and 7:00 p.m. Nighttime and weekend construction may occur on an as-needed basis and would be coordinated with residents. Limit impact pile driving to daytime hours (7:00 a.m. to 7:00 p.m.).	• Authority • Contractors	• During construction • During operations	• In the event of complaints by affected residents due to on-site construction noise generated during nighttime hours, the contractor will monitor noise levels intermittently (between 10:00 p.m. and 7:00 a.m.) at the dwelling unit of the person lodging the complaint. If measured construction noise during nighttime hours exceeds 45 dBA interior L_{max} or 5 dB above ambient noise, whichever is greater, at the dwelling unit, the construction contractor will implement additional sound-attenuating mitigation measures where feasible, such as limitations on the use of noise-generating equipment, or installation of additional temporary barriers or enclosures. Where the above-described strategies are ineffective in reducing noise to the identified levels or where it is infeasible to do so, the affected residents may be offered short-term relocation assistance for the duration of the time that nighttime noise levels are expected to exceed the specified levels. Exceptions to this commitment can be made for legally mandated warning	• Counties

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
	Locate, store, and maintain portable and stationary equipment as far as feasible from nearby residents to ensure that such residents are not exposed to on-site construction noise at unacceptable levels. Blasting at excavation sites will be conducted at a distance of at least 1,000 feet from the nearest noise-sensitive land use.			devices, such as back-up alarms and warning horns.	
	• Develop and implement an underwater sound control, abatement, and monitoring plan to avoid and minimize the effects of underwater construction noise on fish, particularly underwater noise effects associated with impact pile driving activities in the Sacramento River for Alternative 2. The plan would incorporate the following types of measures: ○ Restrict in-water work and bank work within 200 feet of the shoreline to the in-water work windows specified in construction BMPs. ○ Employ underwater noise-reducing methods using the best available and practicable technologies, such as use of vibratory rather than impact pile driving equipment when appropriate; using an impact pile driver to proof piles initially placed with a vibratory pile driver; employing noise attenuation using bubble curtains, air-filled fabric barriers, or isolation piles. Specific techniques to be used will be based on site-specific conditions. ○ Restricting in-water and near-shore impact pile driving to daytime hours (7:00 a.m. to 7:00 p.m.) to provide fish with a 12-hour quiet period between impact pile driving events. ○ Monitoring underwater noise levels during all pile-driving activities on land (within 200 of shore) and in water to ensure that peak and cumulative sound exposure levels do not exceed estimated values. ○ Monitoring the in-water work area for fish that may be showing signs of distress or injury as a result of pile driving activities and stopping work when distressed or injured fish are observed.	• Authority • Contractors	• During construction	• Daily summaries of the hydroacoustic monitoring results. • Daily reporting of any occurrences of stressed, injured, or dead fish.	• CDFW • NMFS
Operation and Maintenance Noise	• Develop and implement a site-specific noise abatement plan to avoid or reduce potential maintenance-, and operation-related noise impacts. • Pump station buildings will be designed and constructed such that operation noise levels at nearby residential receptors do not exceed 50 L_{eq} during daytime hours (7:00 a.m. to 10:00 p.m.) and 45 dBA L_{eq} during nighttime hours (10:00 p.m. to 7:00 a.m.). Acoustical measures such as terrain shielding, pump enclosures, and acoustical building treatments will be incorporated into the facility design in order to meet this performance standard. • Prohibit gasoline or diesel engines from having unmuffled exhaust. • Prevent excessive noise by shutting down idle vehicles or equipment. • Use noise-reducing enclosures around noise-generating equipment.	• Authority • Contractors	• Prior to and during construction • Operations and maintenance	• None	• Counties
Construction Emergency Action Plan	• Develop and implement a construction emergency action plan, which would include emergency notification flowcharts, notification procedures, and a variety of other important emergency response protocols for different types of emergencies that could occur during the construction of facilities, including injuries to construction workers.	• Authority • Contractor(s)	• During construction	• None	• Counties • Cal-OSHA
Emergency Action Plan for Reservoir Operations	• An Emergency Action Plan for Reservoir Operations would be prepared pursuant to the California Office of Emergency Services and include: emergency notification flowcharts, notification procedures, inundation maps, and a variety of other important emergency	• Authority	• Prior to and during operations; reviewed annually	• These plans are typically reviewed annually and periodically tested through tabletop and functional exercises and drills	• California Office of Emergency Services • DSOD

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
	response protocols for notifying downstream entities if an emergency release was anticipated to occur				
Electrical Power Guidelines and EMF Field Management Plan	• The Authority will specify that design and construction of power facilities be in accordance with electric and magnetic field (EMF) guidance adopted by the California Public Utility Commission, EMF Design Guidelines for Electrical Facilities (2006). • Prepare a Field Management Plan that indicates the no-cost and low-cost EMF measures that will be installed as part of the final engineering design for the project. (Required under CPUC Decision No. D. 06-01-042 (January 26, 2006) and CPUC General Order 131-D, Section X(A) (June 8, 1994).	• Authority	• Prior to and during construction	• A Construction Monitor will regularly inspect construction activities to ensure design and construction of power facilities are in accordance with electric and magnetic field (EMF) guidance adopted by the California Public Utility Commission. • The Field Management Plan typically evaluates the no-cost and low-cost measures considered for the project, the measures adopted, and reasons that certain measures were not adopted, and will be prepared during detailed project design.	• CPUC • California Independent System Operators
Construction Equipment Exhaust Reduction Plan	• Prior to construction, the Authority will develop a construction equipment exhaust reduction plan to reduce criteria air pollutants from construction equipment. • Control technology that achieves equivalent or greater reductions than those identified below may be specified as new emissions reduction technologies become available and cost-effective. • Equipment used to construct project facilities achieve fleet-wide average criteria pollutant emissions rates for equipment greater than 50 horsepower that are equivalent to the use of Tier 4 final standards to the extent feasible. Contractors may utilize a combination of newer engines, aftermarket controls, and retrofits to achieve the fleet-wide average performance standard. Potential strategies for achieving this fleet-wide average may include the following: Electrification of equipment Use of diesel particulate filters on non-electrified equipment. Use of compressed natural gas (CNG). Use of Tier 4 engines. • The Authority will quantitatively demonstrate, through equipment-specific modeling, that fleet-wide average achieves criteria pollutant emissions rates for equipment greater than 50 horsepower that are equivalent to the use of Tier 4 final standards have been achieved by the selected equipment and aftermarket controls, to the extent feasible. Some larger and specialized equipment may not be available in compliance with Tier 4 final standards. In addition to Tier 4 final standards, the following best management practices will be incorporated into the reduction plan. • Minimize idling time either by shutting equipment off when not in use or limiting the time of idling to 3 minutes (5 minutes required by 13 CCR 2449[d][3], 2485). Provide clear signage that posts this requirement for workers at the entrances to the site. • Maintain all construction equipment in proper working condition according to manufacturer's specifications. The equipment must be checked by an ASE-certified	• Authority • Contractors • Project-Area air districts	• Prior to and during construction	• The Authority will submit the reduction plan to the appropriate air district for review prior to construction. • Ensure that emissions from all off-road diesel-powered equipment used on the project site do not exceed 40% opacity for more than 3 minutes in any 1 hour. Any equipment found to exceed 40% opacity (or Ringelmann [Based on the Ringelmann scale, which measures the density of smoke in the air]) will be repaired immediately. • Non-compliant equipment will be documented, and a summary provided annually to the Authority and air district with jurisdiction over the construction site. • A visual inspection of all in-operation equipment will be made at least weekly by the contractor and witnessed monthly or more frequently by the Authority and a periodic summary of the visual survey results will be submitted by the contractor throughout the duration of the proposed project, except that the summary will not be required for any 30-day period in which no construction activity occurs. The summary will include the quantity and type of vehicles inspected, as well as the dates of each survey.	• AQMDs /Air Pollution Control Districts (APCDs)

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
	mechanic and determined to be running in proper condition before it is placed in operation. • **Heavy-Duty Haul Trucks:** Prior to construction start for each major project feature, the Authority will ensure that all on-road heavy-duty diesel trucks shall be operated in compliance with the emission standards per CCR Title 13, Section 2025. To the extent feasible, operate on road trucks with engines certified to the 2010 model year or newer heavy-duty diesel engine emissions standards.			• The air districts or other officials may conduct periodic site inspections to determine compliance. Nothing in this measure will supersede other air district or state rules or regulations.	
Fugitive Dust Control Plans	The following measures are based on the Tehama County APCD fugitive PM10 mitigation measures from the 2015 Air Quality Planning and Permitting Handbook. • **Land Clearing/Earth Moving:** Water shall be applied by means of truck(s), hoses, and/or sprinklers as needed prior to any land clearing or earth movement to minimize dust emissions. Haul vehicles transporting soil into or out of the property shall be covered. A publicly visible sign shall be posted with the telephone number and person to contact regarding dust complaints. This person shall respond and take corrective action within 24 hours. The telephone number of the local air district shall also be included and visible on the sign. All excavation, grading, and/or earth moving activities shall be suspended when average wind speeds exceed 25 mph. • **Visibly Dry Disturbed Soil Surface Areas:** All visibly dry disturbed soil surface areas of operation shall be treated with a dust palliative agent and/or watered to minimize dust emissions. • **Paved Road Track out:** Existing roads and streets adjacent to the Project where there are Project construction vehicles actively entering from unpaved roads, shall be cleaned at least once per day unless conditions warrant a greater frequency. • **Visibly Dry Disturbed Unpaved Roads:** All visibly dry disturbed unpaved road surface areas of operation shall be watered to minimize dust emissions. Unpaved roads shall be graveled to reduce dust emissions, to the extent feasible. On-site vehicles shall be limited to a speed of 15-20 miles per hour on unpaved roads. Haul roads shall be sprayed down at the end of the work shift to form a thin crust. This application of water shall be in addition to the minimum rate of application. • **Vehicles Entering/Exiting Construction Area:** Vehicles entering or exiting the construction area shall travel at a speed which minimizes dust emissions. • **Employee Vehicles:** Construction workers shall park in designated parking areas(s) to help reduce dust emissions. • **Soil Piles:** Soil pile surfaces shall be moistened if dust is being emitted from the pile(s). Adequately secured tarps, plastic, or other material may be required to further reduce dust emissions. This includes materials stored in piles for use in the concrete batch plant.	• Authority • Contractor(s)	Prior to final design plans and bid documents. Prior to and during construction.	*Insert*	AQMDs /APCDs

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
Develop and Implement Hazardous Materials Management Plans	• The Authority will ensure that each project contractor will develop and implement a hazardous materials management plan (HMMP) before beginning construction. • It is anticipated that multiple HMMPs will be prepared for the overall project construction activities, each considering site-specific conditions such as hazardous materials present on site and known historic site contamination. • The HMMP will include, but not be limited to, the following measures or practices. Fuel, oil, and other petroleum products will be stored only at designated sites. Hazardous materials containment containers will be clearly labeled with the identity of the hazardous materials contained therein, handling and safety instructions, and emergency contact information. Storage, use, or transfer of hazardous materials in or near wet or dry streams will be consistent with the Fish and Game Code (Section 5650) and/or with the permission of California Department of Fish and Wildlife (CDFW). Material Safety Data Sheets (MSDS) will be made readily available to the contractor's employees and other personnel at the work site. The accumulation and temporary storage of hazardous wastes will not exceed 90 days. Soils contaminated by spills or cleaning wastes will be contained and removed to an approved disposal site by an appropriately certified hazardous waste disposal contractor. Hazardous waste generated at work sites, such as contaminated soil, will be segregated from other construction spoils and properly handled, hauled, and disposed of at an approved disposal facility by a licensed hazardous waste hauler in accordance with applicable law and regulations. The contractor will obtain permits required for such disposal. Emergency spill containment and cleanup kits will be located at the work site. The contents of the kit will be appropriate to the type and quantities of chemical or goods stored at the work site.	• Authority • Contractors • Construction Monitor	• Prior to and during construction • Post construction for substances used during operation and maintenance	• The construction contractors will provide all HMMPs to the Authority for review and approval prior to commencing construction activities. • Maintain a database on known historic instances of contamination and results of any field inspections regarding the presence of hazardous chemicals. • The contractor will obtain permits required for hazardous waste generated at work sites to be disposed of at an approved facility by a licensed hazardous waste hauler in accordance with applicable law and regulations. • The Authority will monitor contractor development of HMMPs by including this requirement in construction contracts. • The Authority will review all HMMPs developed by the construction contractor to ensure compliance with this environmental commitment and inclusion of the measures and practices listed above. • During construction, the Construction Monitor will monitor implementation of specific protocol for the proper handling and disposal of hazardous materials of the measures and practices included in each HMMP by the construction contractor. • The Construction Monitor will immediately report any deficiencies in compliance with the HMMP to the Authority. • The construction contractor will report any inability to comply with the HMMP and any spills of hazardous waste to the Authority immediately.	• City, county, state, and federal emergency response agencies. • Storage, use, or transfer of hazardous materials in or near wet or dry streams will be consistent with the Fish and Game Code (Section 5650) and/or with the permission of CDFW.
Provide Construction Site Security	• As appropriate, provide 24-hour onsite security either through technological means or personnel. • Monitor construction sites, including staging and equipment storage areas. • If, private patrol security operators are hired to provide site security personnel would have appropriate licenses from the California Bureau of Security and Investigative Services. Individual security personnel will have a minimum-security guard registration license that meets the California Bureau of Security and Investigative Services requirements for training and continuation training as required for that license.	• Contractor(s)	• Before and during, construction.	• None.	• None

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
	• All security personnel will also receive environmental training similar to that of onsite construction workers so that they understand the environmental conditions and issues associated with the various areas for which they are responsible at a given time.				
Notification of Construction Activities in Waterways	• Before work begins in the Sacramento River for Alternative 2, post information at nearby marinas, public launch ramps. Specific locations of these notices will be determined by informed stakeholders. • This information will include maintenance site location(s), maintenance schedules, speed limits, and identification of no-wake zone and/or detours, where applicable. • Information on detours would include site-specific details regarding any temporary partial channel closures, including contacting boating organizations, marina operators, city or county parks departments, and California Department of Parks and Recreation (DPR), where applicable.	• Authority • Contractors	• At least 30 days prior to any work in waterways during construction, operations, and maintenance.	• The Authority will determine specific location and types of notices to be provided. Once these are determined, the Authority will contract with the appropriate construction contractor to implement notification and will then monitor implementation and ensure that posting of information is complete 30 days prior to in-water activities.	• Boating organizations • marina operators • city or county parks departments • DPR • U.S. Coast Guard or USACE
Worker Environmental Awareness Program (WEAP)	• All construction crews and contractors will attend WEAP training. • The WEAP training will include documentation and a review by qualified resource specialists of the special-status species and tribal, archaeological, historic built, paleontological, and other sensitive resources and areas within the area of disturbance for a particular facility; the locations of sensitive biological resources and their legal status and protections; measures to be implemented for avoidance of these sensitive resources; and review of other required environmentally related resources for all construction personnel working on site at a particular facility footprint.	• Authority • Contractors	• Prior to the onset of construction, including mobilization and vegetation clearing, and when new personnel are added to the project. • Construction tailgate briefings	• A record of all personnel trained will be maintained by each contractor and submitted to the Authority • The Authority will present WEAP training documentation upon request by regulating or permitting agencies	• CDFW • U.S. Fish and Wildlife Service (USFWS)
Develop and Implement Fish Rescue and Salvage Plans for Funks Reservoir, Stone Corral Creek, Funks Creek, and CBD for Alternatives 1, 2 and 3; for Sacramento River for Alternative 2	• Fish herding and/or rescue operations will occur at any in-water construction site where dewatering and resulting isolation of fish may occur (e.g., when dewatering creates isolated pools within the stream channel). • The plans will identify the appropriate procedures for herding and removing fish from the construction zone and preventing fish from re-entering the construction zone during construction, or prior to dewatering. • These plans will include detailed fish collection, holding, handling, and release procedures. • The appropriate fish collection method will be determined by a qualified fish biologist for all species of interest, in consultation with the designated resource agency biologist, and based on site-specific conditions prior to dewatering and other in-water construction activities. • Prior to construction site dewatering, fish will be herded and/or captured and relocated to minimize direct mortality and other forms of take. Capture, handling, holding, release, and relocation measures will be consistent with the general guidelines and procedures set forth in Chapter 9 of the most recent edition of the CDFW *California Salmonid Stream Habitat Restoration Manual* (California Department of Fish and Game 2010) to minimize impacts to species. • All fish rescue and salvage operations will be conducted under the guidance of a qualified fish biologist. These activities will occur as soon as possible after completion of the activity which results in fish being trapped. • Unless otherwise required by these permits, the project proponents, in undertaking construction at the construction sites, will provide the following.	• Authority • Qualified fish biologist	• Prior to and during construction	• The Authority will oversee development of the Plans in coordination with the Agencies. • The Authority will submit plans to the appropriate resource agencies (CDFW, USFWS, and the National Marine Fisheries Service [NMFS]) for their review and acceptance. • The fish rescue team will notify the contractor when the fish rescue has been completed and that dewatering can recommence. The results of the fish rescue and salvage operations (including date, time, location, comments, method of capture, fish species, number of fish, approximate age, condition, release location, and release time) will be reported to the appropriate resource agencies, as specified in the pertinent permits. • Monitoring the implementation of the Fish Rescue and Salvage Plans and effectiveness of fish salvage and rescue would be species-, site-, and method-	• CDFW • USFWS • NMFS

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
	A minimum 7-day notice to the appropriate fish regulatory agencies, prior to an anticipated activity that could result in isolating fish, such as installation of a coffer dam. A minimum 48-hour notice to the appropriate fish regulatory agencies of dewatering activities that are expected to require fish rescue. Safe working access for the appropriate fish regulatory agency personnel to the construction site for the duration of implementation of the fish rescue plan. Temporary cessation of dewatering if fish rescue workers determine that water levels may drop too quickly to allow successful rescue of fish. A work site that is accessible and safe for fish-rescue workers.			specific, and will be established within each Plan in coordination with the appropriate agencies.	
Construction Best Management Practices and Monitoring for fish, wildlife, and plant species habitats, and natural communities	• Prepare a construction monitoring plan for the protection of fish, wildlife, and plant species. The plan will include, but not be limited to the following elements. Reference to the SWPPP. A summary of preconstruction surveys required for special-status species. Descriptions of measures to be implemented. Descriptions of monitoring parameters (e.g., turbidity), including the specific activities to be monitored (e.g., dredging, grading activities) and monitoring frequency and duration (e.g., once per hour during all in-water construction activities), as well as parameters and reporting criteria. • All in-water construction activities within the Sacramento River under Alternative 2 will be conducted during the allowable in-water work window of September 1 through October 15 and within non-anadromous waters (e.g., Funks Creek, Stone Corral Creek, CBD) from June 1 through October 15 for the protection of fish species. • Qualified biologists will monitor construction activities in sensitive natural communities and in areas identified as suitable habitat for special-status species. The biological monitors will have the authority to temporarily stop work in any area where a special-status species has been observed until that individual has passively or physically been moved outside of the work area, or if any measures are not functioning appropriately for the protection of fish, wildlife, or plant species. • Biological monitors will be professional biologists selected for their knowledge of the special-status species and natural communities that may be affected by construction activities. The qualifications of the biologist(s) will be submitted to the fish and wildlife agencies for review and written approval prior to initiating construction. • High-visibility temporary fencing, temporary signs, staking and flagging, or other visual barriers (pylons and flagging) will be used to identify sensitive biological resources and project personnel will be advised to avoid disturbance of these areas. These areas will be identified during pre-activity surveys. Signs, staking/pylons, and flagging will be inspected by the biological monitor in accordance with permit conditions and mitigation measures and maintained as necessary. • On-site vehicles will be limited to a speed of 15-20 miles per hour on unpaved roads. Personnel driving vehicles in the project area will observe the posted speed limit of 20 miles per hour (mph) on paved roads. • All ingress/egress at the project site will be restricted to those routes identified in the project plans and description. Construction vehicles and equipment will restrict off-road travel to the designated construction areas	• Authority	• Prior to construction • Implementation of plan during construction	• The Authority will appoint construction biological monitor(s) to oversee implementation of BMPs, mitigation measures, and requirements in permits and approvals by the agencies. The construction monitor will also perform inspections as necessary to ensure compliance by construction contractors with these measures and coordinate inspections by other appointed monitors and inspectors. • Prior to construction, the construction monitor will report to the Authority on the status of the monitoring plans. • During construction, the construction monitor will report to the Authority periodically or as agreed upon on the results of construction inspections related to the measures and compliance with wildlife agency requirements. • Water quality monitoring per SWPPP • Construction monitor to maintain a daily log of construction activities, notes any problems identified and solutions implemented to rectify those problems, and notifications to the construction superintendent and/or the fish and wildlife agencies regarding any exceedances of specific parameters (i.e., turbidity) or observations of special-status species. The monitoring log will also document construction start/end times, weather and general site conditions, and any other relevant information.	• USFWS • NMFS • CDFW

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
	• All vehicle parking will be restricted to established areas, existing roads, or other suitable areas. • All food-related trash will be disposed of in closed containers and removed from the work area daily during the work period. Personnel will not feed or otherwise attract fish or wildlife to the work site. • No firearms will be allowed on the project site except for those carried by authorized security personnel or local, state, or federal law enforcement officials. • To prevent harassment, injury, or mortality of sensitive wildlife, pets will not be permitted in the active construction area. • To prevent inadvertent entrapment of wildlife during construction, all excavated, steep-walled holes, trenches, or pits more than 1 foot deep will be covered at the close of each working day with plywood or similar material. Dirt will be shoveled around all the edges of the plywood or other material to prevent animals from crawling under it. In cases where trenches or pits cannot be covered, a section of the trench or pit will be partially backfilled to create an earthen ramp with a 3:1 slope. Before such holes or trenches are filled, they will be thoroughly inspected for trapped animals. If a special-status species is encountered during construction work, construction activities will be diverted away from the animal until it can be moved by a USFWS- or CDFW-approved biologist. • Plastic monofilament netting or similar material will not be used for erosion control, because smaller wildlife may become entangled or trapped in it. Acceptable substitutes include coconut coir matting or tackified hydroseeding compounds. This limitation will be communicated to the contractor through specifications or special provisions included in the construction bid solicitation package. • All construction pipes, culverts, or similar structures; construction equipment; or construction debris left overnight in areas that may be occupied by wildlife will be inspected by the biological monitor prior to being used for construction. Such inspections will occur at the beginning of each day's activities, for those materials to be used or moved that day.				
Control of Invasive Plant Species during Construction and Operation	• All construction crews and contractors will be educated during the WEAP training about the importance of not spreading invasive plants. • Localized infestations of invasive plants with a California Invasive Plant Council rating of moderate or high will be identified and mapped during the botanical surveys. These areas will be flagged and avoided during construction. If these areas cannot be avoided, vegetation will be removed and bagged for disposal at a waste facility prior to work in these areas. • If areas to be cleared contain invasive plants, then chipped vegetation material from those areas will not be used for erosion control; in these cases, the material will be disposed of to minimize the spread of invasive plant propagules (e.g., burning, composting). • Upon completion of the project, all areas subject to temporary ground disturbances will be recontoured to preproject elevations, as appropriate and necessary, and revegetated with native vegetation to promote restoration of the area to pre-project or better conditions. An area subject to "temporary" disturbance is any area that is disturbed to allow for construction of the project, but is not required for operation or maintenance	• Authority • Qualified construction biological monitor(s) or biologists	• Prior to construction • During construction • Postconstruction	• The Authority will monitor and manage invasive species locations throughout construction • This information will be compiled into a report and used to inform the management of invasive species during operation and maintenance	• None

Best Management Practice(s)	Key Features	Responsible Party(ies)	Timing	Monitoring and Reporting Requirements	Regulating or Permitting Agency
	of any project-related infrastructure, will not be subject to further disturbance after project completion, and has the potential to be revegetated. • Infestations of invasive plant species will be targeted for control or eradication as part of the revegetation of temporarily disturbed construction areas. • Appropriate methods and native plant species used to revegetate such areas will be determined on a site-specific basis in consultation with qualified biologists. • Control the spread of invasive aquatic plants (submerged and floating) in Sites Reservoir using existing methods consistent with the Department of Boating and Waterways Aquatic Invasive Plant Control Program (AIPCP).				
Nighttime Work (Alternative 2 Discharge Location on Sacramento River)	• Any nighttime construction work be necessary, work lights will be shaded to minimize illumination of water in order to minimize disturbance to fish and wildlife species.	Authority	Before construction	Included on construction design requirements	None

2D.2 Initial Reservoir Fill Plan

Purpose: The Authority will prepare an Initial Reservoir Fill Plan to describe the monitoring program for the Sites and Golden Gate Dams, saddle dams, saddle dikes, and areas around the reservoir during its initial filling.

Outcomes: Implementing the Initial Reservoir Fill Plan will ensure the Authority fills the reservoir safely, avoids causing landslides or erosion, and minimizes seismic hazards as the reservoir fills.

Content: The Initial Reservoir Fill Plan will:

- Describe acceptable rates for filling the reservoir in consideration of soil pore pressure, material strength, and degree of antecedent saturation to minimize the potential for sliding.
- Describe the appropriate monitoring locations, type of monitoring, and frequency and duration of monitoring.
- *Authority/Engineers insert more content.*

Timing: The Authority and its qualified contractors will complete preparation of the Initial Reservoir Fill Plan 1 year prior to beginning to fill Sites Reservoir and submit the plan to DSOD for review and approval.

2D.3 Reservoir Management Plan

Purpose: The Authority will prepare a Reservoir Management Plan (RMP) to protect and maintain water quality during the operation of the reservoir. This plan will describe the management of water resources in Sites Reservoir, including monitoring water quality, fisheries management (i.e., managing reservoir to minimize accumulation of mercury and other metals in stocked fish), and vector management.

Outcomes: Implementing the RMP will ensure the Authority identifies and implements water quality metrics, standards, testing and monitoring protocols, and actions to respond to water quality concerns (depending on monitoring results) to maintain and protect water quality.

Content: The RMP will contain protocols that follow guidelines for water quality measurements and identify the frequency and location of measurements in the reservoir, the source water, and the reservoir discharge for certain water quality constituents. Water quality metrics, standards, testing, and protocols will follow information and guidance available from the Central Valley Regional Water Quality Control Board. The RMP will include measures to address emerging water quality concerns, such as protocols for invasive aquatic weed control, potential adjustments to inflow and release volumes, minimum reservoir storage levels, and inlet/outlet

(I/O) port selection. The final RMP will be established after meetings and consultation with regulatory agencies and other stakeholders. The Authority has already developed testing and monitoring protocols for several water quality constituents, which are described in Sections 2D.3.1 through 2D.3.5 and incorporated into the impact analysis for Chapter 6, *Surface Water Quality*.

Timing: The timing of testing and monitoring will vary depending on the constituent analyzed, as described below.

2D.3.1 Harmful Algal Blooms

Water quality management in Sites Reservoir as it relates to harmful algal blooms (HABs) will include implementation of a water quality monitoring program and a HABs action plan (below) to minimize the potential for adverse effects on beneficial uses of water in Sites Reservoir and downstream.

1. **Water Quality Monitoring**
    a. Annual seasonal monitoring for benthic and planktonic HABs will occur monthly, at a minimum, beginning April 15 and continuing through October. Monitoring will begin earlier than April 15 if blooms are suspected. Initial early-season monitoring will consist of visual inspection and water sampling. Visual monitoring will be implemented consistent with the Surface Water Ambient Monitoring Program's (SWAMP's) *Visual Guide to Observing Blooms* (California Water Quality Monitoring Council 2017a) in the *California Freshwater Harmful Algal Bloom Field Guide* (SWAMP HAB Field Guide) (California Water Quality Monitoring Council 2018). Visual inspection will be made at several locations along the perimeter of the reservoir, including near the I/O tower.

    b. It may be necessary to confirm that a suspected bloom is a cyanobacteria bloom rather than a non-toxic algal bloom. In this case, field microscopy will used to identify if cyanobacteria are present; water samples will be collected for microscopic visualization consistent with standard operating procedures in the SWAMP HAB Field Guide, which are currently under development. A qualified water quality specialist familiar with identifying cyanobacteria or otherwise appropriately trained person will be responsible for obtaining grab samples and visualizing the samples with a field microscope. If toxic benthic algal mats are suspected, their presence or absence will be confirmed with microscopy.

       Qualified personnel conducting water sampling will follow all applicable steps in the *Standard Operating Procedures – Site Reconnaissance* section of the SWAMP HAB Field Guide (California Water Quality Monitoring Council 2017b) or develop a similar protocol to maintain consistency in sampling and record keeping. This standard operating procedure is intended to describe general and specific methods, procedures, and considerations on documenting the spatial and logistical aspects of each sampling site.

    c. If the presence of cyanobacteria is confirmed, additional water samples will be taken for the purpose of laboratory analysis for cell density and the presence of cyanotoxins (specifically microcystins, anatoxin-a, and cylindrospermopsin) to determine if the trigger levels for planktonic (water column) HABs have been met (see Table 2D-2).

Table 2D-2: California Cyanobacteria and Harmful Algal Bloom Network Trigger Levels for Posting Planktonic Advisory Signs

Criteria	No Advisory[a]	Caution (Tier 1)	Warning (Tier 2)	Danger (Tier 3)
Total Microcystins[b]	< 0.8 µg/L	0.8 µg/L	6 µg/L	20 µg/L
Cylindrospermopsin	< 1 µg/L	1 µg/L	4 µg/L	17 µg/L
Anatoxin-a	Non-detect[c]	Detected[c]	20 µg/L	90 µg/L
Cell Density of Potential Toxin Producers	< 4,000 cells/mL	4,000 cells/mL	----------	----------
Site-Specific Indicators	No site-specific indicators present	Discoloration, scum, algal mats, soupy or paint-like appearance. Suspected illness	----------	----------

Source: California Water Quality Monitoring Council 2021.
µg/L = microgram per liter.
[a] For de-posting, all criteria for no advisory must be met for a minimum of 2 weeks. General awareness sign may remain posted and healthy water habits are still recommended.
[b] Microcystins refers to the sum of all measured Microcystin congeners.
[c] Using an analytical method that detects ≤ 1 µg/L anatoxin-a.

d. Visual and water quality monitoring will continue on a regular basis until cell density and cyanotoxin concentrations at any monitored location exceeds the "Caution" action trigger level. When cell density is at or above the caution action trigger level and/or cyanotoxin concentrations are at or above the trigger levels identified in Table 2D-2, the HABs Action Plan will be implemented.

2. HABs Action Plan

a. Reservoir monitoring and water sampling frequency will increase from monthly to approximately bi-weekly when the "Caution" action trigger level is reached (per cell density and cyanotoxin concentrations). When the "Caution" trigger level is met or exceeded, the Authority will report this to the HABs Hotline (managed by the State Water Resources Control Board [State Water Board] and the Regional Water Quality Control Boards) as follows:

   - Online: Freshwater Bloom Incident Form
   - phone: 1 (844) 729-6466 (toll free)
   - email: CyanoHAB.Reports@waterboards.ca.gov

b. The Authority will coordinate the State Water Resources Control Board and the Central Valley Regional Water Quality Control Board (Central Valley Board) for posting advisory warning signs corresponding to the “Caution”, “Warning” or “Danger” trigger level (as applicable based on cell density and cyanotoxin concentration). Advisory signs will be placed in visible locations around the reservoir, and reservoir operations staff will be notified and informed of the potential health risks associated with cyanobacteria and cyanotoxins.

c. If cyanobacteria and cyanotoxins are confirmed near the I/O tower at a level at or exceeding the “Caution” action trigger level, reservoir releases will be made from deeper in the reservoir, while still considering other water quality objectives (e.g., water temperature for rice).

d. If toxic benthic algal mats are confirmed, the Authority will coordinate with the State Water Board and the Central Valley Board for posting benthic HABs signs.

e. If HABs become a consistent problem near the I/O tower, additional measures may be implemented, such as oxygenation of the hypolimnion to reduce the release of bottom-sediment nutrients.

f. Caution and safety procedures will be used to prevent direct human contact with a bloom. The SWAMP *Health and Safety Guide* (California Water Quality Monitoring Council 2017c) from the SWAMP HAB Field Guide will be consulted to provide information for personnel protection to minimize risks during water sampling.

g. Once the visual indicators and/or cyanotoxin concentrations in the reservoir are below the posting criteria for planktonic HABs or benthic HABs for a minimum of 2 consecutive weeks, signage removal occur and will be coordinated with the State Water Board and/or the Central Valley Water Board.

2D.3.2 Methylmercury

The Authority will implement the following actions as part of the RMP to minimize reservoir methylmercury production and bioaccumulation in reservoir fish. These actions are consistent with recommended actions for new reservoirs as part of the Statewide Mercury Control Program for Reservoirs (State Water Resources Control Board 2017) and will be implemented in coordination with the State Water Board and Central Valley Board as required.

1. Remove vegetation (e.g., brush, trees in the inundation area prior to reservoir filling.
2. Do not stock Sites Reservoir with fish for the first 10 years following its initial filling.
3. Monitor Sites Reservoir fish tissue methylmercury concentration via annual tissue sampling beginning the first year of reservoir stocking for a minimum of 10 years to monitor fish tissue concentrations of methylmercury. Based on results from fish tissue monitoring, and in coordination with the State Water Board, Central Valley Water Board, and the Office of Environmental Health Hazards Assessment, fish consumption warning signs will be posted in several visible locations around the reservoir if fish tissue concentrations exceed the 0.20 mg/kg wet weight (ww) sport

fish objective[1]. Sampling protocol will be consistent with the Office of Environmental Health Hazard Assessment's *General Protocol for Sport Fish Sampling and Analysis* (Gassel and Brodberg 2005).

4. Monitor and manage reservoir water chemistry according to methods proven feasible and effective at reducing mercury methylation by pilot tests undertaken in other mercury-impaired reservoirs. Ongoing monitoring of aqueous and fish tissue methylmercury in Sites Reservoir will be implemented as permit conditions require to assess the effectiveness of these methods.
5. Manage reservoir fisheries according to methods proven feasible and effective at reducing methylmercury bioaccumulation by pilot tests undertaken in other mercury-impaired reservoirs. Fisheries management actions could fish stocking practices to increase the abundance of fish with lower methylmercury levels.
6. Refrain from stocking high trophic level species such as brown trout and bass.

The State Water Board and/or the Central Valley Water Board will include conditions or requirements in a Clean Water Act Section 401 water quality certification, a California Water Code water right order, or other applicable order for implementing the Project. Sites Authority will coordinate with the Central Valley Regional Water Board to implement mercury/methylmercury control or reduction measures pursuant to the mercury total maximum daily load and implementation program for reservoirs (State Water Resources Control Board 2017), once adopted.

2D.3.3 Metals

The metals evaluation will focus on metals that may be affected by flow in the Sacramento River and that have concentrations that are close to or above water quality standards. These include aluminum, copper, iron, and lead. Hexavalent chromium will also be measured, at least for the first year, due to limited existing data for the Sacramento River. Measurements of metal concentrations will be accompanied by measurements of pH, DOC, and hardness because these parameters influence water quality standards for aquatic life protection for some metals.

Past studies of metal concentrations in the Sacramento River have not focused on high flows that would be the source water for Sites Reservoir. To better understand the concentration of metals entering Sites Reservoir, metal concentrations at the diversion(s) will be measured at the first day of diversion and every 2 weeks as diversions continue. Eventually these data will improve understanding of the circumstances that cause elevated concentrations and may allow some metal measurements to serve as surrogates for others. After 2 years of measuring metal concentrations in the diversions, the frequency of measurements will decrease to monthly.

[1] The average methylmercury concentrations shall not exceed 0.2 milligrams per kilogram (mg/kg) fish tissue within a calendar year. The water quality objective must be applied to trophic level 3 or trophic level 4 fish, whichever is the highest existing trophic level in the water body. The objective applies to the wet weight concentration in skinless fillet. Freshwater trophic level 3 fish are between 150 to 500 millimeters (mm) in total length and trophic level 4 fish are between 200 to 500 mm in total length, or as additionally limited in size in accordance with the "legal size" set for recreational fishing, established by Title 14, California Code of Regulations 14 §§ 1 - 53.03.

Metal concentrations will also be measured at Golden Gate Dam every other month on the surface, at mid-depth, and near the reservoir bottom (at an elevation of approximately 300 feet) and in Stone Corral Creek at the base of Sites Dam. In addition, metal concentrations in the main Sites Reservoir release, the TC Canal at the Dunnigan Pipeline, and the Sacramento River upstream of the Sites discharge will be measured when water from Sites Reservoir is being discharged to the Sacramento River. If Sites water is released to the Colusa Basin Drain (CBD), metal concentrations will also be measured in CBD upstream of the Dunnigan Pipeline. If CBD water is released to Yolo Bypass, metal concentrations will be measured in CBD upstream of Yolo Bypass and in Yolo Bypass near Lisbon Weir. The measurements will be used to understand differences between intake and release concentrations and the effects of in-reservoir processes such as settling of suspended sediment and actions such as selection of I/O tower tier for releases. Measurements will also be used to determine if there are vertical differences in concentration, to understand the effect of TC Canal operations and conveyance volumes on metals concentrations, and to inform actions to be taken under Mitigation Measure WQ-1.1.

As understanding of metal processes is refined over time and results in reduced concern regarding metals, monitoring intensity may be reduced.

2D.3.4 Water Temperature

To the extent possible, water will be released from I/O tower ports/tiers to provide water that meets rice growing temperature objectives of 65°F or higher during the rice growing season (** through **). Earlier in the growing season when water is relatively cool, it may be necessary to use upper I/O tower ports/tiers, but later in the season, lower ports/tiers may be used. Warm releases will also benefit native fish in Funks Creek (hitch and roach) that have adapted to warm Central Valley water temperatures. During April through October, vertical water temperature profiles will be measured once every two weeks at 5-foot intervals to inform decisions about which tiers of the I/O tower to use.

Commented [CC5]: Warm water from the project should not be released to the Sacramento River (Knights Landing Outfall Gates for example). Warm water releases/agriculture runoff released to the river are detrimental to native aquatic species at this location.

Commented [CC6]: Generally speaking, the only two native species in the CA CV that are exceptionally known to be tolerant of warmer water conditions are hitch an roach. The large majority of CA CV native fishes do not benefit from augment flows or temperatures. Other native fish in Funks Creek are Sacramento blackfish (Orthodon microlepidotus), Sacramento sucker (Catostomus occidentalis) and Tule perch (Hysterocarpus traski). Blackfish and Tule perch do not persist in waterways that are heavily modified. Please describe how the project will impact water temperature for all native fish species in the project area.

2D.3.5 Salt Pond

Data regarding the Salt Pond is limited regarding the flow and water quality of the salt springs that feed it, and this lack of information represents a high level of uncertainty. Prior to initial filling of Sites Reservoir, after land has been acquired, and during the construction phase, there will be monthly measurements of flow, electrical conductivity (EC), and metals (aluminum, copper, iron, lead, manganese, and nickel) for up to 1 year at the salt springs. These measurements will be collected in accordance with standard procedures and will provide a better understanding of the potential salt and mineral load from the salt springs. Water samples for these measurements will be taken from locations where water is emanating from these springs. One to three springs with the most discharge will be selected for sampling.

Commented [CC7]: Suggest getting a complete profile for every spring. These resources will be compleely altered or eliminated by the project, and the chemical profile may impact water quality in the reservoir or downstream of the reservoir.

The amount of mixing of spring water with reservoir water is uncertain and will depend on EC, temperature, reservoir inflows, and reservoir releases. To determine whether saline spring water is accumulating at the bottom of the reservoir near Golden Gate Dam, EC measurements will be taken at the same times and locations in Sites Reservoir as the metal concentrations measurements in Section 2D.3.3.

If monitoring indicates the unlikely possibility of substantial increases in EC in the reservoir release due to temporary entrainment of accumulated salt spring water, reservoir operations will be modified to prevent this phenomenon by gradually discharging accumulated spring water. Reservoir modifications will be made gradually and may include modifications to discharge volume or selection of I/O tower tiers. For example, releases from lower-level and higher-level tiers may be blended to ensure adequate water quality. As these modifications are made, EC of the reservoir discharge will be measured hourly with a continuous device recorder to ensure that EC remains below 1,000 µmhos/cm.

Commented [CC8]: Suggest removing "the unlikely possibility of substantial" because in the two previous paragraphs salt load is described as unknown or lacking data.

Commented [CC9]: Please provide more information describing the chemical makeup of the spring water, how it will be released to the environment and how it will impact downstream resources. The action of releasing accumulated "spring water" needs supporting information and impacts thoroughly examined prior to the action.

2D.4 Sediment Technical Studies Plan and Adaptive Management

Commented [WN10]: *Authority/Integration: will need to back check this with chapter 11 terminology.*

Purpose: Sediment monitoring and aquatic resource technical studies will be used to further refine the understanding of the effect(s) that entrainment of sediment in diversions has on fish species and potentially necessary adjustments to Project operations to address those effects on fish and provide the means of making those changes.

Outcomes: The sediment monitoring and aquatic resource technical studies would provide data necessary to further understand and refine real-time effects on sediment transport and its subsequent effect on fishery resources; impacts on migration rates, rates of predation, and foraging success. A Sediment Technical Team (STT) will use the results to adjust Project operations to minimize adverse effects on fish and explore whether operations could be implemented to benefit fish. The STT will be a multi-agency team that includes representatives from the Authority, Reclamation, California Department of Water Resources, National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife (CDFW), Central Valley Water Board, and U.S. Army Corps of Engineers (USACE).

Content: The Sediment Technical Studies Plan will consist of sediment monitoring and technical studies to assess the movement of sediment at the RBPP and Hamilton City Pump Station intakes and quantify amounts of entrained sediment. The results of the monitoring will be used to model sediment movement and determine whether sediment management actions are needed (e.g., the need for and feasibility of reintroducing sediment to the river or Delta would be considered).

Timing: Monitoring will begin a minimum of 5 years before start of operations to establish the baseline and will continue for 5 years after start of operations. Modeling will rely on existing sediment transport models and will begin as soon as the SST determines sufficient data are available to inform the models. The Authority and the permitting fish agencies (NMFS, USFWS, and CDFW) will determine the frequency of the sediment management report and timing of any adaptive management actions.

2D.4.1 Sediment Monitoring, Modeling, and Reintroduction

It is estimated that less than 5% of the sediment load in the Sacramento River could be entrained by the RBPP and Hamilton City Pump Station intakes, which may have slight effects on turbidity and therefore on delta smelt habitat (for an example see Chapter 11). However, there is uncertainty in this conclusion and a multi-step process will assess and, if necessary, minimize potential negative effects. The process will include multi-year monitoring and estimation of sediment entrainment during initial operations following Sites Reservoir construction; monitoring and modeling of potential effects relative to performance criteria based on the sediment entrainment estimates; and development and implementation of a sediment reintroduction plan should performance criteria have been exceeded. The process will be implemented by establishing a multi-agency STT of representatives from the Authority, Reclamation, NMFS, USFWS, CDFW, Central Valley Water Board, and USACE. The permitting fish agencies (NMFS, USFWS, and CDFW) will have approval authority for products developed during the process (e.g., monitoring plans and annual reports).

The monitoring program will involve monitoring and estimating sediment entrainment prior to and during the first several years of operations following Sites Reservoir construction. Monitoring duration will be subject to input from the STT and independent peer review but is anticipated to be at least 5 years to account for hydrological variability. Methods for estimating sediment entrainment will be determined during the planning phase and may include measurement of suspended sediment concentration and flow in the Sacramento River upstream and downstream of the RBPP and Hamilton City Pump Station intakes, as well as in the water diverted by each facility. Annual monitoring plans and results reporting will be reviewed by the STT, with initial and periodic independent peer reviews facilitated by the Delta Science Program, and will be subject to approval by NMFS, USFWS, and CDFW.

The second step of the process will involve monitoring and modeling of potential effects relative to performance criteria. The specifics of the performance criteria will be developed with the input of the STT and independent peer review. The performance criteria are expected to include assessments of habitat indicators such as the percentage of time that turbidity at monitoring stations exceeds an established threshold (e.g., 12 nephelometric turbidity units) (Sommer and Mejia 2013). To account for the likely variability in sediment delivery caused by operations (i.e., sediment entrainment) and other factors (e.g., contribution of sediment from other tributaries), sediment modeling (e.g., using methods from Bever et al. 2018) will be used to approximate the incremental effects of operations given the estimates of sediment entrainment made during the first step of the process. Assessments of achievement of performance criteria will receive independent scientific peer review and will be subject to approval by NMFS, USFWS, and CDFW.

If the monitoring and modeling estimates of the second step indicate exceedance of performance criteria attributable to operations, the third step of the proposed process will be initiated. This step will involve development and implementation of a sediment reintroduction plan within 5 years of the end of step two. This plan will aim to reintroduce sediment to allow performance criteria to be met. Sources of sediment to be reintroduced may include proposed or existing facilities (e.g., forebays and canals) or locations unrelated to the Project and will account for factors such as sediment composition to meet performance criteria (e.g., fine particles for turbidity) and reintroduction location. Subject to approval by NMFS, USFWS, and CDFW, alternative means of achieving performance criteria may also be considered (e.g., restoration of turbid tidal habitat in the vicinity of areas that do not appear to be achieving performance standards). Modeling (e.g., using methods such as those of Bever and MacWilliams 2018, Bever et al. 2018) may be used to optimize sediment reintroduction locations relative to performance criteria to be achieved. The sediment reintroduction plan will be prepared to meet required permitting standards from the Central Valley Water Board and USACE. The sediment reintroduction approach will be consistent with objectives for turbidity in the Central Valley Water Board's Water Quality Control Plan for the Sacramento River and San Joaquin River Basins. The STT and independent peer review facilitated by the Delta Science Program will review and provide input on the proposed sediment reintroduction plan and annual reports of its implementation and monitoring to assess achievement of performance standards. The sediment reintroduction plan and reports of its implementation and effectiveness will be subject to approval by NMFS, USFWS, and CDFW.

2D.5 Fish Monitoring and Technical Studies Plan and Adaptive Management

Purpose: The fish monitoring and technical studies plan will be part of an adaptive management process to address potential impacts on fish survival associated with diversion facility operations at the RBPP and Hamilton City Pump Station intakes. The results of the studies will be used in conjunction with existing and new aquatic monitoring to inform real-time operations and further assess impacts of operations.

Outcomes: The technical studies will inform factors such as baseline conditions, including juvenile salmonid migration survival prior to project operations, compliance with protective criteria for screen hydraulics, and changes to baseline conditions as a result of Project operations. The studies will provide the data and reports necessary to document compliance with fish screen NMFS and CDFW performance criteria and will be submitted to NMFS, USFWS, and CDFW for review. The studies will also be used to quantify the amount of take of listed species that may occur and to inform any decisions regarding changes in Project operations needed to ensure that take of listed species remains below authorized levels. A Technical Study Technical Team (TSTT) will use the results to determine what actions may be needed to address impacts on fish resources. The TSTT will be a multi-agency team that includes representatives from Reclamation, the Authority, NMFS, USFWS, and CDFW.

Content: The technical studies will meet agency data collection and reporting requirements and will consist of at least four studies: a fish distribution and density study, a juvenile salmonid survival rates study, a predator density and distribution study, and a long-term hydraulic fish screen evaluation study.

Timing: Studies will commence in October 2023 to collect baseline information and continue for at least 5 years subsequent to the initiation of diversions associated with filling Sites Reservoir. The studies will likely occur periodically thereafter for the life of the Project.

2D.5.1 Technical Studies

The technical studies will be implemented by Reclamation and the Authority with input from the TSTT. Sub-teams may be necessary to address groups of related studies. The permitting fish agencies (NMFS, USFWS, and CDFW) will have approval authority for products developed during the technical studies (e.g., study plans, annual reports, and final reports), with independent peer review of key products facilitated by an entity such as the Delta Science Program. Full details of the technical studies will be developed by the principal investigators of the studies. If the technical studies anticipate resulting in take of listed species, appropriate permits will be obtained prior to their initiation.

The overarching purpose of these technical studies is to confirm accuracy of anticipated levels of impact, further refine and understand the mechanism(s) by which Project operations affect aquatic resources, identify hypotheses for testing ways to diminish potential adverse effects of the Project on aquatic resources, and explore ways in which the Project operations can further benefit fish populations. Sections 2D.5.1.1 through 2D.5.1.4 discuss the specific objectives and assessment types associated with each technical study.

2D.5.1.1 Technical Study 1: Fish Distribution and Density

Objective: Update baseline densities and seasonal distributions of all key fish species as identified by TSTT and life stages and assess evidence for change following commencement of Project operations.

Assessments:

- Determine whether there have been any changes in the vicinity of the diversions with respect to fish abundance, seasonality of movements, spatial distribution of various life history stages, and use of the Sacramento River for rearing and migration.

- Collect data on environmental parameters such as water temperature, sediment, water quality.

2D.5.1.2 Technical Study 2: Juvenile Salmonid Survival Rates

Objective: Update baseline survival rates for juvenile Chinook salmon and steelhead in the Sacramento River in the vicinity of the RBPP and Hamilton City Pump Station intakes and compare to survival rates following commencement of Project operations in the same areas.

Assessments:

- Conduct site-specific studies to assess survival of juvenile Chinook salmon and steelhead migrating downstream in the Sacramento River in the vicinity of the diversions and determine how survival rates vary within and among years and by species.

- Evaluate whether fish size, season, species, flow, velocity, turbidity, and migration rates predict juvenile salmonid inter-reach or intra-reach survival rates.

2D.5.1.3 Technical Study 3: Predator Density and Distribution

Objective: Update baseline information regarding densities and distribution of predators in the immediate vicinity of the RBPP and Hamilton City Pump Station intakes and compare to predator densities and distribution in the same areas following commencement of Project operations.

Assessments:

- Collect and update information on densities, species, and size composition of predatory fish (and piscivorous birds and mammals, if deemed appropriate) in the Sacramento River in the reaches containing the diversions and determine how these data vary within and among years and by sampling location.
- Update information on how predator densities vary by season and in response to changes in Sacramento River flow, water temperatures, turbidity, time of day, and other factors (e.g., flow velocity, areas of turbulence, and proximity to shorelines and structures in the river.
- Update studies on diet and selection of prey species of concern for predators inhabiting the Sacramento River and evaluate how diets vary by species, relative sizes of predator and prey, and time of year.
- Determine whether Project operations affect predator populations and predation rates on prey species of concern.

2D.5.1.4 Technical Study 4: Long-Term Hydraulic Fish Screen Evaluation

Objective: Conduct a long-term evaluation of fish screen hydraulic performance at RBPP and GCID Main Canal at Hamilton City.

Assessments:

- Evaluate fish screen performance under winter diversion and flow scenarios to verify continuing compliance with state and federal screen performance standards, including assessment of screen approach velocities and sweeping velocities at the screens.
- Update evaluation of flow split at the oxbow containing the Hamilton City Pump Station intake under winter diversion conditions and determine fish response to the flow split.

2D.5.2 Aquatic Monitoring

Several aquatic monitoring elements will assist in assessing and limiting potential Project operations effects: rotary screw trapping; entrainment/impingement monitoring; fish attraction to during releases of water from Sites Reservoir; and presence of fish in forebays following fish screen overtopping events. Similar to the technical studies previously described, aquatic monitoring will be implemented by Reclamation and the Authority with input from a multi-agency Aquatic Monitoring Technical Team (AMTT) that includes representatives from Reclamation, the Authority, NMFS, USFWS, and CDFW. Sub-teams may be formed to address different aquatic monitoring elements. The permitting fish agencies (NMFS, USFWS, and CDFW) will have approval authority for products developed during the process (e.g., monitoring plans and annual reports), with independent peer review of products facilitated by an entity such as the Delta Science Program. Full details of the aquatic monitoring elements will be developed as part of monitoring plans; below are basic summaries of the monitoring elements. If there is potential for take of listed species during aquatic monitoring (e.g., collection of juvenile salmonids and green sturgeon during rotary screw trapping), detailed estimates of take will be provided as part of any necessary additional permitting for the aquatic monitoring elements.

2D.5.2.1 Rotary Screw Traps

Real-time Project operations will largely be informed by flow criteria and assessment of fish catches at existing, ongoing rotary screw trap monitoring locations at Red Bluff (River Mile [RM] 243), Hamilton City (RM 205), Tisdale (RM 120), and Knights Landing (RM 87.5). Following existing protocols, rotary screw traps will be checked on a daily or near-daily basis, with adjustments to monitoring frequency based on seasonal fish occurrence.

2D.5.2.2 Entrainment and Impingement

Entrainment monitoring will be conducted where feasible at the RBPP and GCID Main Canal at Hamilton City Pump Station intakes. The monitoring is anticipated to include use of fyke nets and may also include larval light traps. The feasibility of entrainment monitoring will be assessed based on the available facilities (e.g., structures on which to attach fyke nets or place larval light traps). Impingement monitoring will occur along the face of the fish screens and may include the use of diver surveys or wiper blade-mounted video cameras if feasible. The frequency and extent of entrainment and impingement monitoring will be developed based on input from the AMTT, permitting fish agencies, and independent peer review.

2D.5.2.3 Stranding Behind Screens

Very high river flows can result in overtopping of the fish screens at the RBPP and Hamilton City Pump Station intakes. Monitoring (e.g., with seines or trawls in forebays behind the fish screens) will be conducted at the intakes after overtopping events (i.e., when flows are receding) to characterize the extent to which fish are stranded behind the screens. It is anticipated that this monitoring will be required for a limited number of overtopping events and will be subject to input from the AMTT, permitting fish agencies, and independent peer review.

2D.6 Land Management Plan

Purpose: The Authority will prepare a Land Management Plan (LMP) to protect wildlife resources during management and maintenance activities on all non-recreation lands held in fee or easement (including the Project buffer) by the Authority. This plan will include management actions for buffer areas and the specific type and frequency of maintenance activities by location. Land management, maintenance, and monitoring actions for any mitigation areas owned by the Authority will also be described in the LMP. These activities will include vegetation maintenance, invasive terrestrial plant control, and rodent control.

Outcomes: Implementing the LMP will ensure that the Authority considers and implements measures to avoid and minimize potential impacts on wildlife resources from management and maintenance activities. The LMP will also ensure that the Authority and maintenance personnel are aware of the locations where sensitive wildlife resources may be present and what steps will be taken prior to work in these areas. As part of the LMP reporting requirements, annual reports will include recommendations as needed to ensure that potential impacts that were not considered or were not present at the time the plan was prepared are avoided or minimized through the implementation of new or improved measures.

Content: The LMP will include the following components.

- A statement of purpose, including the role of the LMP in satisfying regulatory compliance obligations under state and federal laws.
- Land management, maintenance, and monitoring actions for any mitigation areas owned by the Authority.
- The type and frequency of maintenance activities by location and whether pre-activity wildlife surveys or monitoring of work will be required.
- The frequency, timing, and duration of wildlife surveys or monitoring, if required, and the qualifications of the biologist conducting surveys or monitoring.
- General measures and practices when working in or near habitat for special-status wildlife.
- The procedure for reporting incidental injury or mortality of federal or state listed species.
- Clear statements about the Authority's, hired staff's, and qualified contractor's responsibilities for implementing LMP requirements.
- Description of annual reporting requirements, as approved by regulatory agencies.

The LMP will require a qualified biologist to provide annual training to maintenance personnel on the general measures and practices described in the plan and to document the surveys and monitoring conducted. A qualified biologist with knowledge or oversight of LMP measures and implementation will prepare an annual report summarizing the steps that were taken to minimize impacts on wildlife resources by December 31 of each year. This report will be submitted to USFWS and CDFW by January 31 of the following year. Each annual report will include the following information.

- The date of annual training, the name of the biologist who gave the training, and a list of attendee names and signatures.
- A summary of the general measures and practices that were implemented to avoid and minimize impacts on special-status wildlife habitat when working in or near habitat.
- A summary of wildlife surveys and monitoring that were conducted that year, including the type of maintenance activity for which surveys or monitoring was required, the date(s) and location(s) of the survey(s) or monitoring, the name of the qualified biologist, and observations of the target special-status species or other special-status wildlife during the surveys or monitoring.

- Any problems that were encountered by maintenance staff during implementation of general measures or by biologists conducting surveys or monitoring and an assessment of the success of the LMP in avoiding and minimizing effects on special-status wildlife and their habitats.

- Recommendations for improving existing measures or additional measures to avoid or minimize impacts on wildlife resources, if needed.

- Whether any previously recommended improved or new measures were implemented and the success of those measures in avoiding or minimizing impact on wildlife resources.

Timing: The Authority and its qualified contractors will complete preparation of the LMP within 1 year of the first fee title acquisition by the Authority and will amend the LMP as needed as additional lands are acquired.

2D.7 Cultural Resources Management Plan

The Authority will prepare a Cultural Resources Management Plan (CRMP) prior to construction activities to guide the cultural resources technical studies and resource-specific treatments to be conducted prior to and during construction activities, as well as ongoing monitoring and treatment required during operations. The CRMP will describe procedures that have been identified for avoiding, minimizing, and mitigating known or potential Project impacts on cultural resources. The first step in each procedure will be to consider feasible avoidance of historic resources and archaeological resources.

The CRMP will be developed during the permitting and design process and will be adopted prior to land acquisition. Preparers of the CRMP will meet professional qualification standards established in the *Secretary of the Interior's Professional Qualification Standards* for archaeology and architectural history. The content of the CRMP will follow industry standards, including guidance prepared by the California Office of Historic Preservation and the National Park Service. Each procedure will be attached to the CRMP, as each is completed in accordance with the timing and responsibilities identified below.

The CRMP will include the following.

- A statement of purpose, including the role of the CRMP in satisfying regulatory compliance obligations under state and federal laws.
- A summary of the procedures for identification of significant resources, assessment of Project impacts, development of measures that avoid or reduce impacts during design development or construction, and mitigation treatments.
- Federal requirements, including Reclamation's policies on federal lands.
- An overall discussion of the timing for development and implementation of individual procedures, including consideration of critical path between procedures or how to manage overlapping procedures.

- Clear statements about who is responsible for implementation of CRMP requirements.

2D.7.1 Cultural Resources Phased Identification Procedures (PIP)

Purpose: The Authority, or its qualified contractors, will conduct pedestrian and intensive surveys to complete the identification of archaeological and historic built resources located in the areas of impact. The PIP will provide details about the current cultural resources data gaps and requirements for completing phased identification surveys prior to construction for areas where the Authority currently does not have access. Once these surveys are conducted and the Authority has information about specific resources, it will be able to assess resource-specific project impacts and consider avoidance options and the applicability of other procedures in the CRMP, such as treatment plans, monitoring, documentation, or public programs.

Outcome: Implementing the PIP will ensure that the Authority fills the current data gaps for archaeological and historic built resources and is fully aware of the presence of cultural resources that may be affected by the project. As part of the reporting requirements when implementing the PIP, the survey and evaluation reports will recommend further procedures required in order to avoid, minimize, or mitigate project impacts on significant resources that are not currently known due to limited access.

Content: The PIP will include guidance for phased surveys and National Register of Historic Places/California Register of Historical Resources (NRHP/CRHR) evaluations for historical and archaeological resources and assessment of impacts, should any resources be newly identified. The PIP will specify the ways in which surveys might be phased, taking into consideration the mechanisms for acquiring access to currently inaccessible properties and the schedule for design development.

Timing: The PIP will be prepared and adopted within 6 months of the Notice of Determination (NOD)/Record of Decision (ROD). The PIP will be fully implemented within 2 years of the first fee title acquisition by the Authority and prior to the demolition of any structures or any soil disturbance in areas that do not have survey coverage.

2D.7.2 Cemetery Relocation Procedure

Purpose: The Cemetery Relocation Procedure describes the Authority's plan for relocating two known, dedicated cemeteries located in the inundation area.

Outcome: Avoidance of the disturbance and/or inundation of two known cemeteries is not expected to be feasible except under the No Project Alternative. The Cemetery Relocation Procedure will ensure that all burials in these two cemeteries are treated with respect and in accordance with the wishes of identifiable descendants. The Cemetery Relocation Procedure will also ensure that state and county health and safety codes are followed for those interments that are relocated.

Content: Two dedicated cemeteries in the inundation area would be relocated to a site or sites approved for interment of human remains per requirements of the California Health and Safety Code (Sections 7500–7527). This procedure will be developed through consultation and coordination with descendants and other parties with demonstrated interest in the occupants of the cemeteries. The procedure will outline legal requirements, such as acquiring a written order from the local health department or county superior court before human remains may be moved, and other rules and regulations adopted by the board of health or health officer of the county.

Timing and Responsibility: The Authority and its qualified contractors will complete preparation of the Cemetery Relocation Procedure within 6 months of issuance of the NOD/ROD and adopt the procedure as part of the CRMP, and fully implement the procedure within 2 years of the first fee title acquisition by the Authority and prior to any soil disturbance in the area of the cemeteries and inundation of the reservoir.

2D.7.3 Burial Treatment Procedure

Purpose: The Authority and its qualified contractors will prepare a procedure for treating human remains and/or grave goods encountered during archaeological investigations, Project construction, or Project operations. The Burial Treatment Procedure will also identify ways to avoid or reduce the likelihood of encountering as yet unidentified burials.

Outcome: The Burial Treatment Procedure will ensure that the Authority and its contractors respond to unanticipated discovery of human burials with respect and in accordance with the wishes of identifiable descendants. The Burial Treatment Procedure will also ensure that state and county health and safety codes are followed for those interments that are relocated.

Content: This procedure will identify legal requirements and best practices for treating Native American and non-Native historic burials encountered outside of a dedicated cemetery. The Native American portion of the Burial Treatment Procedure will be developed in consultation with consulting Tribes and may include individual Tribes' burial treatment plans.

Timing and Responsibility: The Authority and its qualified contractors will complete preparation of the Burial Treatment Procedure within 6 months of issuance of the NOD/ROD, adopt the procedure as part of the CRMP prior to selection of the construction contractor, and fully implement the procedure within 2 years of the first fee title acquisition by the Authority and prior to any soil disturbance.

2D.7.4 Archaeological Treatment Procedure

Purpose: The Authority and its qualified contractors will prepare a procedure that provides a range of treatment options for archaeological resources identified as part of implementing the PIP and/or previously identified as NRHP/CRHR eligible.

Outcome: The Archaeological Treatment Procedure will ensure that all archaeological resources potentially affected by the Project will be treated according to best practices and professional standards, and that treatment options will include a range of interventions from avoidance and minimization of impacts to mitigation for the loss of the physical resource.

Content: The Archaeological Treatment Procedure will provide detailed guidance on the professional standards and best practices for a range of treatment types for avoiding and minimizing impacts to archaeological resources, as well as other treatments for how to record the significance of an archaeological site when impacts cannot be avoided or minimized. This procedure will identify when it is appropriate to prepare a resource-specific treatment plan(s) and establish the minimum contents and standards for such plans.

Timing and Responsibility: The Authority and its qualified contractors will complete preparation of the Archaeological Treatment Procedure within 6 months of issuance of the NOD/ROD, adopt the procedure as part of the CRMP and prior to the selection of the construction contractor, and fully implement the procedure within 2 years of the first fee title acquisition by the Authority and prior to any soil disturbance.

2D.7.5 Post-Review Discovery Procedure

Purpose: The Authority and its qualified contractors will prepare a procedure that identifies the critical path actions that must be followed if an unanticipated discovery of cultural materials occurs at any time during Project construction, operations, or maintenance.

Outcome: The Post-Review Discovery Procedure will ensure that any archaeological resources that are disturbed in the course of Project construction, operations, or maintenance will be assessed by qualified archaeologists prior to further ground-disturbing activities, and that treatment options for the avoidance, minimization, or mitigation of further disturbance are developed and applied prior to resumption of construction, operations, or maintenance activity.

Content: The Post-Review Discovery Procedure will specify the steps required for stopping work, assessing the find, coordinating with appropriate agencies or interested parties, developing appropriate treatment, and determining when construction or other activities can continue in the vicinity of any unanticipated discoveries of archaeological resources. This procedure will include a research design and guidance for evaluation and treatment of post-review archaeological discoveries.

Timing and Responsibility: The Authority and its qualified contractors will complete preparation of the Post-Review Discovery Procedure within 6 months of issuance of the NOD/ROD, adopt the procedure as part of the CRMP and prior to the selection of the construction contractor, and fully implement the procedure within 2 years of the first fee title acquisition by the Authority and and prior to the demolition of any structures or any soil disturbance.

2D.7.6 Archaeological Monitoring Procedure

Purpose: The Authority and its qualified contractors will prepare a procedure for the archaeological monitoring that will be performed during construction and on a cyclical basis during Project operations.

Outcome: The Archaeological Monitoring Procedure will ensure that qualified staff perform monitoring during construction and operations to identify any unanticipated discoveries and to implement the Post-Review Discovery Procedure.

Content: The Archaeological Monitoring Procedure will establish the methods and standards for when and how archaeological monitoring activities will be conducted, identify the roles and responsibilities of monitors and construction crews, and specify communication protocols and reporting requirements. This procedure will address monitoring required during construction, as well as a program for survey and monitoring during operations within the reservoir's fluctuation zones.

Timing and Responsibility: The Authority and its qualified contractors will complete preparation of the Archaeological Monitoring Procedure within 6 months of issuance of the NOD/ROD, adopt the procedure as part of the CRMP, fully implement the procedure within 2 years of the first fee title acquisition by the Authority and prior to the demolition of any structures or any soil disturbance, and implement any burial relocation plans/post-review discovery procedure included in the procedure prior to inundation of the reservoir.

2D.7.7 Built Environment Treatment Procedure

Purpose: The Authority and its qualified contractors will prepare a procedure that provides a range of treatment options for historic built environment resources identified as part of implementing the PIP and/or previously identified as NRHP/CRHR eligible.

Outcome: The Built Environment Treatment Procedure will ensure that all historic built environment resources potentially affected by the Project will be treated according to best practices and professional standards, and that treatment options will include a range of interventions from avoidance and minimization of impacts to mitigation for the loss of the physical resource.

Content: This Built Environment Treatment Procedure will provide detailed guidance on the professional standards and best practices for a range of treatment types for avoiding and minimizing impacts to historic built environment resources, as well as other treatments for how to mitigate for the loss of a resource when impacts cannot be avoided or minimized. This procedure will identify when it is appropriate to prepare a resource-specific treatment plan(s) and establish the minimum contents and standards for such plans. Examples of treatments may include but are not limited to feasible relocation of buildings from the inundation area, dust abatement for sensitive structures, protection and/or stabilization measures, Historic American Buildings Survey recordation, public interpretative and educational programs development including with local or regional museums.

Timing and Responsibility: The Authority and its qualified contractors will complete preparation of the Built Environment Treatment Procedure within 6 months of issuance of the NOD/ROD, adopt the procedure as part of the CRMP and prior to the selection of the construction contractor, and fully implement the procedure within 2 years of the first fee title acquisition by the Authority and prior to the demolition of any structures or any soil disturbance in areas documented to have historic built environment resources.

2D.7.8 Built Environment Monitoring, Protection, and Repair of Inadvertent Damage Procedure

Purpose: The Authority and its qualified contractors will prepare a procedure that defines best practices for monitoring historic built environment resources for potential damage caused by project construction or operations and maintenance activities. The procedure will also specify requirements for protection of such resources and required repair activities in the event of inadvertent damage resulting from Project activities.

Outcome: The Built Environment Monitoring, Protection, and Repair of Inadvertent Damage Procedure will ensure that qualified staff perform monitoring during Project construction and operations to identify any inadvertent damage and develop appropriate treatment plans for protection and repair where damage could not be avoided.

Content: This procedure will provide guidance for resource-specific condition assessments, monitoring, and responding to inadvertent damage during construction, including timing, responsible parties, and reporting requirements. Best practices to be included in the procedure include pre-construction condition assessments to establish baseline conditions; construction monitoring, including confirming any inadvertent damage should it occur; and treatment options for mitigating damage. The procedure will specify communication protocols and reporting requirements.

Timing and Responsibility: The Authority and its qualified contractors will complete preparation of the Built Environment Monitoring, Protection, and Repair of Inadvertent Damage Procedure within 6 months of issuance of the NOD/ROD, adopt the procedure as part of the CRMP and prior to the selection of the construction contractor, and fully implement the procedure within 2 years of the first fee title acquisition by the Authority and prior to the demolition of any structures or any soil disturbance in areas documented to have historic built environment resources.

2D.8 Recreation Management Plan

Purpose: The Authority will prepare a Recreation Management Plan to describe the types, management, maintenance and monitoring activities on all Project recreation lands and areas and describe the coordination with Glenn and Colusa Counties to provide emergency services at the recreational facilities.

Outcomes: Implementing the Recreation Management Plan will ensure the Authority safely manages recreational facilities in coordination with Glenn and Colusa County to ensure appropriate emergency response resources are available to respond to emergencies at the recreation areas.

Content: The Recreation Management Plan will:

- Define specific characteristics of the recreation areas and facilities expected to need emergency services and refine expected numbers of visitors based on the final design of the recreational facilities.
- Define and describe the expected needs of each emergency service provider based on the specific characteristics of the final design of recreation areas using standards such as the National Fire Protection Association 1710 Standard for the Organization and Deployment of Fire Suppression Operations.

- Develop different measures, including but not limited to funding of emergency response staff and purchasing equipment, to maintain appropriate service standards and response times based on the characteristics of the recreation areas.
- Annually evaluate emergency response times and performance standards once recreation areas are open and adjust measures accordingly.
- *Authority: insert more.*

Timing: The Authority will complete the Recreation Management Plan at least one year prior to the opening of Project recreational facilities.

2D.9 References

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From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/21/2021 5:07:12 PM
To: Luu, Henry [Henry.Luu@hdrinc.com]
CC: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: RE: Sites Project - Draft Feasibility Cost Estimate

Henry, I am cc'ing Ali on this email so she is aware of the county's concerns incase they come up in her conversations with them.

I understand what he is saying and it makes total sense if you are not in the weeds of the mitigation. The reality of it though is that whether its 11.5, 1 or 39 acers, in the current cost estimate the cost of the GGS mitigation is addressed by mitigation stacking, which means that the current cost for GGS aquatic or upland habitat is included into the Project's overall (e.g., larger) wetland or upland mitigation responsibilities that would be purchased at a mitigation bank (see table 1).

In addition to this, the 2016 costs had very few effects to wetland habitat identified (see Table 2), I'm not sure how they arrived at 0.5 acers of permanent impacts, but it was low considering Delevan. What the 2016 estimate did do, and Mike may not be aware of, was identify 122.9 acers of permanent effects to rice fields as that by far is the dominant landcover and GGS habitat in the Delevan alignment. However, as you can see from the below table, that amounted for only $7-$8.7M, which is not a significant contributor (e.g., "big ticket item") to the 2016 overall cost when compared to other habitat and/or species mitigation. I hope this helps, happy to jump[p on a call again to discuss.

Table 1: Current 2021 Mitigation

Mitigation Measure						
Number	**Name/Description**	**Quantity**	**Unit**	**Unit Price ($)**	**Total ($)**	***Comments***
WILD-1.19	Restore Temporarily Disturbed Giant Gartersnake Aquatic and Upland Habitat to Pre-Project Conditions (Modeled habitat: 21 acres aquatic habitat impact; 18 acres upland habitat impact)	39	EA	$ -	$ -	*Restoration of temporary impact areas to be covered under Construction phase.*
WILD-1.20	Compensate for Permanent and Temporary Losses of Giant Gartersnake Aquatic and Upland Habitats (Modeled habitat: 2 acres aquatic habitat impact; 26 acres upland habitat impact)	28	EA	$ -	$ -	*Assumes aquatic habitat mitigation for permanent impacts to be stacked with emergent wetland bank credits. Assumes mitigation for permanent upland habitat impacts to be stacked with upland credits for other species.*

Table 2: From 2016 mitigation cost memo:

Vegetation/Habitat Type	State-Federally-Listed Species Associations within Primary Study Area[1,2,3,4,5,6,7,8]	Acreage		Assumptions for Mitigation Approach (On-site/Off-site)	Anticipated Mitigation Ratio		Estimated Mitigation Acreage	Estimated Cost/Acre	Mitigation Cost	
		Permanent Loss	Temporary Disturbance	Restoration/Mitigation Banking	Permanent Loss	Temporary Disturbance				
Fresh emergent wetland	GGS; CRLF; GSC4 GE	0.5	18.5		3:1 for GGS*	1:1 for GGS*	20.0	100k to 150k	$240,000 low	$1,800,000 high
Rice	GGS	122.9	1,383.6	assume all rice suitable GGS habitat	3:1 for GGS*	1:1 for GGS*	1,752.3	$4,000 to 5,000/acre	$7,009,200 low	$8,761,500 high

John Spranza

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From: Luu, Henry <Henry.Luu@hdrinc.com>
Sent: Monday, June 21, 2021 2:23 PM
To: Spranza, John <John.Spranza@hdrinc.com>
Subject: FW: Sites Project - Draft Feasibility Cost Estimate

FYI

Henry H. Luu, PE
D 916.679.8857 M 916.754.7566

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From: Michael Azevedo <mjazevedo@countyofcolusa.com>
Sent: Monday, June 21, 2021 2:19 PM
To: Rob Kunde <rkunde@wrmwsd.com>; Jerry Brown <jbrown@sitesproject.org>
Cc: Luu, Henry <Henry.Luu@hdrinc.com>
Subject: RE: Sites Project - Draft Feasibility Cost Estimate

Thanks Rob,

Kinda on point....kinda not.

I missed the lack of "big ticket items" discussion and tech memo, I'll try to be more observant. My issue is just focused on one species, giant garter snake, we've gone from 11.5 miles of affected habitat to approximately 1 mile (conservatively) of GGS habitat. Given the County's previous experience in dealing with giant garter snake mitigation in conjunction with bridge replacement projects here in the Sac Valley, I am dubious the delta between the pre and post Value Planning mitigation estimate is less than 10%.

Thanks for the additional detail. Again, I'll strive to be more observant going forward.

Michael J Azevedo

Colusa County Public Works
530.458.0466

From: Rob Kunde <rkunde@wrmwsd.com>
Sent: Monday, June 21, 2021 11:38 AM
To: Michael Azevedo <mjazevedo@countyofcolusa.com>; Jerry Brown <jbrown@sitesproject.org>
Cc: Luu, Henry <Henry.Luu@hdrinc.com>
Subject: Re: Sites Project - Draft Feasibility Cost Estimate

Mike:

The Value Planning mitigation cost estimate was $540M (no Delevan pipeline). During VP (spring 2020), I asked John Spranza to identify if there were big ticket items that would change the cost estimate by 10%. The answer was there were not any such items identifiable at that time.

Since then, both engineering and mitigation costs have been updated to reflect new information. The current mitigation cost estimate is $562M. This is not a significant change from Value Planning (+ 5%). Spranza says this estimate is conservative since the habitat surveys have been aerial only which usually overestimate mitigatable habitat compared to ground surveys. I seem to recall a Technical Memorandum on the subject was provided to the EP&P Work Group. Or maybe is was a PowerPoint presentation.

So, I don't think the updated cost estimate is "status quo" relative to Value Planning. Staff have updated the information and cost. There is still habitat and species uncertainty (but less uncertainty than with Value Planning). But the resulting cost estimate is not significantly different than Value Planning.

Is this on point with your email below?

Robert J. Kunde, P.E.
Retired Annuitant
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From: Michael Azevedo <mjazevedo@countyofcolusa.com>
Sent: Monday, June 21, 2021 7:43 AM
To: Jerry Brown <jbrown@sitesproject.org>
Cc: Luu, Henry <Henry.Luu@hdrinc.com>; Rob Kunde <rkunde@wrmwsd.com>
Subject: RE: Sites Project - Draft Feasibility Cost Estimate

Thanks for the info Jerry.

Recently (believe it was coordinating committee call) I questioned the mitigation cost not being adjusted for the Delevan pipeline and Mr. Kunde correctly reminded me the Delevan Pipe line was stricken from consideration at the onset of the Value Planning effort. However, after reviewing my notes and consulting Supervisor Evans, it seems to us the cost of mitigation "was to be status qou due to habitat and species uncertainty". Is our recollection correct?

Michael J Azevedo
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From: Jerry Brown <jbrown@sitesproject.org>
Sent: Monday, June 21, 2021 6:52 AM
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Subject: Re: Sites Project - Draft Feasibility Cost Estimate

Reservoir Committee Participants –

Recently, the following two additional items were added to the participant web portal (https://sitesproject.org/participant-portal-documents/) for your use:
1. Final draft of the 2021 mitigation cost update memo – This document includes the requested rationale for the increases in key resource areas as compared to the mitigation cost estimate used on the 2019 Value Planning study.
2. 2021 Feasibility Cost Estimate Fact Sheet – This document is being used to communicate with community leaders and other members of the public on the 2021 Feasibility Cost Estimate. This is in addition to the communication messages that were previously sent to you in the email below and were posted for your use in communicating to your senior management and boards/councils. The information is similar, but reformatted to a fact sheet.
Please don't hesitate to reach out to me or Henry Luu (henry.luu@hdrinc.com) if there is anything else you need in this regard.

Jerry

From: Jerry Brown <jbrown@sitesproject.org>
Date: Tuesday, June 8, 2021 at 3:53 PM

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Subject: Sites Project - Draft Feasibility Cost Estimate

Reservoir Committee Participants,

As you know, the project team has been working with Reservoir Committee workgroups over the past 3 months to develop a feasibility design cost estimate that incorporates the latest design information and value engineering options for the project alternatives. The final feasibility cost estimate is scheduled to be considered for acceptance at this month's Joint Reservoir Committee/Authority Board meeting on June 23, 2021.

This work has resulted in a feasibility design cost estimate increase of ~30% (in 2021 dollars) over the appraisal level cost estimate that came out of value planning. To assist you in communicating the cost changes to your agency's management, boards and councils the project team has put together the attached communications messages. We're getting these to you in advance of the June 23 meeting so that your internal communications can occur prior to the public release of the estimate. Also, for those of you seeking additional details about the cost estimate, we have placed the following reference documents on the participant web portal (https://sitesproject.org/participant-portal-documents/):

1. Feasibility Design Considerations TM – a brief summary of the Sites Project Authority feasibility design and considerations.
2. HR Feasibility Cost Estimate TM – basis of feasibility cost estimate for the reservoir and roadway project features.
3. HC Feasibility Design Basis of Estimate – basis of feasibility cost estimate for the conveyance project features.

As a reminder, the project cost estimate is one of several factors that affect the project's affordability. The project team will present all the updated information around affordability at our July 23 affordability workshop.

Please don't hesitate to reach out to me or Henry Luu (henry.luu@hdrinc.com) if there is anything else you need in this regard.

Jerry

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Annex to the Operations Term Sheet
Between Reclamation, DWR, and the Sites Project Authority

Carriage Water Annex
Dated July 5, 2021

Approach to Carriage Water

The Sites Project Authority (Authority) would operate the Sites Reservoir Project (Sites) in coordination with the SWP and CVP. In most years, Sites would release water to the Sacramento River or the Yolo Bypass. Sites releases to the Sacramento River for South of Delta water uses, through pumping at the SWP Banks Pumping Plant and CVP Jones Pumping Plant, would typically occur in Dry and Critically Dry years. In most years, Sites would also release water to the Delta through the Yolo Bypass for habitat benefits. As such, Sites operations would modify Delta flows in most years by changing Sacramento River at Freeport flow, Yolo Bypass flow, South of Delta Exports, and/or Delta outflow.

Considering long-term operations, Sites releases are unique to carriage water calculations because:

- Sites reliably influences Delta flows.
    - There are several years when Sites releases increase Delta outflow, improving Delta water quality.
- The ultimate fate of Sites releases to the Yolo Bypass (for Prop 1 environmental benefit) is Delta outflow which would reliably benefit Delta water quality in late-Summer and Fall of Wet and Above Normal years.
    - Sites continues to control the Sites water upon release from the Yolo Bypass back to the Delta.
    - The return of Sites Yolo Bypass releases to the Delta positively affect SWP and CVP operations through increased delivery or increased North of Delta storage.
- Sites provides inflows to the Delta at two locations when transferring water South of Delta: Yolo Bypass and Sacramento River.
    - Delta water quality benefits, per unit volume of release, are dependent on Delta inflow location (Freeport versus Yolo Bypass). Per incremental increase, inflows from Yolo Bypass yield greater water quality benefits than inflows from Freeport.
- Reliability of Sites operations in July and August of Dry years could allow the SWP and CVP to more aggressively operate San Luis Reservoir. Modified operations of San Luis have not been modeled and, therefore, are not yet included in the method outlined below.

Delta Water Quality Effects of Sites

As described above, Sites operations affect Sacramento River at Freeport flow, Yolo Bypass flow, South of Delta Exports, and/or Delta outflow. Sites operations, as it relates to the Delta, can be organized into three categories: (1) export years, (2) export and outflow years, and (3) outflow years. Years when Sites only releases water into the Sacramento River for export to South of Delta storage partners are described as export years. Years when Sites releases water into the Sacramento River for export to South of Delta storage partners and releases water into the Yolo Bypass are described as export and outflow years, as it is assumed that the ultimate fate of releases to Yolo Bypass is Delta outflow. Years when Sites only releases water into the Yolo Bypass for Delta outflow are described as outflow years. A summary table of these year categories is below (Table 1).

Year Category	Sacramento River at Freeport Flow	Yolo Bypass Flow
Export	Sites releases water to Sacramento River for export to South of Delta storage partners	Limited or no change
Export and Outflow	Sites releases water to Sacramento River for export to South of Delta storage partners	Sites releases water to Yolo Bypass for Delta outflow
Outflow	Limited or no change	Sites releases water to Yolo Bypass for Delta outflow

Table 1. Summary of Sites Delta Operations

In export years, Sites releases water to the Sacramento River for export at the South Delta. In accordance with non-project water transfers, a portion of the water released to the Sacramento River at Freeport is assumed to be dedicated to Delta outflow to maintain Delta water quality as it would have been in the “without-transfer” conditions. The volume of water dedicated to Delta outflow is described as carriage water.

In export and outflow years, Sites releases water to the Sacramento River and Yolo Bypass. Similar to export years, a volume of water must be dedicated to Delta outflow to offset Delta water quality changes caused by increased South of Delta exports. The volume of water dedicated for Delta outflow may fully or partially be comprised of Sites releases to Yolo Bypass. If the Delta outflow requirement exceeds the volume of Delta inflow from Sites release to Yolo Bypass, a portion of the water released to the Sacramento River would be dedicated to Delta outflow as carriage water.

During outflow years, when Sites releases water for Delta outflow without increasing Delta exports, Delta water quality improves. SWP and CVP operations could benefit from these operations by increasing exports or increasing North of Delta storage (through reduction of releases dedicated to Delta outflow). These actions, individually or combined, would counteract Delta water quality improvements caused by Sites releases to Delta outflow. In these years, Sites may attain a quantifiable carriage water benefit as opposed to incurring a carriage water cost.

Carriage water is expressed as a volume of water (in AF) dedicated to Delta outflow to offset water quality effects of increased Delta exports, or as a volumetric improvement (in AF) to SWP and CVP storage or exports. As such, carriage water may be a positive or negative value. A positive value represents the volume of water dedicated to Delta outflow. A negative value represents improvements to the SWP and CVP.

If Sites provides 100 acre-feet (AF) as Delta inflow from the Sacramento River at Freeport, and 30 AF is needed to offset the incremental increase in Delta water quality, then the remaining 70 AF of the water is available for export. In this case, the assessment of carriage water as a percentage of Sites release to the Sacramento River would be 30 percent (30/100). In other words, 30 percent of the Sites release would be used to maintain Delta salinity conditions as it would have been absent the 100 AF release. If Sites releases 30 AF for Delta outflow, then the carriage water benefit is calculated as the resulting increase in SWP and CVP export and/or storage. Per the example above, this may be as high as 70 AF. During these years, DWR and Reclamation increase Sites deliveries or carryover amount in the SWP and/or CVP to compensate Sites for its benefits to operations.

Pre-Transfer Carriage Water Estimation for Sites Reservoir Releases

Before the water transfer window (July – November) opens, the Authority estimates the carriage water that will be associated with Sites releases and exports. The Authority develops the carriage water estimate, separate from non-Sites transfers, using an estimated amount of release and export water with an assumed pattern, forecasted hydrology, and forecasted operations through the steps below. After the Authority calculates the Sites carriage water volume, DWR then calculates carriage water for non-Sites transfers. A two-step process is required to properly account for and credit Sites contribution to Delta outflow.

1. Perform a DSM2 simulation for a baseline scenario to represent salinity conditions (expressed as electrical conductivity, or EC) that would have occurred absent Sites releases and transfers while meeting all regulatory requirements.
2. Perform a DSM2 simulation for a Sites release and/or export scenario with assumed Sites carriage water. Sites carriage water calculations consider Sites releases to Yolo Bypass for Proposition 1 Ecosystem Benefits. As such, Sites carriage water is the sum of additional Delta inflow at Freeport and the Yolo Bypass. See the Yolo Bypass Inflow Assumptions section regarding Sites releases to the Yolo Bypass.
3. Compare salinity results of the baseline (Step 1) to the with-transfers scenario

(Step 2) at Jersey Point, Bethel Island, and Bacon Island (or Holland Island). These three locations provide a good representation of interior Delta salinity conditions that often control the Projects operations.

4. Repeat Step 2 and Step 3 by adjusting the Sites carriage water (release to Delta outflow during years of Sites transfers, or SWP/CVP exports and/or storage during years of Sites release to Delta outflow) until the results of Step 2 show minimal EC differences from the results of Step 1.

Three stations, Jersey Point, Bethel Island, and Bacon Island (or Holland Island) have been identified to represent Delta locations with salinity standards or markers that often control Delta water operations (e.g., the 250 mg/l chloride standard at Contra Costa Canal in D-1641). The station with the highest carriage water percentage is controlling. For example, if 20 percent carriage water is needed to maintain the same salinity at Jersey Point, 25 percent at Bethel Island, and 30 percent at Bacon Island, then 30 percent is the estimated carriage water. Selecting less than 30 percent would result in impacts to the Projects through export reduction and/or additional reservoir releases to ensure that Bacon Island salinity is not affected by the water quality degradation from facilitating non-Project transfers.

After determining the estimated carriage water, DWR and Reclamation apply the estimation to Sites releases and exports during the transfer window to address the effects of the antecedent water quality conditions to compliance concerns.

Final Carriage Water Determination at Conclusion of Transfer Season

Once the water transfer season is over, data collected during the water transfer period are used to develop a final carriage water value based on the actual conditions. The steps to develop a final Sites carriage water value are provided below. Similar to estimating carriage water volume, DWR calculates carriage water for non-Sites transfers after the Authority calculates a final Sites carriage water volume.

1. Perform a DSM2 simulation with actual data for with-transfer inflows and exports during the transfer period.
2. Perform a DSM2 simulation for a without-transfer scenario with hypothetical exports and Delta inflows:

   Without-transfer inflows = Actual inflow – (Actual Sites transfer amount into Delta + Sites Releases to Yolo Bypass)

   Without-transfer export = Actual pumping – (1 – estimated carriage water percentage) × (Actual Sites transfer amount into Delta + Sites Release to Yolo Bypass)

3. Compare salinity results of the actual with-transfer conditions (Step 1) to the estimated without-transfer conditions (Step 2) at Jersey Point, Bethel Island, and

Bacon Island.

4. Repeat Step 2 and Step 3 by adjusting the carriage water percentage until the results of Step 2 show minimal EC differences from the results of Step 1. This is the final carriage water percentage.

As stated previously, the station with the highest carriage water percentage controls the final carriage water determination.

Carriage Water Accounting and Adjustments for Sites Transfers

For Sites transfers, carriage water volume is adjusted when final carriage water value differs from the estimated value. There are two scenarios in which adjustments may be made to the accounting for the Sites transfer water that was delivered to a Sites Storage Partner:

1. If the final carriage water volume is higher than the estimated carriage water, then the adjustment is to show DWR delivered more transfer water to Sites storage partners. The Authority reduces the storage partner's storage volume to compensate for the adjustment. There is no change to the actual overall quantity of water delivery for that year.
2. If the final carriage water is lower than the estimated carriage water, then the adjustment is to show DWR delivered more transfer water to the Sites storage partners, and the Sites storage partners received less Sites water. DWR increases the storage partner's carryover storage to compensate for the adjustment. There is no change to the actual overall quantity of water delivery for that year.

Yolo Bypass Inflow Assumptions

As noted above, Sites would release water to the Delta through the Yolo Bypass for habitat benefits. A loss factor is assumed for the routing of water from Sites Reservoir through the Colusa Basin Drain and Knights Landing Ridge Cut to the Yolo Bypass. Current modeling assumes a routing loss factor is estimated at 13 percent. As the Sites Project progress, a detailed study, estimating losses in the Colusa Basin Drain, Knights Landing Ridge Cut, and Yolo Bypass, is required to accurately measure Delta inflow increases that result from Sites releases to the Yolo Bypass.

Annex to the Operations Term Sheet
Between Reclamation and the Sites Project Authority

POWER GENERATION AND USE
Dated July 5, 2021

Covering the Coordinated Operations of the Central Valley Project and Sites Reservoir Project

The following table (Table 1) describes each of the locations upstream of the Delta where Sites water will be conveyed by the Sites Project Authority. For the purposes of this document, Sites water refers to water pumped, conveyed, and put to beneficial use under the Sites Project Authority's water right. Reclamation also continues to explore additional Federal involvement, including the use of Sites Reservoir to re-divert CVP water. Using Sites to re-divert CVP water would require an amendment to this annex. The table summarizes which types of power may be used based on the ownership of the facility. The table also identifies the season in which the facility would primarily be used.

Table 1. Description of power use by type of water and season.

Season of Use*	Condition	Location (attached flow chart)	Key terms of Agreement
Excess Conditions (late winter/spring)	1. Power use pumping *Sites water* into the TC and GC canals.	① ②	a. Red Bluff Pumping Plant (RBPP) – Current WAPA power service to be used to pump Sites water to all Sites Participants. If required by WAPA, pumping related to Sites water supplied with market power through separate PLOA with WAPA. PLOA with WAPA would cover Warren Act requirements. b. Hamilton City Pumping Plant (HCPP) – Current PG&E service to be used to pump Sites water for all Sites Participants. Power supply would come through GCID's participation in the Power and Water Resources Pooling Authority (PWRPA). This power use would be covered under Facilities Use Agreement

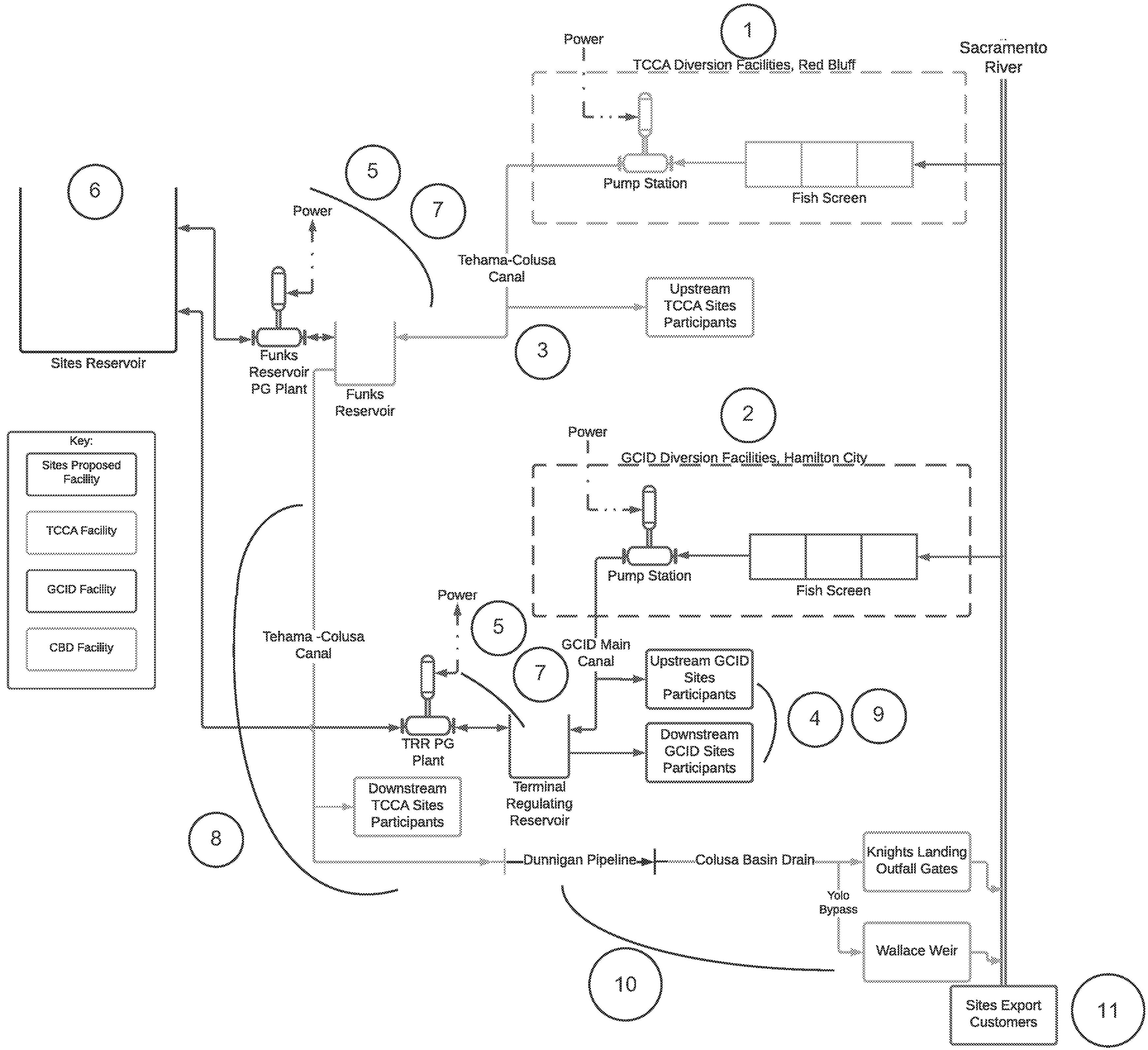
			between Sites Authority and GCID. c. Scheduling Power - WAPA is scheduling coordinator through Cal-ISO for power deliveries to RBPP. PWRPA is scheduling coordinator through Cal-ISO for power deliveries to HCPP. Sites Authority agreement with WAPA and GCID/PWRPA to cover use of facilities and scheduling services with an acceptable accounting procedure.
Excess Conditions (late winter/spring)	2. Power use conveying *Sites Water* within TC and GC canals to the Sites Reservoir	③ ④	a. TC Canal – Current WAPA power service to be used. Sites Authority agreement with WAPA to cover any power use above baseline without Sites project conditions. This power use would be covered under PLOA between Sites Authority and WAPA for pumping. b. GC Canal – Current PG&E service to be used with power supply provided through GCID's participation in PWRPA and under Facility Use Agreement between Sites Authority and GCID.
Excess Conditions (late winter/spring)	3. Power use related to pumping *Sites water* from the TC and GC canals into the Sites Reservoir	⑤	a. Funks PGP and Terminal Regulating Reservoir PGP – New power service from PGE or WAPA (tbd) with the Sites Authority. b. Administration and Maintenance Buildings - New power service from P&GE or WAPA (tbd) with the Sites Authority. c. Dam and Recreation Facilities - New power service from P&GE

		⑥	or WAPA (tbd) with the Sites Authority.
Balanced conditions with available export capacity/reservoirs operating for exports and other demands (summer/early fall)	4. Power generation related to releasing *Sites water* to the TC and GC Canals.	⑦	a. Funks PGP Generator – Generated power wheeled to Sites power provider via reverse metering (assumed) through PG&E or WAPA (tbd) power service provider. b. TRR Generator - Generated power wheeled to Sites power provider via reverse metering (assumed) through power service through PG&E or WAPA (tbd) power service provider.
Balanced conditions with available export capacity/reservoirs operating for exports or conservation (fall/early winter)	5. Power use related to conveying *Sites water* to water users on the TC and GC Canals.	⑧ ⑨	a. TC Canal – Current WAPA power service to be used. Sites Authority agreement with WAPA to cover any power use above baseline without Sites project conditions. This power use would be covered under PLOA between Sites Authority and WAPA for pumping. b. GC Canal – Current PG&E service to be used with power supply provided through GCIDs participation in PWRPA and under Facility Use Agreement between Sites Authority and GCID. c. To NOD Refuges – Conveyance and power supply provided under current wheeling agreement between GCID and Reclamation. d. Reclamation payment for its share of power use could occur through an energy

			exchange at federal facilities or O&M cost reimbursement.
	6. Power use related to conveying *CVP water* to water users on the TC and GC Canals.		a. Use of project use power directly at the TC Canal and through energy exchange at the GC Canal.
Balanced conditions with available export capacity/reservoirs operating for exports or conservation (fall/early winter)	7. Power use related to conveying *Sites water* from the Dunnigan Pipeline turnout at the TC Canal to the Knights Land Outfall Gate.	⑩	a. Metering and monitoring – New power service from PG&E by the Sites Authority. b. Reclamation payment for its share of power use could occur through an energy exchange at federal facilities or O&M cost reimbursement.
	8. Power use related to conveying *CVP water* from the Dunnigan Pipeline turnout at the TC Canal to the Knights Land Outfall Gate.		a. Metering and monitoring – Energy exchange with Reclamation to offset market power use at federal facilities.
Balanced conditions with available export capacity/reservoirs operating for exports or conservation (fall/early winter)	9. Power use related to conveying *Sites water* through the Delta and export pumping through the Jones Pumping Plant		a. To CVP and SWP Contractor – Power provided under Warren Act contract between Sites Participant and Reclamation. b. To IL4 Refuge – To be determined
	10. Effects of water exchange between Sites Authority and		a. To be considered, evaluated, and resolved on a case-by-case basis and incorporated as appropriate in terms and

	Reclamation on power generation at CVP facilities.		conditions of exchange agreement.

*Shown for reference only. Power Usage in the shoulder periods is possible but not shown here.



1
Power
TCCA Diversion Facilities, Red Bluff
Sacramento River
Pump Station
Fish Screen
5
7
6
Power
Tehama-Colusa Canal
Upstream TCCA Sites Participants
Sites Reservoir
Funks Reservoir PG Plant
Funks Reservoir
3
2
Power
GCID Diversion Facilities, Hamilton City
Key:
Sites Proposed Facility
TCCA Facility
GCID Facility
CBD Facility
Pump Station
Fish Screen
Power
5
Tehama -Colusa Canal
7
GCID Main Canal
Upstream GCID Sites Participants
4
9
TRR PG Plant
Downstream GCID Sites Participants
Downstream TCCA Sites Participants
Terminal Regulating Reservoir
8
Dunnigan Pipeline
Colusa Basin Drain
Knights Landing Outfall Gates
Yolo Bypass
Wallace Weir
10
Sites Export Customers
11

From: Laurie Warner Herson [laurie.warner.herson@phenixenv.com]
Sent: 6/22/2021 4:37:57 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Heydinger, Erin [erin.heydinger@hdrinc.com]
CC: Spranza, John [john.spranza@hdrinc.com]
Subject: RE: Prop 1 Projects | DWR CEQA Analysis

Will do – I'm excited to see what they conclude.

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, June 22, 2021 4:22 PM
To: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Heydinger, Erin <erin.heydinger@hdrinc.com>
Cc: Spranza, John <john.spranza@hdrinc.com>
Subject: FW: Prop 1 Projects | DWR CEQA Analysis

Hi Laurie and Erin – See below and attached. We need to review this and get comments back to Jerry on July 20.

Laurie – can you skim this and provide any comments you have?

Erin – Can you read the Sites description carefully to make sure they have characterized the project correctly and have the correct modeling information in here?

John – Including you for awareness.

The file is on SharePoint
here: https://sitesreservoirproject.sharepoint.com/:f:/r/envpermitting/Confidential/WSIP%20Benefits%20Agreement/DWR%20Prop%201%20Cumulative%20Assessment?csf=1&web=1&e=KYWPWe

Please make all changes in track changes and comment bubbles.

Thanks all!

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 |
aforsythe@sitesproject.org | www.SitesProject.org

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Tuesday, June 22, 2021 10:40 AM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Cc: Marcia Kivett <MKivett@sitesproject.org>
Subject: FW: Prop 1 Projects | DWR CEQA Analysis

Ali – Lets discuss during our 1v1 this week.

I read through this report. Nothing in particular stands out for me however I think we need to have someone on the Sites team familiar with all of the current diversion and releases numbers to go through their description for Sites and verify that they are using is current and correct information.

Also if you have any concerns with their conclusions as it relates to Sites we should articulate those in our comments.

Note that comments are due back to Dave O by July 23.

Thanks

Marcia – please give me a reminder 3 days prior to due date

From: "Okita, David@DWR" <David.Okita@water.ca.gov>
Date: Tuesday, June 22, 2021 at 7:08 AM
To: Sylvie Lee <slee@ieua.org>, "Cowin, Mark" <mcowin@geiconsultants.com>, Paul Weghorst <Weghorst@irwd.com>, Marguerite Patil <mpatil@ccwater.com>, Fiona Sanchez <sanchezf@irwd.com>, Jerry Brown <jbrown@sitesproject.org>, Terrie Mitchell <mitchellt@sacsewer.com>, "chakes@valleywater.org" <chakes@valleywater.org>, "mbeuhler@wswaterbank.com" <mbeuhler@wswaterbank.com>, "Young, Amy@DWR" <Amy.Young@water.ca.gov>, "Yun, Joseph@DWR" <Joseph.Yun@water.ca.gov>, Dave Richardson <drichardson@woodardcurran.com>, "Uttley, Paige@Wildlife" <Paige.Uttley@wildlife.ca.gov>, "Davis-Fadtke, Kristal@Wildlife" <Kristal.Davis-Fadtke@wildlife.ca.gov>
Cc: "Melton, Holly" <hmelton@kcwa.com>, Craig Wallace <cwallace@kcwa.com>, Steve Arakawa <sarakawa@mwdh2o.com>, "Chilmakuri, Chandra@SWC" <cchilmakuri@swc.org>, Brandon Goshi <bgoshi@mwg2o.com>, Dwayne Chisam <dchisam@avek.org>, "Laura J. Hidas (laura.hidas@acwd.com)" <laura.hidas@acwd.com>, Amparo Flores <aflores@zone7water.com>, Cindy Kao <ckao@valleywater.org>, "'Rob Kunde (rkunde@wrmwsd.com)'" <rkunde@wrmwsd.com>
Subject: Re: Prop 1 Projects | DWR CEQA Analysis

Attached is the draft cumulative flow analysis for the WSIP projects. Please review carefully that we have described your project correctly. To save time, we did not have AECOM contact each project directly, we relied on past information and this is the opportunity to make updates and corrections. The challenge is that the projects have evolved since the application stage so we may not have captured the most recent numbers. Our thought was that we would show you the format of the analysis, then seek conformation of the numbers.

Although this is being done through the contract for the CEQA Initial Study for the pulse flow projects and DWR actions on the Emergency Supply WSIP public benefits, it may or may not be used in the Initial Study and subsequent CEQA documents pending further review. We will also make a decision on whether additional flow modeling or analysis is necessary. This is not a cumulative analysis of all impacts of the WSIP projects, just flow impacts to the Feather River, the Sacramento River and the Delta.

Please provide comments by July 23. DWR will be participating in a workshop with the State Water Contractors at the end of July and will be sharing general results of this analysis.

David Okita, PE
Department of Water Resources

530 902-7588

From: Jerry Brown [jbrown@sitesproject.org]
Sent: 6/23/2021 7:27:15 AM
To: Michael Azevedo [mjazevedo@countyofcolusa.com]; Rob Kunde [rkunde@wrmwsd.com]
CC: Luu, Henry [Henry.Luu@hdrinc.com]; Alicia Forsythe [aforsythe@sitesproject.org]
Subject: Re: Sites Project - Draft Feasibility Cost Estimate

Mike – we still owe Land Mgmt Cmte a line by line review of the mitigation cost estimate. I believe a meeting is being scheduled next month for this and other items. We can drill down into this issue as part of that review.

Jerry

From: Michael Azevedo <mjazevedo@countyofcolusa.com>
Date: Monday, June 21, 2021 at 2:19 PM
To: Rob Kunde <rkunde@wrmwsd.com>, Jerry Brown <jbrown@sitesproject.org>
Cc: "Luu, Henry" <Henry.Luu@hdrinc.com>
Subject: RE: Sites Project - Draft Feasibility Cost Estimate

Thanks Rob,

Kinda on point....kinda not.

I missed the lack of "big ticket items" discussion and tech memo, I'll try to be more observant. My issue is just focused on one species, giant garter snake, we've gone from 11.5 miles of affected habitat to approximately 1 mile (conservatively) of GGS habitat. Given the County's previous experience in dealing with giant garter snake mitigation in conjunction with bridge replacement projects here in the Sac Valley, I am dubious the delta between the pre and post Value Planning mitigation estimate is less than 10%.

Thanks for the additional detail. Again, I'll strive to be more observant going forward.

Michael J Azevedo
Colusa County Public Works
530.458.0466

From: Rob Kunde <rkunde@wrmwsd.com>
Sent: Monday, June 21, 2021 11:38 AM
To: Michael Azevedo <mjazevedo@countyofcolusa.com>; Jerry Brown <jbrown@sitesproject.org>
Cc: Luu, Henry <Henry.Luu@hdrinc.com>
Subject: Re: Sites Project - Draft Feasibility Cost Estimate

Mike:

The Value Planning mitigation cost estimate was $540M (no Delevan pipeline). During VP (spring 2020), I asked John Spranza to identify if there were big ticket items that would change the cost estimate by 10%. The answer was there were not any such items identifiable at that time.

Since then, both engineering and mitigation costs have been updated to reflect new information. The current mitigation cost estimate is $562M. This is not a significant change from Value Planning (+ 5%). Spranza says this estimate is conservative since the habitat surveys have been aerial only which usually overestimate mitigatable habitat compared to ground surveys. I seem to recall a Technical Memorandum on the subject was provided to the EP&P Work Group. Or maybe is was a PowerPoint presentation.

So, I don't think the updated cost estimate is "status quo" relative to Value Planning. Staff have updated the information and cost. There is still habitat and species uncertainty (but less uncertainty than with Value Planning). But the resulting cost estimate is not significantly different than Value Planning.

Is this on point with your email below?

Robert J. Kunde, P.E.
Retired Annuitant
Wheeler Ridge-Maricopa Water Storage District
cell: 661-345-3719 email: rkunde@wrmwsd.com

From: Michael Azevedo <mjazevedo@countyofcolusa.com>
Sent: Monday, June 21, 2021 7:43 AM
To: Jerry Brown <jbrown@sitesproject.org>
Cc: Luu, Henry <Henry.Luu@hdrinc.com>; Rob Kunde <rkunde@wrmwsd.com>
Subject: RE: Sites Project - Draft Feasibility Cost Estimate

Thanks for the info Jerry.

Recently (believe it was coordinating committee call) I questioned the mitigation cost not being adjusted for the Delevan pipeline and Mr. Kunde correctly reminded me the Delevan Pipe line was stricken from consideration at the onset of the Value Planning effort. However, after reviewing my notes and consulting Supervisor Evans, it seems to us the cost of mitigation "was to be status qou due to habitat and species uncertainty". Is our recollection correct?

Michael J Azevedo
Colusa County Public Works
530.458.0466

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Monday, June 21, 2021 6:52 AM
To: 'fhernandez@cityofamericancanyon.org' <fhernandez@cityofamericancanyon.org>; 'DChisam@avek.org' <DChisam@avek.org>; 'BenCarter@succeed.net' <BenCarter@succeed.net>; 'RCheng@cvwd.org' <RCheng@cvwd.org>; Michael Azevedo <mjazevedo@countyofcolusa.com>; 'CCwd2@frontiernet.net' <CCwd2@frontiernet.net>; 'MKrause@dwa.org' <MKrause@dwa.org>; 'TBettner@gcid.net' <TBettner@gcid.net>; 'weghorst@irwd.com' <weghorst@irwd.com>; 'RNeudeck@mwdh2o.com' <RNeudeck@mwdh2o.com>; 'WVanderwaal@rd108.org' <WVanderwaal@rd108.org>; 'dbartel@rrbwsd.com' <dbartel@rrbwsd.com>; 'BobT@sbvmwd.com'

<BobT@sbvmwd.com>; 'jdavis@sgpwa.com' <jdavis@sgpwa.com>; 'CKao@valleywater.org' <CKao@valleywater.org>; 'DMarks@SCVWA.org' <DMarks@SCVWA.org>; 'JimP@chiconut.com' <JimP@chiconut.com>; 'Jamie@tnpfarms.com' <Jamie@tnpfarms.com>; 'WVanderwaal@rd108.org' <WVanderwaal@rd108.org>; 'Zachary@CanalFarms.com' <Zachary@CanalFarms.com>; 'flylegacy@yahoo.com' <flylegacy@yahoo.com>; 'RKunde@wrmwsd.com' <RKunde@wrmwsd.com>; 'AFlores@zone7water.com' <AFlores@zone7water.com>; 'JHolley@cityofamericancanyon.org' <JHolley@cityofamericancanyon.org>; 'rhendryx@cityofamericancanyon.org' <rhendryx@cityofamericancanyon.org>; 'DFlory@ppeng.com' <DFlory@ppeng.com>; 'AnnCarter4@comcast.net' <AnnCarter4@comcast.net>; 'kccarter13@gmail.com' <kccarter13@gmail.com>; 'ccmp503@gmail.com' <ccmp503@gmail.com>; 'pvasileva@cvwd.org' <pvasileva@cvwd.org>; 'JBarrett@cvwd.org' <JBarrett@cvwd.org>; 'sbermudez@cvwd.org' <sbermudez@cvwd.org>; 'skasumovic@cvwd.org' <skasumovic@cvwd.org>; Gary Evans <gevans@countyofcolusa.com>; Ann Nordyke <boardclerk@countyofcolusa.com>; '1cjm@frontiernet.net' <1cjm@frontiernet.net>; 'SBaca@dwa.org' <SBaca@dwa.org>; 'SJohnson@dwa.org' <SJohnson@dwa.org>; 'hdawley@gcid.net' <hdawley@gcid.net>; 'KHightower@gcid.net' <KHightower@gcid.net>; 'welch@irwd.com' <welch@irwd.com>; 'vanderpl@irwd.com' <vanderpl@irwd.com>; 'NHawk@mwdh2o.com' <NHawk@mwdh2o.com>; 'LBair@RD108.org' <LBair@RD108.org>; 'mmisuraca@rrbwsd.com' <mmisuraca@rrbwsd.com>; 'HeatherD@sbvmwd.com' <HeatherD@sbvmwd.com>; 'josem@sbvmwd.com' <josem@sbvmwd.com>; 'leckhart@sgpwa.com' <leckhart@sgpwa.com>; 'ELeitterman@valleywater.org' <ELeitterman@valleywater.org>; 'scole@SCVWA.org' <scole@SCVWA.org>; 'Jamie@tnpfarms.com' <Jamie@tnpfarms.com>; 'jspoonerfarms@gmail.com' <jspoonerfarms@gmail.com>; 'DRuiz@westsidewd.com' <DRuiz@westsidewd.com>; 'SNicholas@wrmwsd.com' <SNicholas@wrmwsd.com>; 'vpryor@zone7water.com' <vpryor@zone7water.com>; 'cmahoney@zone7water.com' <cmahoney@zone7water.com>; 'lxie@zone7water.com' <lxie@zone7water.com>
Cc: 'logan@canalfarms.com' <logan@canalfarms.com>; 'fdurst@rd108.org' <fdurst@rd108.org>; Gary Evans <gevans@countyofcolusa.com>; '1cjm@frontiernet.net' <1cjm@frontiernet.net>; 'ken.hahn@countyofglenn.net' <ken.hahn@countyofglenn.net>; 'jsutton@tccanal.com' <jsutton@tccanal.com>; 'jdparker@frontiernet.net' <jdparker@frontiernet.net>; 'bhoudesheldt@roseville.ca.us' <bhoudesheldt@roseville.ca.us>; 'SchmitzK@SacCounty.net' <SchmitzK@SacCounty.net>; Michael Azevedo <mjazevedo@countyofcolusa.com>; 'Donald.bransford@gmail.com' <Donald.bransford@gmail.com>; 'sean@dohertyfarms.com' <sean@dohertyfarms.com>; 'hreinhard@rd108.org' <hreinhard@rd108.org>; 'dkorchards@frontiernet.net' <dkorchards@frontiernet.net>; 'grant.Carmon@countyofglenn.net' <grant.Carmon@countyofglenn.net>; 'gcboard@countyofglenn.net' <gcboard@countyofglenn.net>; 'sdemoss@countyofglenn.net' <sdemoss@countyofglenn.net>; 'Zachary@CanalFarms.com' <Zachary@CanalFarms.com>; 'DRuiz@westsidewd.com' <DRuiz@westsidewd.com>; 'jalpine@hotmail.com' <jalpine@hotmail.com>; 'PetersonMi@SacCounty.net' <PetersonMi@SacCounty.net>; 'Jsharris@cityofsacramento.org' <Jsharris@cityofsacramento.org>; 'BEwart@cityofsacramento.org' <BEwart@cityofsacramento.org>; 'asanger@cityofsacramento.org' <asanger@cityofsacramento.org>; 'Wbusath@cityofsacramento.org' <Wbusath@cityofsacramento.org>; 'glallen337@gmail.com' <glallen337@gmail.com>; 'Jamie@tnpfarms.com' <Jamie@tnpfarms.com>; 'greg@greatrice.com' <greg@greatrice.com>; 'Zachary@CanalFarms.com' <Zachary@CanalFarms.com>; 'ted@westerncanal.com' <ted@westerncanal.com>; Alicia Forsythe <aforsythe@sitesproject.org>; Kevin Spesert <kspesert@sitesproject.org>; Joe Trapasso <jtrapasso@sitesproject.org>; JP Robinette <jrobinette@brwncald.com>; Henry Luu <Henry.Luu@hdrinc.com>; Robert Boling <Robert.Boling@HDRinc.com>; Heydinger, Erin <erin.heydinger@hdrinc.com>; Spranza, John <john.spranza@hdrinc.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; 'Cathy.Westcot@hdrinc.com' <Cathy.Westcot@hdrinc.com>; mmaltby@brwncald.com
Subject: Re: Sites Project - Draft Feasibility Cost Estimate

Reservoir Committee Participants –

Recently, the following two additional items were added to the participant web portal (https://sitesproject.org/participant-portal-documents/) for your use:

1. Final draft of the 2021 mitigation cost update memo – This document includes the requested rationale for the increases in key resource areas as compared to the mitigation cost estimate used on the 2019 Value Planning study.
2. 2021 Feasibility Cost Estimate Fact Sheet – This document is being used to communicate with community leaders and other members of the public on the 2021 Feasibility Cost Estimate. This is in addition to the communication messages that were previously sent to you in the email below and were posted for your use in communicating to your senior management and boards/councils. The information is similar, but reformatted to a fact sheet.
Please don't hesitate to reach out to me or Henry Luu (henry.luu@hdrinc.com) if there is anything else you need in this regard.

Jerry

From: Jerry Brown <jbrown@sitesproject.org>
Date: Tuesday, June 8, 2021 at 3:53 PM
To: "'fhernandez@cityofamericancanyon.org'" <fhernandez@cityofamericancanyon.org>, "'DChisam@avek.org'" <DChisam@avek.org>, "'BenCarter@succeed.net'" <BenCarter@succeed.net>, "'RCheng@cvwd.org'" <RCheng@cvwd.org>, "'MJAzevedo@countyofcolusa.org'" <MJAzevedo@countyofcolusa.org>, "'CCwd2@frontiernet.net'" <CCwd2@frontiernet.net>, "'MKrause@dwa.org'" <MKrause@dwa.org>, "'TBettner@gcid.net'" <TBettner@gcid.net>, "'weghorst@irwd.com'" <weghorst@irwd.com>, "'RNeudeck@mwdh2o.com'" <RNeudeck@mwdh2o.com>, "'WVanderwaal@rd108.org'" <WVanderwaal@rd108.org>, "'dbartel@rrbwsd.com'" <dbartel@rrbwsd.com>, "'BobT@sbvmwd.com'" <BobT@sbvmwd.com>, "'jdavis@sgpwa.com'" <jdavis@sgpwa.com>, "'CKao@valleywater.org'" <CKao@valleywater.org>, "'DMarks@SCVWA.org'" <DMarks@SCVWA.org>, "'JimP@chiconut.com'" <JimP@chiconut.com>, "'Jamie@tnpfarms.com'" <Jamie@tnpfarms.com>, "'WVanderwaal@rd108.org'" <WVanderwaal@rd108.org>, "'Zachary@CanalFarms.com'" <Zachary@CanalFarms.com>, "'flylegacy@yahoo.com'" <flylegacy@yahoo.com>, "'RKunde@wrmwsd.com'" <RKunde@wrmwsd.com>, Amparo Flores <AFlores@zone7water.com>, "'JHolley@cityofamericancanyon.org'" <JHolley@cityofamericancanyon.org>, "'rhendryx@cityofamericancanyon.org'" <rhendryx@cityofamericancanyon.org>, "'DFlory@ppeng.com'" <DFlory@ppeng.com>, "'AnnCarter4@comcast.net'" <AnnCarter4@comcast.net>, "'kccarter13@gmail.com'" <kccarter13@gmail.com>, "'ccmp503@gmail.com'" <ccmp503@gmail.com>, "'pvasileva@cvwd.org'" <pvasileva@cvwd.org>, "'JBarrett@cvwd.org'" <JBarrett@cvwd.org>, "'sbermudez@cvwd.org'" <sbermudez@cvwd.org>, "'skasumovic@cvwd.org'" <skasumovic@cvwd.org>, "'GEvans@countyofcolusa.org'" <GEvans@countyofcolusa.org>, "'boardclerk@countyofcolusa.com'" <boardclerk@countyofcolusa.com>, "'1cjm@frontiernet.net'" <1cjm@frontiernet.net>, "'SBaca@dwa.org'" <SBaca@dwa.org>, "'SJohnson@dwa.org'" <SJohnson@dwa.org>, "'hdawley@gcid.net'" <hdawley@gcid.net>, "'KHightower@gcid.net'" <KHightower@gcid.net>, "'welch@irwd.com'" <welch@irwd.com>, "'vanderpl@irwd.com'" <vanderpl@irwd.com>, "'NHawk@mwdh2o.com'" <NHawk@mwdh2o.com>, "'LBair@RD108.org'" <LBair@RD108.org>, "'mmisuraca@rrbwsd.com'" <mmisuraca@rrbwsd.com>, "'HeatherD@sbvmwd.com'" <HeatherD@sbvmwd.com>, "'josem@sbvmwd.com'" <josem@sbvmwd.com>, "'leckhart@sgpwa.com'" <leckhart@sgpwa.com>, "'ELeitterman@valleywater.org'" <ELeitterman@valleywater.org>, "'scole@SCVWA.org'" <scole@SCVWA.org>, "'Jamie@tnpfarms.com'" <Jamie@tnpfarms.com>, "'jspoonerfarms@gmail.com'" <jspoonerfarms@gmail.com>, "'DRuiz@westsidewd.com'" <DRuiz@westsidewd.com>, "'SNicholas@wrmwsd.com'" <SNicholas@wrmwsd.com>, "'vpryor@zone7water.com'" <vpryor@zone7water.com>, "'cmahoney@zone7water.com'" <cmahoney@zone7water.com>, "'lxie@zone7water.com'" <lxie@zone7water.com>

Cc: "'logan@canalfarms.com'" <logan@canalfarms.com>, Fritz Durst <fdurst@rd108.org>, "'GEvans@countyofcolusa.org'" <GEvans@countyofcolusa.org>, "'1cjm@frontiernet.net'" <1cjm@frontiernet.net>, "'ken.hahn@countyofglenn.net'" <ken.hahn@countyofglenn.net>, "'jsutton@tccanal.com'" <jsutton@tccanal.com>, "'jdparker@frontiernet.net'" <jdparker@frontiernet.net>, "'bhoudesheldt@roseville.ca.us'" <bhoudesheldt@roseville.ca.us>, "'SchmitzK@SacCounty.net'" <SchmitzK@SacCounty.net>, "'MJAzevedo@countyofcolusa.org'" <MJAzevedo@countyofcolusa.org>, "'Donald.bransford@gmail.com'" <Donald.bransford@gmail.com>, "'sean@dohertyfarms.com'" <sean@dohertyfarms.com>, "'hreinhard@rd108.org'" <hreinhard@rd108.org>, "'dkorchards@frontiernet.net'" <dkorchards@frontiernet.net>, "'grant.Carmon@countyofglenn.net'" <grant.Carmon@countyofglenn.net>, "'gcboard@countyofglenn.net'" <gcboard@countyofglenn.net>, "'sdemoss@countyofglenn.net'" <sdemoss@countyofglenn.net>, "'Zachary@CanalFarms.com'" <Zachary@CanalFarms.com>, "'DRuiz@westsidewd.com'" <DRuiz@westsidewd.com>, "'jalpine@hotmail.com'" <jalpine@hotmail.com>, "'PetersonMi@SacCounty.net'" <PetersonMi@SacCounty.net>, "'Jsharris@cityofsacramento.org'" <Jsharris@cityofsacramento.org>, "'BEwart@cityofsacramento.org'" <BEwart@cityofsacramento.org>, "'asanger@cityofsacramento.org'" <asanger@cityofsacramento.org>, "'Wbusath@cityofsacramento.org'" <Wbusath@cityofsacramento.org>, "'glallen337@gmail.com'" <glallen337@gmail.com>, "'Jamie@tnpfarms.com'" <Jamie@tnpfarms.com>, "'greg@greatrice.com'" <greg@greatrice.com>, "'Zachary@CanalFarms.com'" <Zachary@CanalFarms.com>, "'ted@westerncanal.com'" <ted@westerncanal.com>, Jerry Brown <jbrown@sitesproject.org>, Alicia Forsythe <aforsythe@sitesproject.org>, Kevin Spesert <kspesert@sitesproject.org>, Joe Trapasso <jtrapasso@sitesproject.org>, JP Robinette <jrobinette@brwncald.com>, Henry Luu <Henry.Luu@hdrinc.com>, Robert Boling <Robert.Boling@HDRinc.com>, "Heydinger, Erin" <erin.heydinger@hdrinc.com>, "Spranza, John" <john.spranza@hdrinc.com>, Laurie Warner Herson <laurie.warner.herson@phenixenv.com>, "'Cathy.Westcot@hdrinc.com'" <Cathy.Westcot@hdrinc.com>, "mmaltby@brwncald.com" <mmaltby@brwncald.com>
Subject: Sites Project - Draft Feasibility Cost Estimate

Reservoir Committee Participants,

As you know, the project team has been working with Reservoir Committee workgroups over the past 3 months to develop a feasibility design cost estimate that incorporates the latest design information and value engineering options for the project alternatives. The final feasibility cost estimate is scheduled to be considered for acceptance at this month's Joint Reservoir Committee/Authority Board meeting on June 23, 2021.

This work has resulted in a feasibility design cost estimate increase of ~30% (in 2021 dollars) over the appraisal level cost estimate that came out of value planning. To assist you in communicating the cost changes to your agency's management, boards and councils the project team has put together the attached communications messages. We're getting these to you in advance of the June 23 meeting so that your internal communications can occur prior to the public release of the estimate. Also, for those of you seeking additional details about the cost estimate, we have placed the following reference documents on the participant web portal (https://sitesproject.org/participant-portal-documents/):

1. Feasibility Design Considerations TM – a brief summary of the Sites Project Authority feasibility design and considerations.
2. HR Feasibility Cost Estimate TM – basis of feasibility cost estimate for the reservoir and roadway project features.
3. HC Feasibility Design Basis of Estimate – basis of feasibility cost estimate for the conveyance project features.

As a reminder, the project cost estimate is one of several factors that affect the project's affordability. The project team will present all the updated information around affordability at our July 23 affordability workshop.

Please don't hesitate to reach out to me or Henry Luu (henry.luu@hdrinc.com) if there is anything else you need in this regard.

Jerry

Jerry Brown | Executive Director | Sites Reservoir Project | 925.260.7417
| jbrown@sitesproject.org | www.SitesProject.org

From: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Sent: 6/23/2021 8:02:41 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: Ops Update
Attachments: Proforma_SA_list_052021.xlsx

Hi Ali,

I updated the agenda for the ops check in on SharePoint for you guys today:

I also wanted to give you a quick update of where things are on operations before I head out, especially with our vacations running one after the other.

EIR/EIS Appendices:
As of last week, had 3 outstanding appendices. Two were supposed to be submitted last week, one this week. I only got one last week (USRDOM) and we really need appendix 5A done which discusses the modeling generally and the modeling of the alternatives. The other one is climate change, lower priority but still needed this week.

Storage Allocation:
This is the high-level, marketing forward presentation Jerry asked me to develop with some HDR "experts." This is in the orwksa nd a draft should be ready shortly after I get back. One of the question is "how does my agency determine how much storage we need?" I've asked CH to do a high-level probability estimate on the likelihood of multiple dry years. That is noted in the agenda. This can help participants think about planning for drought circumstances with their Sites storage.

WSIP Benefits:
We are coming in high (around $860M for the State). I've asked Henry to walk through this with Jerry. The good news I that everybody is showing a BCR above 1. The bad news is that $860M is higher than our board target. We need to determine if this level is acceptable or if we'd like to remodel with a smaller storage account for the State. Henry is aware of all of this.

Proforma:
Sounds like modeling for the proforma has proven to be more challenging than originally anticipated. I asked CH to not worry too much about coding the changes into CalSim if it was giving them a lot of issues and to instead think about how we might post-process to get some results (similar to the "Sites in 2021" exercise). Reed sent me the attached table with an approach for each alternative. From what I can tell, it looks like they might still be pushing forward with CalSim. They may need some wrangling on this; MDA needs some results by the end of the week to start working on. Not necessarily every scenario done, but something. I asked Cheyanne to temper expectations with Brian Grubbs that we might not have monthly data, which is what he originally requested.

Unimpaired Flows:
The State Board asked about this last week. I'm thinking they will want us to explain the analysis we have done to date. I asked CH to put this back on their priority list.

I think that's it for now! Looking forward to catching up a bit more when I get back.

Thanks,
Erin

Erin Heydinger, PE, PMP
Project Manager
Water/Wastewater

HDR
2379 Gateway Oaks Dr, #200
Sacramento, CA 95833
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From: Michael Azevedo [mjazevedo@countyofcolusa.com]
Sent: 6/23/2021 8:48:05 AM
To: Jerry Brown [jbrown@sitesproject.org]; Rob Kunde [rkunde@wrmwsd.com]
CC: Luu, Henry [Henry.Luu@hdrinc.com]; Alicia Forsythe [aforsythe@sitesproject.org]
Subject: RE: Sites Project - Draft Feasibility Cost Estimate

Thank Jerry.

Michael J Azevedo
Colusa County Public Works
530.458.0466

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Wednesday, June 23, 2021 7:27 AM
To: Michael Azevedo <mjazevedo@countyofcolusa.com>; Rob Kunde <rkunde@wrmwsd.com>
Cc: Luu, Henry <Henry.Luu@hdrinc.com>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Sites Project - Draft Feasibility Cost Estimate

> REMINDER: This email originated from outside of the organization, only you can prevent ransomware attacks. Do not click links or open attachments unless you recognize the sender and know the content is safe. When in doubt, contact the Helpdesk at helpdesk@countyofcolusa.com.

Mike – we still owe Land Mgmt Cmte a line by line review of the mitigation cost estimate. I believe a meeting is being scheduled next month for this and other items. We can drill down into this issue as part of that review.

Jerry

From: Michael Azevedo <mjazevedo@countyofcolusa.com>
Date: Monday, June 21, 2021 at 2:19 PM
To: Rob Kunde <rkunde@wrmwsd.com>, Jerry Brown <jbrown@sitesproject.org>
Cc: "Luu, Henry" <Henry.Luu@hdrinc.com>
Subject: RE: Sites Project - Draft Feasibility Cost Estimate

Thanks Rob,

Kinda on point....kinda not.

I missed the lack of "big ticket items" discussion and tech memo, I'll try to be more observant. My issue is just focused on one species, giant garter snake, we've gone from 11.5 miles of affected habitat to approximately 1 mile (conservatively) of GGS habitat. Given the County's previous experience in dealing with giant garter snake mitigation in conjunction with bridge replacement projects here in the Sac Valley, I am dubious the delta between the pre and post Value Planning mitigation estimate is less than 10%.

Thanks for the additional detail. Again, I'll strive to be more observant going forward.

Michael J Azevedo
Colusa County Public Works

530.458.0466

From: Rob Kunde <rkunde@wrmwsd.com>
Sent: Monday, June 21, 2021 11:38 AM
To: Michael Azevedo <mjazevedo@countyofcolusa.com>; Jerry Brown <jbrown@sitesproject.org>
Cc: Luu, Henry <Henry.Luu@hdrinc.com>
Subject: Re: Sites Project - Draft Feasibility Cost Estimate

Mike:

The Value Planning mitigation cost estimate was $540M (no Delevan pipeline). During VP (spring 2020), I asked John Spranza to identify if there were big ticket items that would change the cost estimate by 10%. The answer was there were not any such items identifiable at that time.

Since then, both engineering and mitigation costs have been updated to reflect new information. The current mitigation cost estimate is $562M. This is not a significant change from Value Planning (+ 5%). Spranza says this estimate is conservative since the habitat surveys have been aerial only which usually overestimate mitigatable habitat compared to ground surveys. I seem to recall a Technical Memorandum on the subject was provided to the EP&P Work Group. Or maybe is was a PowerPoint presentation.

So, I don't think the updated cost estimate is "status quo" relative to Value Planning. Staff have updated the information and cost. There is still habitat and species uncertainty (but less uncertainty than with Value Planning). But the resulting cost estimate is not significantly different than Value Planning.

Is this on point with your email below?

Robert J. Kunde, P.E.
Retired Annuitant
Wheeler Ridge-Maricopa Water Storage District
cell: 661-345-3719 email: rkunde@wrmwsd.com

From: Michael Azevedo <mjazevedo@countyofcolusa.com>
Sent: Monday, June 21, 2021 7:43 AM
To: Jerry Brown <jbrown@sitesproject.org>
Cc: Luu, Henry <Henry.Luu@hdrinc.com>; Rob Kunde <rkunde@wrmwsd.com>
Subject: RE: Sites Project - Draft Feasibility Cost Estimate

Thanks for the info Jerry.

Recently (believe it was coordinating committee call) I questioned the mitigation cost not being adjusted for the Delevan pipeline and Mr. Kunde correctly reminded me the Delevan Pipe line was stricken from consideration at the onset of the

Value Planning effort. However, after reviewing my notes and consulting Supervisor Evans, it seems to us the cost of mitigation “was to be status qou due to habitat and species uncertainty”. Is our recollection correct?

Michael J Azevedo

Colusa County Public Works
530.458.0466

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Monday, June 21, 2021 6:52 AM
To: 'fhernandez@cityofamericancanyon.org' <fhernandez@cityofamericancanyon.org>; 'DChisam@avek.org' <DChisam@avek.org>; 'BenCarter@succeed.net' <BenCarter@succeed.net>; 'RCheng@cvwd.org' <RCheng@cvwd.org>; Michael Azevedo <mjazevedo@countyofcolusa.com>; 'CCwd2@frontiernet.net' <CCwd2@frontiernet.net>; 'MKrause@dwa.org' <MKrause@dwa.org>; 'TBettner@gcid.net' <TBettner@gcid.net>; 'weghorst@irwd.com' <weghorst@irwd.com>; 'RNeudeck@mwdh2o.com' <RNeudeck@mwdh2o.com>; 'WVanderwaal@rd108.org' <WVanderwaal@rd108.org>; 'dbartel@rrbwsd.com' <dbartel@rrbwsd.com>; 'BobT@sbvmwd.com' <BobT@sbvmwd.com>; 'jdavis@sgpwa.com' <jdavis@sgpwa.com>; 'CKao@valleywater.org' <CKao@valleywater.org>; 'DMarks@SCVWA.org' <DMarks@SCVWA.org>; 'JimP@chiconut.com' <JimP@chiconut.com>; 'Jamie@tnpfarms.com' <Jamie@tnpfarms.com>; 'WVanderwaal@rd108.org' <WVanderwaal@rd108.org>; 'Zachary@CanalFarms.com' <Zachary@CanalFarms.com>; 'flylegacy@yahoo.com' <flylegacy@yahoo.com>; 'RKunde@wrmwsd.com' <RKunde@wrmwsd.com>; 'AFlores@zone7water.com' <AFlores@zone7water.com>; 'JHolley@cityofamericancanyon.org' <JHolley@cityofamericancanyon.org>; 'rhendryx@cityofamericancanyon.org' <rhendryx@cityofamericancanyon.org>; 'DFlory@ppeng.com' <DFlory@ppeng.com>; 'AnnCarter4@comcast.net' <AnnCarter4@comcast.net>; 'kccarter13@gmail.com' <kccarter13@gmail.com>; 'ccmp503@gmail.com' <ccmp503@gmail.com>; 'pvasileva@cvwd.org' <pvasileva@cvwd.org>; 'JBarrett@cvwd.org' <JBarrett@cvwd.org>; 'sbermudez@cvwd.org' <sbermudez@cvwd.org>; 'skasumovic@cvwd.org' <skasumovic@cvwd.org>; Gary Evans <gevans@countyofcolusa.com>; Ann Nordyke <boardclerk@countyofcolusa.com>; '1cjm@frontiernet.net' <1cjm@frontiernet.net>; 'SBaca@dwa.org' <SBaca@dwa.org>; 'SJohnson@dwa.org' <SJohnson@dwa.org>; 'hdawley@gcid.net' <hdawley@gcid.net>; 'KHightower@gcid.net' <KHightower@gcid.net>; 'welch@irwd.com' <welch@irwd.com>; 'vanderpl@irwd.com' <vanderpl@irwd.com>; 'NHawk@mwdh2o.com' <NHawk@mwdh2o.com>; 'LBair@RD108.org' <LBair@RD108.org>; 'mmisuraca@rrbwsd.com' <mmisuraca@rrbwsd.com>; 'HeatherD@sbvmwd.com' <HeatherD@sbvmwd.com>; 'josem@sbvmwd.com' <josem@sbvmwd.com>; 'leckhart@sgpwa.com' <leckhart@sgpwa.com>; 'ELeitterman@valleywater.org' <ELeitterman@valleywater.org>; 'scole@SCVWA.org' <scole@SCVWA.org>; 'Jamie@tnpfarms.com' <Jamie@tnpfarms.com>; 'jspoonerfarms@gmail.com' <jspoonerfarms@gmail.com>; 'DRuiz@westsidewd.com' <DRuiz@westsidewd.com>; 'SNicholas@wrmwsd.com' <SNicholas@wrmwsd.com>; 'vpryor@zone7water.com' <vpryor@zone7water.com>; 'cmahoney@zone7water.com' <cmahoney@zone7water.com>; 'lxie@zone7water.com' <lxie@zone7water.com>
Cc: 'logan@canalfarms.com' <logan@canalfarms.com>; 'fdurst@rd108.org' <fdurst@rd108.org>; Gary Evans <gevans@countyofcolusa.com>; '1cjm@frontiernet.net' <1cjm@frontiernet.net>; 'ken.hahn@countyofglenn.net' <ken.hahn@countyofglenn.net>; 'jsutton@tccanal.com' <jsutton@tccanal.com>; 'jdparker@frontiernet.net' <jdparker@frontiernet.net>; 'bhoudesheldt@roseville.ca.us' <bhoudesheldt@roseville.ca.us>; 'SchmitzK@SacCounty.net' <SchmitzK@SacCounty.net>; Michael Azevedo <mjazevedo@countyofcolusa.com>; 'Donald.bransford@gmail.com' <Donald.bransford@gmail.com>; 'sean@dohertyfarms.com' <sean@dohertyfarms.com>; 'hreinhard@rd108.org' <hreinhard@rd108.org>; 'dkorchards@frontiernet.net' <dkorchards@frontiernet.net>; 'grant.Carmon@countyofglenn.net' <grant.Carmon@countyofglenn.net>; 'gcboard@countyofglenn.net' <gcboard@countyofglenn.net>; 'sdemoss@countyofglenn.net' <sdemoss@countyofglenn.net>; 'Zachary@CanalFarms.com' <Zachary@CanalFarms.com>; 'DRuiz@westsidewd.com' <DRuiz@westsidewd.com>; 'jalpine@hotmail.com' <jalpine@hotmail.com>; 'PetersonMi@SacCounty.net' <PetersonMi@SacCounty.net>; 'Jsharris@cityofsacramento.org' <Jsharris@cityofsacramento.org>; 'BEwart@cityofsacramento.org' <BEwart@cityofsacramento.org>; 'asanger@cityofsacramento.org' <asanger@cityofsacramento.org>; 'Wbusath@cityofsacramento.org' <Wbusath@cityofsacramento.org>; 'glallen337@gmail.com' <glallen337@gmail.com>; 'Jamie@tnpfarms.com' <Jamie@tnpfarms.com>;

'greg@greatrice.com' <greg@greatrice.com>; 'Zachary@CanalFarms.com' <Zachary@CanalFarms.com>; 'ted@westerncanal.com' <ted@westerncanal.com>; Alicia Forsythe <aforsythe@sitesproject.org>; Kevin Spesert <kspesert@sitesproject.org>; Joe Trapasso <jtrapasso@sitesproject.org>; JP Robinette <jrobinette@brwncald.com>; Henry Luu <Henry.Luu@hdrinc.com>; Robert Boling <Robert.Boling@HDRinc.com>; Heydinger, Erin <erin.heydinger@hdrinc.com>; Spranza, John <john.spranza@hdrinc.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; 'Cathy.Westcot@hdrinc.com' <Cathy.Westcot@hdrinc.com>; mmaltby@brwncald.com
Subject: Re: Sites Project - Draft Feasibility Cost Estimate

Reservoir Committee Participants –

Recently, the following two additional items were added to the participant web portal (https://sitesproject.org/participant-portal-documents/) for your use:
1. Final draft of the 2021 mitigation cost update memo – This document includes the requested rationale for the increases in key resource areas as compared to the mitigation cost estimate used on the 2019 Value Planning study.
2. 2021 Feasibility Cost Estimate Fact Sheet – This document is being used to communicate with community leaders and other members of the public on the 2021 Feasibility Cost Estimate. This is in addition to the communication messages that were previously sent to you in the email below and were posted for your use in communicating to your senior management and boards/councils. The information is similar, but reformatted to a fact sheet.
Please don't hesitate to reach out to me or Henry Luu (henry.luu@hdrinc.com) if there is anything else you need in this regard.

Jerry

From: Jerry Brown <jbrown@sitesproject.org>
Date: Tuesday, June 8, 2021 at 3:53 PM
To: "'fhernandez@cityofamericancanyon.org'" <fhernandez@cityofamericancanyon.org>, "'DChisam@avek.org'" <DChisam@avek.org>, "'BenCarter@succeed.net'" <BenCarter@succeed.net>, "'RCheng@cvwd.org'" <RCheng@cvwd.org>, "'MJAzevedo@countyofcolusa.org'" <MJAzevedo@countyofcolusa.org>, "'CCwd2@frontiernet.net'" <CCwd2@frontiernet.net>, "'MKrause@dwa.org'" <MKrause@dwa.org>, "'TBettner@gcid.net'" <TBettner@gcid.net>, "'weghorst@irwd.com'" <weghorst@irwd.com>, "'RNeudeck@mwdh2o.com'" <RNeudeck@mwdh2o.com>, "'WVanderwaal@rd108.org'" <WVanderwaal@rd108.org>, "'dbartel@rrbwsd.com'" <dbartel@rrbwsd.com>, "'BobT@sbvmwd.com'" <BobT@sbvmwd.com>, "'jdavis@sgpwa.com'" <jdavis@sgpwa.com>, "'CKao@valleywater.org'" <CKao@valleywater.org>, "'DMarks@SCVWA.org'" <DMarks@SCVWA.org>, "'JimP@chiconut.com'" <JimP@chiconut.com>, "'Jamie@tnpfarms.com'" <Jamie@tnpfarms.com>, "'WVanderwaal@rd108.org'" <WVanderwaal@rd108.org>, "'Zachary@CanalFarms.com'" <Zachary@CanalFarms.com>, "'flylegacy@yahoo.com'" <flylegacy@yahoo.com>, "'RKunde@wrmwsd.com'" <RKunde@wrmwsd.com>, Amparo Flores <AFlores@zone7water.com>, "'JHolley@cityofamericancanyon.org'" <JHolley@cityofamericancanyon.org>, "'rhendryx@cityofamericancanyon.org'" <rhendryx@cityofamericancanyon.org>, "'DFlory@ppeng.com'" <DFlory@ppeng.com>, "'AnnCarter4@comcast.net'" <AnnCarter4@comcast.net>, "'kccarter13@gmail.com'" <kccarter13@gmail.com>, "'ccmp503@gmail.com'" <ccmp503@gmail.com>, "'pvasileva@cvwd.org'" <pvasileva@cvwd.org>, "'JBarrett@cvwd.org'" <JBarrett@cvwd.org>, "'sbermudez@cvwd.org'"

<sbermudez@cvwd.org>, "'skasumovic@cvwd.org'" <skasumovic@cvwd.org>, "'GEvans@countyofcolusa.org'" <GEvans@countyofcolusa.org>, "'boardclerk@countyofcolusa.com'" <boardclerk@countyofcolusa.com>, "'1cjm@frontiernet.net'" <1cjm@frontiernet.net>, "'SBaca@dwa.org'" <SBaca@dwa.org>, "'SJohnson@dwa.org'" <SJohnson@dwa.org>, "'hdawley@gcid.net'" <hdawley@gcid.net>, "'KHightower@gcid.net'" <KHightower@gcid.net>, "'welch@irwd.com'" <welch@irwd.com>, "'vanderpl@irwd.com'" <vanderpl@irwd.com>, "'NHawk@mwdh2o.com'" <NHawk@mwdh2o.com>, "'LBair@RD108.org'" <LBair@RD108.org>, "'mmisuraca@rrbwsd.com'" <mmisuraca@rrbwsd.com>, "'HeatherD@sbvmwd.com'" <HeatherD@sbvmwd.com>, "'josem@sbvmwd.com'" <josem@sbvmwd.com>, "'leckhart@sgpwa.com'" <leckhart@sgpwa.com>, "'ELeitterman@valleywater.org'" <ELeitterman@valleywater.org>, "'scole@SCVWA.org'" <scole@SCVWA.org>, "'Jamie@tnpfarms.com'" <Jamie@tnpfarms.com>, "'jspoonerfarms@gmail.com'" <jspoonerfarms@gmail.com>, "'DRuiz@westsidewd.com'" <DRuiz@westsidewd.com>, "'SNicholas@wrmwsd.com'" <SNicholas@wrmwsd.com>, "'vpryor@zone7water.com'" <vpryor@zone7water.com>, "'cmahoney@zone7water.com'" <cmahoney@zone7water.com>, "'lxie@zone7water.com'" <lxie@zone7water.com>
Cc: "'logan@canalfarms.com'" <logan@canalfarms.com>, Fritz Durst <fdurst@rd108.org>, "'GEvans@countyofcolusa.org'" <GEvans@countyofcolusa.org>, "'1cjm@frontiernet.net'" <1cjm@frontiernet.net>, "'ken.hahn@countyofglenn.net'" <ken.hahn@countyofglenn.net>, "'jsutton@tccanal.com'" <jsutton@tccanal.com>, "'jdparker@frontiernet.net'" <jdparker@frontiernet.net>, "'bhoudesheldt@roseville.ca.us'" <bhoudesheldt@roseville.ca.us>, "'SchmitzK@SacCounty.net'" <SchmitzK@SacCounty.net>, "'MJAzevedo@countyofcolusa.org'" <MJAzevedo@countyofcolusa.org>, "'Donald.bransford@gmail.com'" <Donald.bransford@gmail.com>, "'sean@dohertyfarms.com'" <sean@dohertyfarms.com>, "'hreinhard@rd108.org'" <hreinhard@rd108.org>, "'dkorchards@frontiernet.net'" <dkorchards@frontiernet.net>, "'grant.Carmon@countyofglenn.net'" <grant.Carmon@countyofglenn.net>, "'gcboard@countyofglenn.net'" <gcboard@countyofglenn.net>, "'sdemoss@countyofglenn.net'" <sdemoss@countyofglenn.net>, "'Zachary@CanalFarms.com'" <Zachary@CanalFarms.com>, "'DRuiz@westsidewd.com'" <DRuiz@westsidewd.com>, "'jalpine@hotmail.com'" <jalpine@hotmail.com>, "'PetersonMi@SacCounty.net'" <PetersonMi@SacCounty.net>, "'Jsharris@cityofsacramento.org'" <Jsharris@cityofsacramento.org>, "'BEwart@cityofsacramento.org'" <BEwart@cityofsacramento.org>, "'asanger@cityofsacramento.org'" <asanger@cityofsacramento.org>, "'Wbusath@cityofsacramento.org'" <Wbusath@cityofsacramento.org>, "'glallen337@gmail.com'" <glallen337@gmail.com>, "'Jamie@tnpfarms.com'" <Jamie@tnpfarms.com>, "'greg@greatrice.com'" <greg@greatrice.com>, "'Zachary@CanalFarms.com'" <Zachary@CanalFarms.com>, "'ted@westerncanal.com'" <ted@westerncanal.com>, Jerry Brown <jbrown@sitesproject.org>, Alicia Forsythe <aforsythe@sitesproject.org>, Kevin Spesert <kspesert@sitesproject.org>, Joe Trapasso <jtrapasso@sitesproject.org>, JP Robinette <jrobinette@brwncald.com>, Henry Luu <Henry.Luu@hdrinc.com>, Robert Boling <Robert.Boling@HDRinc.com>, "Heydinger, Erin" <erin.heydinger@hdrinc.com>, "Spranza, John" <john.spranza@hdrinc.com>, Laurie Warner Herson <laurie.warner.herson@phenixenv.com>, "'Cathy.Westcot@hdrinc.com'" <Cathy.Westcot@hdrinc.com>, "mmaltby@brwncald.com" <mmaltby@brwncald.com>
Subject: Sites Project - Draft Feasibility Cost Estimate

Reservoir Committee Participants,

As you know, the project team has been working with Reservoir Committee workgroups over the past 3 months to develop a feasibility design cost estimate that incorporates the latest design information and value engineering options for the project alternatives. The final feasibility cost estimate is scheduled to be considered for acceptance at this month's Joint Reservoir Committee/Authority Board meeting on June 23, 2021.

This work has resulted in a feasibility design cost estimate increase of ~30% (in 2021 dollars) over the appraisal level cost estimate that came out of value planning. To assist you in communicating the cost changes to your agency's management, boards and councils the project team has put together the attached communications messages. We're getting these to you in advance of the June 23 meeting so that your internal communications can occur prior to the public release of the estimate. Also, for those of you seeking additional details about the cost estimate, we have placed the following reference documents on the participant web portal (https://sitesproject.org/participant-portal-documents/):

1. Feasibility Design Considerations TM – a brief summary of the Sites Project Authority feasibility design and considerations.
2. HR Feasibility Cost Estimate TM – basis of feasibility cost estimate for the reservoir and roadway project features.
3. HC Feasibility Design Basis of Estimate – basis of feasibility cost estimate for the conveyance project features.

As a reminder, the project cost estimate is one of several factors that affect the project's affordability. The project team will present all the updated information around affordability at our July 23 affordability workshop.

Please don't hesitate to reach out to me or Henry Luu (henry.luu@hdrinc.com) if there is anything else you need in this regard.

Jerry

Jerry Brown | Executive Director | Sites Reservoir Project | 925.260.7417
| jbrown@sitesproject.org | www.SitesProject.org

From: Holly Dawley [hdawley@gcid.net]
Sent: 6/23/2021 8:58:50 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]
CC: Spranza, John [john.spranza@hdrinc.com]; Laurie Warner Herson [laurie.warner.herson@phenixenv.com]
Subject: RE: EIR/EIS

Thanks, Ali.
I'll work through these items and may have more questions for you.

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Monday, June 21, 2021 2:15 PM
To: Holly Dawley <hdawley@gcid.net>
Cc: Spranza, John <john.spranza@hdrinc.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: RE: EIR/EIS

Hey Holly – Sorry for the delay in getting back to you on this. I've been racking my brain on your question. I've copied Laurie and John here also as they may have some ideas too. But the three that come to my mind are:

1. We are assuming all green power – eventually. Here's text from the project description. We state it as an aspirational goal (the Authority would "target"). Please keep in mind that this is not for GCID "regular" power. But power that the Authority buys to pump Sites water at GCID facilities is targeted to be all renewable by 2045.

While hydropower generation would be an incidental benefit of conveying water through specific Project facilities and would be influenced by the timing of releases and movement of water and seasonal operational decisions, the Authority would work to schedule releases and outages such that it sought to maximize power generation to offset the Project's power needs. Additional operations power needs beyond those generated by the Project would be purchased from market sources, with a target of purchasing at least 60% of the Project's operations power needs from renewable, carbon-free sources from the start of operations to 2045. Starting in 2045, the Authority would target purchasing 100% of the Project's operations power needs from renewable, carbon-free sources. This target does not include any operational power needs attributable to Reclamation's participation, including the conveyance and pumping of Incremental Level 4 Refuge water supply. (page 2-80)

2. Funks and Stone Corral Creek releases. We are uncertain as to when and how much water would need to be released into Funks and Stone Corral Creeks (I assume it is some, but maybe not necessarily year round). To address this, we've included a study effort in the Project Description. For design purposes, we are assuming a max of 100 cfs. But we need to complete a future study to determine this (I am proposing that this study would be completed in Amendment 3, next year, so we can tie this down for final design). Here's the text from the Project Description (2-78).

The Project includes releases from Sites Reservoir into both Funks and Stone Corral Creeks. These releases would be made to comply with California Fish and Game Code Section 5937 and ensure no harm to downstream water right holders on these creeks. At this time, access to the creeks is restricted and there is not sufficient existing information on these two creeks, including current fish assemblage, channel capacity, and existing habitat, to determine a specific release pattern or approach to releases into these two creeks. Field studies would be conducted once access is obtained and before final design for Sites and Golden Gate Dam is completed to determine the following:

- Existing fish assemblage in these creeks, including fish species presence and habitat use;
- Characterization of habitats available (e.g., spawning, rearing, foraging, and sheltering habitats) at varying flow levels;

- Characterization of flows, including assessing the base flow during the summer months;
- Conducting a fluvial geomorphologic study to characterize bed load and flow levels necessary for mobilization; and
- Hydrological studies to define flow temperature relationships.

Using information from these field studies, along with currently available information, the Authority would prepare a Funks and Stone Corral Creeks Operations Plan that would identify the approach for releases, including release schedule and volumes, a monitoring plan, and an adaptive management plan to maintain fish in good condition consistent with California Fish and Game Code Section 5937. Releases into these creeks need to be made in consideration of the flood control benefits of the Project and in such a way as to not overtop the stream banks and flood downstream areas.

Water released into Funks Creek would be made through the transition manifold at the base of Golden Gate Dam and a new pipeline that terminates at Funks Creek below Golden Gate Dam. These facilities are currently being designed to carry up to 100 cfs with a release range of 0 to 100 cfs into Funks Creek. Water released into Stone Corral Creek would be made through the permanent outlet at Sites Dam. This outlet is currently being designed with a release range of 0 to 100 cfs, with an emergency release capacity of up to 2,500 cfs.

I think there is some concern about the precent that these releases might set – these releases would be exclusive to Fish and Game Code 5937, which states:

The owner of any dam shall allow sufficient water at all times to pass through a fishway, or in the absence of a fishway, allow sufficient water to pass over, around or through the dam, to keep in good condition any fish that may be planted or exist below the dam. During the minimum flow of water in any river or stream, permission may be granted by the department to the owner of any dam to allow sufficient water to pass through a culvert, waste gate, or over or around the dam, to keep in good condition any fish that may be planted or exist below the dam, when, in the judgment of the department, it is impracticable or detrimental to the owner to pass the water through the fishway.

So these releases are really driven by the construction of the new dams as a result of Sites and would not be applicable to GCID's operations/activities.

3. I think we would also like to review with you the land cover and species mapping w/r/t GCID facilities. We plan to do this at our July 6 meeting.

I'll think about any others and let you know.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Holly Dawley <hdawley@gcid.net>
Sent: Wednesday, June 16, 2021 1:48 PM

To: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: EIR/EIS

Hi Ali,
As I review the EIR/EIS, do you have any insights as to whether there are items that I should particularly take note of? I think there is concern that there might be policy issues hidden somewhere like in the last round (i.e. assuming all green power).

I hope you were able to enjoy your vacation!
Holly

Sites Reservoir Projec

y Off-Stream Storage Facility Enhancing Secure Water Suppl
All of California

EPA WIFIA Letter of Interest Planning
June 23, 2021

Sites

What is WIFIA?

- WIFIA = Water Infrastructure Finance Innovation Act
- Administered by EPA
- Provides low-cost, long-term loans for eligible water and wastewater projects
- 2021 Notice of Funding = $5.5 Billion available for loans
- Letters of Interest Due by July 23

Sites

Pro's and Cons associated with a WIFIA loan; EBMUD noted AIS and annual servicing payments

Why WIFIA?

LOW INTEREST
Interest rate will be equal to or greater than the U.S. Treasury rate of a similar maturity.

REPAYMENT DEFERRAL
Max. time that repayment may be deferred after substantial completion of the project.
Total loan term can be 35 yrs.

EARLIER CERTAINTY
The WIFIA program has allowed agencies to "lock-in" the interest rate at loan closing.

I wish I was here to tell you about free grant money, but those are gone. WIFIA is not grants, but has some important benefits.

WIFIA Program Application Process - 2 Phases

Project Selection	Review, Negotiation, & Closing
• Notice of Funding Availability • Letter of Interest (LOI) Submission • LOI Evaluation • Project Selection	• Application Submission • Application Evaluation • Negotiation of Term Sheet • Project Recommendation • Approval • Closing Activities

Source: EPA WIFIA Handbook

Funding Request – NEED TO UPDATE

Total Eligible Project Costs	$	4,300,000,000
WSIP Funds	$	840,000,000
Federal Funds	$	1,100,000,000
USDA Loan Proceeds	$	440,000,000
WIFIA Loan Request – 2021 LOI	**$**	**600,000,000**

Sites

35% (or more than 1/3) of the total money available.
Another option is $1.1B in the plan. $1.1B vs $1.9B.
$1.1B
Is the JPA going to be able to sign for $1.9B?

Review of Key Points

- Addresses key stressor from Climate Change
  - Reduces reliance on strained GW supplies; Also allows for GW banking (ASR)
  - Severe drought currently: Sites Reservoir would have allowed 1 million AFY
  - Prop 1 Env Benefits
- One of the few water projects that is truly regionally/nationally significant
  - Allows for food production
- Addresses Aging infrastructure
  - Addresses aging infrastructure of the State Water Project
- Serves "Economically Stressed Communities";
  - Price per AF is substantially less than cost of water reuse;
  - Almost a 10% reduction in cost of water
  - Individual landowners are putting a lien on their farms to buy into a sustainable water supply
- Project is ready to proceed, and fits WIFIA's Program schedule/milestones
  - WIFIA moves the project ahead more quickly;
- Bipartisan alignment – both locally and at the federal level
  - Aligns with water resource needs/challenges for the entire region

Sites


Questions
Sites

Notice of Funding Availability

- EPA 2021 NOFA Priorities:
  - Economically stressed communities
  - Protection against extreme weather events (i.e. Climate Change)
  - Repair, rehabilitate, and replace aging infrastructure and conveyance systems
  - Lead and emerging contaminants
  - New or innovative approaches

Sites

Criteria and Weighting

- **Project Impact (100 of the 300 total)**
  - Nationally/regionally Significant – 5 points
  - Protects against extreme weather – 20 points
  - Serves regions with energy exploration – 5 points
  - Serves regions with water resources challenges – 5 points
  - Addresses identified priorities – 5 points
  - Addresses aging infrastructure – 20 points
  - Serves economically stressed communities – 20 points
  - Addresses Lead and Emerging Contaminants – 20 points
- **Project Readiness (100 of the 300 total)**
  - Readiness to proceed towards development – 40 points
  - Preliminary engineering feasibility analysis score – 40 points
  - New or Innovative approaches – 20 points

Sites

Criteria and Weighting

- **Borrower Creditworthiness (100 of the 300 total)**
  - Enable project to proceed earlier – 10 points
  - Project financing plan – 10 points
  - Reduces Federal Assistance – 10 points
  - Budget Authority required to fund the project – 10 points
  - Preliminary Creditworthiness Assessment – 60 points

Sites

Reservoir Committee Meeting

Agenda Item 3-1, Revised Draft EIR/
Supplemental Draft EIS Briefing, Part 3 –
Operations-Related Effects and Growth Inducement

June 23, 2021

Sites

Agenda

- Operations-related Analysis
- Growth Inducement Analysis

Speaker: John

Preliminary Determinations

Chapter (# and Title)	Impacts Requiring Mitigation	Significant and Unavoidable Impacts
5, Surface Water Resources	None	None
11, Aquatic Resources	All Alts – Tidal habitat restoration to address operations effects on Longfin Smelt	None
20, Air Quality*	All Alts – Increase in criteria pollutant for which region is nonattainment during construction; odors from asphalt batch plant during construction and operations; recreational boat emissions during operations	Some air quality modeling is still underway and any additional effects will be reported at the July meeting
21, Greenhouse Gas Emissions (GHG)	All Alts – Develop a GHG Reduction Plan to achieve net-zero emissions during construction and operations	None

Speaker: Nicole

Draft - Predecisional Working Document - For Discussion Purposes Only

Growth Inducing

- No impact determination
- Evaluates direct and indirect growth inducing effects from construction and operations
- Approach considers:
  - Water supply reliability describing simulated deliveries to agriculture and M&I uses by hydrologic regions
  - Population growth over last 20 years and projected growth
  - Local authority of governments over land use planning
- Alternatives are not growth-inducing and would not induce secondary growth impacts

Speaker: Nicole

Chapters Remaining for July Briefing

- Surface Water Quality
- Air Quality (final analysis)
- Climate Change (NEPA only)
- Indian Trust Assets (NEPA only)
- Socioeconomics and Environmental Justice (NEPA only)
- Cumulative Impacts
- EIR/EIS Document Distribution

Speaker: Nicole

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Process for Approval of Release of the Revised Draft EIR

- April – Part 1 Overview
  - CEQA overview and process presentation
- May – Part 2, Key Sections
  - Construction-Related Sections and Local Issues
- June – Part 3, Key Sections
  - Operations-Related Sections and Growth Inducement
- July – Request approval
  - All Remaining Chapters, including Cumulative
  - Request approval from the Reservoir Committee and Authority Board for release of the public RDEIR in August
- August 2021 – Release of RDEIR
  - Schedule assumes parallel review and release of SDEIS as joint document

Speaker: Laurie

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Questions

Sites

Sites

Preliminary Determinations – Chapters with Only Less Than Significant Impacts

- Surface Water
- Fluvial Geomorphology
- Groundwater Resources
- Minerals
- Recreation
- Energy
- Noise
- Population and Housing
- Public Services and Utilities
- Public Health and Environmental Hazards

Speaker: Nicole

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Preliminary Determinations – Chapters with Impacts Requiring Mitigation

- Air Quality
- Greenhouse Gases
- Aquatic Biological Resources
- Cultural Resources
- Vegetation and Wetlands
- Wildlife
- Geology and Soils
- Agricultural Resources
- Tribal Cultural Resources
- Environmental Justice

Speaker: Nicole

Blue are ones that have been added to this list; gray are ones we previously discussed

Preliminary Determinations – Chapters with Significant Unavoidable Impacts

- Air Quality
- Vegetation and Wetlands
- Wildlife
- Geology and Soils
- Agricultural Resources
- Land Use
- Cultural Resources
- Visual Character and Quality
- Tribal Cultural Resources
- Transportation and Traffic
- Environmental Justice

Speaker: Nicole

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Aquatic Biological Resources – Overview

- Evaluated 20 Impacts
  - Impact FISH-1: Construction
  - Impact FISH-2 through -19: Operation effects on listed species and special status species of concern, including Killer Whales
  - Impact FISH-20: Maintenance Effects
- Impact assessments rely primarily on modeled hydrologic changes in SWP and CVP operations that would occur as a result of Project operations
- Depending on the species and location, the specifics of the assessment methodologies differ

Speaker: Mike

Aquatic Biological Resources – Examples of Analyses

- **CALSIM II**: Monthly flow output used to assess changes in reservoir water surface elevation, storage, and instream flows associated with implementation of the alternatives. The CALSIM II monthly flow output also served as input to many of the other models used to analyze potential impacts to aquatic resources.
- **Weighted Usable Area**: Provides estimates of the amount of suitable spawning and rearing habitat of fishes available in rivers and streams at various levels of flow.
- **SALMOD**: Used to evaluate flow and temperature related mortality of early life stages and overall production of each race of Chinook salmon in the Sacramento River.
- **Juvenile Stranding**: Juvenile stranding is computed using USRDOM daily flow estimates for Alternatives 1–3 and the NAA at three locations in the upper Sacramento River: Keswick Dam, Clear Creek, and Battle Creek.
- **Martin and Anderson**: Winter-Run Chinook Salmon eggs are positively correlated with water temperature.
- **HEC5Q**: Used for Sacramento River and American River daily water temperature analysis
- **Reclamation Temperature Model**: Used for Feather River temperature analysis

Speaker: Mike

Aquatic Biological Resources – Species Evaluated

Listed Species	Other Species
Delta smelt, Longfin Smelt	California Bay Shrimp
Killer Whale	Starry Flounder, Northern Anchovy
Green Sturgeon	Pacific Lamprey, River Lamprey
Steelhead	Native Minnows
Fall-run/Late Fall-run Chinook	Striped Bass, Black Bass
Spring-run Chinook	American Shad, Threadfin Shad
Winter-run Chinook	White Sturgeon

Speaker: Mike

Mike to fill out other species

Aquatic Biological Resources – Examples of Key Drivers of Less than Significant Determination

- **Weighted Usable Area**:
  - Indicates that Alternatives 1 and 2 would have little effect on **late fall–run** spawning WUA and Alternative 3 would have moderate, primarily beneficial, effects
  - Indicates that the Alternatives would result in frequent minor reductions in spawning habitat WUA for **fall-run**, and occasional somewhat greater reductions, primarily for Alternative 3
  - The Alternatives are expected to have little effect on **spring-run** spawning in the Sacramento River
  - The Alternatives are not expected to substantially affect **winter-run** spawning WUA
- **SALMOD**: Overall results show a minimal effects of Alternatives on salmon mortality and potential production in the Sacramento River
- **HEC5Q:** Mean monthly temperatures by water year type between alternatives in the Sacramento, American, and Feather rivers indicates that water temperatures would be similar among alternatives during the period of presence of (where applicable):
  - Winter-run, spring-run, fall-run/late fall–run Chinook salmon, steelhead
  - Native Minnows
  - Lamprey
  - Sturgeon (white and green)
  - Striped Bass
  - American Shad

Speaker: Mike

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Aquatic Biological Resources – Mitigation Measures

- Mitigation Measure FISH-9.1: Tidal Habitat Restoration for Longfin Smelt
  - Tidal habitat restoration mitigation for longfin smelt was calculated based on the same method recently applied by DWR (2019d: 5-5). The method is described in more detail in Appendix 11F, *Smelt Analysis*. The mitigation requirement for each alternative varies between 11 and 15 acres, depending on the alternative

Speaker: Mike

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Aquatic Biological Resources – BMPs and Plans

- Example BMPs
  - Develop and implement an underwater sound control, abatement, and monitoring plan to avoid and minimize the effects of underwater construction noise on fish
  - Worker Environmental Awareness Program (WEAP)
  - Develop and Implement Fish Rescue and Salvage Plans
- Sediment Technical Studies Plan and Adaptive Management
  - Sediment Monitoring
  - Sediment Modeling
  - Sediment Reintroduction
- Fish Monitoring and Technical Studies Plan and Adaptive Management
  - 4 Technical Studies: Fish Distribution and Density; Juvenile Salmonid Survival Rates; Predator Density and Distribution; Long-Term Hydraulic Fish Screen Evaluation
  - 3 Types of Aquatic Monitoring: Rotary Screw Traps; Entrainment and Impingement; and Stranding Behind Screens

Speaker: Mike

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Meeting: **Sites Reservoir Project** **2021 June 23**

Subject: **Joint Authority Board & Reservoir Committee Meeting** **1:30 – 4:00 PM**

Location: Click here to join the meeting Call in:**1-213-379-5743**
Code: **656 062 706#**

Board Chair: Fritz Durst (Reclamation District 108)
Board Vice Chair: Jeff Sutton (Tehama-Colusa Canal Authority)
Res Comm Chair: Jeff Davis (San Gorgonio Pass Water Agency)
Res Comm Vice Chair: Bill Vanderwaal (RD 108/Dunnigan Water District)
Treasurer: Jamie Traynham (Davis Water District)

AGENDA

Notice: Pursuant to Executive Order N-29-20, issued by Governor Newsom on March 17, 2020, as modified by Executive Order N-08-21, this meeting will be conducted by teleconference. The public may attend the meeting and offer public comments by phone, using the call-in number above. Members of the Committee will participate by teleconference from other locations.

ROLL CALL & CALL TO ORDER:

- Introductions.
- Pledge of Allegiance.
- Approval of June 23, 2021 Joint Meeting Agenda.
- Period for Public Comment.

1. Consent Agenda: Approximate start time 1:45 pm

The Executive Director reviewed the following items. To his knowledge, there is no opposition to the action. The items can be acted on in one consolidated motion as recommended or may be removed from the Consent Calendar and separately considered at the request of any person.

1.1 Consider Approval of the May 20, 2021 Reservoir Committee Meeting Minutes. **(Attachments A & B)**

1.2 Consider Approval of the May 26, 2021 Authority Board Meeting Minutes. **(Attachment A)**

1.3 Consider acceptance of the Sites Project Authority Treasurer's Report. **(Attachment A)**

1.4 Consider approval of the Payment of Claims. **(Attachments A, B & C)**

1.5 Consider approval of an amendment to Fechter and Company's contract to include conducting a Single Audit in the amount of $3,500 bringing their existing contract amount to $61,754.

1.6 Consider authorizing the Executive Director to enter into a new Cost Sharing Memorandum of Agreement with the United States Bureau of Reclamation.

2. Action Items: Approximate start time 2:00 pm

2.1 Consider acceptance of the updated Feasibility Total Project Cost Estimate.

2.2 Consider approval to submit a Water Infrastructure Finance and Innovation Act Letter of Intent.

2.3 Direct staff to prepare the Amendment 3 Work Plan based on a 36-month work plan period. **(Attachment A)**

3. Discussion and Information Items: Approximate start time 3:00 pm

3.1 Review and comment on the key outcomes of the operations-related chapters and growth inducement analysis in the Revised Draft EIR/Supplemental Draft EIS (RDEIR/SDEIS). **(Attachment A)**

3.2 Review and comment on the Sites Reservoir Benefits and Obligations Guiding Principles and Preliminary Terms Draft. **(Attachment A)**

4. Reports: Approximate start time 3:45 pm

4.1 Member's Reports:

4.1.1 Chairpersons' Report:

This time is set aside to allow the Chair/Co-Chair an opportunity to disclose/discuss items related to the Sites Project.

4.1.2 Committee & Workgroup Chairpersons' Report:

This time is set aside to allow the Workgroup Chairpersons' an opportunity to disclose/discuss items related to the Sites Project.

4.1.3 Authority Board & Reservoir Committee Participant Reports:

This time is set aside to allow Representatives or their Alternates an opportunity to disclose/discuss items related to the Sites Project.

4.2 Executive Director's Reports:

- Monthly status report. **(Attachment A)**
- Work Plan Key Deliverables Report. **(Attachment B)**
- Meetings Action Items Summary. **(Attachment C)**

5. Recap: Approximate start time 4:00 pm

5.1 Suggested Future Agenda Items.

5.2 Upcoming Meetings:

Reservoir Committee
Thursday, July 15, 2021, 1:30 PM – 4:00 PM
Virtual and in-person at the Maxwell Project Office

Authority Board
Wednesday, July 21, 2021, 1:30 PM – 4:00 PM
Virtual and in-person at the Maxwell Project Office

Joint Plan of Finance Workshop – Affordability Review
Friday, July 23, 2021, 9:00 AM – 12:00 PM
Virtual and In-person at the Maxwell Project Office
PLEASE INVITE YOUR AGENCY STAFF THAT WILL BE INVOLVED IN FINANCING FOR THE PROJECT

ADJOURN

PERIOD OF PUBLIC COMMENT: Any person may speak about any subject of concern, provided it is within the jurisdiction of the Reservoir Committee and is not already on today's agenda. The total amount of time allotted for receiving such public communication shall be limited to a total of 10 minutes per issue and each individual or group will be limited to no more than 3 minutes each within the 10 minutes allocated per issue. **Note:** No action shall be taken on comments made under this comment period.

ADA COMPLIANCE: Upon request, agendas will be made available in alternative formats to accommodate persons with disabilities. In addition, any person with a disability who requires a modification or accommodation to participate or attend this meeting may request necessary accommodation. Please make your request to the Board Clerk, specifying your disability, the format in which you would like to receive this Agenda and any other accommodation required no later than 24 hours prior to the start of the meeting.

This meeting will be recorded.

From: Micko, Steve/SAC [Steve.Micko@jacobs.com]
Sent: 6/24/2021 8:45:56 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Leaf, Rob/SAC [Rob.Leaf@jacobs.com]
CC: Heydinger, Erin [erin.heydinger@hdrinc.com]
Subject: RE: Prop 1 Projects | CALSIM

Absolutely! We'll take a look and let you know.

Best,
Steve

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Wednesday, June 23, 2021 12:46 PM
To: Micko, Steve/SAC <Steve.Micko@jacobs.com>; Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Cc: Heydinger, Erin <erin.heydinger@hdrinc.com>
Subject: [EXTERNAL] FW: Prop 1 Projects | CALSIM

Steve and Rob – Please see David's message below. Can you take a look at the CALSIM modeling link he provided to see if any of this affects Sites? I am not sure if they are actually including Sites in the model.

Let me know when you get a chance. There is no due date on David's email, but I suspect we'd want to get back to them sooner rather than later.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Wednesday, June 23, 2021 10:43 AM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Heydinger, Erin <erin.heydinger@hdrinc.com>
Subject: FW: Prop 1 Projects | CALSIM

I appreciate Dave forwarding this information but I don't believe anything here affects the Sites Project. Please confirm.

I think all of this relates to the pulse flow projects and DWR's modeling efforts around those projects.

From: "Okita, David@DWR" <David.Okita@water.ca.gov>
Date: Wednesday, June 23, 2021 at 10:15 AM
To: Sylvie Lee <slee@ieua.org>, "Cowin, Mark" <mcowin@geiconsultants.com>, Paul Weghorst <Weghorst@irwd.com>, Marguerite Patil <mpatil@ccwater.com>, Fiona Sanchez <sanchezf@irwd.com>, Jerry Brown <jbrown@sitesproject.org>, Terrie Mitchell <mitchellt@sacsewer.com>, "chakes@valleywater.org" <chakes@valleywater.org>, "mbeuhler@wswaterbank.com" <mbeuhler@wswaterbank.com>, "Young, Amy@DWR" <Amy.Young@water.ca.gov>, "Yun, Joseph@DWR" <Joseph.Yun@water.ca.gov>, Dave Richardson <drichardson@woodardcurran.com>, "Uttley, Paige@Wildlife" <Paige.Uttley@wildlife.ca.gov>,

"Davis-Fadtke, Kristal@Wildlife" <Kristal.Davis-Fadtke@wildlife.ca.gov>
Cc: "Davis-Fadtke, Kristal@Wildlife" <Kristal.Davis-Fadtke@wildlife.ca.gov>, "Uttley, Paige@Wildlife" <Paige.Uttley@wildlife.ca.gov>
Subject: Re: Prop 1 Projects | CALSIM

I am using this mailing list to update projects on updated CALSIM modeling. DWR and CDFW previously provided guidance on updates to CALSIM modeling to be used by WSIP projects for public benefit agreement purposes to reflect new regulatory changes from the application stage.
We also agreed that the new CALSIM modeling should incorporate the 2030 and 2070 climate change assumptions used at the application stage.

We have had requests for DWR to provide updated CALSIM modeling results. We have provided the updated baseline CALSIM2 run developed by DWR staff.

https://cadwr.app.box.com/s/n763qucwdb1ktq0rwrfky10e74qu5cx1

DWR staff does not have the time to do the 2030 and 2070 runs, so DWR will be using MBK to develop these runs. We will be coordinating with USBR to ensure their operations are represented adequately in the updated model for the 2030 and 2070 scenarios. Note that these discussions may lead to a revision to the "base" run linked above. USBR and DWR revise the models from time to time to improve it. I understand that there are several CALSIM versions currently being used.

Due to time for contacting and consultations with Reclamation we estimate that this work will be done in September. We will get DWR/USBR concurrence on the scenario runs and share results with all of you who are interested. If we get any comments they can be addressed, then we can deem the results final.

David Okita, PE
Department of Water Resources
530 902-7588

From: Okita, David@DWR <David.Okita@water.ca.gov>
Sent: Tuesday, June 22, 2021 7:08 AM
To: Sylvie Lee <slee@ieua.org>; Cowin, Mark <mcowin@geiconsultants.com>; Paul Weghorst <Weghorst@irwd.com>; Marguerite Patil <mpatil@ccwater.com>; Fiona Sanchez <sanchezf@irwd.com>; Jerry Brown <jbrown@sitesproject.org>; Mitchell. Terrie <mitchellt@sacsewer.com>; chakes@valleywater.org <chakes@valleywater.org>; mbeuhler@wswaterbank.com <mbeuhler@wswaterbank.com>; Young, Amy@DWR <Amy.Young@water.ca.gov>; Yun, Joseph@DWR <Joseph.Yun@water.ca.gov>; Dave Richardson <drichardson@woodardcurran.com>; Uttley, Paige@Wildlife <Paige.Uttley@wildlife.ca.gov>; Davis-Fadtke, Kristal@Wildlife <Kristal.Davis-Fadtke@wildlife.ca.gov>
Cc: Melton, Holly <hmelton@kcwa.com>; Craig Wallace <cwallace@kcwa.com>; Stephen Arakawa <sarakawa@mwdh2o.com>; Chilmakuri, Chandra@SWC <cchilmakuri@swc.org>; Brandon Goshi <bgoshi@mwg2o.com>; Dwayne Chisam <dchisam@avek.org>; Laura J. Hidas (laura.hidas@acwd.com) <laura.hidas@acwd.com>; Flores, Amparo <aflores@zone7water.com>; Cindy Kao <ckao@valleywater.org>; 'Rob Kunde

(rkunde@wrmwsd.com)' <rkunde@wrmwsd.com>
Subject: Re: Prop 1 Projects | DWR CEQA Analysis

Attached is the draft cumulative flow analysis for the WSIP projects. Please review carefully that we have described your project correctly. To save time, we did not have AECOM contact each project directly, we relied on past information and this is the opportunity to make updates and corrections. The challenge is that the projects have evolved since the application stage so we may not have captured the most recent numbers. Our thought was that we would show you the format of the analysis, then seek conformation of the numbers.

Although this is being done through the contract for the CEQA Initial Study for the pulse flow projects and DWR actions on the Emergency Supply WSIP public benefits, it may or may not be used in the Initial Study and subsequent CEQA documents pending further review. We will also make a decision on whether additional flow modeling or analysis is necessary. This is not a cumulative analysis of all impacts of the WSIP projects, just flow impacts to the Feather River, the Sacramento River and the Delta.

Please provide comments by July 23. DWR will be participating in a workshop with the State Water Contractors at the end of July and will be sharing general results of this analysis.

David Okita, PE

Department of Water Resources

530 902-7588

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/24/2021 12:31:45 PM
To: Luu, Henry [Henry.Luu@hdrinc.com]; jeff.herrin@aecom.com
CC: Alicia Forsythe [aforsythe@sitesproject.org]; Laurie Warner Herson [laurie.warner.herson@phenixenv.com]
Subject: Sites Dam Outlet

Henry and Jeff,
The CEQA team has identified a significant water quality impact associated with the location of the Site's dam outlet, or more specifically, the intake portion. It seems that the elevation of the intake is positioned such that under the right conditions we could potentially violate the Basin Plan's requirements for receiving waters. The proposed mitigation is not really ideal (stop or treat the water), so I was wondering if there was a design component that could be used to draw water from higher up in the reservoir. Say maybe 20 or so feet?

Thanks,
John

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

HDR
2379 Gateway Oaks Drive, Suite 200
Sacramento, CA 95833
D 916.679.8858 M 818.640.2487
john.spranza@hdrinc.com

hdrinc.com/follow-us
hdrinc.com/follow-us

From: Laurie Warner Herson [laurie.warner.herson@phenixenv.com]
Sent: 6/24/2021 1:24:11 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]
CC: Linda Fisher (linda.fisher@hdrinc.com) [linda.fisher@hdrinc.com]
Subject: FW: Critical Milestones

FYI

From: Briard, Monique <Monique.Briard@icf.com>
Sent: Tuesday, June 1, 2021 5:25 PM
To: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Williams, Nicole <Nicole.Williams@icf.com>
Cc: Linda Fisher (linda.fisher@hdrinc.com) <linda.fisher@hdrinc.com>
Subject: RE: Critical Milestones

Thanks, Laurie.

I grabbed a few of the line items from the schedule (I deleted the green highlighting) to tee up what I'd like to talk about, mainly the 3 week timeline between receiving all consolidated comments on 6/25 and the live edit meetings. We currently have them mapped through 7/16, which only gives us 3 working days from our last meeting to meet the 7/21 due date to Reclamation. We'd like to move these up and schedule the live edit meetings of the Group 2 and 3 chapters to occur the week of 7/6- 7/9. This will make review of comments and updates by the technical authors tight but it will give us 7 working days to finalize the document for Reclamation, which we'll need. Penciling this out together to figure out what chapters can be deemed as done and what will be pushed to the last day for the live edit meetings will be helpful.

We should also talk more about the AQ chapter review with the analysis of the modeling that will be complete 7/9 and then will need to be added to the chapter.

Also, are we assuming that once it is sent to Reclamation on 7/21 that pencils are down and no one will be making changes to the document after that date. I believe we talked about not anticipating any changes from Reclamation but wanted to confirm. This also means we will move our ADA process to start on 7/21 vs. 8/2 to finalize the document.

If I've done my simple math correctly – our authors have 27 days (-1 for the 7/5 holiday) left to finish the document before it needs to go to editing and then to Reclamation. I'd love to be proven wrong 😉

Thanks,
Monique

May 24	Admin RDEIR/SDEIS Group 1 Returned to ICF w/ consolidated comments
May 24	Admin RDEIR/SDEIS Group 2 Submittal by ICF (all but Group 1, Ch 11, Aquatic Biological Resources; Ch 28, Climate Change; Ch 31, Cumulative; Executive Summary. Note that Chapter 20, Air Quality; will be incomplete, we will have a better idea of when that can be provided later this week, but it would likely come between May 31 and June 21)
May 31	Admin RDEIR/SDEIS Remaining Chapter 11 - based on ICF proposed schedule 1/29/21; Ch 28, Climate Change; Ch 31, Cumulative; Executive Summary. Some Ch 11 appendices may need to be pushed to June. Working with the Aquatics team to identify appendices that may be at risk of meeting a 5/31 date.
May 24-June 18	Admin RDEIR/SDEIS Group 2 Review by Reclamation/Authority/Legal
June 25	Complete Admin RDEIR/SDEIS Returned to ICF w/ consolidated comments
June 29 to July 16	Live Edit Meetings (note: some live edit meetings on Admin RDEIR/SDEIS Group 1 could occur, if needed, prior to this time frame).

July/August	Reclamation NEPA Process – Needs to be integrated with overall schedule
August 2, 2021	Start ADA Compliance Process with chapters/appendices that are considered final (note: this could also start before August 2, but if we haven't started by August 2, we need to at that time)

From: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Sent: Tuesday, June 1, 2021 3:12 PM
To: Briard, Monique <Monique.Briard@icf.com>; Williams, Nicole <Nicole.Williams@icf.com>
Cc: Linda Fisher (linda.fisher@hdrinc.com) <linda.fisher@hdrinc.com>
Subject: Critical Milestones

Hi Monique,

As we discussed on the 2pm call, the critical milestone schedule we discussed in March and the EIR/EIS schedule are on SharePoint:
https://sitesreservoirproject.sharepoint.com/:f:/r/EnvPlanning/Shared%20Documents/EIR_EIS%20Schedule?csf=1&web=1&e=ut7ty7.

Please take a look at this – it was done in March and became quickly outdated regarding the Group 1-3 deliverables but end dates did not change.

Thank you,

Laurie

Laurie Warner Herson
Principal/Owner
Phenix
Environmental Planning

916.201.3935
laurie.warner.herson@phenixenv.com
State of California Small Business (#1796182)
Supplier Clearinghouse Women Business Enterprise (#16000323)

http://phenixenv.com/

From: Herrin, Jeff [jeff.herrin@aecom.com]
Sent: 6/24/2021 2:02:23 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Spranza, John [john.spranza@hdrinc.com]; Luu, Henry [Henry.Luu@hdrinc.com]
CC: Laurie Warner Herson [laurie.warner.herson@phenixenv.com]; Forrest, Michael [michael.forrest@aecom.com]
Subject: RE: Sites Dam Outlet

Okay. I'm sure we can come up with something, but it isn't an obvious answer. Raising the intake 20 ft. isn't inexpensive. Maybe we can collect it from the creeks upstream.

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Thursday, June 24, 2021 12:54 PM
To: Herrin, Jeff <jeff.herrin@aecom.com>; Spranza, John <john.spranza@hdrinc.com>; Luu, Henry <Henry.Luu@hdrinc.com>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Forrest, Michael <michael.forrest@aecom.com>
Subject: [EXTERNAL] RE: Sites Dam Outlet

Jeff – See attached and search for Stone Corral. The impact and mitigation will come up. It's about the potential for metal accumulations in the bottom of the reservoir. We're uncertain of this, but it will be hard to mitigate / address IF it does occur. So thinking of possible ways to make sure this isn't a problem – can we engineer a solution to prevent this from ever happening?

We can also have a call with the water quality folks at ICF to talk more about the concern as this might help the engineering team in thinking about a possible engineering solution.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Herrin, Jeff <jeff.herrin@aecom.com>
Sent: Thursday, June 24, 2021 12:42 PM
To: Spranza, John <john.spranza@hdrinc.com>; Luu, Henry <Henry.Luu@hdrinc.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Forrest, Michael <michael.forrest@aecom.com>
Subject: RE: Sites Dam Outlet

John,

What are we trying to achieve? The water is never 20 ft deep going into the creek under existing conditions. Are you worried about long-term sediment accumulations in the bottom of the reservoir? The water won't be as cold higher up. Not sure if this is temperature driven.

Jeff

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Thursday, June 24, 2021 12:32 PM
To: Luu, Henry <Henry.Luu@hdrinc.com>; Herrin, Jeff <jeff.herrin@aecom.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: [EXTERNAL] Sites Dam Outlet

Henry and Jeff,
The CEQA team has identified a significant water quality impact associated with the location of the Site's dam outlet, or more specifically, the intake portion. It seems that the elevation of the intake is positioned such that under the right conditions we could potentially violate the Basin Plan's requirements for receiving waters. The proposed mitigation is not really ideal (stop or treat the water), so I was wondering if there was a design component that could be used to draw water from higher up in the reservoir. Say maybe 20 or so feet?

Thanks,
John

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

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Sacramento, CA 95833
D 916.679.8858 M 818.640.2487
john.spranza@hdrinc.com

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hdrinc.com/follow-us

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/24/2021 2:18:38 PM
To: jeff.herrin@aecom.com; Alicia Forsythe [aforsythe@sitesproject.org]; Luu, Henry [Henry.Luu@hdrinc.com]
CC: Laurie Warner Herson [laurie.warner.herson@phenixenv.com]; Forrest, Michael [michael.forrest@aecom.com]
Subject: RE: Sites Dam Outlet

Yeah, I understand. We are open to all options, we just need to make sure we can move any environmental water that we are required to release into Stone Corral in a manner that would not be subject to yearly interruptions due to water quality or cause significant effects to the downstream aquatic resources. That would not only put the project in some hot water with the agencies, it could lead to all sort of environmental commitments/mitigation that would be a lifetime requirement.

John Spranza

D 916.679.8858 M 818.640.2487

From: Herrin, Jeff <jeff.herrin@aecom.com>
Sent: Thursday, June 24, 2021 2:02 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Spranza, John <John.Spranza@hdrinc.com>; Luu, Henry <Henry.Luu@hdrinc.com>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Forrest, Michael <michael.forrest@aecom.com>
Subject: RE: Sites Dam Outlet

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From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Thursday, June 24, 2021 12:54 PM
To: Herrin, Jeff <jeff.herrin@aecom.com>; Spranza, John <john.spranza@hdrinc.com>; Luu, Henry <Henry.Luu@hdrinc.com>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Forrest, Michael <michael.forrest@aecom.com>
Subject: [EXTERNAL] RE: Sites Dam Outlet

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We can also have a call with the water quality folks at ICF to talk more about the concern as this might help the engineering team in thinking about a possible engineering solution.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

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From: Herrin, Jeff <jeff.herrin@aecom.com>
Sent: Thursday, June 24, 2021 12:42 PM
To: Spranza, John <john.spranza@hdrinc.com>; Luu, Henry <Henry.Luu@hdrinc.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Forrest, Michael <michael.forrest@aecom.com>
Subject: RE: Sites Dam Outlet

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Sent: Thursday, June 24, 2021 12:32 PM
To: Luu, Henry <Henry.Luu@hdrinc.com>; Herrin, Jeff <jeff.herrin@aecom.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: [EXTERNAL] Sites Dam Outlet

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The CEQA team has identified a significant water quality impact associated with the location of the Site's dam outlet, or more specifically, the intake portion. It seems that the elevation of the intake is positioned such that under the right conditions we could potentially violate the Basin Plan's requirements for receiving waters. The proposed mitigation is not really ideal (stop or treat the water), so I was wondering if there was a design component that could be used to draw water from higher up in the reservoir. Say maybe 20 or so feet?

Thanks,
John

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

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Sacramento, CA 95833
D 916.679.8858 M 818.640.2487
john.spranza@hdrinc.com

hdrinc.com/follow-us
hdrinc.com/follow-us

From: Beakes, Michael P [mbeakes@usbr.gov]
Sent: 6/25/2021 2:58:53 PM
To: King, Vanessa M [vking@usbr.gov]; Spranza, John [john.spranza@hdrinc.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Heydinger, Erin [erin.heydinger@hdrinc.com]; Lecky, Jim [jim.lecky@icf.com]; Hassrick, Jason [jason.hassrick@icf.com]; Hendrick, Mike [mike.hendrick@icf.com]; steve.micko@jacobs.com; Manugian, Suzanne C [smanugian@usbr.gov]; Mooney, David M [dmmooney@usbr.gov]; Manzo, Mario A [MManzo@usbr.gov]; Wittler, Rodney (Rod) J [RJWittler@usbr.gov]; Mosley, Michael I [mmosley@usbr.gov]; Sumer, Derya [dsumer@usbr.gov]; Dekar, Melissa D [mdekar@usbr.gov]; Cook, Megan T [megan_cook@fws.gov]; Casillas, Heather M [hcasillas@usbr.gov]
CC: Hunt, Shane D [shunt@usbr.gov]; Leaf, Rob/SAC [Rob.Leaf@jacobs.com]
Subject: Re: Sites SIT modeling
Attachments: SITES SIT Modeling Presentation_25June2021.pptx; Peterson and Duarte 2021.pdf

Good afternoon everyone,

I've attached the PowerPoint from today's meeting and the paper I referenced.

Have a great weekend,

Mike

From: King, Vanessa M
Sent: Tuesday, June 22, 2021 9:27 AM
To: King, Vanessa M <vking@usbr.gov>; John Spranza <john.spranza@hdrinc.com>; Alicia Forsythe <aforsythe@sitesproject.org>; Erin Heydinger <erin.heydinger@hdrinc.com>; Lecky, Jim <jim.lecky@icf.com>; Hassrick, Jason <jason.hassrick@icf.com>; Hendrick, Mike <mike.hendrick@icf.com>; Micko, Steve/SAC <steve.micko@jacobs.com>; Manugian, Suzanne C <smanugian@usbr.gov>; Mooney, David M <dmmooney@usbr.gov>; Manzo, Mario A <MManzo@usbr.gov>; Wittler, Rodney (Rod) J <RJWittler@usbr.gov>; Mosley, Michael I <mmosley@usbr.gov>; Sumer, Derya <dsumer@usbr.gov>; Dekar, Melissa D <mdekar@usbr.gov>; Cook, Megan T <megan_cook@fws.gov>; Casillas, Heather M <hcasillas@usbr.gov>
Cc: Hunt, Shane D <shunt@usbr.gov>; Leaf, Rob/SAC <Rob.Leaf@jacobs.com>; Beakes, Michael P <mbeakes@usbr.gov>
Subject: Sites SIT modeling
When: Friday, June 25, 2021 2:00 PM-3:00 PM.
Where:

Meeting between Reclamation and the Sites Authority to discuss the possibility of doing SIT modeling to support the Sites aquatics analysis.

Microsoft Teams meeting

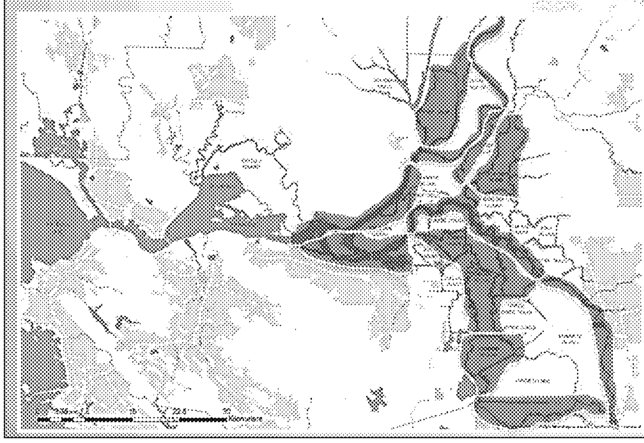
Join on your computer or mobile app
Click here to join the meeting

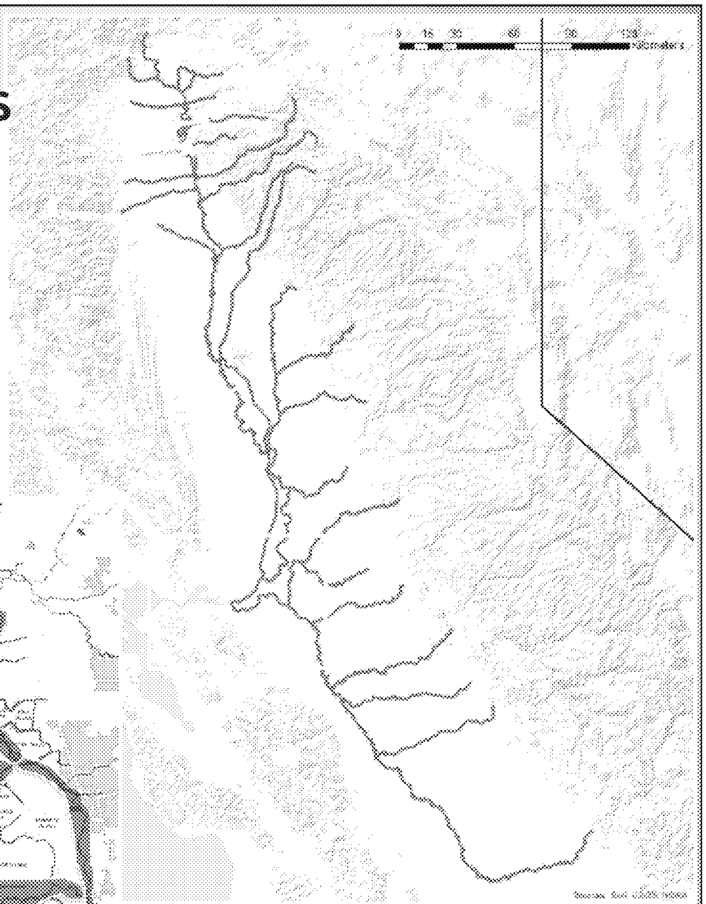
Learn More | Meeting options

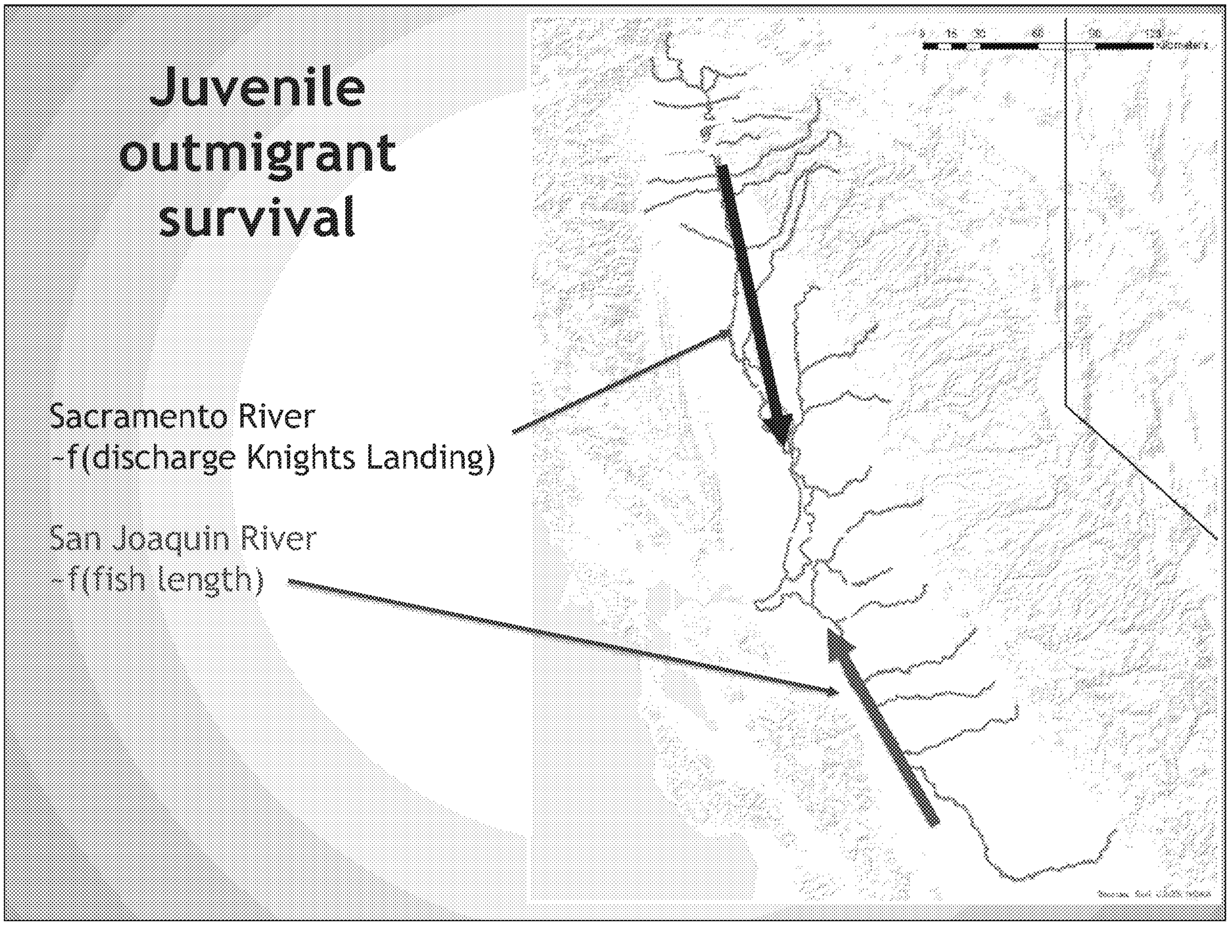
SIT models for juvenile outmigrants

Sacramento &
San Joaquin Rivers

Delta: 13 zones






Juvenile outmigrant survival
Sacramento River
~f(discharge Knights Landing)
San Joaquin River
~f(fish length)

Chinook Delta Routing and Survival

Movement and survival parameters

North Delta

NRC Research Press

ARTICLE

Flow-mediated effects on travel time, routing, and survival of juvenile Chinook salmon in a spatially complex, tidally forced river delta

Russell W. Perry, Adam C. Pope, Jason G. Romine, Patricia L. Brandes, Jon R. Burau, Aaron R. Blake, Arnold J. Ammann, and Cyril J. Michel

South Delta (2008-2015) Meta-analysis

U.S. Fish & Wildlife Service

Lodi Fish & Wildlife Office

Serving the people and conserving the fish, wildlife and plants of California

Juvenile Salmonid Survival Studies

Chinook salmon

North Delta Routing & Survival

North delta
Yolo entrainment
Sutter/steamboat
Delta Cross Channel*
Georgiana Slough

f(discharge Freeport)

* DCC open/closed

Chinook salmon

South Delta Routing

Head of old river ~ f(physical barrier, discharge Vernalis)

Turner cut ~ f(discharge at Stockton)

SWP entrainment ~ f(exports)

CVP entrainment ~ f(pumps operating)

South Delta Survival

Varied by region

Q Vernalis, Temperature Vernalis & Prisoners Point

(meta analysis of tagging data)

Water project specific estimates published studies

The model (cont)

Developed statistical models to relate:

- Upstream flows to downstream flows
- Temperature to flows and air temperature

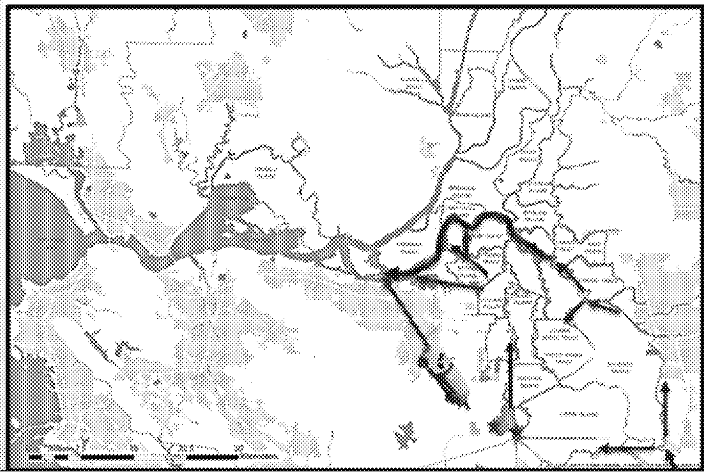
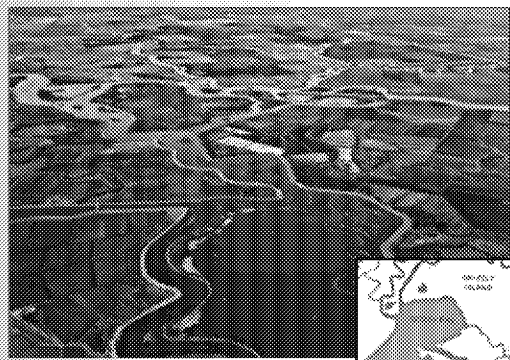
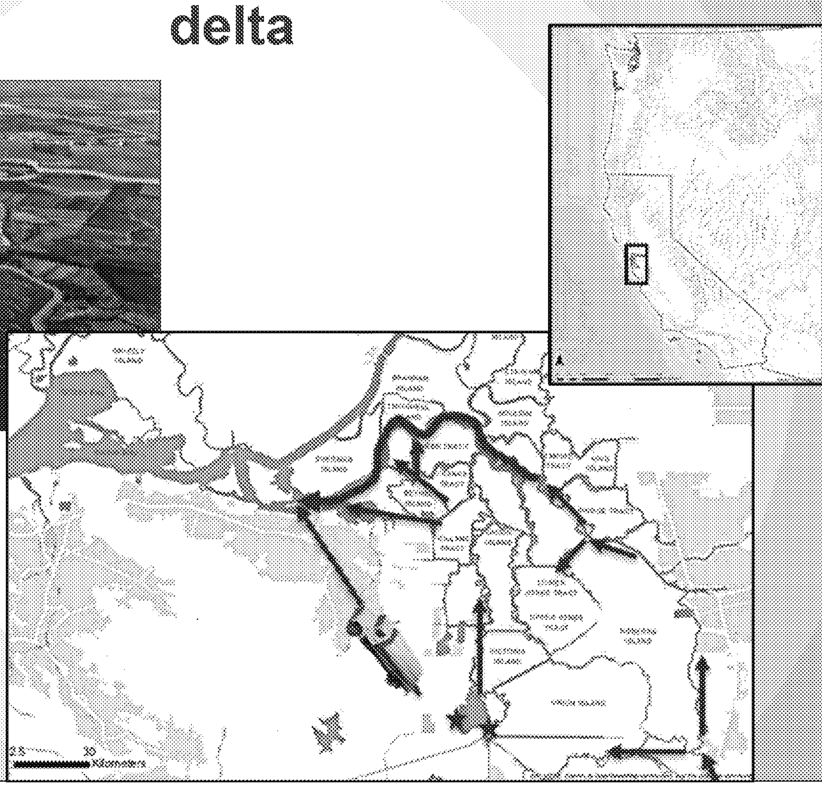


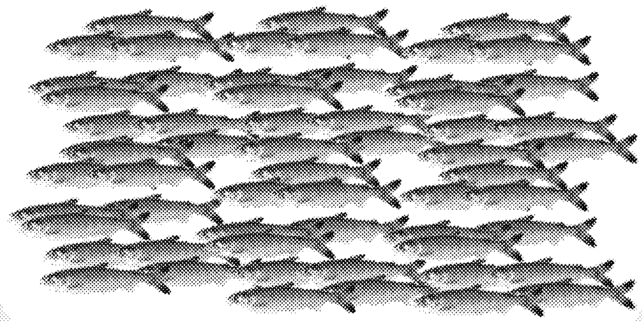
Illustration: Managing flows for Chinook salmon in south delta





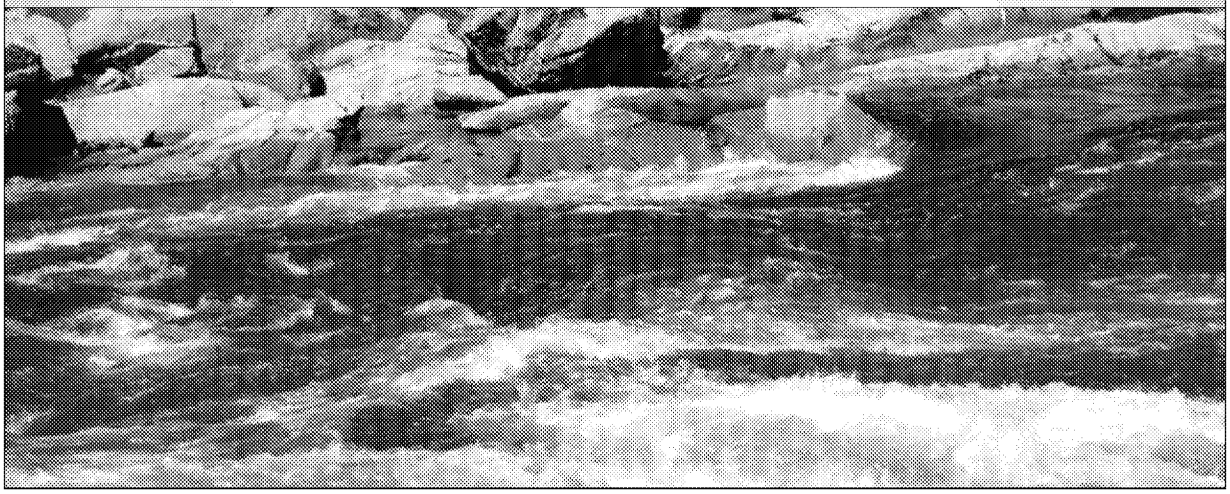
Objective

Maximize the number of fish that survive to the bay



Decision Alternatives

Given an amount of water for pulse flows and a minimum flow, how do we allocate water?



Optimization procedure

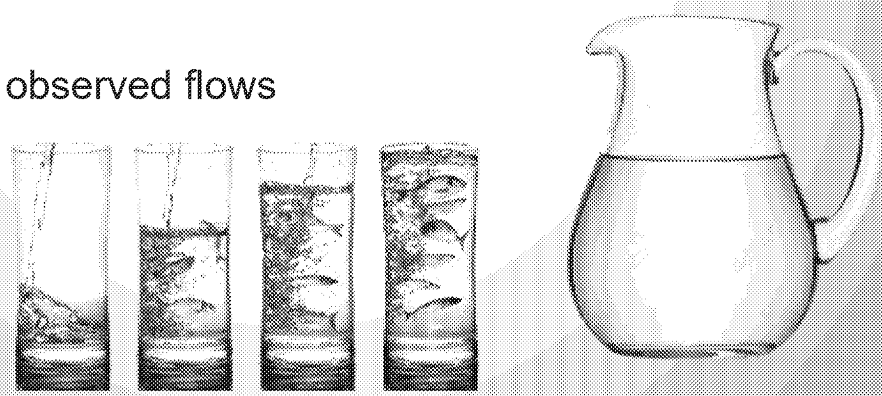
Allowed pulse flows to vary weekly over a 120-day period

Equality constraint (can't allocate > 100% of water):

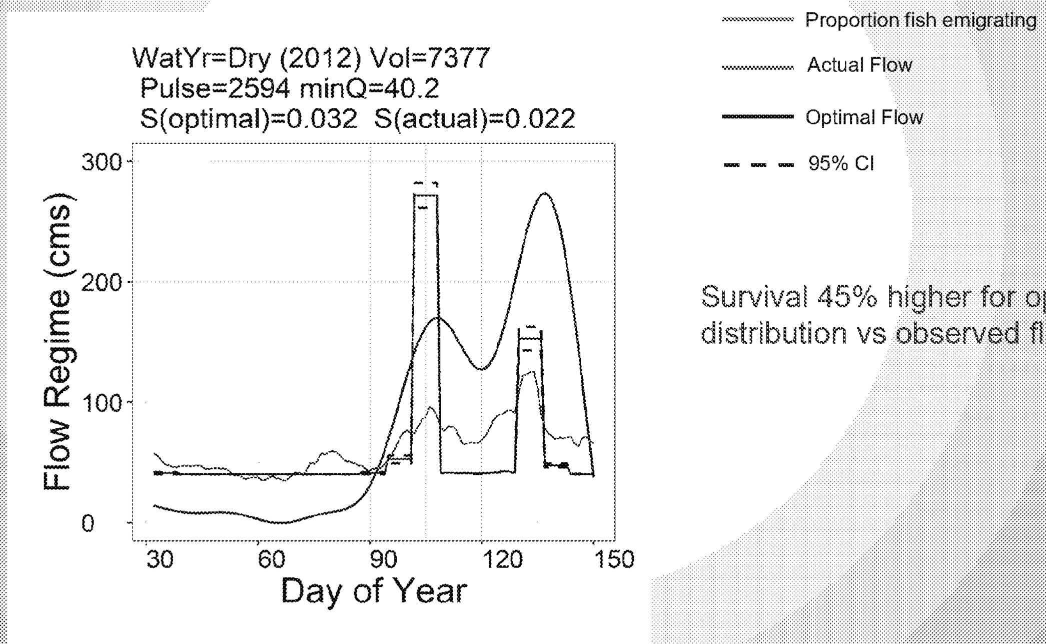
Solved model with nonlinear optimization:

- Simulation-optimization (includes variability)

Compared to observed flows

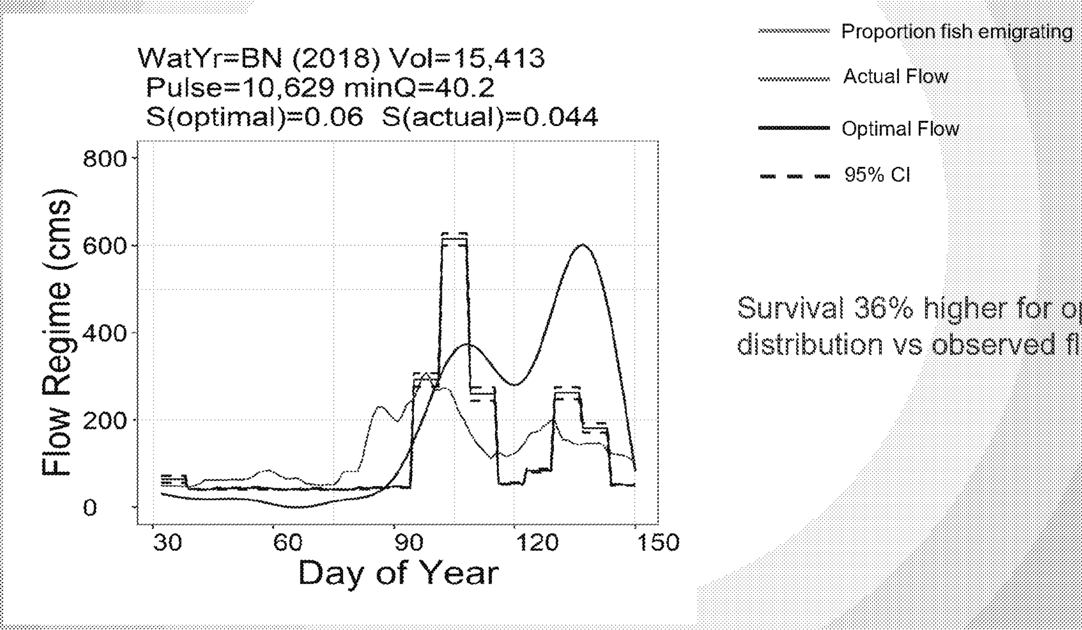


Dry Water year 2012



Survival 45% higher for optimal distribution vs observed flow

Below Normal Water year 2018



Survival 36% higher for optimal distribution vs observed flow

Moving forward

Similar evaluations for Sacramento and North Delta

Big uncertainties remain

Sacramento and north delta routing models

- built-in assumptions regarding the relationships between flows and other factors affecting juvenile salmon survival (temperature predation)

Limited in usefulness if relationships change

- Change operations
- Climate change

RESTORATION ECOLOGY
The Journal of the Society for Ecological Restoration
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RESEARCH ARTICLE

Decision analysis for greater insights into the development and evaluation of Chinook salmon restoration strategies in California's Central Valley

James T. Peterson[1,2], Adam Duarte[3]

Considerable resources have been invested in ecological restoration projects across the globe to restore ecosystem integrity. Restoration strategies are often diverse and have been met with mixed success. In this article, we describe the Chinook salmon (*Oncorhynchus tshawytscha*) decision-support models developed by the Central Valley Project Improvement Act Science Integration Team as part of a larger structured decision-making effort aimed at maximizing natural adult production of Chinook salmon in California's Central Valley, the United States. We then describe the decision-analytic tools the stakeholder group used to solve the models and explore model results, including stochastic dynamic programming, forward simulation, proportional scoring, relative loss, expected value of perfect information, response profile analyses, and indifference curves. Using these tools, the stakeholder group was able to develop and evaluate restoration strategies for multiple Chinook salmon runs simultaneously, a first for the restoration program. We found that actions targeted at one run were detrimental to others, which was unexpected. Furthermore, information uncovered during this process was used to direct efforts towards targeted research/monitoring to reduce critical uncertainties in salmon demographic rates and make better restoration decisions moving forward. The decision sciences have established a wide range of analytical tools and approaches to simplify complex problems into key components, and we believe the concepts described in this article are of great interest and can be applied by many restoration practitioners that undoubtedly face similar difficulties when implementing restoration strategies for complex systems.

Key words: decision-support model, habitat restoration, *Oncorhynchus tshawytscha*, stochastic dynamic programming, structured decision-making, value of perfect information

Implications for Practice

- Restoration ecology practitioners are increasingly using models to help guide restoration priorities and actions. These efforts will have greater insights and success if they utilize quantitative decision analysis tools.
- Decision-analytic tools allow managers to identify factors that largely drive restoration decision-making helping them focus on those aspects of the restoration that are most important and providing the basis for simplification of complex problems.
- Sensitivity analysis measures, such as the value of perfect and imperfect information, provide a common currency for evaluating trade-offs between research, monitoring, and restoration.

Introduction

The loss of global biodiversity and ecosystem integrity over the past century has been largely attributed to the degradation and damage to ecosystems caused by human land development and resource exploitation. To address these declines, the field of restoration ecology was established in the 1980s (Young et al. 2005). Since then, considerable effort has been expended on restoring ecosystems throughout the globe. The Society for Ecological Restoration's project voluntary database documents more than 240 restoration projects worldwide with 45% in North America (SER 2020). These efforts have resulted in billions of dollars in economic impact to local and regional economies (Nielsen-Pincus & Moseley 2013; BenDor et al. 2015).

Despite the widespread implementation of restoration, there is considerable variation in restoration approaches and

Author contributions: JTP conceived and designed the approach; JTP, AD organized and facilitated the stakeholder meetings; JTP analyzed the data and built the models; AD modified and calibrated the models; JTP developed the optimal policies; AD conducted the simulations and sensitivity analysis and both contributed equally in the writing of the manuscript.

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disagreement on the best (Matzek et al. 2017). At its core, ecological restoration includes management objectives, candidate actions intended to achieve those objectives, and models (e.g. conceptual, heuristic, quantitative) to evaluate candidate actions prior to implementation. The decision sciences have developed a variety of analytical tools and formalized an approach to decision-making that has been recently adopted for natural resource management (e.g. structured decision-making [SDM], Conroy & Peterson 2013). Although there are several excellent examples of decision-analytic approaches to inform restoration decision-making (e.g. Kozak & Piazza 2015; Martin et al. 2018), few of these took full advantage of the decision-analytic tools available.

Anadromous fish restoration in California's Central Valley, United States, is a typical example of a long-term, large-scale ecological restoration. Chinook salmon (*Oncorhynchus tshawytscha*) were once abundant throughout the watershed and included four seasonal runs that once supported economically and culturally significant fisheries (Yoshiyama 2007). However, mining, land development, river impoundment and fragmentation, and water use over the past century have led to widespread habitat degradation and fragmentation (Cummins et al. 2008). These changes have, in part, resulted in significant declines in Chinook salmon and other anadromous fishes. In response to the observed declines, the U.S. Congress passed the Central Valley Project Improvement Act (CVPIA) in 1992. The legislation directed the Department of Interior (DOI) to make "all reasonable efforts" to sustain a doubling of the number of naturally produced [adult] anadromous fishes in the Central Valley by 2002. The CVPIA fisheries program is among the largest anadromous fish restoration programs in the world, with funding in excess of $25 million annually (Cummins et al. 2008). To achieve the doubling goal, the program began restoration efforts focused on screening water diversions, reducing stream temperatures, increasing flows, improving fish passage, and restoring stream and riparian habitats. Unfortunately by 2002, the doubling goal was not achieved and remains unfulfilled today.

In response to a perceived lack of progress towards the doubling goal, the DOI initiated an independent science review of the CVPIA Fish Resource Area Activities. The review identified the need to develop a new comprehensive, science-based approach to restoration that explicitly links activities with program objectives (Cummins et al. 2008). This motivated the initiation of an SDM process in 2013. Since its inception, a group of stakeholders—known as the Science Integration Team (SIT) (Science Integration Team 2002)—have met bimonthly to participate in the SDM process that includes identifying objectives and decision alternatives, developing decision-support models (DSMs), and conceiving restoration strategies. The SIT uses a wide variety of decision-analytic tools to develop and evaluate candidate restoration strategies; identify key uncertainties; estimate the value of future monitoring and research; and develop monitoring priorities. Here, we describe the Chinook salmon DSMs developed by the SIT and highlight the uses of decision-analytic tools to facilitate the development of more efficient and effective restoration strategies. We focus primarily on the quantitative aspects of SDM rather than the process itself. Our objectives are to:

(1) introduce the Chinook salmon DSMs;
(2) identify optimal Chinook salmon restoration policies;
(3) evaluate alternative restoration strategies; and
(4) identify key uncertainties and estimate the value of conducting further research or monitoring.

Methods

Management Area

The Central Valley watershed is located in California, and is comprised of three main drainage systems encompassing 160,000 km^2; the Sacramento, San Joaquin, and Tulare river basins. The majority of the runoff in the Central Valley flows through the Sacramento and San Joaquin rivers and they join to form the Sacramento-San Joaquin River Delta. The spatial extent of the decision problem comprised the Sacramento and San Joaquin rivers, their major tributaries, the delta, and the major tributaries draining into the delta. Within each tributary, the uppermost extent for candidate management actions was defined as the upper limit that could be currently accessed by anadromous fishes. The Sacramento River below Keswick Dam was subdivided into four sections delineated by Red Bluff diversion, the Feather River confluence, the American River confluence, and Freeport, CA (Fig. 1). The San Joaquin River included the segment of river from the Merced River confluence to Vernalis, CA. The delta was bounded to the north at Freeport, Vernalis to the south, and Chipps Island to the west and included the Yolo Bypass and Colusa Basin Drain. The delta was subdivided into 13 subregions to facilitate the modeling of juvenile Chinook salmon that are routed through the delta (Fig. 1). The spatial extent of the model also included Sutter Bypass located east of the Sacramento River below Butte Creek. The spatial grain of the model consisted of individual tributaries, the segments of the Sacramento and San Joaquin rivers, the bypasses, and the delta subregions.

Model Overview

The Chinook salmon DSMs were stochastic stage-based models that tracked the number of Chinook salmon in six groups that include four juvenile size classes: small, <42 mm total length; medium, 42–72 mm; large, 72–110 mm; and very large, >110 mm and adult stages natural and hatchery origin (Fig. 2, top). The DSMs operated on a monthly time step and simulated 20 years. Transitions between stages were estimated using submodels that predicted survival, growth, and movement as functions of input parameters (Supplement S1) that represented conditions in the bay, delta, migratory corridors, and natal tributaries. The DSMs were developed by the SIT for fall-, winter- and spring-runs and were refined over a 4-year period. They were parameterized using empirical data, existing models, analyses of existing data, and a minimal amount of expert opinion (Table S1). The DSMs for the three Chinook salmon runs had the same basic structure but differed with respect to timing and DSM inputs (Fig. 2, bottom).

Chinook salmon DSMs began with an initial number of natural and hatchery origin adults returning to freshwater environments.

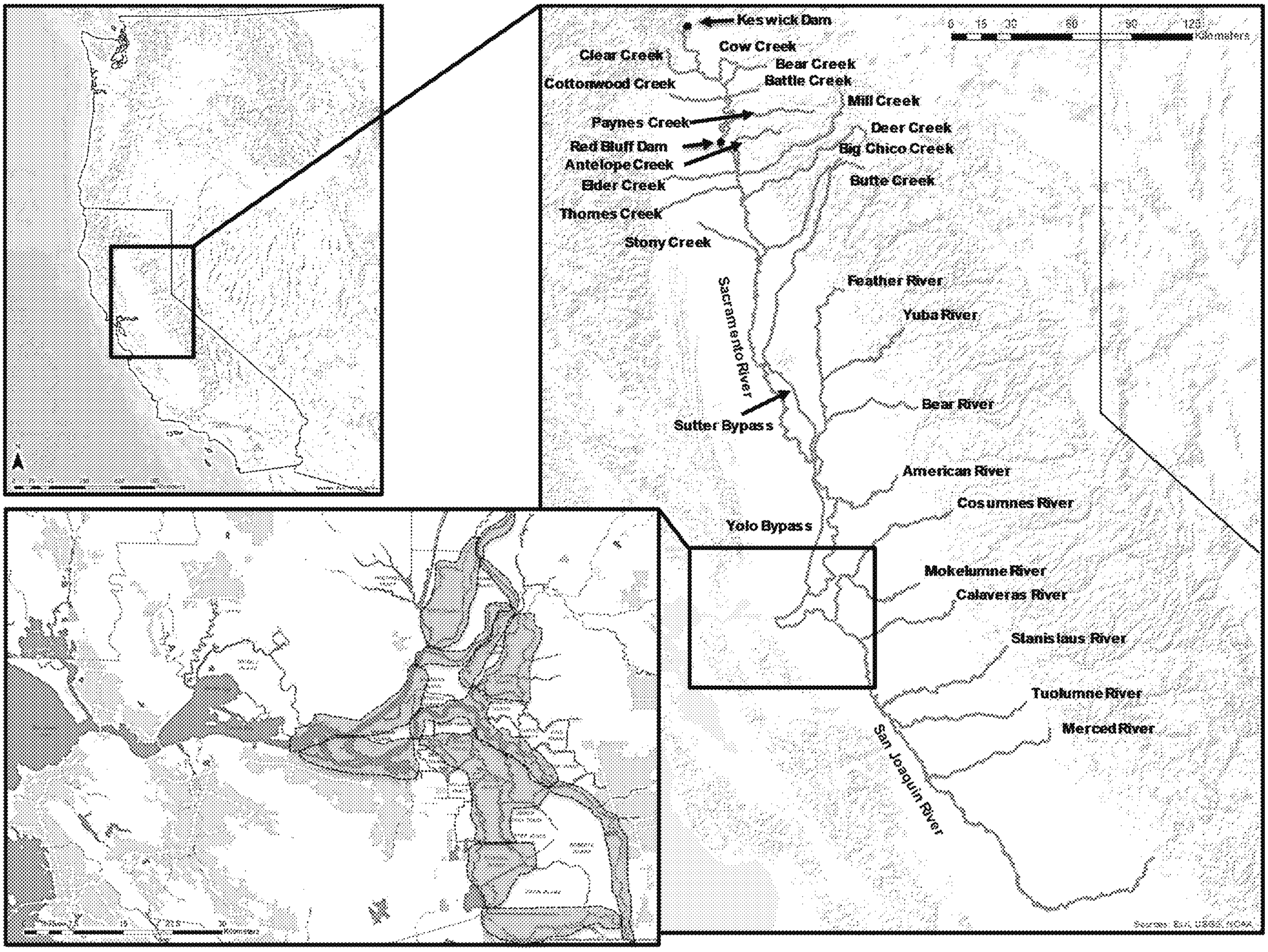

Figure 1 The location of the Central Valley and tributaries and river sections (labeled) and the Sacramento-San Joaquin Delta subregions (shaded) included in the evaluation of Chinook salmon restoration strategies.

These individuals were randomly assigned to each adult return month (Fig. 2, bottom) using a discrete triangle distribution. Returning adults experienced mortality (en route survival submodel) and were allowed to stray among tributaries (stray submodel). Adults that arrived to the spawning grounds also experienced mortality (prespawn survival submodel). The number of spring-run adults surviving on the spawning grounds was truncated by the capacity of holding habitat. Surviving females created a redd in the available spawning habitat and spawned. If the redd capacity was exceeded, females in later arriving groups then destroyed redds of females that previously spawned (i.e. each late arriving female would destroy one redd). The number of small size juvenile Chinook salmon produced by each arrival group was estimated as a function of the number of intact redds, female fecundity, and egg-to-fry survival (Table S1).

Juvenile Chinook salmon reared in natal tributaries, mainstem sections of the Sacramento and San Joaquin rivers, and the delta. Juvenile fish initially reared in their natal tributaries unless rearing habitat capacity was exceeded. Juvenile rearing habitat capacity was a function of juvenile size class-specific territory size. Fish habitat use and movement out of watersheds was based on the following rulesets. At each time step, juvenile fish occupy all available juvenile habitat within a spatial unit with larger fish being assigned to habitat first, followed by smaller fish. If seasonally inundated (floodplain) habitat was available during a time step, juvenile fish were assigned to floodplain habitat first followed by perennially inundated (in-channel) habitat. Juvenile fish assigned to habitat remained in a habitat for the time step. If habitat was unavailable, the juveniles not assigned to a habitat left the watershed and only moved downstream. If a fish grew to the very large size class, it left the watershed during the start of the next time step and migrated to the ocean within that time step. Juvenile Chinook salmon movement was also influenced by environmental factors such as discharge (e.g. pulsed flows) and time of year. Fish leaving watersheds were allowed to rear in available juvenile rearing habitat in downstream reaches, the bypasses, the delta, and the bay. Juvenile fish arriving in the downstream location were allocated to available habitat proportionally with larger fish

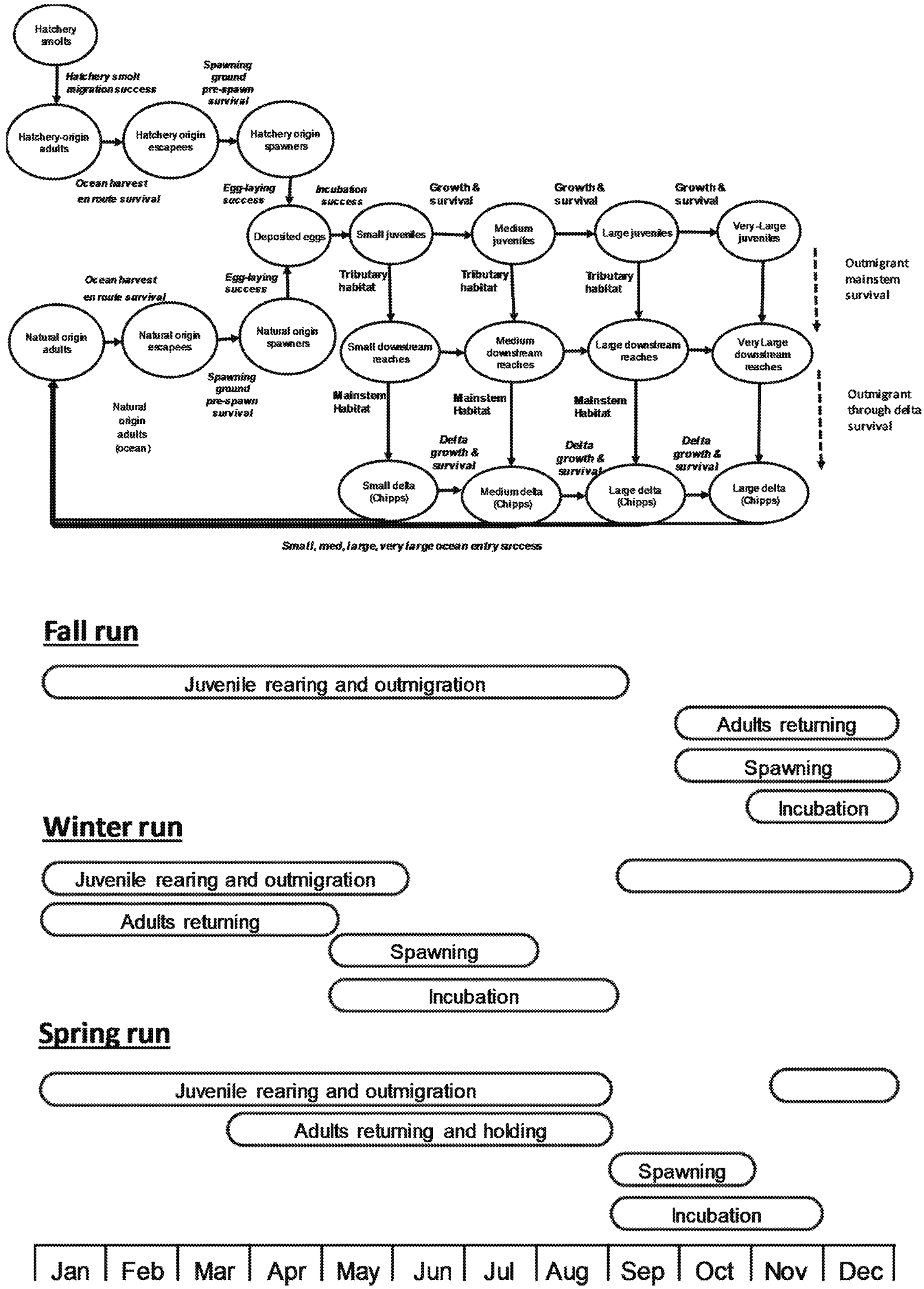

Figure 2 Conceptual Chinook salmon population dynamics used to evaluate Chinook salmon restoration strategies (top) and timing of life history activities for the three Chinook salmon runs with labeled bubbles representing the times that the activities occurred (bottom). Labeled arcs (top) indicate submodels that were used to model state transitions.

being assigned first. For example, if 100 and 200 fish from two tributaries arrived at a downstream location, 33% and 67% of the fish from each tributary, respectively, would be allocated to the available habitat. The transitions among the juvenile size classes occurred at the end of a time step and were modeled as a function of fish growth and rearing survival, which differed with habitat type: seasonally inundated (floodplain, including the Yolo and Sutter bypasses) and perennially inundated (in-channel). Juvenile fish migrating to downstream locations survived as a function of outmigrant survival. Once in the delta, fish survived and grew assuming delta-specific growth rates (Table S1) and survival (delta rearing survival submodel). When a fish arrived in the delta due to lack of upstream habitat, it remained in the delta until it increased to the very large size class or if the delta habitat capacity was reached. Very large size juveniles that arrived to the delta left to the bay during the same time step. Fish actively migrating through the delta were routed and survived as a function of water pumping operations, flows, and water temperatures (delta routing submodels). All juveniles that left the delta migrated to the bay and then the ocean and survived as a function of ocean entry survival. In the last month of the juvenile rearing/outmigrating period, all surviving juvenile fish were routed to the ocean with one exception. For spring-run only, small- and medium-size class fish that were reared in their natal tributary in the last month exhibited a yearling life history strategy. Yearling fish continued to experience habitat-specific mortality over the summer, but growth did not resume until September. In November, yearling fish immediately migrated to the ocean.

Spawning and rearing habitats are known to change through time due to fluvial processes (Gregory & Bisson 1997). In systems with sediment trapping dams, these changes usually result in degradation or a decrease in habitat through time unless habitats are maintained through management. To approximate the habitat degradation process in the tributaries with sediment trapping dams, the DSMs included habitat degradation rates for spawning habitat that varied with tributary and were based on expert opinion (Table S1). Habitat degradation occurred on an annual time step and was applied before the start of the adult spawning. We assumed that perennial juvenile rearing habitat degradation rate was half the spawning habitat rate and that streams without dams were in dynamic equilibrium (i.e. the maximum potential habitat amounts remained constant across time).

All modeling was conducted using R statistical software (R Core Team 2018). The DSMs were calibrated by minimizing the sum of squared differences between the predicted (simulated) and observed (Azat 2019) natural origin adult escapement using a genetic algorithm (R package *rgenoud*; Sekhon & Mebane Jr. 1998; see Supplement S2 for a detailed description of the model calibration process).

Model Inputs

The Chinook salmon DSMs required multiple inputs that represented environmental conditions (i.e. flows, temperatures), existing amounts of habitat, fish inland harvest rates, and water diversions (Table S2). Hydrologic and operations inputs were created using outputs from existing runs of CalSimII (a modification of Draper et al. 2004). Notably, this flow model required that inputs aligned with historical water years because it was designed to evaluate potential water operation rulesets across previous water years. Thus, DSM flow inputs aligned with 1980–2000, but incorporated current water operation rulesets. The source for water temperature inputs varied based on data availability and matched the same years as the flow inputs. Water temperatures were created using HEC-5Q models, measured water temperatures, statistical models relating air temperature to water temperature, and by matching tributaries that were similar in hydrology and geomorphology. Habitat inputs also varied by data availability. When possible, these inputs were created using previously published flow-habitat relationships that were scaled to the length of the tributary. In the absence of these estimated relationships, suitable instream areas were scaled from a nearby, geomorphically similar watershed. Miscellaneous inputs, except predator prevalence, were derived from a variety of published sources. All DSM input databases are documented and are currently available in an R package (https://flowwest.github.io/cvpiaData/).

Candidate Actions

Chinook salmon restoration activities in the Central Valley typically involve habitat restoration, barrier removal or fish passage improvement to allow access to upstream habitats, actions to minimize fish entrainment, such as screening water diversions, and actions to increase flows during critical periods to increase habitat and connectivity. At the coarse resolution of our model, actions that facilitate access to additional habitats, such as barrier removal, were identical to habitat restoration actions because they resulted in an increase in the available habitat inputs to the DSM. Thus, we reduced the set of candidate management actions to four: restore spawning habitat, restore perennially inundated juvenile rearing habitat, restore seasonally inundated juvenile rearing habitat, and decrease or screen water diversions. To facilitate comparisons within and among actions across watersheds, we compiled information on project costs and the amount of change that resulted from implementation of restoration projects to derive roughly equal units of effort (Supplement S2). The water diversion action unit corresponded to an average increase in small juvenile survival of 0.5%. Importantly, we used that value rather than changing the diversion inputs during simulations because data on small diversions within the Central Valley were unavailable. Based on the design specifications of recent habitat restoration projects in the Central Valley, we assumed an annual probability of seasonal habitat inundation of 0.67, a 2-month inundation duration, and an equal probability of inundation initiation in January–March. Candidate actions for the downstream mainstem sections of the Sacramento and San Joaquin rivers included only juvenile habitat restoration.

Optimal Chinook Salmon Restoration Policy Development

Habitat restoration can be thought of as a Markovian decision process (MDP) that consists of a sequence of actions through time with each action influencing the state of the system within the given time step. However, the trajectory of states over time (i.e. system dynamics) is dependent on the entire sequence of restoration actions, and decision-making is focused on optimizing (or at least prioritizing) these actions relative to maximizing the sum of naturally produced adult Chinook salmon. Thus, we used stochastic dynamic programming (SDP) to determine the optimal restoration actions in each natal tributary across combinations of habitat availability, juvenile survival, and number of female spawners (Supplement S3). These state-dependent restoration policies were used during simulations to identify the optimal restoration action to be implemented for each annual time step. Stochastic dynamic programing uses backward induction to solve an MDP and identify the optimal state-dependent management actions (Bellman 1957). The objective of SDP is to maximize the sum of all future returns, here, the number of naturally produced adult Chinook salmon. It has been used to solve a variety of natural resource problems ranging from endangered species management (Brignon et al. 2017; Duarte et al. 2017) to animal harvest management (Walters & Hilborn 1976; Lubow 1996; Gerber 2015). Stochastic dynamic programing incorporates stochasticity and uncertainty through the use of state-transition matrices (Marescot et al. 2013). We used four system state metrics: the amount of spawning habitat per female spawner, the amount of perennial juvenile rearing habitat per female spawner, the amount of seasonal juvenile rearing habitat per female spawner, and small size class juvenile survival. To incorporate seasonal fluctuations in habitat availability and differences in juvenile outmigrant survival based on the distance from a tributary to the ocean, we subdivided the tributaries into six groups and created optimal policies for each group (Table S3; see Supplement S3 information for a detailed description of restoration policy development).

When using SDP the number of dimensions can become intractable if there are too many systems and information states. Given the complexity of the upstream conditions for the non-natal mainstem sections of the Sacramento and San Joaquin rivers, we approached optimal policy development differently for these areas. In particular, we evaluated the benefit of restoring perennially or seasonally inundated rearing habitat each year in each mainstem section by estimating the number of adult fish returns in subsequent years from that year's juvenile cohort. The action that resulted in the most adult fish returns was considered optimal for that mainstem section in that specific year. Thus, our approach to identify the optimal policy in the mainstem sections of the Sacramento and San Joaquin rivers only considered future returns based on that year's cohort. It did not consider the sum of all future returns in the same way SDP did for the natal tributaries.

Restoration Strategy Development and Evaluation by Forward Simulation

We used forward simulation to evaluate the relative gains when implementing the optimal restoration policies and to evaluate other stakeholder strategies that did not include the implementation of the optimal restoration policies. Using the results of preliminary modeling efforts and knowledge of the system, the stakeholder group proposed 14 candidate restoration strategies to evaluate (Table 1). Strategy zero was a null model because no actions were implemented. The remaining strategies were strategies that selected the optimal state-dependent restoration actions for sites each year during each stochastic iteration based on the system state (e.g. spawning habitat per female spawner) using a 5-year running average on the number of female spawners. Thus, the selected optimal restoration actions varied by iteration based on the state of the stochastic system. We restricted the DSMs such that only five restoration actions were implemented each year, except strategy 11, which required six per year. This annual level of effort was based on the number of new restoration projects implemented by the CVPIA fisheries program each year and to ensure that restoration efforts were roughly equal across candidate strategies.

To evaluate each candidate strategy, we simulated Chinook salmon dynamics from 1980 to 2000 with each run-specific DSM. We seeded the DSMs with adult fish for the initial 5 years of the simulations using the average escapement estimates from 2013 to 2017 (Azat 2019). These fish spawned, and their young moved through the system following the DSM rulesets. This allowed the simulations to begin with a reasonable starting age distribution of adults returning from the ocean. Once these cohorts made it to the ocean, the DSM inputs were reset to begin at 1980. This allowed the simulations to incorporate 20 years of restoration actions. Each candidate strategy was simulated for 1,000 iterations and output the estimated number of naturally produced adults per year for the entire Central Valley.

We identified the best performing restoration strategies by ranking each scenario from best to worst based on the total number of naturally produced adults across the 20-year simulation period (i.e. the sum). To facilitate comparisons across the three runs with very different run sizes, the total number of naturally produced adults across years was calculated (i.e. one number per strategy) and used to calculate utilities (U) for each objective using proportional scoring (Conroy & Peterson 2013) as:

$$U(x_i) = \frac{[x_i - \text{worst}(x_i)]}{\text{best}(x_i) - \text{worst}(x_i)},$$

where x_i is the total number of naturally produced adults and worst(x_i) and best(x_i) are the smallest and greatest total number of naturally produced adults across scenarios for salmon run i. The scores for each run were combined into an objective function using two methods. The first method equally weighted and summed the scores for each Chinook salmon run as:

$$U(x) = \sum_{3}^{i} \frac{U(x_i)}{w_i},$$

where w is the weight of run i (i.e. one-third for each run). The second method we used was to multiply the three run-specific scores together. Both methods resulted in scores for candidate decisions that ranged from zero (worst strategy) to one (best strategy). However, the second method guaranteed that the worst strategy (score = 0) for any run would result in a combined score of zero. For each run, we also calculated the expected loss of implementing a candidate strategy relative to the best strategy as:

Table 1 The candidate strategies evaluated by the science integration team when developing the near term restoration strategy. Locations of tributaries are in Fig. 1.

Strategy	*Description*
0	Implement no restoration
1	Juvenile perennial habitat restoration focused in upper and lower-mid Sacramento River; Butte, Deer, and Battle creeks; and the Stanislaus and Feather rivers
2	Juvenile perennial habitat restoration focused in upper and lower-mid Sacramento River; Butte, Deer, and Clear creeks; and the Stanislaus and Feather rivers
3	Juvenile perennial habitat restoration focused in upper and lower-mid Sacramento River; Butte and Clear creeks; and the Stanislaus, Mokelumne, and Feather rivers
4	Juvenile perennial habitat restoration focused in the mainstem Sacramento and San Joaquin rivers
5	Juvenile perennial habitat restoration focused in the upper, upper-mid, and lower-mid Sacramento River and Cow and Clear creeks
6	Juvenile perennial habitat restoration focused in the upper and lower-mid Sacramento River; American River; and Clear Creek with maintaining existing habitat in Clear and Butte creeks and the Upper Sacramento River
7	Juvenile seasonally inundated habitat restoration focused in the mainstem Sacramento and San Joaquin rivers
8	Optimal habitat restoration actions for winter-run in the mainstem Sacramento with an emphasis on the Sacramento River below Red Bluff diversion dam
9	Optimal habitat restoration actions for spring-run in the upper-mid and lower Sacramento River; Battle, Butte, Clear, Deer, Mill, and Antelope creeks; and the Feather River with an emphasis on the Sacramento River and Battle, Butte, and Clear creeks
10	Optimal habitat restoration actions for spring-run in the upper-mid Sacramento River and Battle, Butte, Clear, Deer, Mill, and Antelope creeks; and the Feather River with effort equally allocated across tributaries
11	Optimal habitat restoration actions for fall-run with one action per year in each diversity group listed in Table S2 and one action per year in the mainstem Sacramento and San Joaquin rivers
12	Optimal habitat restoration actions for fall-run in the upper and lower Sacramento River and the American, Stanislaus, and Calaveras rivers with effort equally allocated across tributaries
13	Optimal habitat restoration actions for fall-run in the upper and lower Sacramento River and the American, Stanislaus, and Mokelumne rivers with effort equally allocated across tributaries

$$RL_i = \frac{\text{Max}(X) - X_i}{\text{Max}(X)}$$

where RL is relative loss of objective X (i.e. natural adult production) for strategy i.

Identify Key Uncertainties Using Sensitivity Analyses

We used sensitivity analysis to evaluate the behavior of the DSMs, ensure they were performing as expected, identify components that largely drive the identity of the best strategy, and identify components that could be improved in future modeling efforts through monitoring or research. We used one-way, response profile sensitivity analysis to evaluate the sensitivity of best scenarios to the DSM components (Conroy & Peterson 2013). During the sensitivity analysis, we used current conditions for all DSM parameters (e.g. survival) or inputs (e.g. habitat availability). We then varied the value of each component one at a time from 0.5 to 1.5 times their current value in increments of 0.1 and then estimated the total number of naturally produced adults each year for each candidate restoration strategy over the 20-year period. We then plotted these values to examine how the rankings of the top three strategies (i.e. the three with the greatest number of naturally produced adults) changed over the range of values for the DSM parameters and inputs. We also estimated the relative value of improving parameter estimates or inputs by calculating the expected value of perfect information (EVPI; Conroy & Peterson 2013). The EVPI is the expected increase in a decision maker's objective, here number of naturally produced adult Chinook salmon, if the uncertainty regarding a parameter value or DSM input were completely eliminated.

When combining scores across objectives (here, runs), stakeholders may be concerned that the objective weights may affect the combined utility scores. Therefore, we also evaluated the sensitivity of the strategy rankings to the weighting for each run with indifference curves (Conroy & Peterson 2013). For this analysis, we evaluated alternative weighting for winter- and spring-run (one at a time) by varying the run-specific weight across a wide range of values and allowing the two other runs to divide the remainder equally. The combined utility scores were plotted across the range of varied weights to identify the value of weights where the rankings of the candidate strategies changed.

Results

Optimal Restoration Policies

Optimal restoration actions differed by optimization group but tended to reveal the same patterns. When juvenile survival was low, the optimal actions included seasonal inundated habitat restoration when spawning habitat was high, whereas perennially inundated habitat actions were best with increasing survival (Fig. 3, top). Increase spawning habitat was generally the optimal action when spawning habitat per female spawner was low and the perennially inundated rearing habitat was relatively high. One notable exception to these patterns was for the San Joaquin River tributaries. At very low juvenile survival, optimal restoration actions were to increase seasonal rearing habitat when spawning habitat was high (Fig. 3, bottom). In addition, restoring perennial rearing occurred over the greatest range of system state combinations.

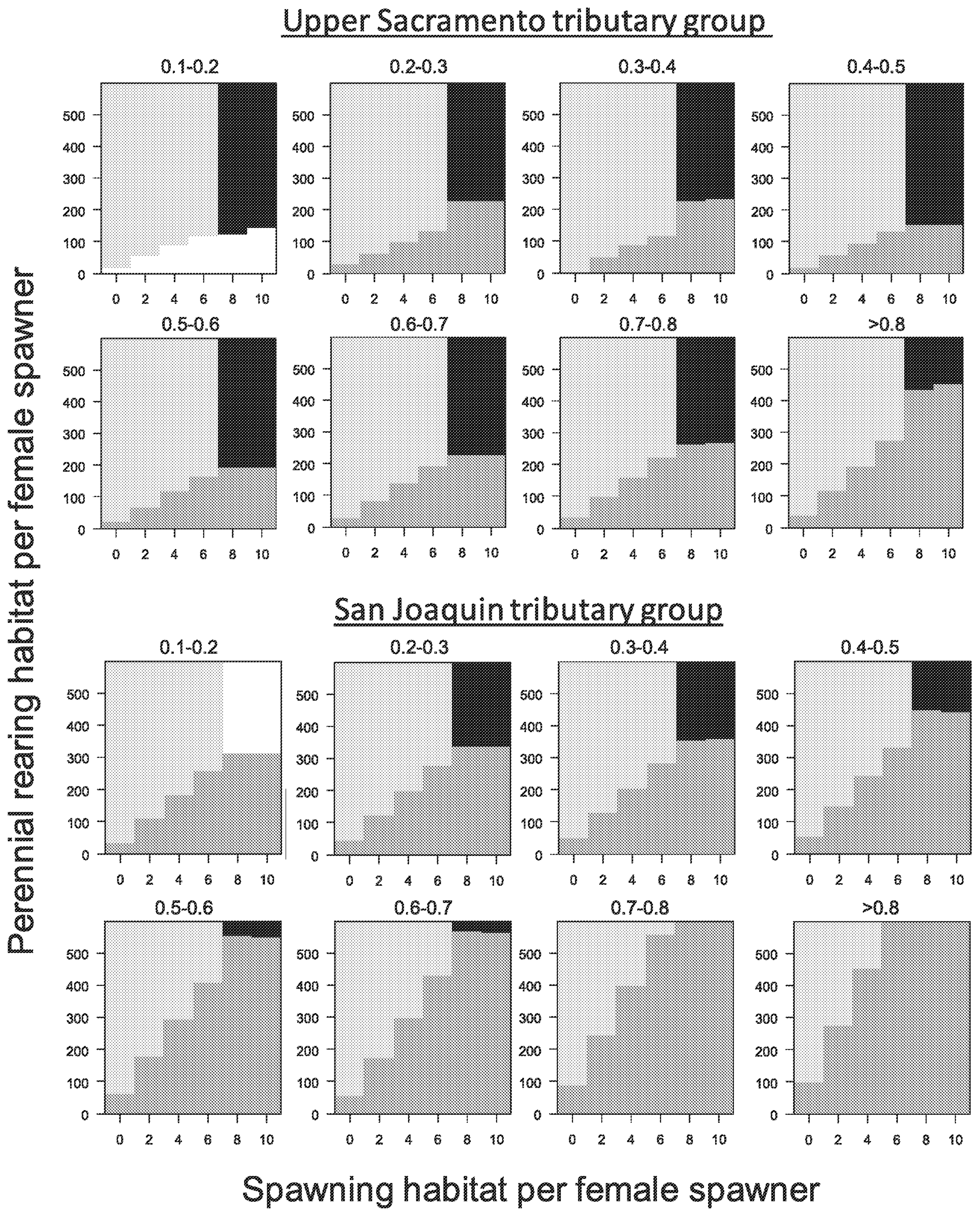

Figure 3 Example policy plots displaying optimal restoration actions, increase spawning habitat (light gray), increase perennially (dark gray), and seasonally (white) inundated rearing habitat, and increase survival 0.5% (black) for various combinations of spawning habitat (m^2) per female spawner, perennially inundated rearing habitat (m^2) per female spawner, and small size class juvenile monthly survival (ranges above each plot) for two tributary groups. In all cases, seasonally inundated habitat was initially zero.

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Strategy by Forward Simulation

Strategy 6 was the best for fall- and winter-run and 9 for spring-run based on total natural adult production (Fig. 4). Strategies 1–3, 5, and 6 were also among the best for both fall- and winter-run based on natural production. All of these strategies involved juvenile habitat restoration focused on the mainstem Sacramento River and Clear Creek. Interestingly, winter- and spring-run natural adult production under strategy 7 and

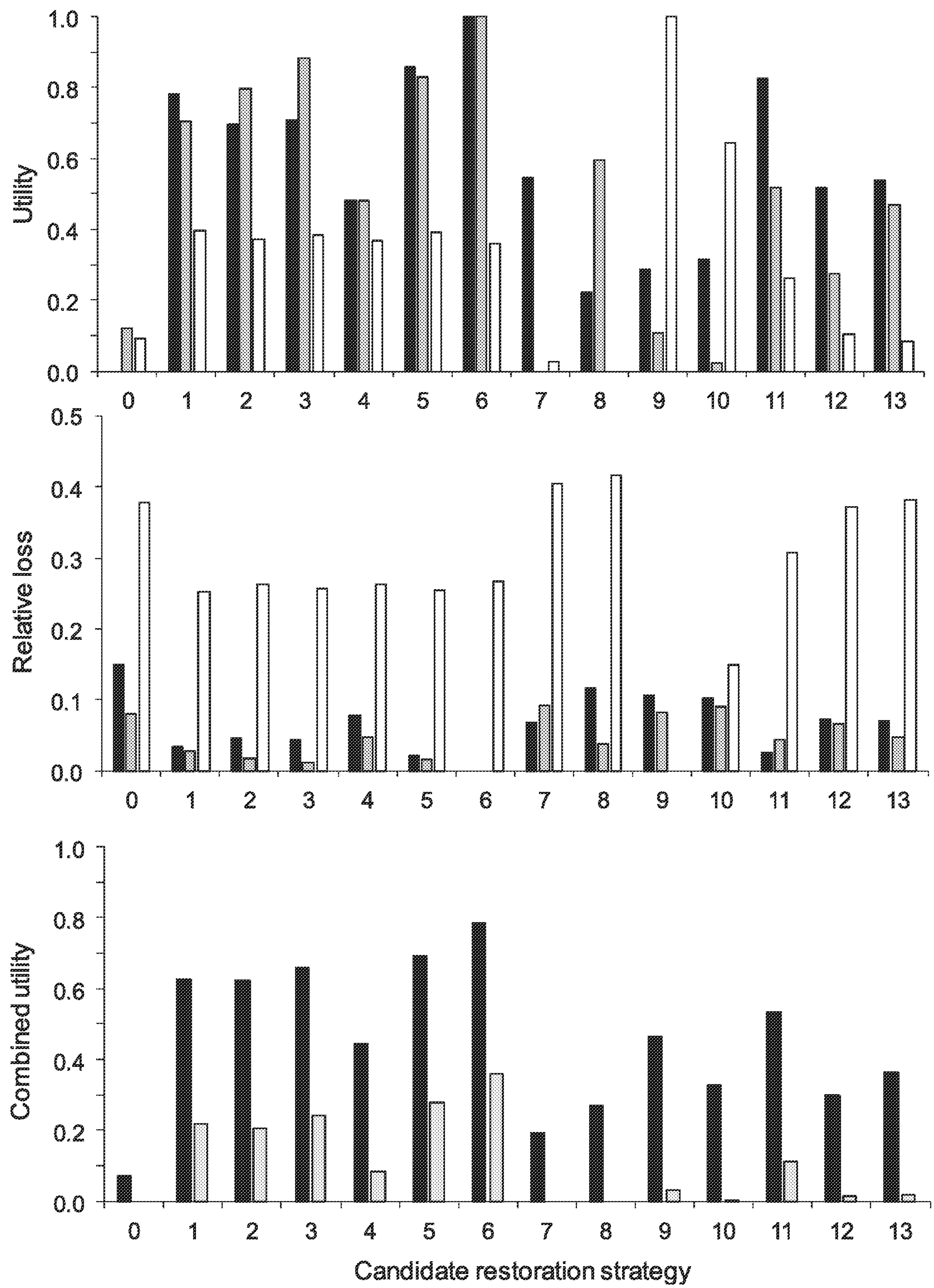

Figure 4 Strategy-specific utilities for fall- (black), winter- (gray), and spring-run (white) Chinook salmon (top), relative loss in natural adult production for fall- (black), winter- (gray), and spring-run (white) Chinook salmon (middle), combined utilities (bottom) with additive with equal weighting (black) and multiplicative (gray).

Table 2 The number of times the top 3 strategies changed during response profile sensitivity analysis of decision-support model inputs and the mean and range "parenthesis" for expected value of perfect information, by Chinook salmon run. Model inputs are grouped by type and may include several individual inputs as indicated by the range.

	Changes in Top Decisions			*Expected Value of Perfect Information*		
	Fall	*Winter*	*Spring*	*Fall*	*Winter*	*Spring*
Habitat						
Bypass habitat area	0	0	0	0	0	0
Adult holding habitat (spring-run only)			0			0
Spawning habitat	0	3	1	2,679	0	0
Perennially inundated juvenile habitat	3	5	3	1,386 (63–2,709)	0	0
Seasonally inundated juvenile habitat	3	5	1	0	0	13
Delta juvenile rearing habitat	0	0	0	10,413	0	0
Discharge and temperature						
Delta inflow	0	4	0	0	0	0
Median discharge	9	19	8	705 (9–2,709)	8 (0–21)	0
Proportion natal discharge	0	0	0	0	0	1 (0–1)
Proportion flow at Yolo and Sutter bypasses	0	0	0	0	0	0
Proportion pulse flow	0	0	0	0	0	0
Mean temperature	6	14	5	486 (0–1842)	0	1 (0–1)
Operations						
Cross channel gate is open						
Exports from CVP and SWP	0	0	0	0	0	0
Total diversion	0	5	0	69	44	1 (0–1)
Miscellaneous						
Initial number of adults	0	5	1	0	0	0
Predator contact points	0	4	0	70	10	101
Hatchery smolts						
Angler (instream) and ocean harvest rates	0	0	0	0	0	0
Predator prevalence	0	0	0	0	0	0
Hatchery returning adults' stray rate	0	0	0	0	0	0

Table 3 The number of times the top 3 strategies changed during response profile sensitivity analysis of model parameters and the mean and range "parenthesis" for expected value of perfect information, by Chinook salmon run. Model parameters are grouped by submodel and may include several individual model parameters as indicated by the range.

	Changes in Top Decisions			*Expected Value of Perfect Information*		
Submodel/Parameter	*Fall*	*Winter*	*Spring*	*Fall*	*Winter*	*Spring*
Adult en route survival	0	8	1	0	15 (0–62)	0
Adult prespawn survival	0	9	5	0	0	0
Adult straying	0	0	2	372 (0–2,052)	0	38 (0–152)
Egg-to-fry survival	6	16	3	52 (0–115)	2 (0–5)	0
Juvenile river rearing survival	6	35	6	1,008 (0–7,760)	127 (0–608)	242 (0–2,278)
Juvenile delta rearing survival	9	25	0	21,954 (0–169,362)	42 (0–217)	0 (0–1)
Juvenile bypass rearing survival	3	5	5	1,414 (0–7,760)	60 (0–358)	411 (0–2,278)
Juvenile movement with flows	3	2	0	4 (0–160)	30 (0–118)	0
Juvenile Sacramento River outmigrant survival	0	0	0	0	0	0
Juvenile San Joaquin River outmigrant survival	0	0	0	83 (50–117)	0	0
Juvenile ocean entry survival	6	14	5	1874 (3–5,318)	260 (2–508)	949 (2–2,621)
Juvenile territory size	3	5	3	8,936	43	358 (358–358)
Juvenile growth rate	6	7	5	75,166 (26299–124,032)	4,756 (0–9,513)	1766 (1430–2,101)
North delta routing and survival	2	28	6	843 (0–9,595)	132 (0–1721)	146 (0–2004)
South delta routing and survival	0	0	0	19 (0–202)	0	0
Fecundity	3	4	5	6,657	0	0
Redd size	3	0	4	12,075	0	199
Sex ratio	0	4	4	0	0	0
Habitat degradation	6	5	1	719 (296–1,142)	11 (0–22)	5 (0–10)

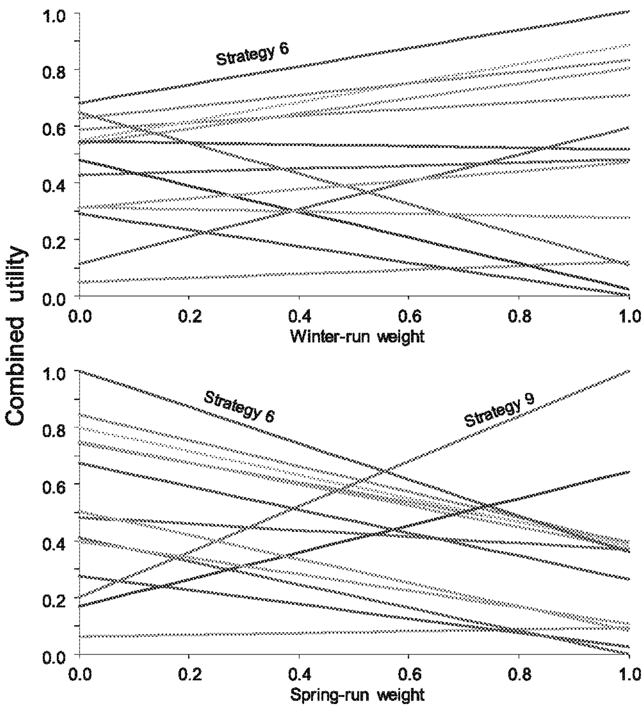

Figure 5 Indifference curves for the weight of winter-run (top) and spring-run (bottom) Chinook salmon. Each line represents a candidate restoration strategy and the top line in each plot is the best restoration strategy.

spring-run natural adult production under strategy 8 were smaller than the no-action strategy. The combined utilities suggested a similar pattern with strategies 5 and 6 with the greatest utilities and 0, 7, and 8 with the lowest, regardless of whether the utilities were weighted or multiplied (Fig. 4).

The relative loss metric suggested that decreases in natural production relative to the best strategy was minor for both fall- and winter-run (Fig. 4, middle). Relative loss for spring-run Chinook salmon was much greater under most strategies except the two best spring-run strategies. However, relative loss for spring-run was constant across the best fall- and winter-run strategies one to 3, 5, and 6 with loss averaging about 25% of the best spring-run strategy (Fig. 4, middle).

Sensitivity Analysis

The sensitivity analysis indicated that the most influential DSM inputs included the current estimates of existing habitat, median discharge, and temperature across all runs and initial abundance and total amount of water diverted for winter-run (Table 2). Sensitivity analysis of the DSM parameters indicated that the DSMs were most sensitive to multiple juvenile survival parameters at all points in their life history (i.e. rearing, migrating) and at all locations included in the DSMs (i.e. tributaries, mainstem, delta, and ocean; Table 3). The second most influential parameters included juvenile growth and body size parameters, followed by reproduction parameters and habitat degradation rate. For winter- and spring-run, adult survival along the migratory corridor and on the spawning grounds were also influential (Table 3).

The value of perfect information estimates for the DSM inputs mirrored the sensitivity analysis with the greatest expected gain for fall-run of more than 10,000 naturally produced adults per year, on average, if the amount of juvenile rearing habitat in the delta was known with certainty (Table 2). The estimated value of perfect information was similarly high for spawning habitat and perennially inundated juvenile rearing habitat. In contrast, the value of perfect information for winter- and spring-run were much lower (Table 3) presumably because the run sizes were also smaller than fall-run. The value of perfect information for the DSM parameters was substantially greater than for the DSM inputs (Table 3). The greatest gain across runs was for juvenile growth rate in each habitat type, which averaged more than 75,000 naturally produced adults per year, on average. Large gains in annual production were also observed if the factors affecting juvenile survival at all locations were known with certainty particularly for juvenile fall-run rearing in the delta, which averaged more than 21,000 adults per year (Table 3).

Indifference curves indicated that the strategy with the greatest utility was unaffected by the weight of winter-run in the combined utility (Fig. 5). However, the best restoration strategy changed from 6 to 9 as the weighting of spring-run Chinook increased. The two strategy lines cross at a weight of 0.55 (Fig. 5) indicating that decision makers would have to value spring-run 2.4 times (0.55/[0.45/2]) more than fall- and winter-run before adopting strategy 9.

Discussion

Quantitative models are increasingly developed to evaluate restoration actions for a variety of ecological systems. Unfortunately, in practice, many of these models are developed without input from the stakeholders that are expected to use them. In our experience, this often leads to confusion concerning what the model is capable of evaluating; the underlying processes or rulesets that govern model results; and the data used to parameterize the model. Ultimately, this approach can lead to mistrust in the model and, in turn, doubt in results that are produced by the model, which understandably limits its use for real-world decision-making. The SDM process involves the stakeholder group throughout model development, evaluation, and refinement to facilitate understanding of, and trust in, the model and each of its components. Although stakeholder input at every stage of model development can slow the decision-making process (particularly with large stakeholder groups), we believe it is an essential, but often overlooked, component to the overall success of a restoration program. In our example, the SIT participated in a series of workshops to iteratively work through the SDM process. During this time, members of the SIT shared their knowledge of tributaries within the Central Valley and their, sometimes competing, hypotheses on how fish respond to environmental heterogeneity within the watershed. This information was translated into the initial conceptual models that were the foundation for the first version of the SIT's Chinook salmon DSMs. Over time, the SIT has refined the DSMs to better approximate their hypotheses concerning system dynamics, and the DSMs have increasingly relied on inputs that were either collected by members of the SIT or are data in which they have greater confidence. Through this iterative process, the SIT has developed a sense of ownership of, and trust in, the DSMs, which was essential to the understanding and acceptance of the simulation results.

Results of the decision-support model simulations and sensitivity analyses were used to develop a Chinook salmon restoration strategy for California's Central Valley. The strategy centered on two processes: reducing habitat fragmentation in the Sacramento and San Joaquin river basins and increasing the spatial diversity of Chinook salmon populations. Habitat fragmentation in riverine landscapes is one of the major factors responsible for the loss of aquatic biodiversity and productivity (Ward et al. 2002; Jansson et al. 2007; Seliger & Zeiringer 2018). Spatial diversity is also an important factor that can promote stability and persistence in salmon populations (Lindley et al. 2007; Carlson & Satterthwaite 2011). The simulation results indicated that restoration strategies that focused on non-natal reaches of the mainstem Sacramento and San Joaquin rivers were among the most beneficial for all three runs. A restoration strategy focused in mainstem reaches would also increase connectivity from natal tributaries to the delta. The simulations also indicated that strategies that took spatial diversity into account were among the best for fall-run with minimal loss to winter- and spring-run. Based on these DSM predictions, the final restoration strategy created from the 13 strategies consisted of a set of restoration actions that focused on juvenile habitat in the mainstem Sacramento and San Joaquin rivers and in tributaries within each salmonid diversity group that was predicted to have the greatest gain in natural production. Further analyses of the DSM predictions and behavior provided additional insights that aided in restoration planning.

Prior to the initiation of the SDM process, there was a common belief among CVPIA restoration practitioners that actions targeted at a specific salmon run would likely benefit all sympatric salmonids (*Oncorhynchus* spp.) or at a minimum that restoration actions would not harm non-target salmonids. The simulated total adult natural production for winter- and spring-run under two juvenile habitat restoration strategies were lower than the *do nothing* strategy, suggesting that restoration actions intended to benefit one run could be worse than no investment in restoration. At a fundamental level, juvenile rearing habitat in the Chinook salmon DSMs hold and grow juveniles. Holding juveniles too long or at times when environmental conditions in the natal tributary, migratory corridor, and ocean become harmful (e.g. high water temperatures, after the ocean turns, so on) can result in decreased juvenile survival and subsequent reduction in natural adult production. Thus, some actions intended to benefit one run may be detrimental to another because the runs differ with respect to the timing of life-history events. Such results are often not intuitive, particularly given the complexity of the system, but can be revealed when using DSMs to develop restoration strategies across multiple runs. This highlights the value of using quantitative DSMs for evaluating how hypotheses concerning system dynamics might affect restoration outcomes.

Ecological models have become increasingly more complex over the past two decades as ecologists attempt to create more realistic approximations of system dynamics (Guo et al. 2015). Not all ecological models, however, are useful for decision-making (Schuwirth et al. 2019). Useful DSMs contain only those elements that are necessary to solve the problem (i.e. requisite decision modeling; Phillips 1984). The Chinook salmon DSMs developed by the SIT contained 165 parameters. Of these, only 19 fall-run, 50 winter-run, and 28 spring-run parameters changed the rankings on the three best restoration strategies during sensitivity analyses. To decision makers in the Central Valley, this means that a relatively small number of parameters are important with respect to their decision, which is consistent with most decision analysis problems (Conroy & Peterson 2013). This does not mean that other parameters did not affect natural adult production estimates, only that these other parameters did not influence the identity of the best decisions (strategies). In requisite decision modeling, DSMs are simplified by iteratively removing the uninfluential parameters or by making them constants and re-evaluating model behavior and sensitivity (Clemen & Reilly 2001). Using this process, we simplified the Chinook salmon tributary dynamics submodel to include 12 parameters and 5 system states. This allowed us to use SDP and the rulesets developed by the SIT to identify the state-dependent optimal policies for each tributary and greatly facilitated the development of the restoration strategies. These simplifications and refinements of DSMs are often required to take full advantage of decision-analytic tools, particularly those used to obtain globally optimal solutions to stochastic problems, such as SDP.

When working in a team environment, stakeholders can, and often do, have conflicting ideas about system dynamics and the structure and composition of the DSM needed to approximate these conflicting ideas. Although differences of opinion can lead to productive discussions, they can also end in gridlock within the decision-making process. Sensitivity analyses can be useful for resolving or postponing conflicts among stakeholders and allows the process to continue to move forward. For example, members of the SIT had profound differences of opinion on the relative effect of predation on juvenile salmon survival and how predation should be included in the DSMs. To resolve the disagreements, we included a predation effect in the DSMs and found that it was highly influential on restoration priorities during sensitivity analyses. This prompted the initiation of research focused on understanding the relative role of predation and identifying potential restoration actions to reduce predation.

Similarly, in situations with multiple restoration objectives, disagreements about the relative importance of each objective can frequently be resolved using indifference curves. Indifference curves often reveal that the best decision does not change regardless of how an objective is weighted, as illustrated by winter-run Chinook salmon. When the best decisions change one or more times with the objective weight, it provides a common frame of reference for initiating a discussion. For instance, the discussion of the relative importance of spring-run Chinook salmon began with the question: are spring-run twice as important as fall- and winter-run? The decision sciences have developed these and other tools that help teams identify things that matter from those that do not with respect to the decision at hand.

Ecological restoration programs often struggle with decisions on how to prioritize resources for restoration, monitoring, and research. The EVPI provides a means for comparison among research, monitoring, and restoration actions using a common measure. We found that perfect information on juvenile survival would increase fall-run natural adult production, on average, 5,047 per year. This value is more than twice the expected maximum annual increase in natural adult production following the implementation of one unit of fall-run habitat restoration, 1,845 per year on average. Such a large difference motivated the SIT to focus future research and monitoring on improving juvenile survival estimates for better decision-making and ultimately greater natural adult production. Measures such as EVPI and the expected value of imperfect information (Conroy & Peterson 2013) provide managers and decision makers with the means to evaluate trade-offs and identify optimal levels of monitoring and research effort.

Considerable resources have been invested in ecological restoration projects across the globe to restore ecosystem integrity. Given the inherent complexity in ecological systems, it is not surprising that restoration strategies are diverse and these efforts have been met with mixed success. The decision sciences have developed a wide range of tools and approaches to simplify complex problems into key components. In this article, we demonstrated how the SIT was able to use many of these analytical tools to inform the development and evaluation of restoration strategies for multiple Chinook salmon runs in California's Central Valley. In doing so, we highlighted tools and approaches that we believe are of great interest to many restoration practitioners that undoubtedly face similar difficulties.

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Supporting Information

The following information may be found in the online version of this article:

Supplement S1. Parameter estimates and sources for fall-run (f), spring-run (s), and winter-run (w) Chinook salmon decision-support model submodels.
Supplement S2. Chinook Salmon Decision Support Model Calibration.
Supplement S3. Optimal Chinook salmon restoration policy development.
Figure S1. Calibration results for fall-run (A), spring-run (B) and winter-run (C) Chinook salmon.
Table S1. Mean and standard deviation (SD) of Chinook salmon model parameters used to create state-transition matrices and simulate Chinook salmon population responses to candidate restoration actions.
Table S2. A description of the Chinook salmon decision-support model inputs.
Table S3. Tributaries and sections of the Sacramento and San Joaquin Rivers included in the Chinook salmon decision-support model, their associated optimization and diversity groups, and salmon runs: fall (F), winter (W), and spring (S).
Table S4. Small juvenile Chinook salmon (< 45 mm) outmigrant survival from natal tributary mouths, by optimization group through the delta used to create state-transition matrices for stochastic dynamic programming.

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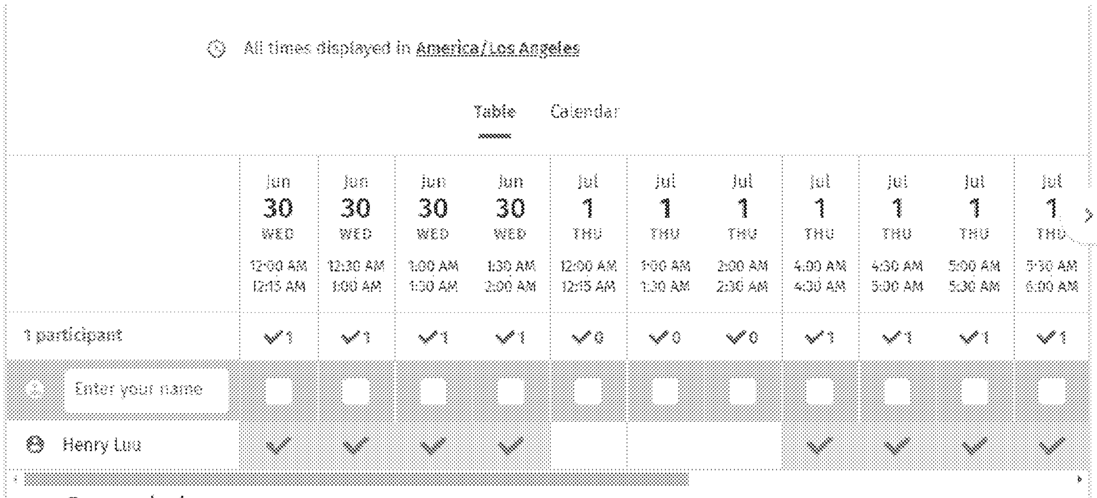
Subject: RE: Amendment 3 design needs from wildlife permitting team: REVISED

Mine is showing the same thing so it's not just you Ali. John, this is what we are seeing:



From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Monday, June 28, 2021 11:20 AM
To: John Spranza <John.Spranza@hdrinc.com>; Briard, Monique <Monique.Briard@icf.com>; Forrest, Michael <michael.forrest@aecom.com>; jeff.herrin@aecom.com; Michael, Howard <howard.michael@aecom.com>; Luu, Henry <Henry.Luu@hdrinc.com>; Haire, Jennifer <Jennifer.Haire@icf.com>
Subject: RE: Amendment 3 design needs from wildlife permitting team: REVISED

John – My computer may be completely freaking out, but the doodle poll is all in AM times. Like 1 AM? I assumed this was all PM.

Let me know as if my computer is freaking, I want to get on that.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Spranza, John <John.Spranza@hdrinc.com>
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<Jennifer.Haire@icf.com>
Subject: RE: Amendment 3 design needs from wildlife permitting team: REVISED

Hey Folks, I'm sending this back around because I neglected to add the ICF biologists to the first email. I am hoping to have this meeting this week so please provide your availability for the revised dates at the following link ASAP.
Thanks.

https://doodle.com/poll/b7fdcpaibad5m965?utm_source=poll&utm_medium=link

John Spranza

D 916.679.8858 M 818.640.2487

From: Spranza, John
Sent: Wednesday, June 16, 2021 9:51 AM
To: Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Forrest, Michael <michael.forrest@aecom.com>; Herrin, Jeff (jeff.herrin@aecom.com) <jeff.herrin@aecom.com>; Michael, Howard <howard.michael@aecom.com>; Luu, Henry <henry.luu@hdrinc.com>
Subject: Amendment 3 design needs from wildlife permitting team

Hello,
I would like to get the design team on a call to talk about the need for wildlife crossings and bat-friendly bridge design along the a few of the project roads. We ended up with a significant impact for wildlife movement and have some requirements to address it (see below)

Please take a moment to fill out the doodle poll below and I will get this meeting scheduled.
Thanks.

https://doodle.com/poll/yi5t99fn3x6wgiu2?utm_source=poll&utm_medium=link

Mitigation Measure WILD-2.1: Design and Construct Wildlife Crossings for New Roadways at Suitable Locations

The Authority will employ a qualified wildlife biologist with expertise in wildlife crossing use and design to conduct a wildlife connectivity and crossing assessment and to determine where suitable wildlife crossing structures would be most effective along North Road, Sites Lodoga Road, and other roads as determined by the Authority and the wildlife biologist. Wildlife crossing structures will be designed and constructed at suitable locations to provide habitat connectivity and safe movement for an array of wildlife likely to use the Project area. To ensure that the assessment is inclusive of a variety of species a wildlife crossing species guild (WCG) approach will be used as detailed in Kintsch et al. 2015. This WCG approach will include ecological and behavioral needs of a variety of species inhabiting the Project area/region. Wildlife crossing locations and design will be determined based on WCG species inhabiting the Project area/region, habitat features, topography, and the future state of the Project area through a wildlife connectivity and crossing assessment.

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John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

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Sacramento, CA 95833
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john.spranza@hdrinc.com

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CNRA Meeting Agenda

Affordable Water, Sustainably Managed

Our Core Values – Safety, Trust and Integrity, Respect for Local Communities, Environmental Stewardship, Shared Responsibility and Shared Benefits, Accountability and Transparency, Proactive Innovation, Diversity and Inclusivity
Our Commitment – To live up to these values in everything we do

Meeting Information:

Date:	July 13, 2021	**Location:**	1416 9th St #1311, Sacramento, CA 95814
Start Time:	10:30 a.m.	**Finish Time:**	11:30 a.m.
Purpose:	Update of the Sites Reservoir Project		

Meeting Participants:

Wade Crowfoot, Secretary, CNRA
Chuck Bonham, Director, CDFW
Karla Nemeth, Director, DWR
Nancy Vogel, Director, CNRA
Joseph Yun, Exe. Officer, CWC
Fritz Durst, RD108/Authority Board Chair
Jeff Sutton, TCCA/Authority Board Vice-Chair
Jeff Davis, San Gorgonio Pass WA/Reservoir Committee Chair
Thad Bettner, GCID/Sites Participant
Gary Evans, Colusa County/Sites Participant
Randal Neudeck, MWD/Sites Participant
Valarie Pryor, Zone 7/Participant
Deven Upadhyay, MWD/Sites Participant
Jerry Brown, Executive Director, Sites
Ali Forsythe, Environmental Planning & Permitting, Sites

Agenda:

Discussion Topic	Topic Leader	Time Allotted
1. Introductions	All	5 mins
2. Overview of the “Rightsized” Project		5 mins
3. Review How Objectives Laid Out in the Governor’s Water Resilience Portfolio Can be Achieved a. Accelerate project permitting b. Acquire through a contract a portion of Sites storage for Prop 1 investment		20 mins
4. Leveraging State Prop 1 investment with Federal Dollars a. Reclamation participation b. State Support for WIFIA and WIIN		20 mins
5. Next Steps		5 mins

Sites Asks of the Secretary:

1. Assign a person from the Secretary's office to regularly report to the Secretary on the progress being made within the state agencies to support the Sites project schedule and conduct regular check-in meetings with the Secretary and the Sites project team.

2. Engage at the federal level by showing State support for WIFIA and WIIN program designations and appropriations to Prop 1 storage projects including the Sites Reservoir Project.

Milestones and Dates Involving State Agencies for the Sites Reservoir Project

Description	Needed Completion Date	Agency(ies) Involved
Activities Related to Prop 1		
Initiate public review of RDEIR/SDEIS	September 3, 2021	Sites
Complete State Feasibility Determination	December 17, 2021	CWC
Confirm 75% Non-Public Benefit Cost Share Commitment	December 17, 2021	DWR
Complete Final EIR/EIS, CEQA Findings, and Adopt Project	July 2022	Sites
Initiate Benefit Agreements	January 2022	Sites, DWR, CDFW
Consider increasing the amount of early funding levels for eligible Prop 1 projects	March 2022	CWC
Complete Benefit Agreements and Final Award of Prop 1 Funds	June 2023	DWR, CDFW, CWC
Activities Related to Water Rights		
Support Development of Sites Water Right Application	December 20, 2021	DWR, CDFW, SWRCB
Submit Sites Water Right Application	December 20, 2021	Sites
Complete Application Review and Issue Public Notice	February 14, 2022	SWRCB
Complete Resolution of Protests	December 2022	Sites, SWRCB
Conduct Hearing on Any Remaining Issues	March 2023	SWRCB
Issue Final Order and Water Right Permit	July 2023	SWRCB
Activities Related to Critical Permits		
State Incidental Take Permits		
Develop and Submit ITP Applications	December 20, 2021	Sites, CDFW
Issue Incidental Take Permits	August 2022	CDFW
401 Water Quality Certification		
Develop and Submit Draft Permit Application	December 20, 2021	Sites, SWRCB
Review and Refinement of Draft Application	June 2022	Sites, SWRCB
Submit Application	July 2022	Sites
401 Certification Issued	November 2022	SWRCB
Permit to Construct Dams		
Concurrence with Design Approach	December 2022	DWR/DSOD
Activities Related to Operations Coordination		
Confirm State Water Project Contract modifications needed for Sites	October 1, 2021	DWR
Execute Agreement to Coordinate Operations of SWP and Sites	December 2022	DWR

From: Herrin, Jeff [jeff.herrin@aecom.com]
Sent: 6/28/2021 12:03:25 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Spranza, John [john.spranza@hdrinc.com]; Monique Briard (monique.briard@icf.com) [monique.briard@icf.com]; Forrest, Michael [michael.forrest@aecom.com]; Michael, Howard [howard.michael@aecom.com]; Luu, Henry [Henry.Luu@hdrinc.com]; Haire, Jennifer [Jennifer.Haire@icf.com]
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I'm seeing the same thing.

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Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

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To: Briard, Monique [Monique.Briard@icf.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Forrest, Michael [michael.forrest@aecom.com]; jeff.herrin@aecom.com; Michael, Howard [howard.michael@aecom.com]; Luu, Henry [Henry.Luu@hdrinc.com]; Haire, Jennifer [Jennifer.Haire@icf.com]
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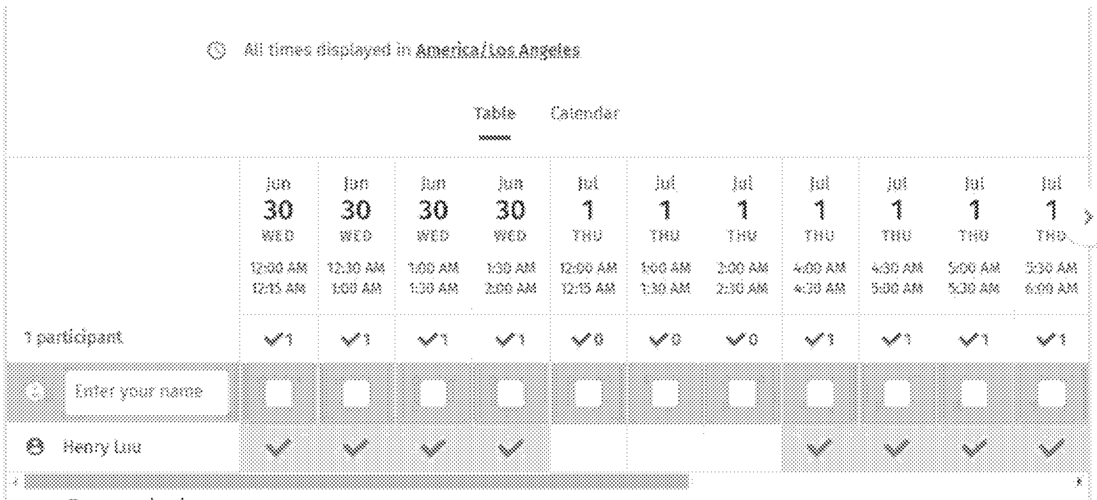

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Sent: 6/28/2021 1:05:36 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Kevin Spesert [kspesert@sitesproject.org]; monique.briard@icf.com; laurie.warner.herson@phenixenv.com; linda.fisher@hdrinc.com
CC: Sarah Rossetto [srossetto@katzandassociates.com]; Sara M. Katz [SKatz@katzandassociates.com]; Emily Fan Michaelson [emichaelson@katzandassociates.com]
Subject: Sites - Draft EIR/EIS Outreach Planning Session: Agenda and Materials
Attachments: Sites Reservoir Draft EIR-_EIS Public Outreach Planning_Mtg_6.30.21.pdf; Sites Reservoir Draft EIR_EIS Implementation Plan_DRAFT 6.29.2021.pdf

Flag: Follow up

All:

In preparation for our EIR/EIS Outreach Planning meeting on Wednesday, June 30, attached please find the proposed agenda and a draft implementation plan for your review and our discussion. In its draft form, the implementation plan provides a framework for decisions regarding noticing, format and logistics for public meetings, and input into the development of informational materials. Areas highlighted in yellow are those for which we need clarification, more information, and/or consensus.

We look forward to seeing you (virtually) on Wednesday afternoon! Please let us know if you have any questions in the meantime.

Thanks,

Kim Floyd
Katz & Associates Team

(916) 838-2666 (cell)
kim@floydcommunications.com

Draft EIR/EIS Public Outreach Planning Meeting Agenda

Sites Reservoir Project

Date: June 30, 2021 **Location:** Microsoft Teams (link in meeting invite)

Time: 2:30-4 p.m.

Leader:	Sara Katz	**Recorder:** Kim Floyd

Agenda Item	**Lead**
1. Team Introductions	All
2. Meeting goals/outcomes	Sara Katz
3. Project Updates • Draft Document Status • Other Current Activities • Schedule	Ali Forsythe and Lori Warner-Herson
4. Clarification of Scope • Public Outreach v. Environmental Consultant	Sara Katz
5. Draft Implementation Plan Review	Emily Fan Michaelson
6. Questions • Key Issues • Messaging	K&A

Sites Reservoir Project
Revised Draft EIR/Supplemental Draft EIS
Public Meetings

Implementation Plan

DRAFT v6.28.2021

Contents

Tables

I. **Introduction:** The Draft EIR/EIS public comment period is XX days and is expected to begin on Thursday, August 26, 2021, and end on [DATE]. One in-person Draft EIR/EIS public meeting and one virtual Draft EIR/EIS public meeting are tentatively scheduled for late September 2021. Comment collection details are included below in Section IV. Two in-person stakeholder meetings with landowners are tentatively planned, one to occur prior to the release of the Draft EIR/EIS and one to occur after the release but prior to the two Draft EIR/EIS public meetings. Landowner meeting details are included in Section XI.

The following dates, times, and locations have been identified for the Draft EIR/EIS public meetings.

Table 1. Schedule

Type	Date & Time	Location
Virtual Public Meeting	[DATE] [TIME]	Zoom Webinar
In-Person Public Meeting	[DATE] [TIME]	Sites Project Authority Office, 122 Old Highway 99 West, Maxwell, CA 95955

Staff who have a role during the public meetings as identified in Tables 6 and 7 need to join the Zoom Webinar for the virtual public meeting and arrive at the venue for the in-person meeting 30 minutes prior to the meeting start time.

II. **Notifications:** The public will be notified of the meeting dates, times, and locations via the notification methods and channels listed in the table below. The responsibility for posting or distributing the notice is identified along with the suggested target date(s) for posting or distributing.

Table 2. Notifications

Notification	Responsible	Target Date(s) for Post/Distribution
Notice of Availability/Public Meetings	Environmental Team/Reclamation	August 26, 2021
News Release	Communications Team	August 26, 2021
Letter – Elected Officials/Agencies	Environmental Team/Reclamation	August 25, 2021
Postcard Mailer – Proximate Properties	Environmental Team/Reclamation	August 25, 2021
Website Update	Communications Team/Reclamation	August 26, 2021
E-blasts	Communications Team	August 26, 2021; reminder prior to public meetings; and before end of comment period
Newspaper Display Advertisements	Communications Team	August 26, 2021 (dates will vary based on newspaper publication schedule)
Social Media	Communications Team/Reclamation (paid social media)	August 26, 2021; reminder prior to public meetings; and before end of comment period

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Notification	Responsible	Target Date(s) for Post/Distribution
Radio Public Service Announcements (PSAs)	Communications Team	August 26, 2021; reminder prior to public meetings
Flier	Communications Team	August 26, 2021
JPA Member Communication (version of flier or e-blast)	Communications Team	August 26, 2021
Information Repositories	Environmental Team	August 26, 2021

III. Meeting Format:

a. ***Virtual Public Meeting:*** The virtual public meeting will be conducted via Zoom Webinar and will consist of a project presentation and formal public comment component to accept verbal comments.

Following the project presentation, breakout sessions that cover the topics listed in Table 6 will open and be conducted via Zoom Webinar. The breakout sessions will allow members of the public to have their informal questions answered, since formal/official questions will not be answered during the virtual public meeting but will be responded to in the Final EIR/EIS. Links to the breakout sessions will be available on the project website. The breakout sessions will be open while the formal public comment session is being conducted and will stay open for one hour after the virtual public meeting concludes.

The project presentation will be delivered at the beginning of the meeting. After the presentation, the moderator will kick off the formal public comment session. Official public comments will be received verbally during the formal public comment session (written comments would be submitted via the accepted methods of mail and email). Instructions on how to provide public comments will be discussed at the beginning of the meeting and again after the project presentation. Instructions for joining the breakout sessions will also be provided after the presentation along with a reminder that if participants missed the presentation, a recording of the presentation can be found on the project website.

The virtual public meeting is scheduled to conclude at [TIME]; however, if there are participants who have their hand raised and have not been called on yet to provide their comments, the virtual public meeting should remain open until all participants who raised their hand prior to [TIME] have been given the opportunity to provide their comments.

Participants who are logged in to Zoom Webinar online can raise their hand by clicking on the hand icon. Participants who call in on the phone can dial *9 to raise their hand. When a participant raises their hand using either method, the moderator can see that a hand is raised, call on that participant, and enable the participant to complete the unmute process to provide a comment during the virtual public meeting or ask a question during the breakout sessions.

Zoom Webinar has a Q&A feature that allows participants to submit written questions, which will be viewable to only the host and panelists, unless the host or a panelist make the question public to the rest of the attendees. The question can be answered verbally and/or answered in writing through the Q&A feature. The Q&A feature will be enabled for the breakout sessions but disabled for the virtual public meeting.

In addition to the Q&A feature, there is a chat function that can be enabled or disabled. If enabled, attendees can contact the project team via the chat function. The chat settings would be set to only allow communication with the project team and no other attendees. The project team could use the chat function to post links or reminder messages. The chat function could be used to collect Draft EIR/EIS comments during the virtual public meeting.

Since staff will need to be in contact with each other to manage the virtual public meeting, a Microsoft Teams chat session or a messaging platform can be used for internal, back-end communications.

Zoom Webinar: Zoom Webinar is the recommended platform for the virtual public meeting and breakout sessions due to its ease of use and simple user interface, general familiarity by the public, and built-in controls. Zoom Webinar can support up to 10,000 participants and allow participants to dial in with their standard telephone, computer, or smartphone to participate. Zoom Webinar allows participation without registration or downloads, including a phone-in option for those who may not have Internet access. Unlike a Zoom Meeting that can be subject to hijacking or "conference bombing," Zoom Webinar has additional controls, whereas the webinar host controls all audio, video, and screen-sharing functions. Participants do not have access to these controls.

Agenda: Based on the format outlined above, the proposed agenda for the virtual public meeting will be as follows:

Table 3. Virtual Public Meeting Agenda

Item	Presenter(s)	Time
Project Presentation	TBD	**[TIME]** XX minutes
Formal Public Comment Session	TBD	**[TIME]** XX minutes
Breakout Sessions	TBD	**[TIME]** XX minutes

b. ***In-Person Public Meeting:*** The in-person public meeting will consist of staffed informational poster stations, a project presentation, and a formal public comment component to accept verbal comments.

Tables will be set up for attendees to sign in for the meetings and provide their contact information. Attendees can also choose to sign up to receive future project updates. At this location, staff will explain the meeting format and required COVID-19 safety measures.

Poster stations that cover the topics listed in Table 7 will be staffed by project team members who will be available to engage in one-on-one conversations with the public and answer questions. The staffed information stations will close once the project presentation and formal public comment session begin. A station for submitting written comments will also be set up.

The project presentation will begin one hour after the start of the meeting. Following the project presentation, the formal public comment session will be initiated and run for the remainder of the public meeting. Alternatively, the project presentation could be repeated if there are not many verbal comments but an influx of people who were not at the meeting when the project presentation was first conducted, or the staffed informational poster stations could be reopened.

COVID-19 Precautions: The in-person public meeting will be conducted as safely as possible and in accordance with face covering requirements. Signage at the entrances will remind people that they cannot enter the meeting if they are not feeling well (fever, cough, etc.). Signage will be posted throughout the venue reminding attendees to wear a face covering if not vaccinated. Masks will be kept at the sign-in tables to provide to attendees if they do not have a face covering to wear. Attendees who are not vaccinated and refuse to wear a mask will not be allowed into the meeting room. Hand sanitizer will be placed at the sign-in tables and written comment station. Venue staff or the project team will wipe down high-touch areas during the meetings, which could include the presentation podium, microphones, shared pens, etc. If the meeting venue has doors that open to the outside, the doors can be kept open for increased air circulation.

Agenda: Based on the format outlined above, the proposed agenda for the in-person public meeting will be as follows:

Table 4. In-Person Public Meeting Agenda

Item	Presenter(s)	Time
Open House Information Stations	TBD	**[TIME]** XX minutes
Project Presentation	TBD	**[TIME]** XX minutes
Formal Public Comment Session	TBD	**[TIME]** XX minutes

IV. Comment Collection:

a. ***Virtual Public Meeting:*** During the virtual public meetings, verbal public comments can be submitted via audio when individuals are called upon and their microphone is unmuted. The moderator will call on individuals in the order they raised their hand to speak and ask each person to state and spell their name for the record. Speakers will be asked to limit their comments to X minutes. A court reporter will transcribe verbal comments. Formal comments will not be accepted during the breakout sessions, and this will be made clear to participants. Written public comments will be accepted by mail and email throughout the public comment period; to consider is also accepting public comments through an auto-fill form on the project website.

b. ***In-Person Public Meeting:*** During the in-person public meeting, public comments can be submitted via two methods: (1) in writing via printed comment forms; and (2) verbal comments during the formal public comment session transcribed by a court reporter. A comment station will be provided for the public to have a dedicated space to write comments. Written comments could be collected in a box similar to a voting box. This ensures comment privacy or anonymity, if desired. The comment station will be staffed by the project team to ensure the written comments are secure. Written public comments will also be accepted by mail and email throughout the public comment period.

Individuals will sign up to provide their comments verbally during the formal public comment session. The moderator will call on individuals in the order they signed up and ask each person to state and spell their name for the record; to consider is whether elected officials would be allowed to provide their comments first. Speakers will be asked to limit their comments to X minutes. If desired, a second court reporter could be made available to collect verbal comments in a semi-private setting for individuals who do not wish to speak their comment in front of an audience during the formal public comment session. This second court reporter could be stationed in a separate room or a quiet corner of the meeting room.

V. **Language Interpretation and Translation:** The need for Spanish language interpretation at the meetings will be determined by requests received. The notices will include language directing participants to contact the project team for reasonable accommodations.

The project presentation will be translated and recorded in Spanish, and the recording could be posted to the project website. The project fact sheet will also be translated into Spanish.

VI. **Section 508 Compliance:** Closed captioning during the virtual public meeting is needed for Section 508 compliance. Closed captioning will be generated by Zoom (CC live transcription).

VII. **Recording:** The virtual public meeting will be recorded. The recording of the project presentation portion or the entire virtual public meeting could be posted to the project website. The in-person public meeting will not be recorded.

VIII. **Informational Materials:** A variety of informational materials will be developed to support the Draft EIR/EIS public comment period and meetings. The materials will provide information and address anticipated stakeholder concerns and questions. The type, quantity, format, and topics for the informational materials are listed in the table below. Materials will be posted to the project website in advance of the meetings. Other methods for providing the informational materials are also listed.

Table 5. Informational Materials

Material	Quantity/ Format	Availability	Topics
Fact Sheet	Two-page fact sheet	• Project website • In-person public meeting • Information repositories • Mailed to individuals without access to Internet or computer	Project overview, alternatives, environmental review process
Posters	8	• Project website • In-person public meeting • Information repositories • Mailed to individuals without access to Internet or computer	*Potential poster topics:* 1. Location 2. Project overview 3. Alternatives 4. Resource areas analyzed 5. Environmental analysis – water quality 6. Environmental analysis – fisheries 7. Environmental analysis – other biological resources 8. Environmental analysis – cultural resources

Table 5. Informational Materials

Material	Quantity/ Format	Availability	Topics
			9. Environmental analysis – local impacts (traffic) 10. Environmental review process 11. Trinity River
Video Vignettes	4 two-minute videos	• Project website • In-person public meeting	1. 2. 3. 4.
Project Presentation	1	• Project website (recording) • Virtual public meeting • In-person public meeting • Presentation slides mailed to individuals without access to Internet or computer	Project overview, alternatives, environmental analysis, environmental review process
Draft EIR/EIS Community Guide	1 (up to 20 pages)	• Project website • In-person public meeting • Information repositories • Mailed to individuals without access to Internet or computer	Project overview, key elements of the environmental analysis provided in the Draft EIR/EIS
FAQs	1	• Project website • In-person public meeting • Mailed to individuals without access to Internet or computer	

IX. Dry-Run Practice Sessions: Several dry-run practice sessions will be held prior to the public meetings. The initial dry run for the virtual public meeting will include a run through of the technology and an opportunity for the project team to practice using the technology. Subsequent dry runs could include an overview of the meeting format and logistics; familiarization with informational materials; a run through of the PowerPoint presentation; and a dry run of potential public interactions in a Q&A setting at poster stations or breakout sessions.

X. Documentation: A summary of outreach activities will be developed and will include meeting noticing, materials developed, number of meeting attendees, list of representative groups and media who identified themselves during the meetings, and general comments heard. Court reporters will prepare a transcript of verbal comments provided at the public meetings. A team debrief will be held the morning after each meeting to capture team comments of issues and concerns heard at their poster stations or breakout sessions.

Table 6. Virtual Public Meeting Roles and Staffing

To be developed

Table 7. In-Person Public Meeting Roles and Staffing

To be developed

Table 8. In-Person Meeting Materials

To be developed

XI. Landowner Meetings: Two in-person stakeholder meetings with landowners are tentatively planned, one to occur prior to the release of the Draft EIR/EIS and one to occur after the release but prior to the two Draft EIR/EIS public meetings. The landowner meetings would be held at the Sites Project Authority Office in Maxwell. The purpose would be to review Draft EIR/EIS highlights and answer questions. Formal comments will not be accepted during the landowner meetings, and this will be made clear to participants.

From: Laurie Warner Herson [laurie.warner.herson@phenixenv.com]
Sent: 6/28/2021 2:36:37 PM
To: Michael Azevedo [mjazevedo@countyofcolusa.com]; Alicia Forsythe [aforsythe@sitesproject.org]
CC: Linda Fisher (linda.fisher@hdrinc.com) [linda.fisher@hdrinc.com]
Subject: RE: support appendices

Thanks Mike – I am checking with ICF on the status of Appendices 20A and 20B. They had some delays in AQ modeling due to the need to revise assumptions and we have not yet received those appendices.

From: Michael Azevedo <mjazevedo@countyofcolusa.com>
Sent: Monday, June 28, 2021 2:12 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Linda Fisher (linda.fisher@hdrinc.com) <linda.fisher@hdrinc.com>
Subject: RE: support appendices

My mistake…. 2D, Best Management Practices is available…. Just looking for 20A and 20B….

Michael J Azevedo
Colusa County Public Works
530.458.0466

From: Michael Azevedo
Sent: Monday, June 28, 2021 1:00 PM
To: 'Alicia Forsythe' <aforsythe@sitesproject.org>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Linda Fisher (linda.fisher@hdrinc.com) <linda.fisher@hdrinc.com>
Subject: support appendices

Ali-

Colusa County APCO would like to review the following appendices in conjunction with review of draft chapter:

Appendix 20A, *Methodology for Air Quality and GHG Emissions Calculations,* Appendix 20B, *Air Quality and Greenhouse Gas Emissions Calculation and Model Output Files and* Appendix 2D, *Best Management Practices*

I don't see them on the portal, are they available?

Michael J Azevedo
Colusa County Public Works
530.458.0466

From: Laurie Warner Herson [laurie.warner.herson@phenixenv.com]
Sent: 6/28/2021 2:37:39 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Linda Fisher (linda.fisher@hdrinc.com) [linda.fisher@hdrinc.com]
Subject: RE: support appendices

Our emails crossed paths – the AQ appendices are delayed.

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Monday, June 28, 2021 2:36 PM
To: Linda Fisher (linda.fisher@hdrinc.com) <linda.fisher@hdrinc.com>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: FW: support appendices

Linda – See below. Can you help with Mike's request below? I don't know the status of these appendices.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Michael Azevedo <mjazevedo@countyofcolusa.com>
Sent: Monday, June 28, 2021 2:12 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Linda Fisher (linda.fisher@hdrinc.com) <linda.fisher@hdrinc.com>
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Michael J Azevedo
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To: 'Alicia Forsythe' <aforsythe@sitesproject.org>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Linda Fisher (linda.fisher@hdrinc.com) <linda.fisher@hdrinc.com>
Subject: support appendices

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I don't see them on the portal, are they available?

Michael J Azevedo

Colusa County Public Works
530.458.0466

From: Bader, Donald P [DBader@usbr.gov]
Sent: 6/28/2021 2:52:07 PM
To: Zedonis, Paul A [pzedonis@usbr.gov]
CC: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: Fw: [EXTERNAL] RE: Sites - Trinity River Update
Attachments: 20210322_Trinity River Small Group_Presentation.pptx; 20210430_Trinity River Small Group_Presentation.pptx

Paul

please join us if your available.

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Monday, June 28, 2021 11:33 AM
To: Bader, Donald P <DBader@usbr.gov>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Dixon, Michael D <MDixon@usbr.gov>; Heydinger, Erin <erin.heydinger@hdrinc.com>; King, Vanessa M <vking@usbr.gov>
Cc: Spranza, John <john.spranza@hdrinc.com>
Subject: [EXTERNAL] RE: Sites - Trinity River Update

This email has been received from outside of DOI - Use caution before clicking on links, opening attachments, or responding.

Hi all – We've had 2 meetings with the Trinity River interests. Attached are the PowerPoint presentations from both. We will talk through these on our call tomorrow afternoon

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

-----Original Appointment-----
From: Alicia Forsythe
Sent: Saturday, June 5, 2021 6:50 AM
To: Alicia Forsythe; Bader, Donald P; Laurie Warner Herson; Dixon, Michael D; Heydinger, Erin; King, Vanessa M
Cc: John Spranza (john.spranza@hdrinc.com)
Subject: Sites - Trinity River Update
When: Tuesday, June 29, 2021 2:00 PM-3:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

Microsoft Teams meeting

Join on your computer or mobile app
Click here to join the meeting

Or call in (audio only)
+1 916-538-7066,,799179004#   United States, Sacramento
Phone Conference ID: 799 179 004#
Find a local number | Reset PIN

Learn More | Meeting options

Trinity River Small Group

Overview and Discussion of the Sites Project's Trinity River Effects

March 22, 2021

Sites

Agenda

1. Introductions
2. Group Norms
3. Brief Overview of Project Description and Water Rights Approach
4. Trinity River CalSim Modeling Approach
5. Water Right Approach and Possible Water Right Term
6. Additional Topics from the Group
7. Action Items and Next Steps

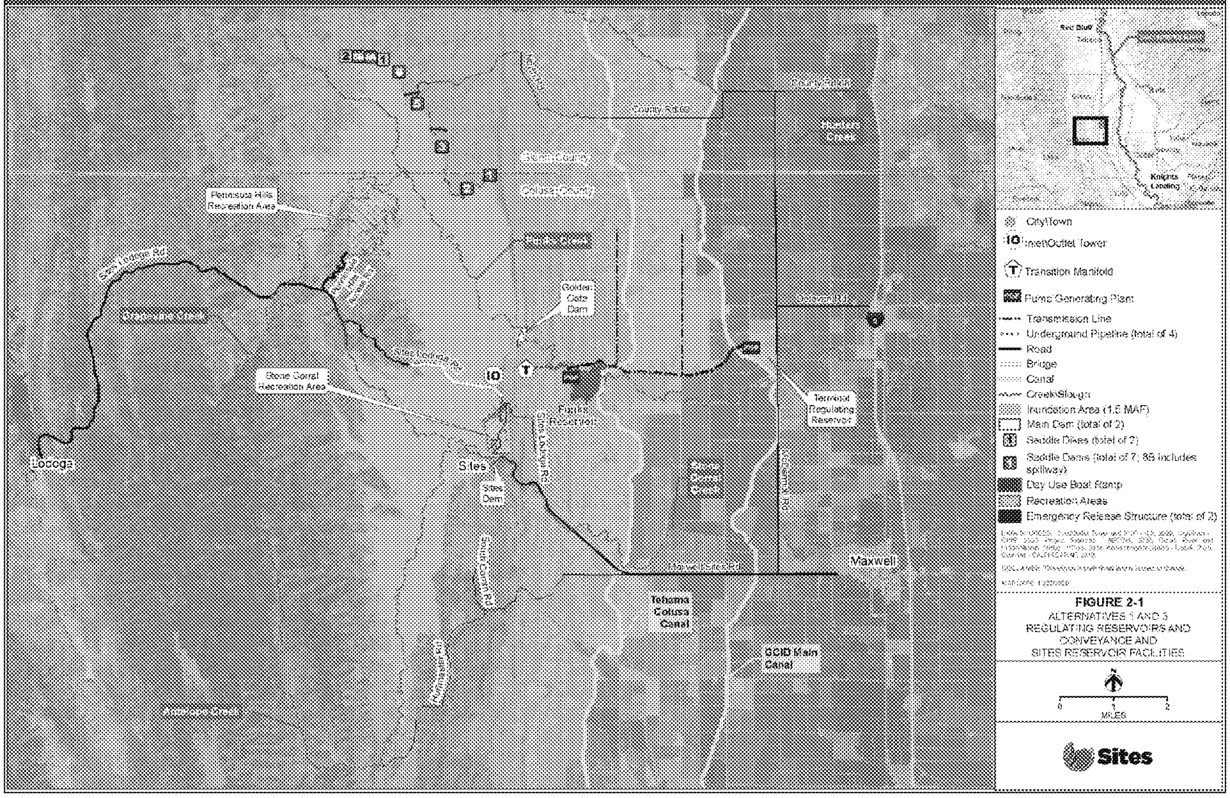
Group Norms

- Encourage everyone to be on video
- Mute yourself when others are speaking
- Respectful, professional dialogue
- Ask questions throughout, lets have a dialogue
  - Let the speaker finish their point
  - Use the raise your hand function in Teams if needed
- Focus is on the Sites Project

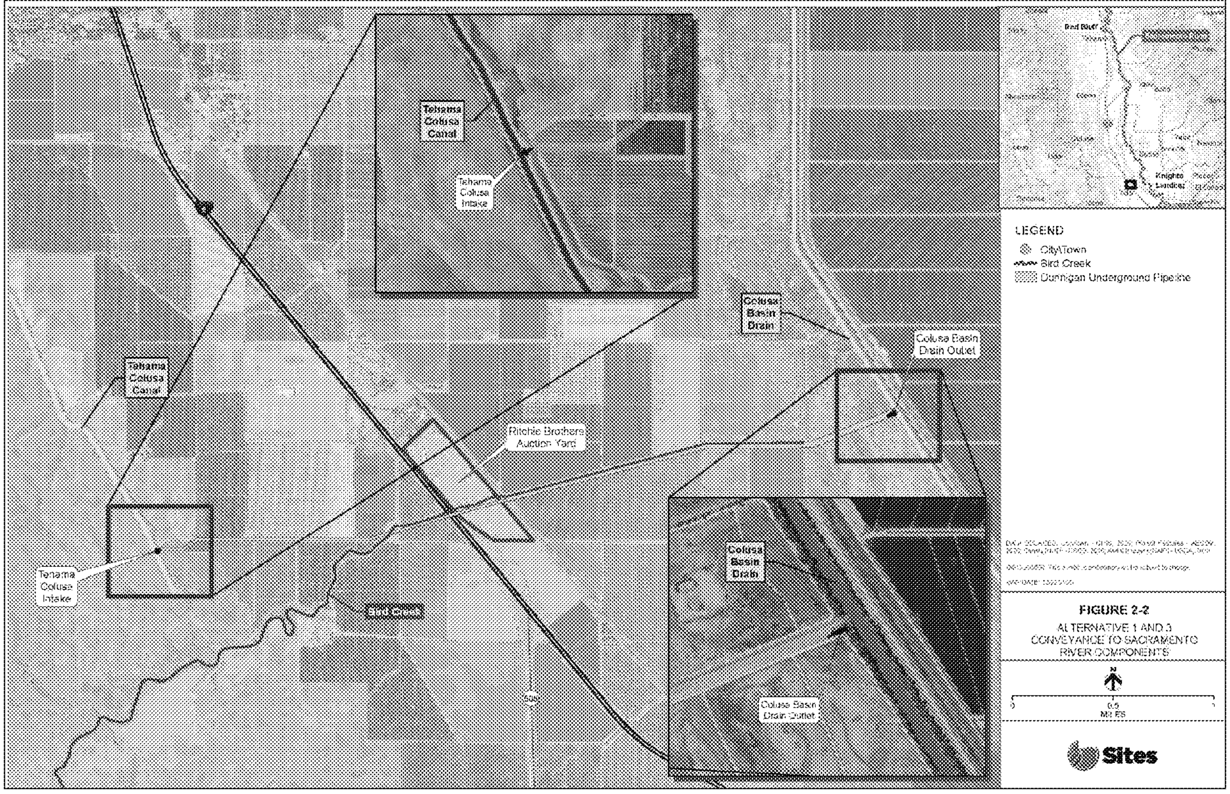
Alt 1 – Authority's Preferred Project

Facilities / Operations	Alternative 1
Reservoir Size	1.5 MAF
Diversion(s)	Diversion from Sacramento River into existing TC Canal at Red Bluff and the existing GCID Main Canal at Hamilton City
Conveyance Release / Dunnigan Release	Release 1,000 cfs into new pipeline to the Colusa Basin Drain
Releases into Funks and Stone Corral Creeks	Specific flow criteria to maintain flows to protect downstream water right holders and ecological function
Reclamation Involvement	• Funding Partner up to 7% Cost-Share • Operational exchanges
DWR Involvement	Operational Exchanges with Oroville and use of SWP facilities South-of-Delta
Hydropower	Incidental power generation up to 40 megawatts each at Funks PGP and TRR PGP

Alt 1 – Preferred Project



Alt 1 – Preferred Project



Water Right Approach

- Sources:
  - Sacramento River
  - Stone Corral Creek
  - Funks Creek
- Points of diversion:
  - Tehama-Colusa Canal (existing, screened facility)
  - Glenn-Colusa Irrigation District's Main Canal (existing, screened facility)
  - Sites Dam
  - Golden Gate Dam
- Seeking to appropriate unregulated flows that come into the Sacramento River below Keswick

Water Right Approach

- Sites seeking to divert Sacramento River flows when all of the following conditions are met:
  - Flow exceed minimum diversion criteria
  - Delta is in "excess" conditions
  - Senior downstream water rights and other more senior flow priorities have been satisfied
  - Flow are available above those needed to meet all applicable laws, regulations, BiOps and court orders in place at the time of diversion
- Sites would operate within all applicable laws, regulations, biological opinions and incidental take permits, and court orders in place at the time
- Sites is not applying for a water right to divert or redivert Trinity River water

Modeling Approach

- Calsim II used for overall operations of Sites
  - Hydrological planning tool used to represent state-wide changes that would result from Sites
  - Monthly timestep
  - Results are comparisons, not absolute values
- Updates made to Sites Calsim model – baseline now contains actions within:
  - 2019 Reinitiation of Consultation on the CVP and SWP
  - 2020 SWP Incidental Take Permit

Trinity River CalSim Modeling Approach

- Modelled No Action Alternative
  - Includes:
    - Trinity ROD Flows
    - Lower Klamath Augmentation Flows
- Held Trinity River operations consistent with No Action Alternative when modelled the Project alternatives
- Reclamation has same obligations and operating principles in operating the Trinity River with and without Sites
- Sites is not limiting, constraining, changing, or affecting Reclamation's obligations in their Trinity River operations

Water Right Approach and Possible Term

- Developing water right terms:
  - Implementable and under the control of the Sites Authority
  - Measurable, identifiable, reportable
  - Addresses the issue at hand
- Open to a term, but we believe that it should meet the criteria above

Water Right Approach and Possible Term

- What are the key factors that the group is concerned about?
- How might we put those into a water right term?
- Could we address in a different way? For example, through a statement from Sites Board

Additional Topics from the Group

- Any additional questions or thoughts?

Action Items and Next Steps

Thank you!

Sites

Proposed Water Right Term from Humboldt County

Trinity River water shall not be used to fill Sites Reservoir unless the Trinity River Division of the Central Valley Project is releasing water as a result of storage conditions requiring "Safety of Dams" releases beyond normal operating plans and concurrently when Shasta Reservoir is making flood control releases. Furthermore, Humboldt County's 1959 water contract with the Bureau of Reclamation, Trinity River Record of Decision (ROD) flows, and releases to implement the Bureau of Reclamation's Long-Term Plan to Protect Adult Salmon in the Lower Klamath River shall not be reduced or negatively impacted in any way as a result of any Sites Reservoir decisions, modeling, operational plans, and water right petitions.

Trinity River Small Group

Follow up from Previous Meeting and Discussion of Possible Water Right Term

April 30, 2021

Sites

Agenda

1. Introductions
2. Action Items and Follow up from Last Meeting
   a. AB 52 – Reconsider scope
   b. 1959 Contract "reasonably foreseeable"
   c. Discussion on 1959 Water Contract use
3. Discussion of Possible Water Rights Term
4. Action Items and Next Steps

Action Items and Follow up from Last Meeting

- AB 52 – Reconsider scope
- 1959 Contract "reasonably foreseeable"
- Discussion on 1959 Water Contract use

Water Right Approach and Possible Term

- Developing water right terms:
  - Implementable and under the control of the Sites Authority
  - Measurable, identifiable, reportable
  - Addresses the issue at hand
- Open to a term, but we believe that it should meet the criteria above

Discussion of Possible Water Rights Term

- Preliminary discussion
- Any term would need to be approved by the Sites Board prior to submittal in the application

Possible Water Rights Term

Trinity River water shall not be used to fill Sites Reservoir under this Permit unless the Trinity River Division of the Central Valley Project is releasing water to meet flood space regulatory requirements and all other diversion criteria in this Permit are met.

Furthermore, implementation of the Sites Project shall not change the Bureau of Reclamation's obligations in its Trinity River operations, including but not limited to the 1959 Contract Between the United States and Humboldt County, the Trinity River Mainstem Fishery Restoration Record of Decision, and the Long-Term Plan to Protect Adult Salmon in the Lower Klamath River Record of Decision.

Action Items and Next Steps

Thank you!

Sites

Proposed Water Right Term from Humboldt County

Trinity River water shall not be used to fill Sites Reservoir unless the Trinity River Division of the Central Valley Project is releasing water as a result of storage conditions requiring "Safety of Dams" releases beyond normal operating plans and concurrently when Shasta Reservoir is making flood control releases.

Furthermore, Humboldt County's 1959 water contract with the Bureau of Reclamation, Trinity River Record of Decision (ROD) flows, and releases to implement the Bureau of Reclamation's Long-Term Plan to Protect Adult Salmon in the Lower Klamath River shall not be reduced or negatively impacted in any way as a result of any Sites Reservoir decisions, modeling, operational plans, and water right petitions.

Group Norms

- Encourage everyone to be on video
- Mute yourself when others are speaking
- Respectful, professional dialogue
- Ask questions throughout, lets have a dialogue
  - Let the speaker finish their point
  - Use the raise your hand function in Teams if needed
- Focus is on the Sites Project

From: Kim Floyd [kim@floydcommunications.com]
Sent: 6/28/2021 4:04:30 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Kevin Spesert [kspesert@sitesproject.org]; monique.briard@icf.com; laurie.warner.herson@phenixenv.com; linda.fisher@hdrinc.com
CC: Sarah Rossetto [srossetto@katzandassociates.com]; Sara M. Katz [SKatz@katzandassociates.com]; Emily Fan Michaelson [emichaelson@katzandassociates.com]
Subject: RE: Sites - Draft EIR/EIS Outreach Planning Session: Agenda and Materials

Hi, Ali! I think it's fine to share, and thank you for including them.

Kim

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Monday, June 28, 2021 3:57 PM
To: Kim Floyd <kim@floydcommunications.com>; Kevin Spesert <kspesert@sitesproject.org>; monique.briard@icf.com; laurie.warner.herson@phenixenv.com; linda.fisher@hdrinc.com
Cc: Sarah Rossetto <srossetto@katzandassociates.com>; Sara M. Katz <SKatz@katzandassociates.com>; Emily Fan Michaelson <emichaelson@katzandassociates.com>
Subject: RE: Sites - Draft EIR/EIS Outreach Planning Session: Agenda and Materials

Hi all – I've added Reclamation to our meeting on Wednesday. I haven't read through the materials, but any concerns with sending the materials them also?

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

---

From: Kim Floyd <kim@floydcommunications.com>
Sent: Monday, June 28, 2021 1:06 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Kevin Spesert <kspesert@sitesproject.org>; monique.briard@icf.com; laurie.warner.herson@phenixenv.com; linda.fisher@hdrinc.com
Cc: Sarah Rossetto <srossetto@katzandassociates.com>; Sara M. Katz <SKatz@katzandassociates.com>; Emily Fan Michaelson <emichaelson@katzandassociates.com>
Subject: Sites - Draft EIR/EIS Outreach Planning Session: Agenda and Materials

All:

In preparation for our EIR/EIS Outreach Planning meeting on Wednesday, June 30, attached please find the proposed agenda and a draft implementation plan for your review and our discussion. In its draft form, the implementation plan provides a framework for decisions regarding noticing, format and logistics for public meetings, and input into the development of informational materials. Areas highlighted in yellow are those for which we need clarification, more information, and/or consensus.

We look forward to seeing you (virtually) on Wednesday afternoon! Please let us know if you have any questions in the meantime.

Thanks,

Kim Floyd
Katz & Associates Team

(916) 838-2666 (cell)
kim@floydcommunications.com

From: Sara M. Katz [skatz@katzandassociates.com]
Sent: 6/28/2021 4:09:14 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: RE: Sites - Draft EIR/EIS Outreach Planning Session: Agenda and Materials

Nope.

K&A KATZ&ASSOCIATES

Sara M. Katz
Founder/CEO
mobile: 619.813.9551
San Diego · Los Angeles · San Francisco

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Monday, June 28, 2021 3:57 PM
To: Kim Floyd <kim@floydcommunications.com>; Kevin Spesert <kspesert@sitesproject.org>; monique.briard@icf.com; laurie.warner.herson@phenixenv.com; linda.fisher@hdrinc.com
Cc: Sarah Rossetto <srossetto@katzandassociates.com>; Sara M. Katz <skatz@katzandassociates.com>; Emily Fan Michaelson <emichaelson@katzandassociates.com>
Subject: RE: Sites - Draft EIR/EIS Outreach Planning Session: Agenda and Materials

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Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Kim Floyd <kim@floydcommunications.com>
Sent: Monday, June 28, 2021 1:06 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Kevin Spesert <kspesert@sitesproject.org>; monique.briard@icf.com; laurie.warner.herson@phenixenv.com; linda.fisher@hdrinc.com
Cc: Sarah Rossetto <srossetto@katzandassociates.com>; Sara M. Katz <SKatz@katzandassociates.com>; Emily Fan Michaelson <emichaelson@katzandassociates.com>
Subject: Sites - Draft EIR/EIS Outreach Planning Session: Agenda and Materials

All:

In preparation for our EIR/EIS Outreach Planning meeting on Wednesday, June 30, attached please find the proposed agenda and a draft implementation plan for your review and our discussion. In its draft form, the implementation plan provides a framework for decisions regarding noticing, format and logistics for public meetings, and input into the development of informational materials. Areas highlighted in yellow are those for which we need clarification, more information, and/or consensus.

We look forward to seeing you (virtually) on Wednesday afternoon! Please let us know if you have any questions in the meantime.

Thanks,

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Katz & Associates Team

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Reservoir Operating Elevations and Emergency Release Management Technical Memorandum

Sites
Program Management Team

To:	Sites Project Authority
CC:	Henry Luu, P.E. (HDR)
Date:	August 18, 2020
From:	Joseph Barnes, P.E.
Quality Review by:	Mike Forrest, P.E., Jeff Herrin
Authority Agent Review by:	Henry Luu, P.E. (HDR)
Subject:	Funks and Stone Corral Creeks Reservoir Operating Elevations and Emergency Release Management Task Order No.1, Task HR2.94

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Acronyms and Abbreviations

Authority	Sites Project Authority
cfs	cubic feet per second
DSOD	California Department of Water Resources, Division of Safety of Dams
DWR	California Department of Water Resources, Division of Engineering
I/O	Inlet/Outlet
MAF	million-acre-feet
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
TM	Technical Memorandum
TRR	Terminal Regulating Reservoir
Reclamation, USBR	U.S. Bureau of Reclamation

1.0 Introduction

1.1 Project Overview

The Sites Project Authority (Authority) is preparing a feasibility-level evaluation for a 1.5-million-acre-foot (MAF) reservoir as a preferred option for the Sites Reservoir Project. This reservoir would be in the same location as the reservoir studied previously by the California Department of Water Resources, Division of Engineering (DWR), and the U. S. Bureau of Reclamation (Reclamation). Smaller main dams and saddle dams would be constructed to form the smaller reservoir.

This Technical Memorandum (TM) provides guidance on normal maximum and minimum operating water levels and managing the design Probable Maximum Flood (PMF) event. The TM also presents an approach to demonstrate that the reservoir water surface can be drawn down in the event of an emergency to comply with the current criteria of the California Department of Water Resources, Division of Safety of Dams (DSOD).

Because the Authority may also choose to evaluate an option with a smaller, 1.3-MAF reservoir, the parameters for the smaller reservoir are also provided in this TM.

1.2 Limitations

The scope of work for this TM was restricted to the development of feasibility designs for the Sites Reservoir. It did not include consideration of other Sites facilities beyond those specifically listed.

AECOM represents that our services were conducted in a manner consistent with the standard of care ordinarily applied as the state of practice in the profession within the limits prescribed by our client.

This TM is intended for the sole use of the Sites Project Authority. The scope of services performed may not be appropriate to satisfy the needs of other users, and any use or re-use of this document or of the findings, conclusions, or recommendations presented herein is at the sole risk of said user.

2.0 Reservoir Operating Water Levels

The reservoir operating water levels are established based on area-capacity information provided by DWR in their preliminary design report for the main dams and saddle dams (DWR, 2003). This information must be verified once new topographic information becomes available for the project. Table 2-1 provides a summary of the normal operating water levels and active storage for 1.5-MAF and 1.3-MAF reservoirs.

Table 2-1. Reservoir Normal Operating Water Levels and Storage

Nominal Reservoir Gross Storage	1.5 MAF	1.3 MAF
Maximum Normal Operating Water Elevation	498 feet	482 feet
Minimum Normal Operating Water Elevation	340 feet	340 feet
Top of Dead Pool	300 feet	300 feet
Active Storage Capacity[1]	1.4 MAF	1.2 MAF

1. Between minimum normal operating water elevation (elevation 340.0 feet) and maximum normal operating water elevation

The minimum normal operating elevations and top of dead pool provided in Table 2-1 are the same as used in all previous reservoir studies. Water stored between these two elevations is available to the project in drought years by making releases through the low-level outlet in the reservoir. Water levels associated with flood routing and PMF storage are discussed below.

3.0 Flood Control Spillway

3.1 Background

A flood control spillway was not included in the DWR design for Sites Reservoir because the drainage area is small relative to reservoir size, and because the runoff from the PMF from the drainage area can be fully captured and contained within the reservoir while still providing required freeboard for the dams. However, a signal spillway pipe of limited capacity (7-foot-diameter pipe) was proposed at Saddle Dam No. 4. A similar concept was employed for the Diamond Valley Lake Project in Southern California. If water is observed flowing through the pipe during routine post-storm inspections, the operation and maintenance staff would be alerted that the reservoir was above the PMF storage level so that appropriate action could be taken to reduce the water level. Causes for the continued reservoir rise could be the result of ongoing runoff from the drainage basin or over-pumping into the reservoir. Over-pumping refers to pumping from the pumping plants (from Terminal Regulating Reservoir (TRR) and Funks Pumping Plants), at 3,900 cubic feet per second (cfs), into Sites Reservoir; and if left unchecked, “over-pumping” would result. Over-pumping could cause discharge over the spillway. This would be an extremely low-probability event (see also Section 3.3). Several emails, including a short description of the signal spillway concept, are available from DWR files (DWR, 2006), but there is no indication that the signal spillway concept was acceptable to DSOD.

On January 19, 2019, the Authority and AECOM provided DSOD an informal briefing on the status of reservoir design for the project, including dam design concepts. The need for a spillway was discussed. DSOD indicated they could require a flood control spillway more substantial than a signal spillway, even with the capability to fully store the PMF. Over-pumping could be a possible criterion for spillway design. Based on this meeting, it is prudent for the feasibility study to include a spillway in the scope of the project. A gravity dam and spillway concept for the feasibility study is presented below, but formal consultation with DSOD would be required to finalize the spillway concept and criteria for final design.

3.2 Probable Maximum Flood Determination

To develop Probable Maximum Precipitation (PMP) over the reservoir basin, DWR prepared an updated PMF study using Hydrometeorological Report 58, Probable Maximum Precipitation for California – Calculation Procedures (NOAA, 1998) and Hydrometeorological Report 59, Probable Maximum Precipitation for California (NOAA, 1999). Study details are provided in a Memorandum prepared by DWR (DWR, 2004). Precipitation was dispersed over the subbasins and reservoir area and non-infiltrated rainwater was routed down to the reservoir using U.S. Army Corp of Engineers Hydrologic Modeling System (USACE, 2018). Table 3-1 summarizes the study results.

Table 3-1 PMF Study Results

3-Day PMP Rainfall Total	20.63 inches
Total Volume Influx with No Releases	79,375 acre-feet
Peak Inflow	68,500 cfs

AECOM believes the inflow hydrograph from the DWR study is still adequate for use in the current feasibility study. However, consultation with DSOD would be necessary prior to final design to confirm PMF selection and spillway design criteria. Concepts to use the spillway to route a portion of the PMF downstream, and to fully store the PMF are discussed below.

3.3 Spillway Options

Topography favors locating a spillway at the northern end of the reservoir in conjunction with one of the smaller saddle dams for the 1.5-MAF reservoir. For this TM, the spillway would be incorporated into a concrete gravity dam located at Saddle Dam No. 8B. Spillway discharge would flow down tributaries to Hunters Creek, and ultimately flow to the Colusa Basin Drain. The following two spillway options have been evaluated:

- Option 1 – Spillway with crest elevation set at the maximum normal operating water surface elevation. Spillway would release water during a PMF event, or if unanticipated over-pumping were to occur.
- Option 2 – Spillway with crest elevation set to fully store the PMF runoff, with potential for subsequent over-pumping.

3.3.1 Option 1

Design considerations:

- The spillway crest elevation would be set at the maximum normal operating water surface elevation for the reservoir.
- Spillway would be sized to safely pass flows from unplanned over-pumping into the reservoir. For the 1.5-MAF reservoir, the over-pumping rate would be a maximum of 3,900 cfs coming from the TRR and GCID Canal pumping plants. The same rate would apply for the 1.3-MAF reservoir.
- With the crest set to the maximum normal operating water surface elevation, the spillway would also pass water during a PMF event.
- The spillway crest length (estimated at approximately 85.5 feet with central bridge pier) is selected so that estimated peak discharges and associated maximum reservoir water elevations are the same for both over-pumping and PMF flood routing.

It is assumed the above criteria would satisfy DSOD requirements for a spillway with a reasonable design basis that incorporates both over-pumping and the PMF. Over-pumping and PMF events have a very low probability of simultaneous occurrence.

Level pool flood routing (Modified Puls Method) was used for flood routing through the reservoir and spillway. The spillway was assumed to be a concrete structure with ogee crest similar to the one used in the recent Reclamation feasibility study for a 1.8-MAF reservoir. The rating curve for the spillway crest was estimated in accordance with the procedures presented in Section 9.12 of the Design of Small Dams (USBR, 1987). Table 3-2 summarizes the results of the routing.

Table 3-2 Flood Routing

Nominal Reservoir Gross Storage	1.5 MAF	1.3 MAF
Spillway Crest Elevation	498 feet	482 feet
Spillway Crest Length (Effective Hydraulic Length)	80 feet	65 feet
Maximum Depth over Spillway	5.33 feet	6.21 feet
Maximum Reservoir Elevation with Flood	503.33 feet	488.21 feet
Peak Discharge (Over-pumping or PMF Case)	3,908 cfs	4,076 cfs

The peak discharge from flood routing in Table 3-2 closely matches the over-pumping rate. The reservoir maximum flood elevation was considered in selecting the recommended freeboard for the dams.

An issue with this option is the amount of discharge that would be routed down Hunters Creek, and the potential effects on the channel and downstream infrastructure. It is not uncommon to consider and address downstream impacts up to and including the PMF through flood easements and other measures. It is not possible to fully define these impacts now for this study. However, one approach to address these issues would be to fully store the PMF and coordinate with DSOD to minimize the over-pumping design flow for the spillway. This is Option 2, described below.

3.3.2 Option 2

Option 2 includes full storage of the PMF. The maximum reservoir water levels that would result from full storage are presented in Table 3-3.

Table 3-3 PMF Storage

Nominal Reservoir Gross Storage	**1.5 MAF**	**1.3 MAF**
Maximum Reservoir Elevation with PMF Storage	503.8 feet	486.8 feet
Spillway Crest Elevation Proposed	504.0 feet	487.0 feet

For Option 2, the crest of the spillway section in the gravity dam would be raised to elevation 504.0 feet for the 1.5-MAF reservoir. The length of the spillway would be maintained at 85.5 feet, as with Option 1.

Without consultation with DSOD, it is not possible to select a design flow for the spillway at this time. Given the very low probability that an over-pumping event would occur in combination with a PMF event, and accounting for all of the reservoir inspection and operating procedures that would be in place, it may be possible to agree to a design flow less than the over-pumping flow with DSOD. Also, there is significant flexibility in the length of the spillway crest section that can be provided in a gravity dam. If the current length is inadequate for the design flow, the crest length can be increased by a factor of three or more to accommodate the flow and avoid impacts to dam freeboard.

3.3.3 Recommended Option

For the feasibility study, AECOM proceeded with Option 2 to fully contain the PMF. The design flow for a spillway would be developed in consultation with DSOD. With full containment of the PMF and recognizing the low probability of over-pumping, it may be possible to handle over-pumping as an emergency condition that can be addressed as part of the emergency action plan for the reservoir.

4.0 Emergency Drawdown

Regulatory Required Emergency Drawdown and Release Impacts: In the extreme and unanticipated condition that the reservoir has to be drawdown due to emergency, localized flooding downstream may occur. The extent of these potential impacts have not yet been evaluated in detail. It should be noted that the reservoir provides flood control benefits by controlling currently uncontrolled streams and creeks, which will reduce localized flooding on a regular basis. To improve understanding of the risk and the potential scale of these rare, if ever, emergency events, an inundation review encompassing the potential release areas will be performed.

Criteria: Below is a summary of the applicable DSOD criteria for emergency reservoir drawdown that is the basis for sizing the emergency release facilities. The criteria require sizing the outlet works for the worst-case condition for which evacuation is needed under a full reservoir condition. If the reservoir is at a lower elevation when evacuation is needed, release rates would be lower.

- Emergency release facilities must be able to reduce the depth of water in the reservoir by 10 percent of the reservoir depth within 7 days. Reservoir depth is defined as the elevation difference between the maximum normal operating water elevation and the top of dead pool elevation.
- The emergency release facilities must be able to drain the reservoir to dead pool within 90 to 120 days.

Table 4-1 summarizes drawdown requirements.

Table 4-1. Emergency Drawdown Requirements

Reservoir Size	1.5 MAF	1.3 MAF
Maximum Normal Operating Water Elevation	498 feet	482 feet
Reservoir Depth Above Dead Pool	198 feet	182 feet
10 Percent of Depth	19.8 feet	18.2 feet
7-Day, 10 Percent Release Volume Required1	249,000 acre-feet	214,500 acre-feet

1. Based on area-capacity curve

Application: AECOM prepared a feasibility-level evaluation of an emergency drawdown system that would meet the DSOD criteria, which are described below. There is no requirement that would prevent distributing the emergency release to multiple locations around the reservoir. For the 1.5-MAF reservoir, release locations would include Stone Corral Creek at Sites Dam; Funks Creek below the downstream portal of the Inlet/Outlet (I/O) tunnels near Golden Gate Dam; and two locations at the large saddle dams at the northern end of the reservoir, where reservoir head is adequate to release a significant amount of water during the first 7 days. It may also be possible to use the TRR Pipeline to convey some of the water from the I/O Tunnels to the TRR for release to Funks Creek at that location.

Table 4-2 provides a summary of the facilities selected for an emergency release study.

Table 4-2. Assumed Emergency Release Facilities for Feasibility Evaluation

Locations	I/O Tunnel Golden Gate	Sites Dam	Saddle Dam No. 3	Saddle Dam No. 5
Energy Dissipating Valves (Number/Size)	4, 90-inch	1, 72-inch	2, 54-inch	2, 54-inch
Valve Discharge Center Line elevation	216 feet	250 feet	450 feet	450 feet
Gross head with Normal Maximum Water Surface	282 feet	248 feet	48 feet	48 feet
Assumed Head Loss Upstream to Valve	30 feet	10 feet	10 feet	10 feet
Net Head on Valve	252 feet	238 feet	38 feet	38 feet
Discharge Coefficient (Cd)	0.71	0.71	0.71	0.71
Maximum Release per Valve	3,996 cfs	2,485 cfs	559 cfs	559 cfs
Total Release (Maximum)	15,984 cfs	2,485 cfs	1,118 cfs	1,118 cfs
Total Maximum Release All Valves	20,705 cfs			

Table 4-2 includes the following considerations:

- Releases at the northern end of the reservoir would be at Saddle Dams No. 3 and 5. Release facilities would include an intake in the reservoir at or below existing grade elevation 450.0 feet; steel-lined tunnels through the ridge away from the left abutments of both dams; energy dissipation valve structure; and local erosion protection measures at the discharge structure.
- Releases at Sites Dam to Stone Corral Creek would be made through facilities incorporated into the construction diversion tunnel on the left abutment of the dam.
- Releases from the I/O Tunnel near Golden Gate Dam would be made through an energy dissipation valve structure into Funks Reservoir. Valve center line is assumed to be at Elevation 216.0 feet, two feet above the top of Funks Dam (Elevation 214.0 feet). The existing spillway at Funks Dam is capable of passing flows up to 22,000 cfs based on a gate structure rating curve on the design drawings. It may also be possible to convey a portion of the release at the I/O Tunnels to the TRR Reservoir through the TRR Pipeline for release to Funks Creek further to the east.
- The discharge coefficient for the valves was based on vendor information.

Drawdown Study Results: The outlet facilities and characteristics identified in Table 4-2 were used to verify the ability to draw down the reservoir in compliance with the DSOD criteria. The results of the analysis are presented on Figure 4-1 and Figure 4-2. Analysis approach and findings are summarized as follows:

- The 7-day and 90-day criteria are met.
- During the first 7 days, the discharge varies from 20,705 cfs down to 19,415 cfs.
- At the end of Day 7, releases at the saddle dams would be terminated because the head on the valves is significantly reducing, and the emergency release rates at the two other locations can be reduced by approximately 40 percent by partially closing the valves. This would help manage downstream impacts and still achieve lowering in 90 days. On Day 8, release rate would be dropped from approximately 19,415 cfs to approximately 10,700 cfs.
- As the reservoir level approaches dead pool elevation, the flow from the valves would be further reduced in steps to avoid air entrainment and poor valve performance as the submergence decreases over the low-level inlet in the reservoir.
- Meeting the 90-day criteria rather than 120 days was selected for this study. In consultation with DSOD, it may be possible to obtain concurrence to use 120 days, but this study assumes 90 days in the event the longer time is not accepted.

Error! Reference source not found. Table 4-3 provides a summary of the releases at each location during the first 7 days.

Table 4-3. Summary of 7-Day Releases, 1.5 MAF Reservoir

Locations	I/O Tunnel Golden Gate	Sites Dam	Saddle Dam No. 3	Saddle Dam No. 5
7-Day Starting Release Rate	15,984 cfs	2,485 cfs	1,118 cfs	1,118 cfs
7-Day Ending Release Rate	15,442 cfs	2,385 cfs	794 cfs	794 cfs

The release approach described above was selected to demonstrate that the DSOD criteria can be met for the 1.5-MAF reservoir. Equipment selections and release rates can be varied as design progresses, as long as analyses show that criteria are being met.

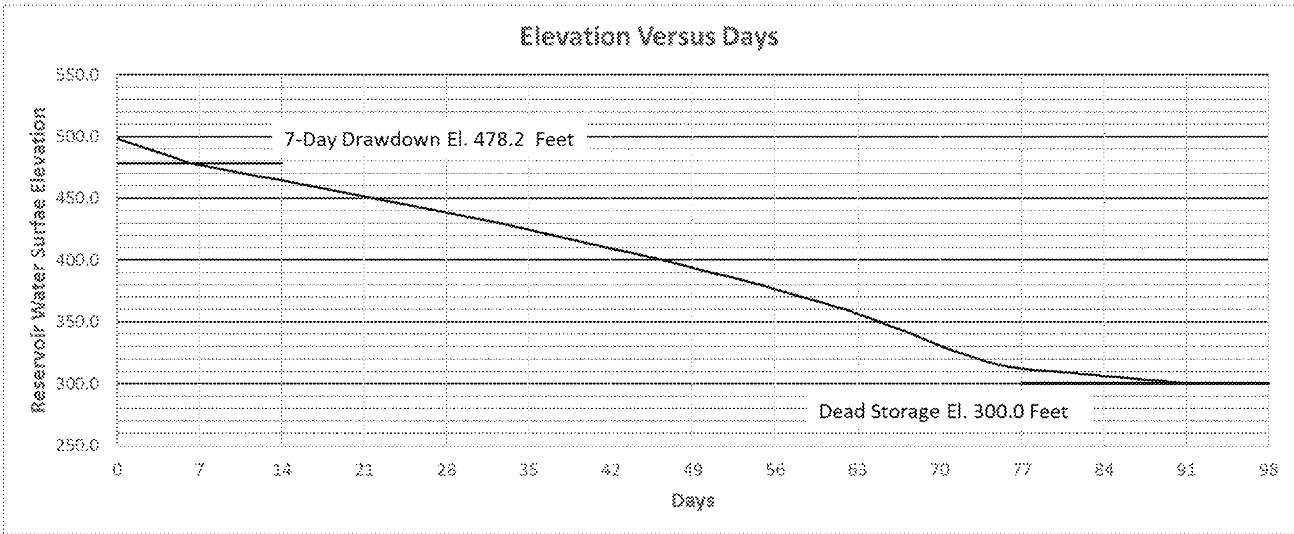

Figure 4-1. Reservoir Elevation Versus Days, 1.5-MAF Reservoir

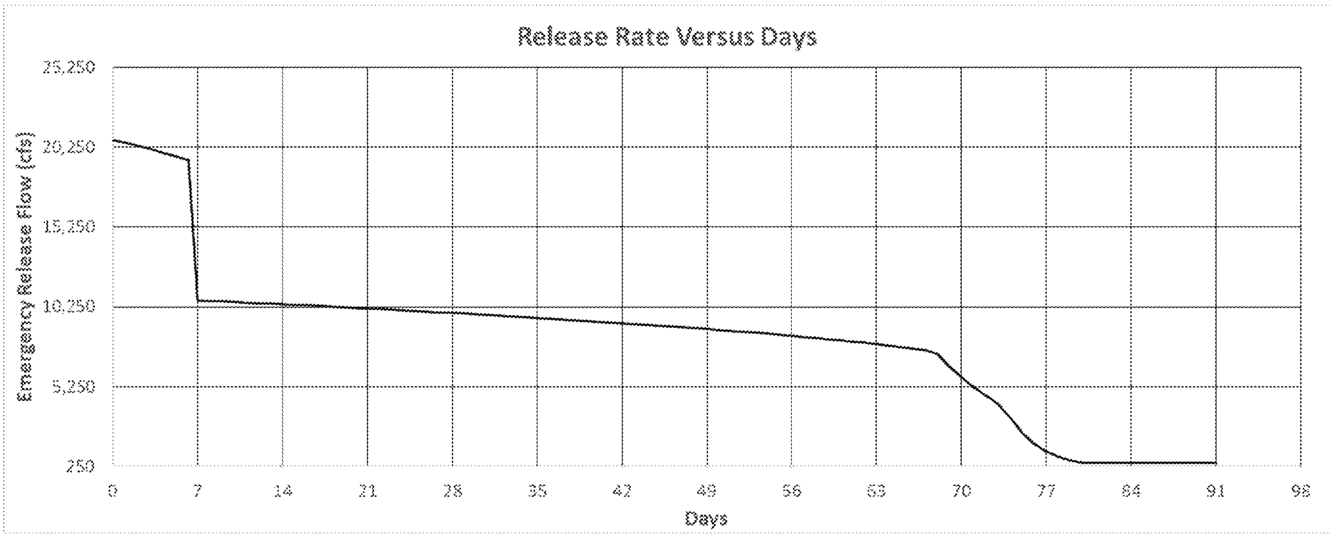

Figure 4-2. Emergency Release Flow Versus Days, 1.5-MAF Reservoir

The release approach described above was selected to demonstrate that the DSOD criteria can be met for the 1.5-MAF reservoir. Equipment selections and release rates can be varied as design progresses, as long as analyses shows that criteria are being met.

For the 1.3-MAF reservoir, the release approach described above would still be applicable, with a minor adjustment in energy dissipation valve sizing. However, the ability to make releases at the northern saddle dams would reduce due to topography and reduced reservoir water levels.

As mentioned previously, the intent of this TM is to identify the emergency drawdown criteria that would apply to the 1.5-MAF reservoir, and identify an emergency release scenario to demonstrate that the criteria can be met. The benefits of discharging more water out the northern end of the reservoir to reduce flows in Funks and Stone Corral Creeks are understood. There is opportunity to add at least one additional outlet to a saddle dam at the northern end of the reservoir for the 1.5-MAF reservoir. In addition, it may be possible to identify other tunnel locations through the ridge away from the saddle dams that can also be used for making additional releases. The costs and benefits of such alternatives can be further evaluated in the next phase of the project.

5.0 Estimated Quantities and Disturbance Areas

This TM provides backup information for locating and sizing the spillway and emergency release facilities. Disturbance areas and estimated quantities for these facilities are provided in the TMs for the Main Dams and Saddle Dams and Creek Diversions.

6.0 References

DWR (2003). Department of Water Resources, Sites Reservoir Engineering Feasibility Study, Golden Gate, Sites, and Saddle Dams. February.

DWR (2004). Department of Water Resources, Memorandum, Sites Reservoir PMF Analysis. August 12.

DWR (2006). Department of Water Resources, Email Chain, Sites Emergency Spillway. July.

NOAA (1998). National Oceanic and Atmospheric Administration, Hydrometeorological Report No.58 – Probable Maximum Precipitation for California – Calculation Procedures.

NOAA (1999). National Oceanic and Atmospheric Administration, Hydrometeorological Report No.59 – Probable Maximum Precipitation for California.

USACE (2018). U.S. Army Corps of Engineers (USACE) Hydrologic Modeling System (HEC-HMS).

USBR (1987). U.S. Bureau of Reclamation, Design of Small Dams.

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/29/2021 1:53:25 PM
To: Monique Briard (monique.briard@icf.com) [monique.briard@icf.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Forrest, Michael [michael.forrest@aecom.com]; jeff.herrin@aecom.com; Michael, Howard [howard.michael@aecom.com]; Luu, Henry [Henry.Luu@hdrinc.com]; Haire, Jennifer [Jennifer.Haire@icf.com]
Subject: RE: Amendment 3 design needs from wildlife permitting team: REVISED

Just a friendly reminder to fill this poll out. Thanks.

John Spranza

D 916.679.8858 M 818.640.2487

From: Spranza, John
Sent: Monday, June 28, 2021 9:17 AM
To: Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Forrest, Michael <michael.forrest@aecom.com>; Herrin, Jeff (jeff.herrin@aecom.com) <jeff.herrin@aecom.com>; Michael, Howard <howard.michael@aecom.com>; Luu, Henry <henry.luu@hdrinc.com>; Haire, Jennifer <Jennifer.Haire@icf.com>
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Hey Folks, I'm sending this back around because I neglected to add the ICF biologists to the first email. I am hoping to have this meeting this week so please provide your availability for the revised dates at the following link ASAP. Thanks.

https://doodle.com/poll/b7fdcpaibad5m965?utm_source=poll&utm_medium=link

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Subject: Amendment 3 design needs from wildlife permitting team

Hello,
I would like to get the design team on a call to talk about the need for wildlife crossings and bat-friendly bridge design along the a few of the project roads. We ended up with a significant impact for wildlife movement and have some requirements to address it (see below)

Please take a moment to fill out the doodle poll below and I will get this meeting scheduled.
Thanks.

https://doodle.com/poll/yi5t99fn3x6wgiu2?utm_source=poll&utm_medium=link

Mitigation Measure WILD-2.1: Design and Construct Wildlife Crossings for New Roadways at Suitable Locations

The Authority will employ a qualified wildlife biologist with expertise in wildlife crossing use and design to conduct a wildlife connectivity and crossing assessment and to determine where suitable wildlife crossing structures would be most effective along North Road, Sites Lodoga Road, and other roads as determined by the Authority and the wildlife biologist. Wildlife crossing structures will be designed and constructed at suitable locations to provide habitat connectivity and safe movement for an array of wildlife likely to use the Project area. To ensure that the assessment is inclusive of a variety of species a wildlife crossing species guild (WCG) approach will be used as detailed in Kintsch et al. 2015. This WCG approach will include ecological and behavioral needs of a variety of species inhabiting the Project area/region. Wildlife crossing locations and design will be determined based on WCG species inhabiting the Project area/region, habitat features, topography, and the future state of the Project area through a wildlife connectivity and crossing assessment.

Prior to final roadway design for the Project, a wildlife connectivity assessment will be conducted to assess existing and expected wildlife movement and habitat connectivity conditions, Project-related impact on connectivity and species movement, and identify appropriate wildlife crossing locations and designs. The assessment will include a landscape-scale and local (Project)-scale assessments. The assessment may use database research, field surveys, photo monitoring, GIS modeling, or a combination thereof to identify existing wildlife species in the Project area, determine how connectivity and species movement may be affected by the Project, and determine the appropriate locations and designs of wildlife crossings.

Wildlife crossings will be located at appropriate frequencies to accommodate a range of species expected to move through the area. For example, for small-bodied animals like amphibians, reptiles, and small mammals, where species habitat and movement needs are present, wildlife crossings may be located no more than 1,000 feet apart or as determined appropriate for specific target species. For medium- and large-bodied animals, such as bobcats, coyotes, and deer, wildlife crossings may be located no more than 1 mile apart.

Wildlife crossings will be located where there is suitable habitat on both sides of the roadway. If feasible and depending on the size and ecological and behavioral needs of target species, vegetative cover will be provided near entrances to give animals security and reduce negative effects such as lights and noise associated with the road. Suitable habitat and/or cover will also be provided in the crossing structure wherever feasible. This may be achieved by designing culverts to be high enough to allow light for plants to grow, installing rubble piles, stumps, or branches to provide cover for smaller animals in the crossings, and leaving earthen bottoms in crossing structures.

When possible, wildlife crossings will be located away from areas used or dominated by humans, including recreation areas, trails, and lighted areas to avoid reduced wildlife crossing movement function and to prevent human-wildlife conflict.

Wildlife crossings will be designed to optimally facilitate movement for multiple WCG species. When possible, proposed culverts will be designed to function as multi-use culverts, which are designed to ensure that they facilitate wildlife movement. Multi-use culvert crossings will be designed to be optimally accessible to wildlife movement and will also be designed to require minimal maintenance.

Wildlife fencing will be installed to direct wildlife towards crossings and prevent wildlife access to roadways and other areas they must be excluded from. Escape opportunities such as jump-out ramps, may be provided as appropriate in conjunction with fencing to allow animals to escape from the roadway.

Mitigation Measure WILD-2.2: Monitor and Maintain Wildlife Crossings

Because many wildlife species will avoid or be obstructed by structures with a substantial amount of debris or blockages, the Authority will employ a qualified wildlife crossing biologist to regularly monitor crossings and culverts and clear them or oversee the clearing of debris and other blockages. Vegetative cover will be maintained near entrances to provide cover and reduce negative effects such as artificial lighting and noise associated with the road. A monitoring and maintenance plan for wildlife crossings will be developed during design of wildlife crossings (Mitigation Measure WILD-2.1) to document post-construction conditions, determine the frequency of monitoring and maintenance, performance standards, and reporting requirements

John Spranza, MS, CCN

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Subject: RE: Amendment 3 design needs from wildlife permitting team: REVISED

John,

I get an error message when I open it up.

Jeff

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Subject: [EXTERNAL] RE: Amendment 3 design needs from wildlife permitting team: REVISED

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From: Spranza, John
Sent: Wednesday, June 16, 2021 9:51 AM
To: Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Forrest, Michael <michael.forrest@aecom.com>; Herrin, Jeff (jeff.herrin@aecom.com)

<jeff.herrin@aecom.com>; Michael, Howard <howard.michael@aecom.com>; Luu, Henry <henry.luu@hdrinc.com>
Subject: Amendment 3 design needs from wildlife permitting team

Hello,
I would like to get the design team on a call to talk about the need for wildlife crossings and bat-friendly bridge design along the a few of the project roads. We ended up with a significant impact for wildlife movement and have some requirements to address it (see below)

Please take a moment to fill out the doodle poll below and I will get this meeting scheduled.
Thanks.

https://doodle.com/poll/yi5t99fn3x6wgiu2?utm_source=poll&utm_medium=link

Mitigation Measure WILD-2.1: Design and Construct Wildlife Crossings for New Roadways at Suitable Locations

The Authority will employ a qualified wildlife biologist with expertise in wildlife crossing use and design to conduct a wildlife connectivity and crossing assessment and to determine where suitable wildlife crossing structures would be most effective along North Road, Sites Lodoga Road, and other roads as determined by the Authority and the wildlife biologist. Wildlife crossing structures will be designed and constructed at suitable locations to provide habitat connectivity and safe movement for an array of wildlife likely to use the Project area. To ensure that the assessment is inclusive of a variety of species a wildlife crossing species guild (WCG) approach will be used as detailed in Kintsch et al. 2015. This WCG approach will include ecological and behavioral needs of a variety of species inhabiting the Project area/region. Wildlife crossing locations and design will be determined based on WCG species inhabiting the Project area/region, habitat features, topography, and the future state of the Project area through a wildlife connectivity and crossing assessment.

Prior to final roadway design for the Project, a wildlife connectivity assessment will be conducted to assess existing and expected wildlife movement and habitat connectivity conditions, Project-related impact on connectivity and species movement, and identify appropriate wildlife crossing locations and designs. The assessment will include a landscape-scale and local (Project)-scale assessments. The assessment may use database research, field surveys, photo monitoring, GIS modeling, or a combination thereof to identify existing wildlife species in the Project area, determine how connectivity and species movement may be affected by the Project, and determine the appropriate locations and designs of wildlife crossings.

Wildlife crossings will be located at appropriate frequencies to accommodate a range of species expected to move through the area. For example, for small-bodied animals like amphibians, reptiles, and small mammals, where species habitat and movement needs are present, wildlife crossings may be located no more than 1,000 feet apart or as determined appropriate for specific target species. For medium- and large-bodied animals, such as bobcats, coyotes, and deer, wildlife crossings may be located no more than 1 mile apart.

Wildlife crossings will be located where there is suitable habitat on both sides of the roadway. If feasible and depending on the size and ecological and behavioral needs of target species, vegetative cover will be provided near entrances to give animals security and reduce negative effects such as lights and noise associated with the road. Suitable habitat and/or cover will also be provided in the crossing structure wherever feasible. This may be achieved by designing culverts to be high enough to allow light for plants to grow, installing rubble piles, stumps, or branches to provide cover for smaller animals in the crossings, and leaving earthen bottoms in crossing structures.

When possible, wildlife crossings will be located away from areas used or dominated by humans, including recreation areas, trails, and lighted areas to avoid reduced wildlife crossing movement function and to prevent human-wildlife conflict.

Wildlife crossings will be designed to optimally facilitate movement for multiple WCG species. When possible, proposed culverts will be designed to function as multi-use culverts, which are designed to ensure that they facilitate wildlife movement. Multi-use culvert crossings will be designed to be optimally accessible to wildlife movement and will also be designed to require minimal maintenance.

Wildlife fencing will be installed to direct wildlife towards crossings and prevent wildlife access to roadways and other areas they must be excluded from. Escape opportunities such as jump-out ramps, may be provided as appropriate in conjunction with fencing to allow animals to escape from the roadway.

Mitigation Measure WILD-2.2: Monitor and Maintain Wildlife Crossings

Because many wildlife species will avoid or be obstructed by structures with a substantial amount of debris or blockages, the Authority will employ a qualified wildlife crossing biologist to regularly monitor crossings and culverts and clear them or oversee the clearing of debris and other blockages. Vegetative cover will be maintained near entrances to provide cover and reduce negative effects such as artificial lighting and noise associated with the road. A monitoring and maintenance plan for wildlife crossings will be developed during design of wildlife crossings (Mitigation Measure WILD-2.1) to document post-construction conditions, determine the frequency of monitoring and maintenance, performance standards, and reporting requirements

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

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2379 Gateway Oaks Drive, Suite 200
Sacramento, CA 95833
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From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 6/29/2021 3:02:06 PM
To: jeff.herrin@aecom.com; Monique Briard (monique.briard@icf.com) [monique.briard@icf.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Forrest, Michael [michael.forrest@aecom.com]; Michael, Howard [howard.michael@aecom.com]; Luu, Henry [Henry.Luu@hdrinc.com]; Haire, Jennifer [Jennifer.Haire@icf.com]
Subject: RE: Amendment 3 design needs from wildlife permitting team: REVISED

Please use this link. Thanks

https://doodle.com/poll/m6fmzcerghqw2iam?utm_source=poll&utm_medium=link

John Spranza

D 916.679.8858 M 818.640.2487

From: Herrin, Jeff <jeff.herrin@aecom.com>
Sent: Tuesday, June 29, 2021 2:30 PM
To: Spranza, John <John.Spranza@hdrinc.com>; Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; Alicia Forsythe <aforsythe@sitesproject.org>; Forrest, Michael <michael.forrest@aecom.com>; Michael, Howard <howard.michael@aecom.com>; Luu, Henry <Henry.Luu@hdrinc.com>; Haire, Jennifer <Jennifer.Haire@icf.com>
Subject: RE: Amendment 3 design needs from wildlife permitting team: REVISED

John,

I get an error message when I open it up.

Jeff

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Tuesday, June 29, 2021 1:53 PM
To: Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; Alicia Forsythe <aforsythe@sitesproject.org>; Forrest, Michael <michael.forrest@aecom.com>; Herrin, Jeff <jeff.herrin@aecom.com>; Michael, Howard <howard.michael@aecom.com>; Luu, Henry <Henry.Luu@hdrinc.com>; Haire, Jennifer <Jennifer.Haire@icf.com>
Subject: [EXTERNAL] RE: Amendment 3 design needs from wildlife permitting team: REVISED

Just a friendly reminder to fill this poll out. Thanks.

John Spranza

D 916.679.8858 M 818.640.2487

From: Spranza, John
Sent: Monday, June 28, 2021 9:17 AM
To: Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Forrest, Michael <michael.forrest@aecom.com>; Herrin, Jeff (jeff.herrin@aecom.com)

<jeff.herrin@aecom.com>; Michael, Howard <howard.michael@aecom.com>; Luu, Henry <henry.luu@hdrinc.com>; Haire, Jennifer <Jennifer.Haire@icf.com>
Subject: RE: Amendment 3 design needs from wildlife permitting team: REVISED

Hey Folks, I'm sending this back around because I neglected to add the ICF biologists to the first email. I am hoping to have this meeting this week so please provide your availability for the revised dates at the following link ASAP.
Thanks.

https://doodle.com/poll/b7fdcpaibad5m965?utm_source=poll&utm_medium=link

John Spranza

D 916.679.8858 M 818.640.2487

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To: Monique Briard (monique.briard@icf.com) <monique.briard@icf.com>; aforsythe (aforsythe@sitesproject.org) <aforsythe@sitesproject.org>; Forrest, Michael <michael.forrest@aecom.com>; Herrin, Jeff (jeff.herrin@aecom.com) <jeff.herrin@aecom.com>; Michael, Howard <howard.michael@aecom.com>; Luu, Henry <henry.luu@hdrinc.com>
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John Spranza, MS, CCN
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From: Micko, Steve/SAC [Steve.Micko@jacobs.com]
Sent: 6/29/2021 6:06:50 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Heydinger, Erin [erin.heydinger@hdrinc.com]
CC: Leaf, Rob/SAC [Rob.Leaf@jacobs.com]
Subject: RE: Sites: Draft Carriage Water Document
Attachments: SPJPA_Sites_CarriageWaterApproach_rev04_20210629_DRAFT.docx; SPJPA_Sites_CarriageWaterApproach_rev04_20210629_DRAFT_clean.docx

Hi Ali,

The following files are attached:

- SPJPA_Sites_CarriageWaterApproach_rev04_20210629_DRAFT.docx
  - Final write-up with revisions in track changes
- SPJPA_Sites_CarriageWaterApproach_rev04_20210629_DRAFT_Clean.docx
  - Clean version of above

I'm keeping language regarding the potential benefits to CVP/SWP operations during years when Sites releases to Yolo Bypass and does not release to South of Delta.
I would like to maintain that Sites provides a benefit even if DWR and Reclamation are not currently interested in accounting for it.

Please let us know how you and Jerry would like to proceed.

Best,
Steve

From: Micko, Steve/SAC
Sent: Tuesday, June 29, 2021 9:27 AM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Heydinger, Erin <erin.heydinger@hdrinc.com>
Cc: Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Subject: RE: Sites: Draft Carriage Water Document

Makes sense to me! I'll finalize and send a "final write-up" ASAP.

Best,
Steve

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Monday, June 28, 2021 11:08 AM
To: Micko, Steve/SAC <Steve.Micko@jacobs.com>; Heydinger, Erin <erin.heydinger@hdrinc.com>
Cc: Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Subject: [EXTERNAL] RE: Sites: Draft Carriage Water Document

Hi Steve – I talked to Jerry today about whether there is anything needed right now on carriage losses. He asked for a "final write-up" for the proposal from Jacobs. He said that he had heard nothing back from DWR or Reclamation. He would like to finish a complete draft ops term sheet by Friday so would like to get a final write-up as soon as possible this week.

I haven't really been involved in this effort. Does this make sense? If not, let me know and maybe we can get on a quick call with Jerry to confirm what he is looking for.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Micko, Steve/SAC <Steve.Micko@jacobs.com>
Sent: Thursday, June 3, 2021 1:50 PM
To: Heydinger, Erin <erin.heydinger@hdrinc.com>
Cc: Leaf, Rob/SAC <Rob.Leaf@jacobs.com>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Sites: Draft Carriage Water Document

Hi Erin,

Draft document, in pdf and Word, is attached.
This document points towards an approach.
I added comments to aspects that are either key assumptions, or up in the air (e.g. benefits to San Luis).

Please let me know if you have any questions.

Best,
Steve

From: Micko, Steve/SAC
Sent: Wednesday, June 2, 2021 3:48 PM
To: Heydinger, Erin <erin.heydinger@hdrinc.com>
Cc: Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Subject: FW: Sites: Draft Carriage Water Document

FYI – I'll update by tomorrow morning.

Best,
Steve

From: Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Sent: Wednesday, June 2, 2021 9:47 AM
To: Micko, Steve/SAC <Steve.Micko@jacobs.com>
Subject: RE: Sites: Draft Carriage Water Document

From: Micko, Steve/SAC <Steve.Micko@jacobs.com>
Sent: Thursday, May 20, 2021 3:21 PM
To: Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Subject: Sites: Draft Carriage Water Document

Hi Rob,

Could you please review the draft carriage water approach document?
Right now, the document points towards an approach.
I added comments to aspects that are either key assumptions, or up in the air (e.g. benefits to San Luis).

Please let me know if you have any questions.

Best,
Steve

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Sites Project: Approach to Carriage Water

The Sites Project Authority (Authority) would operate the Sites Reservoir Project (Sites) in coordination with the SWP and CVP. In most years, Sites would release water to the Sacramento River or the Yolo Bypass. Sites releases to the Sacramento River for South of Delta water uses, through pumping at the SWP Banks Pumping Plant and CVP Jones Pumping Plant, would typically occur in Dry and Critically Dry years. In most years, Sites would also release water to the Delta through the Yolo Bypass for habitat benefits. As such, Sites operations would modify Delta flows in most years by changing Sacramento River at Freeport flow, Yolo Bypass flow, South of Delta Exports, and/or Delta outflow.

Considering long-term operations, Sites releases are unique to carriage water calculations because:

- Sites reliably influences Delta flows.
    - There are several years when Sites releases ~~water to the Delta~~ specifically for increase Delta outflow, improving Delta water quality~~. As such Delta water quality improves during these years~~.

Commented [HE1]: Not sure I understand this – when would Sites release specifically for outflow? Seems like it would always be incidental to other releases.

- The ultimate fate of Sites releases to the Yolo Bypass (for Prop 1 environmental benefit) is Delta outflow which would reliably benefit Delta water quality in late-Summer and Fall of Wet and Above Normal years.
    - Sites continues to control the Sites water upon release from the Yolo Bypass back to the Delta.
    - The return of Sites Yolo Bypass releases to the Delta positively affect SWP and CVP ~~could yield realize benefits~~ operations~~,~~ through increased delivery or increased North of Delta storage~~, from Sites releases to the Yolo Bypass~~.
- Sites provides inflows to the Delta at two locations when transferring water South of Delta: Yolo Bypass and Sacramento River.
    - Delta water quality benefits, per unit volume of release, are dependent on Delta inflow location (Freeport versus Yolo Bypass). Per incremental increase, inflows from Yolo Bypass yield greater water quality benefits than inflows from Freeport.
- Reliability of Sites operations in July and August of Dry years could allow the SWP and CVP to more aggressively operate San Luis Reservoir. Modified operations of San Luis have not been modeled and, therefore, are not yet included in the method outlined below.

Commented [MS2]: As this is not currently modeled, the potential benefits to SWP and CVP operations are not considered in the conceptual carriage water calculations below.

Commented [HE3R2]: Makes sense. I put some proposed language in here.

Delta Water Quality Effects of Sites

As described above, Sites operations affect Sacramento River at Freeport flow, Yolo Bypass flow, South of Delta Exports, and/or Delta outflow. Sites operations, as it relates to the Delta, can be organized into three categories: (1) export years, (2) export and outflow years, and (3) outflow years. Years when Sites only releases water into the Sacramento River for export to

South of Delta storage partners are described as export years. Years when Sites releases water into the Sacramento River for export to South of Delta storage partners and releases water into the Yolo Bypass ~~for Delta outflow~~ are described as export and outflow years, as it is assumed that the ultimate fate of releases to Yolo Bypass is Delta outflow. Years when Sites only releases water into the Yolo Bypass for Delta outflow are described as outflow years. A summary table of these year categories is below (Table 1).

Year Category	Sacramento River at Freeport Flow	Yolo Bypass Flow
Export	Sites releases water to Sacramento River for export to South of Delta storage partners	Limited or no change
Export and Outflow	Sites releases water to Sacramento River for export to South of Delta storage partners	Sites releases water to Yolo Bypass for Delta outflow
Outflow	Limited or no change	Sites releases water to Yolo Bypass for Delta outflow

Table 1. Summary of Sites Delta Operations

Commented [HE4]: I think "for Delta outflow" might be a little strong here. I think what you are saying is that Prop 1 water eventually goes to outflow, correct? If so, I propose we describe at the beginning that assumption: water is released to the Yolo Bypass for food production and is assumed to continue through the Delta to outflow.

Commented [MS5R4]: Thanks – I clarified. Let me know what you think.

In export years, Sites releases water to the Sacramento River for export at the South ~~of~~ Delta. In accordance with non-project water transfers, a portion of the water released to the Sacramento River at Freeport is assumed to~~shall~~ be dedicated to Delta outflow to maintain Delta water quality as it would have been in the "without-transfer" conditions. The volume of water dedicated to Delta outflow is described as carriage water.

Commented [MS6]: This document assumes that Delta water quality benefits from Yolo Bypass flows would be attributed to Sites.

Commented [HE7R6]: I think that's fair.

In export and outflow years, Sites releases water to the Sacramento River and Yolo Bypass. Similar to export years, a volume of water must be dedicated to Delta outflow to offset Delta water quality changes caused by increased South of Delta exports. The volume of water dedicated for Delta outflow may fully or partially be comprised of Sites releases to Yolo Bypass. If the Delta outflow requirement exceeds the volume of Delta inflow from Sites release to Yolo Bypass, a portion of the water released to the Sacramento River would be dedicated to Delta outflow as carriage water.

Commented [MS8]: Calculation of carriage water cost would be affected by the proportion of Yolo Bypass water contributing to carriage water volume.

During outflow years, when Sites releases water for Delta outflow without increasing Delta exports, Delta water quality improves. SWP and CVP operations could benefit from these operations by increasing exports or increasing North of Delta storage (through reduction of releases dedicated to Delta outflow). These actions, individually or combined, would counteract Delta water quality improvements caused by Sites releases to Delta outflow. In these years, Sites may attain a quantifiable carriage water benefit as opposed to incurring a carriage water cost.

Carriage water is expressed as a volume of water (in AF) dedicated to Delta outflow to offset water quality effects of increased Delta exports, or as a volumetric improvement (in AF) to SWP and CVP storage or exports. As such, carriage water may be a positive or negative value. A positive value represents the volume of water dedicated to Delta outflow. A negative value represents improvements to the SWP and CVP.

If Sites provides 100 acre-feet (AF) as Delta inflow from the Sacramento River at Freeport, and 30 AF is needed to offset the incremental increase in Delta water quality, then the remaining 70 AF of the water is available for export. In this case, the assessment of carriage water as a percentage of Sites release to the Sacramento River would be 30 percent (30/100). In other words, 30 percent of the Sites release would be used to maintain Delta salinity conditions as it would have been absent the 100 AF release. If Sites releases 30 AF for Delta outflow, then the carriage water benefit is calculated as the resulting increase in SWP and CVP export and/or storage. Per the example above, this may be as high as 70 AF. During these years, DWR and Reclamation increase Sites deliveries or carryover amount in the SWP and/or CVP to compensate Sites for its benefits to operations.

Pre-Transfer Carriage Water Estimation for Sites Reservoir Releases

Before the water transfer window (July – November) opens, the Authority estimates the carriage water that will be associated with Sites releases and exports. The Authority develops the carriage water estimate, separate from non-Sites transfers, using an estimated amount of release and export water with an assumed pattern, forecasted hydrology, and forecasted operations through the steps below. After the Authority calculates the Sites carriage water volume, DWR then calculates carriage water for non-Sites transfers. A two-step process is required to properly account for and credit Sites contribution to Delta outflow.

1. Perform a DSM2 simulation for a baseline scenario to represent salinity conditions (expressed as electrical conductivity, or EC) that would have occurred absent Sites releases and transfers while meeting all regulatory requirements.
2. Perform a DSM2 simulation for a Sites release and/or export scenario with assumed Sites carriage water. Sites carriage water calculations consider Sites releases to Yolo Bypass for Proposition 1 Ecosystem Benefits. As such, Sites carriage water is the sum of additional Delta inflow at Freeport and the Yolo Bypass. See the Yolo Bypass Inflow Assumptions section regarding Sites releases to the Yolo Bypass.
3. Compare salinity results of the baseline (Step 1) to the with-transfers scenario (Step 2) at Jersey Point, Bethel Island, and Bacon Island (or Holland Island). These three locations provide a good representation of interior Delta salinity conditions that often control the Projects operations.
4. Repeat Step 2 and Step 3 by adjusting the Sites carriage water (release to Delta outflow during years of Sites transfers, or SWP/CVP exports and/or storage during

Commented [MS9]: As we progress technical analysis, Sites benefits to San Luis operations could be quantified. If analysis is conducted, quantified volume could augment Sites carriage benefits.

Commented [HE10R9]: Where would this occur? It would be stored in San Luis? If so, would it be subject to spill? Alternatively, we could send it to a SOD participant like Met who would have storage available.

Commented [MS11R9]: It's unlikely San Luis would spill.

It'd be easiest if these benefit volumes would be sent SOD.

Commented [MS12]: For preliminary modeling of long-term planning simulations, an estimated carriage water cost of 35% in Wet, Above Normal and Below Normal years, and 20% in Dry and Critically Dry years will be utilized.

Commented [MS13]: Inflow from Yolo Bypass is more effective at preventing salinity intrusion. As such, for carriage water cost purposes, Yolo Bypass inflow may be "more valuable" than inflow at Freeport.

Commented [HE14R13]: Noted.

Commented [jb15R13]: What is assumed in the model for how much of the Yolo Bypass released water actually makes it back to the Delta for repelling seawater? Are there any losses? Please clarify what our proposal is for making any adjustments.

Commented [MS16R13]: With a Sites release of 30 TAF, assumed Yolo Bypass inflow volume to the Delta is 24 TAF. Losses are assumed in the Colusa Basin Drain and Knights Landing Ridge Cut.

years of Sites release to Delta outflow) until the results of Step 2 show minimal EC differences from the results of Step 1.

Three stations, Jersey Point, Bethel Island, and Bacon Island (or Holland Island) have been identified to represent Delta locations with salinity standards or markers that often control Delta water operations (e.g., the 250 mg/l chloride standard at Contra Costa Canal in D-1641). The station with the highest carriage water percentage is controlling. For example, if 20 percent carriage water is needed to maintain the same salinity at Jersey Point, 25 percent at Bethel Island, and 30 percent at Bacon Island, then 30 percent is the estimated carriage water. Selecting less than 30 percent would result in impacts to the Projects through export reduction and/or additional reservoir releases to ensure that Bacon Island salinity is not affected by the water quality degradation from facilitating non-Project transfers.

After determining the estimated carriage water, DWR and Reclamation apply the estimation to Sites releases and exports during the transfer window to address the effects of the antecedent water quality conditions to compliance concerns.

Final Carriage Water Determination at Conclusion of Transfer Season

Once the water transfer season is over, data collected during the water transfer period are used to develop a final carriage water value based on the actual conditions. The steps to develop a final Sites carriage water value ~~is~~ are provided below. Similar to estimating carriage water volume, DWR calculates carriage water for non-Sites transfers after the Authority calculates a final Sites carriage water volume.

1. Perform a DSM2 simulation with actual data for with-transfer inflows and exports during the transfer period.
2. Perform a DSM2 simulation for a without-transfer scenario with hypothetical exports and Delta inflows:

   Without-transfer inflows = Actual inflow – (Actual Sites transfer amount into Delta + Sites Releases to Yolo Bypass)

   Without-transfer export = Actual pumping – (1 – estimated carriage water percentage) × (Actual Sites transfer amount into Delta + Sites Release to Yolo Bypass)

3. Compare salinity results of the actual with-transfer conditions (Step 1) to the estimated without-transfer conditions (Step 2) at Jersey Point, Bethel Island, and Bacon Island.
4. Repeat Step 2 and Step 3 by adjusting the carriage water percentage until the results of Step 2 show minimal EC differences from the results of Step 1. This is the final carriage water percentage.

As stated previously, the station with the highest carriage water percentage controls the final carriage water determination.

Carriage Water Accounting and Adjustments for Sites Transfers

For Sites transfers, carriage water volume is adjusted when final carriage water value differs from the estimated value. There are two scenarios in which adjustments may be made to the accounting for the Sites transfer water that was delivered to a Sites Storage Partner:

1. If the final carriage water volume is higher than the estimated carriage water, then the adjustment is to show DWR delivered more transfer water to Sites storage partners. The Authority reduces the storage partner's storage volume to compensate for the adjustment. There is no change to the actual overall quantity of water delivery for that year.
2. If the final carriage water is lower than the estimated carriage water, then the adjustment is to show DWR delivered more transfer water to the Sites storage partners, and the Sites storage partners received less Sites water. DWR increases the storage partner's carryover storage to compensate for the adjustment. There is no change to the actual overall quantity of water delivery for that year.

Yolo Bypass Inflow Assumptions

As noted above, Sites would release water to the Delta through the Yolo Bypass for habitat benefits. A loss factor is assumed for the routing of water from Sites Reservoir through the Colusa Basin Drain and Knights Landing Ridge Cut to the Yolo Bypass. Current modeling assumes a routing loss factor is estimated at 13 percent. As the Sites Project progress, a detailed study, estimating losses in the Colusa Basin Drain, Knights Landing Ridge Cut, and Yolo Bypass, is required to accurately measure Delta inflow increases that result from Sites releases to the Yolo Bypass.

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Sites Project: Approach to Carriage Water

The Sites Project Authority (Authority) would operate the Sites Reservoir Project (Sites) in coordination with the SWP and CVP. In most years, Sites would release water to the Sacramento River or the Yolo Bypass. Sites releases to the Sacramento River for South of Delta water uses, through pumping at the SWP Banks Pumping Plant and CVP Jones Pumping Plant, would typically occur in Dry and Critically Dry years. In most years, Sites would also release water to the Delta through the Yolo Bypass for habitat benefits. As such, Sites operations would modify Delta flows in most years by changing Sacramento River at Freeport flow, Yolo Bypass flow, South of Delta Exports, and/or Delta outflow.

Considering long-term operations, Sites releases are unique to carriage water calculations because:

- Sites reliably influences Delta flows.
    - There are several years when Sites releases increase Delta outflow, improving Delta water quality.
- The ultimate fate of Sites releases to the Yolo Bypass (for Prop 1 environmental benefit) is Delta outflow which would reliably benefit Delta water quality in late-Summer and Fall of Wet and Above Normal years.
    - Sites continues to control the Sites water upon release from the Yolo Bypass back to the Delta.
    - The return of Sites Yolo Bypass releases to the Delta positively affect SWP and CVP operations through increased delivery or increased North of Delta storage.
- Sites provides inflows to the Delta at two locations when transferring water South of Delta: Yolo Bypass and Sacramento River.
    - Delta water quality benefits, per unit volume of release, are dependent on Delta inflow location (Freeport versus Yolo Bypass). Per incremental increase, inflows from Yolo Bypass yield greater water quality benefits than inflows from Freeport.
- Reliability of Sites operations in July and August of Dry years could allow the SWP and CVP to more aggressively operate San Luis Reservoir. Modified operations of San Luis have not been modeled and, therefore, are not yet included in the method outlined below.

Delta Water Quality Effects of Sites

As described above, Sites operations affect Sacramento River at Freeport flow, Yolo Bypass flow, South of Delta Exports, and/or Delta outflow. Sites operations, as it relates to the Delta, can be organized into three categories: (1) export years, (2) export and outflow years, and (3) outflow years. Years when Sites only releases water into the Sacramento River for export to South of Delta storage partners are described as export years. Years when Sites releases water into the Sacramento River for export to South of Delta storage partners and releases water into the Yolo Bypass are described as export and outflow years, as it is assumed that the ultimate fate of releases to Yolo Bypass is Delta outflow. Years when Sites only releases water into the Yolo Bypass for Delta outflow are described as outflow years. A summary table of these year categories is below (Table 1).

Year Category	**Sacramento River at Freeport Flow**	**Yolo Bypass Flow**
Export	Sites releases water to Sacramento River for export to South of Delta storage partners	Limited or no change
Export and Outflow	Sites releases water to Sacramento River for export to South of Delta storage partners	Sites releases water to Yolo Bypass for Delta outflow
Outflow	Limited or no change	Sites releases water to Yolo Bypass for Delta outflow

Table 1. Summary of Sites Delta Operations

In export years, Sites releases water to the Sacramento River for export at the South Delta. In accordance with non-project water transfers, a portion of the water released to the Sacramento River at Freeport is assumed to be dedicated to Delta outflow to maintain Delta water quality as it would have been in the "without-transfer" conditions. The volume of water dedicated to Delta outflow is described as carriage water.

In export and outflow years, Sites releases water to the Sacramento River and Yolo Bypass. Similar to export years, a volume of water must be dedicated to Delta outflow to offset Delta water quality changes caused by increased South of Delta exports. The volume of water dedicated for Delta outflow may fully or partially be comprised of Sites releases to Yolo Bypass. If the Delta outflow requirement exceeds the volume of Delta inflow from Sites release to Yolo Bypass, a portion of the water released to the Sacramento River would be dedicated to Delta outflow as carriage water.

During outflow years, when Sites releases water for Delta outflow without increasing Delta exports, Delta water quality improves. SWP and CVP operations could benefit from these operations by increasing exports or increasing North of Delta storage (through reduction of releases dedicated to Delta outflow). These actions, individually or combined, would counteract Delta water quality improvements caused by Sites releases to Delta outflow. In these years, Sites may attain a quantifiable carriage water benefit as opposed to incurring a carriage water cost.

Carriage water is expressed as a volume of water (in AF) dedicated to Delta outflow to offset water quality effects of increased Delta exports, or as a volumetric improvement (in AF) to SWP and CVP storage or exports. As such, carriage water may be a positive or negative value. A positive value represents the volume of water dedicated to Delta outflow. A negative value represents improvements to the SWP and CVP.

If Sites provides 100 acre-feet (AF) as Delta inflow from the Sacramento River at Freeport, and 30 AF is needed to offset the incremental increase in Delta water quality, then the remaining 70 AF of the water is available for export. In this case, the assessment of carriage water as a percentage of Sites release to the Sacramento River would be 30 percent (30/100). In other words, 30 percent of the Sites release would be used to maintain Delta salinity conditions as it would have been absent the 100 AF release. If Sites releases 30 AF for Delta outflow, then the carriage water benefit is calculated as the resulting increase in SWP and CVP export and/or storage. Per the example above, this may be as high as 70 AF. During these years, DWR and Reclamation increase Sites deliveries or carryover amount in the SWP and/or CVP to compensate Sites for its benefits to operations.

Pre-Transfer Carriage Water Estimation for Sites Reservoir Releases

Before the water transfer window (July – November) opens, the Authority estimates the carriage water that will be associated with Sites releases and exports. The Authority develops the carriage water estimate, separate from non-Sites transfers, using an estimated amount of release and export water with an assumed pattern, forecasted hydrology, and forecasted operations through the steps below. After the Authority calculates the Sites carriage water volume, DWR then calculates carriage water for non-Sites transfers. A two-step process is required to properly account for and credit Sites contribution to Delta outflow.

1. Perform a DSM2 simulation for a baseline scenario to represent salinity conditions (expressed as electrical conductivity, or EC) that would have occurred absent Sites releases and transfers while meeting all regulatory requirements.
2. Perform a DSM2 simulation for a Sites release and/or export scenario with assumed Sites carriage water. Sites carriage water calculations consider Sites releases to Yolo Bypass for Proposition 1 Ecosystem Benefits. As such, Sites carriage water is the sum of additional Delta inflow at Freeport and the Yolo Bypass. See the Yolo Bypass Inflow Assumptions section regarding Sites releases to the Yolo Bypass.
3. Compare salinity results of the baseline (Step 1) to the with-transfers scenario (Step 2) at Jersey Point, Bethel Island, and Bacon Island (or Holland Island). These three locations provide a good representation of interior Delta salinity conditions that often control the Projects operations.
4. Repeat Step 2 and Step 3 by adjusting the Sites carriage water (release to Delta outflow during years of Sites transfers, or SWP/CVP exports and/or storage during years of Sites release to Delta outflow) until the results of Step 2 show minimal EC differences from the results of Step 1.

Three stations, Jersey Point, Bethel Island, and Bacon Island (or Holland Island) have been identified to represent Delta locations with salinity standards or markers that often control Delta water operations (e.g., the 250 mg/l chloride standard at Contra Costa Canal in D-1641). The station with the highest carriage water percentage is controlling. For example, if 20 percent carriage water is needed to maintain the same salinity at Jersey Point, 25 percent at Bethel Island, and 30 percent at Bacon Island, then 30 percent is the estimated carriage water. Selecting less than 30 percent would result in impacts to the Projects through export reduction and/or additional reservoir releases to ensure that Bacon Island salinity is not affected by the water quality degradation from facilitating non-Project transfers.

After determining the estimated carriage water, DWR and Reclamation apply the estimation to Sites releases and exports during the transfer window to address the effects of the antecedent water quality conditions to compliance concerns.

Final Carriage Water Determination at Conclusion of Transfer Season

Once the water transfer season is over, data collected during the water transfer period are used to develop a final carriage water value based on the actual conditions. The steps to develop a final Sites carriage water value are provided below. Similar to estimating carriage water volume, DWR calculates carriage water for non-Sites transfers after the Authority calculates a final Sites carriage water volume.

1. Perform a DSM2 simulation with actual data for with-transfer inflows and exports during the transfer period.
2. Perform a DSM2 simulation for a without-transfer scenario with hypothetical exports and Delta inflows:

   Without-transfer inflows = Actual inflow – (Actual Sites transfer amount into Delta + Sites Releases to Yolo Bypass)

   Without-transfer export = Actual pumping – (1 – estimated carriage water percentage) × (Actual Sites transfer amount into Delta + Sites Release to Yolo Bypass)
3. Compare salinity results of the actual with-transfer conditions (Step 1) to the estimated without-transfer conditions (Step 2) at Jersey Point, Bethel Island, and Bacon Island.
4. Repeat Step 2 and Step 3 by adjusting the carriage water percentage until the results of Step 2 show minimal EC differences from the results of Step 1. This is the final carriage water percentage.

As stated previously, the station with the highest carriage water percentage controls the final carriage water determination.

Carriage Water Accounting and Adjustments for Sites Transfers

For Sites transfers, carriage water volume is adjusted when final carriage water value differs from the estimated value. There are two scenarios in which adjustments may be made to the accounting for the Sites transfer water that was delivered to a Sites Storage Partner:

1. If the final carriage water volume is higher than the estimated carriage water, then the adjustment is to show DWR delivered more transfer water to Sites storage partners. The Authority reduces the storage partner's storage volume to compensate for the adjustment. There is no change to the actual overall quantity of water delivery for that year.
2. If the final carriage water is lower than the estimated carriage water, then the adjustment is to show DWR delivered more transfer water to the Sites storage partners, and the Sites storage partners received less Sites water. DWR increases the storage partner's carryover storage to compensate for the adjustment. There is no change to the actual overall quantity of water delivery for that year.

Yolo Bypass Inflow Assumptions

As noted above, Sites would release water to the Delta through the Yolo Bypass for habitat benefits. A loss factor is assumed for the routing of water from Sites Reservoir through the Colusa Basin Drain and Knights Landing Ridge Cut to the Yolo Bypass. Current modeling assumes a routing loss factor is estimated at 13 percent. As the Sites Project progress, a detailed study, estimating losses in the Colusa Basin Drain, Knights Landing Ridge Cut, and Yolo Bypass, is required to accurately measure Delta inflow increases that result from Sites releases to the Yolo Bypass.

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Project name:
WSIP Cumulative Flow Analysis

From:
Elizabeth Nielsen, AECOM

Date:
June 21, 2021

DRAFT

To: David Okita
California Department of Water Resources
Division of Environmental Services

CC: Leah McNearney, DWR

Memo

Subject: WSIP Cumulative Analysis for Hydrology

1. Introduction

The Water Storage Investment Program (WSIP) is a $2.7 billion program for investments in water storage projects in California, approved by the voters through Proposition 1 in 2014 and administered by the California Water Commission (CWC). Seven projects have been selected for funding consideration to date based on a rigorous review process. In addition to water storage benefits, the CWC selected projects that demonstrate an ability to provide public benefits related to flood control, ecosystem improvement, water quality improvement, recreation, and emergency response. The selected WSIP projects range from expanding existing reservoirs to boosting groundwater storage to building modern surface storage facilities. Once operational, the seven WSIP projects listed below would increase California's water storage capacity by 4.3 million acre-feet over the current (2021) baseline.

- Chino Basin Conjunctive Use Environmental Water Storage/Exchange Program (CBEWP)
- Kern Fan Groundwater Storage Project (Kern Fan Project)
- Willow Springs Water Bank Conjunctive Use Project (WSWB Project)
- Los Vaqueros Reservoir Expansion Project (LVE Project)
- Sites Reservoir Project (Sites Project)
- Pacheco Reservoir Expansion Project (Pacheco Project)
- Harvest Water Program

The projects are described in Section 2.2. Implementation of the WSIP projects could cumulatively affect water project operations, including Sacramento River flows, south-of-Delta exports, and water availability in the system at various times in the year. This memorandum considers the cumulative change to hydrologic conditions in the Feather River, Sacramento River, and Sacramento-San Joaquin Delta (Delta) with operation of the seven WSIP projects and is based on a review of publicly available information. It documents anticipated changes in flows due to these projects including amounts, annual seasonality, and year types. It also considers the magnitude of these changes compared to baseline flows and hydrologic conditions (i.e., excess or balanced conditions) to provide context for the anticipated changes.

The purpose of this cumulative flow analysis is to document what can be expected to the flows in the Feather River, Sacramento River, and Delta areas if all seven WSIP projects were in operation. There has been no similar analysis as the projects have evolved, and some are still evolving since the CWC application stage. This analysis puts the cumulative flow changes associated with the projects in the context of overall flows in the waterways on a seasonal and water-year-type basis. This analysis may be helpful identifying flow aspects that need further detailed evaluation. This memorandum does not address the environmental impacts of the WSIP projects pursuant to the California Environmental Quality Act (CEQA). Each WSIP project has either completed or is in the process of completing its own environmental documentation for CEQA compliance, including a discussion of cumulative effects as required by CEQA.

2. Background

This section provides background information on the SWP and the seven WSIP projects considered in the cumulative effect analysis for hydrology. The location of the WSIP projects are shown on Figure 1.

2.1 State Water Project Deliveries

California Department of Water Resources (DWR) holds contracts with 29 public agencies for water supplies from the State Water Project (SWP). The SWP's main facilities are Lake Oroville, the Harvey O. Banks Pumping Plant (Banks Pumping Plant), and San Luis Reservoir. These facilities are operated and connected by a network of canals, aqueducts, and other facilities to deliver on average approximately 2.6 million acre-feet of contracted water supplies annually (Reclamation, 2019).

The U.S. Department of the Interior Bureau of Reclamation (Reclamation) also exports water from the Delta at its Central Valley Project (CVP) pumping plant in the south Delta, Jones Pumping Plant, and either delivers it directly or stores water in San Luis Reservoir for later delivery to its contractors south of the Delta. DWR and Reclamation coordinate their operations on a daily basis. Some factors that DWR and Reclamation consider when coordinating their joint operations include required in-Delta flows, Delta outflow, water quality, fish species protections, schedules for the joint use facilities (e.g., San Luis Reservoir), pumping/wheeling arrangements,[1] and any facility capacity limitations.

During balanced water conditions, DWR and Reclamation share a responsibility to meet in-basin uses and maintain a daily water accounting of the SWP and CVP obligations in conformance with the Coordinated Operation Agreement between the two projects. Balanced water conditions are defined as periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flows approximately equal the water supply needed to meet Sacramento Valley in-basin uses plus exports. Excess water conditions are periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flows exceed Sacramento Valley in-basin uses plus exports. The duration of balanced water conditions varies from year to year. While balanced conditions may never occur in some very wet years, some very dry years may have long continuous periods of balanced conditions, and still other years may have several periods of balanced conditions interspersed with excess water conditions.

[1] Wheeling involves the act of "using the water supply facilities by someone other than the owner or operator to transport water" for a fee.

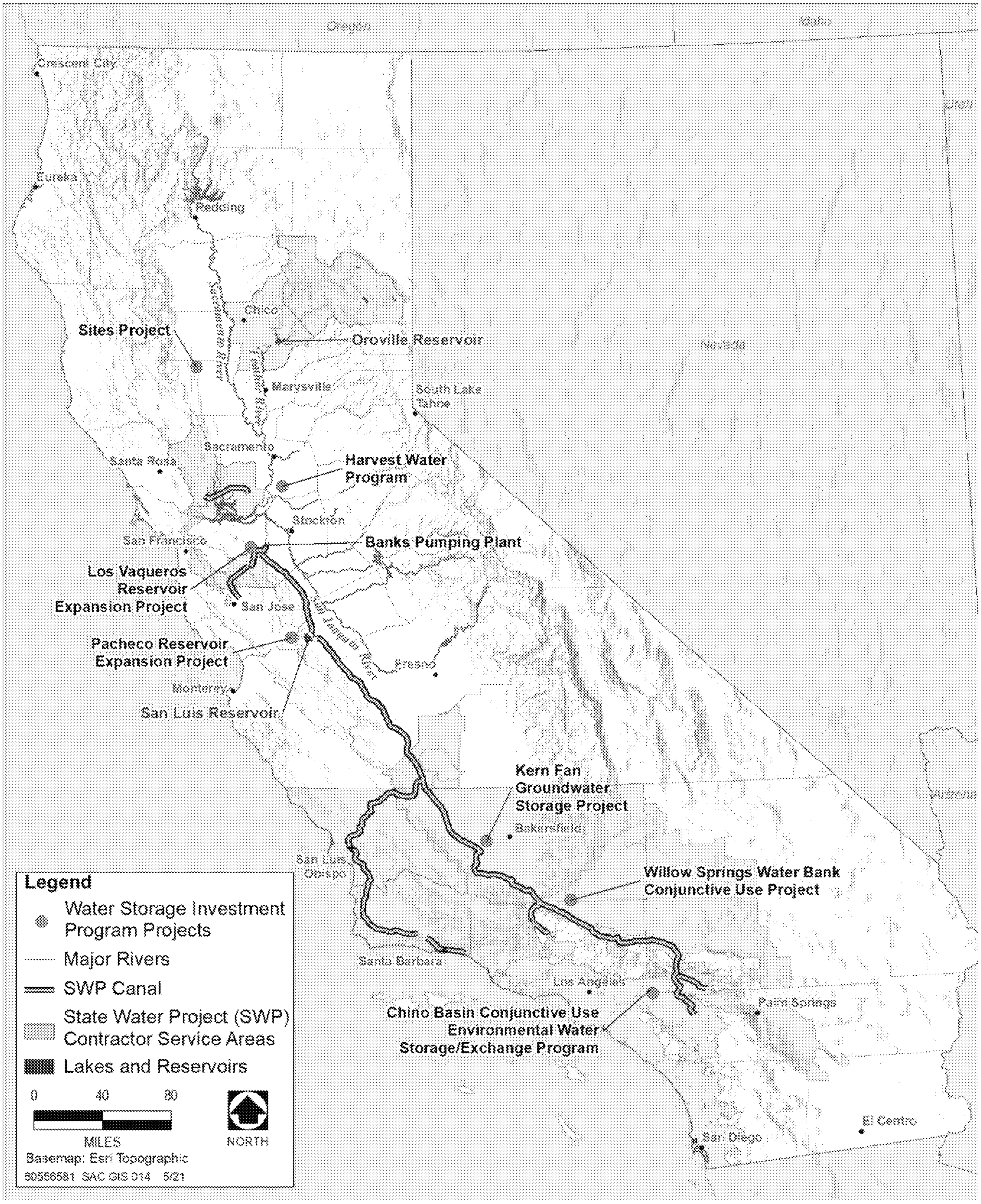

Figure 1. WSIP Project Locations

During excess water conditions, sufficient water is available to meet all beneficial uses, and the CVP and SWP are not required to supplement the supply with water from reservoir storage. In excess water conditions, the “excess water” can be made available to CVP and SWP contractors. As specified in the Coordinated Operation Agreement, DWR and Reclamation have the responsibility during excess water conditions to store and export as much water as possible within physical, legal, and contractual limits (Reclamation, 2019).

Note that Article 21 water is one of several types of SWP water supply made available to the SWP partner contractors under the long-term water supply contracts between DWR and the SWP contractors. Unlike Table A water, which is the maximum allocated annual supply made available for scheduled delivery throughout the year, Article 21 water is made available only when certain conditions exist (which occur predominately in wet years). As with all SWP water, Article 21 water is supplied under existing SWP water rights permits, and is pumped from the Delta under the same environmental, regulatory, and operational constraints that apply to all SWP supplies.

Article 21 water is typically offered to contractors on a short-term (daily or weekly) basis when all of the following conditions exist: (1) the SWP share of San Luis Reservoir is physically full, or projected to be physically full within approximately 1 week at permitted pumping rates; (2) other SWP reservoirs south of the Delta are at their storage targets or the conveyance capacity to fill these reservoirs is maximized; (3) the Delta is in excess condition; (4) current Table A demand is being fully met; and (5) Banks Pumping Plant has export capacity beyond that which is needed to meet current Table A and other SWP operational demands. The increment of available unused Banks Pumping Plant capacity is offered as the Article 21 delivery capacity (Reclamation, 2008).

2.2 WSIP Projects

The seven WSIP projects are described below. As indicated above, these WSIP projects range from expanding existing reservoirs to boosting groundwater storage to building modern surface storage facilities. The location of each of the projects and how operations can affect hydrologic conditions are also described below. For the five WSIP projects that involve the SWP, DWR has not yet approved operations of the projects, so the operations described below are subject to change.

Chino Basin Conjunctive Use Environmental Water Storage/Exchange Program

The CBEWP would expand existing capacity or construct a new advanced water treatment facility and distribution facilities in western San Bernardino County that would store up to 15 thousand acre-feet (TAF) per year of treated wastewater in the existing Chino Basin Water Bank. The Chino Basin Water Bank would be operated to dedicate blocks of water, assumed to be in increments of 50 TAF,[2] for ecosystem benefits. In dry and below normal years, this stored water would be used to provide pulse flows to enhance spring instream flows in the Feather River below Lake Oroville. A water exchange process is required to replace water used for pulse flows with stored groundwater. This would require agreements with one or more of the SWP partner contractors (e.g., Metropolitan Water District of Southern California), to forego SWP Table A deliveries equivalent to the pulse flow amount in exchange for receiving an equivalent amount of Table A water from the Chino Basin Water Bank. It would also require agreements with DWR and California Department of Fish and Wildlife (CDFW) to re-operate Lake Oroville and manage the water to provide the pulse flows. South-of-Delta exports needed to meet SWP partner contractor Table A demands would be reduced by the 50 TAF in a pulse flow year; however, there would not be an overall reduction in exports because the SWP would utilize any available diversion capacity if it has the ability to do so. After the initial 25 years of operation and

[2] Pulse flows are modeled as 50 TAF, occurring on average every 4.4 years.

fulfilling ecosystem public benefits, pulse flows would cease, and the CBEWP would be operated for local water supply benefits.

Kern Fan Groundwater Storage Project

The Kern Fan Project would develop a regional water bank in Kern County, west of Bakersfield, that would store up to 100 TAF per year of Article 21 water. The Kern Fan Project would be operated so that in wet years, the project would divert Article 21 supplies for groundwater storage. The project would use 75 percent of the stored water for water supply purposes. The remaining 25 percent of the stored water would be dedicated for ecosystem benefits in blocks of water assumed to be 18 TAF[3] each. In dry and below normal years, this stored water would be used to provide pulse flows to enhance spring instream flows in the Feather River below Lake Oroville. A water exchange process is required to replace water used for the pulse flow with the stored groundwater. This would require agreements with one or more of the SWP partner contractors (e.g., Kern County Water Agency and Dudley Ridge Water District), to forego SWP Table A deliveries equivalent to the pulse flow amount in exchange for receiving an equivalent amount of Table A water from the Kern Fan Project. It would also require agreements with DWR and CDFW to re-operate Lake Oroville and manage the water to provide the pulse flows. South-of-Delta exports needed to meet SWP partner contractor Table A demands would be reduced by 18 TAF in a pulse flow year; however, there would not be an overall reduction in exports because the SWP would utilize any available diversion capacity if it has the ability to do so. After the initial 50 years of operation and fulfilling ecosystem public benefits, pulse flows would cease, and the Kern Fan Project would be operated for local water supply benefits.

Willow Springs Water Bank Conjunctive Use Project

The WSWB Project would enhance the existing Willow Springs Water Bank located in southern Kern County, northwest of the City of Lancaster, in the adjudicated Antelope Valley Groundwater Basin. The WSWB Project is a conjunctive use and reservoir reoperation project that would leverage 500 TAF of existing groundwater storage facilities at the Willow Springs Water Bank and operate conjunctively with the SWP. The WSWB Project is reformulating its operations plan, so a revised operation scenario is not available at this time and the source of pre-delivery water has not yet been specified. For the purposes of this analysis, the volumes of pulse flows modeled in the original application to the CWC is used.

Pre-delivery of allocated Table A water would be delivered to the WSWB Project and be stored for future use by SWP partner contractors. Article 21 water would not be utilized. By depositing the Table A water in the groundwater bank, the pre-delivery process reduces the amount of water stored in SWP facilities, thus increasing available storage capacity in SWP facilities to be filled at a later date. “New” water is created when the pre-delivery allows SWP facilities to capture water that would otherwise not be pumped at Banks Pumping Plant due to storage capacity limitations. This would effectively increase pumping at Banks Pumping Plant equivalent to the pulse flow amount over time. Pumping would occur when the SWP has water rights to divert and storage space or direct delivery capability in excess or balanced conditions.

The WSWB Project would be operated to dedicate blocks of water assumed to be 28 TAF[4] for ecosystem benefits. In dry and below normal years, this stored water would be used to provide pulse flows to enhance spring instream flows in the Feather River below Lake Oroville. A water exchange process is required to replace water used for the pulse flow with the stored groundwater. This would require agreements with one or more of the SWP partner contractors to forego SWP Table A deliveries equivalent to the pulse flow amount in exchange for receiving an equivalent amount of Table A water

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[3] Pulse flows are modeled as 18 TAF, occurring on average every 4.7 years.
[4] Pulse flows are modeled as 28 TAF, occurring on average every 3.3 years.

from the WSWB Project. It would also require agreements with DWR and CDFW to re-operate Lake Oroville and manage the water to provide the pulse flows. South-of-Delta exports needed to meet SWP partner contractor demands would be reduced by the 28 TAF in a pulse flow year; however, there would not be an overall reduction in exports because the SWP would utilize any available diversion capacity if it has the ability to do so. After the initial 50 years of operation and fulfilling ecosystem public benefits, pulse flows would cease, and the WSWB Project would be operated for local water supply benefits.

Los Vaqueros Reservoir Expansion Project

The LVE Project is a surface storage project located in southeastern Contra Costa County that would enlarge the capacity of an existing off-stream reservoir by 115 TAF (from 160 TAF to 275 TAF). This project would also upgrade existing conveyance facilities, construct new conveyance, and re-operate existing facilities to develop water supplies for ecosystem public benefits and increased water supply reliability for project participants. The LVE Project would divert water from the Delta at Contra Costa Water District's Rock Slough, Old River, and Middle River intakes, divert water from the Sacramento River at the Freeport Intake, and deliver water to project participants within Contra Costa Water District's service area, the Bay Area, the Delta, neighboring regions, and south-of-Delta wildlife refuges.

Diversions for the LVE Project can be used for direct deliveries and for diversion to storage. Diversions would occur during excess and balanced conditions. During balanced conditions, total diversions at the Delta and Freeport intakes would increase by a long-term average of 58 TAF per year.[5] These diversions represent a reduction of about 1 percent or less of Delta outflow during dry and critical dry years[6], when balanced conditions are expected. During excess conditions total diversions at the Delta and Freeport intakes would increase by a long-term average of 69 TAF per year.[7] These diversions represent less than 0.5 percent reduction of Delta outflow during wet and above normal years,[8] when excess conditions are expected.

The maximum diversion rates at the intakes are 250 cubic feet per second (cfs) for the Old River Intake, 250 cfs for the Middle River Intake, 350 cfs for the Rock Slough Intake, and 155 cfs (of project supplies) at the Freeport Intake. Diversion to storage requires the use of the Transfer Pump Station, which has a pumping capacity of 200 cfs, so the rate of diversion to storage is limited to 200 cfs. Direct diversions up to 300 cfs can be made to the California Aqueduct through the proposed Bethany Transfer Pipeline.

Sites Reservoir Project

The Sites Project is a new surface storage reservoir located in Colusa County in the Sacramento Valley west of the town of Maxwell. The Sites Project would be an off-stream 1.5 million acre-feet (MAF) reservoir that would impound Funks Creek and Stone Coral Creek and provide storage capacity for Sacramento River diversions. This project also includes conveyance through the use of the existing Tehama Colusa Canal and Glenn-Colusa Irrigation District Canal diversion and conveyance facilities. Operation of the proposed reservoir would be in cooperation with the operations of existing CVP and SWP system facilities. The Sites Project would release water to tributaries to the

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[5] This value represents the difference between Alternative 1B with transfers and the no project/no action alternative under existing conditions (see Reclamation 2020, revised Table 4.2-6 in Appendix B-1, Updated Modeling Analysis).
[6] Long-term Delta outflow is estimated at 16.3 million acre-feet per year (MAF/yr), with an average of 28.7 MAF/yr in wet years, 17.7 MAF/yr in above normal years, 9.5 MAF/yr in below normal years, 9.5 MAF/yr in dry years, and 5.3 MAF/yr in critical dry years (Reclamation 2019, Appendix D – Modeling, Table 41-1, Current Operations).
[7] This value represents the difference between Alternative 1B and the no project/no action alternative under existing conditions (see Reclamation, 2020; Revised Table 4.2-8 in Appendix B-1, Updated Modeling Analysis).
[8] See footnote 6.

Sacramento River to deliver water to project participants within neighboring areas, to SWP and CVP contractors, and to south-of-Delta wildlife refuges. The project also includes exchanges with upstream reservoirs to preserve cold water releases for fishery benefits.

Annual diversions would range from 60 to 390 TAF per year, depending on hydrologic conditions, availability of Sacramento River water, and diversion and conveyance facility capacities.[9] Diversions would occur only under excess conditions. The maximum Sacramento River diversion rate is 3,900 cfs. Sacramento River flows would be diverted at the Red Bluff Pumping Plant (up to 2,100 cfs) and the Hamilton City Pump Station (up to 1,800 cfs). Modeling for the environmental documents show that the Sites Project diversions during wet weather years from January through March when excess conditions are expected shows a 3 to 4 percent reduction in flows in the Sacramento River downstream of Red Bluff Diversion Dam.

Excess condition diversions could occur anytime between September 1 to June 15, the timeframe that the Sacramento River is not fully appropriated; however, most diversions would occur from December through March during wet and above normal water years. Diversions are expected to decrease Sacramento River inflow to the Delta by about 2 percent or less, assuming that a 390 TAF annual diversion occurs in a wet or above normal year.[10]

Average annual releases from the Sites Project to Sacramento River tributaries would range from 116 to 382 TAF per year, depending on water year type, with a long-term average annual release of 243 TAF per year (over all year types).[11] Water would be conveyed via existing waterways and a new pipeline to the Sacramento River. Maximum reservoir releases would be 1,000 cfs. Releases would occur during balanced conditions.

Approximately 60 TAF per year, on an average annual basis, could be exchanged with upstream reservoirs to preserve cold water in the upstream reservoirs for fishery benefits, with most of the exchanges occurring in dry and critical water year types.[12] These releases from the Sites Project for exchanges would typically occur in spring and early summer with the exchanges listed below occurring in late summer and fall. Exchanges would occur during balanced conditions.

- Shasta Lake exchanges would result in the Sites Project releasing water in the spring in exchange for Shasta Lake releases in August and September.
- Lake Oroville exchanges would result in the Sites Project releasing water in June and July in exchange for Lake Oroville releases in August through November.
- Folsom Lake exchanges would result in the Sites Project releasing water in the spring and early summer in exchange for Folsom Lake releases in late summer and fall.
- Real-time exchanges with local participants would result in deliveries from the Sites Project to CVP partner contractors in lieu of direct diversions from the Sacramento River.

Pacheco Reservoir Expansion Project

The Pacheco Project is a surface storage project located in southeast Santa Clara County that would enlarge an existing reservoir by 136 TAF (from 6 TAF to 142 TAF). The project would construct new conveyance infrastructure to segments of the CVP San Felipe Division in Merced and Santa Clara counties, and deliver water supply to up to eight south-of-Delta wildlife refuges in Merced County. The

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[9] Sites Project Authority, 2021; Section 2.5.2.
[10] Long-term Sacramento River flow at Freeport is estimated at 15.5 MAF/yr, with an average of 22.4 MAF/yr in wet years, 18.2 MAF/yr in above normal years, 12.2 MAF/yr in below normal years, 11.5 MAF/yr in dry years, and 7.6 MAF/yr in critical dry years (Reclamation 2019, Appendix D – Modeling, Table 29-1, Current Operations).
[11] Sites Project Authority, 2020; Table 5-2 and 5-3 and Table B1-1.
[12] Sites Project Authority, 2020; Section 5.2.

primary water sources to fill the expanded reservoir would be natural inflows from the North and East Forks of Pacheco Creek. Supplemental flows to the expanded reservoir would arrive from Valley Water's and the San Benito County Water District's share of contracted CVP pumped water from San Luis Reservoir.

San Luis Reservoir storage is expected to decrease due to transfers to Pacheco Reservoir. This would increase the amount of available San Luis Reservoir storage that can be used by the SWP and CVP. South-of-Delta diversions could increase in both excess and balanced conditions. Modeling is currently not available to quantify these increases.

Harvest Water Program

The Harvest Water Program is a conjunctive use project in Sacramento County, formerly named the South Sacramento County Agriculture and Habitat Lands Recycled Water, Groundwater Storage, and Conjunctive Use Program (South County Ag Program). The project would store and manage groundwater (via in lieu use) while improving stream flow, enhancing groundwater dependent riparian habitats, sustaining prime agricultural lands, and improving regional water supply reliability. Sources of water would be up to 50 TAF per year of tertiary-treated recycled water produced by Sacramento Regional County Sanitation District (Regional San) and diverted from discharge into the Sacramento River. Water produced from the Harvest Water Program would be used to irrigate up to 16,000 acres of agriculture and habitat lands in Sacramento County near the lower Cosumnes River and Stone Lakes National Wildlife Refuge.

Up to 50 TAF per year of recycled water would be applied to lands in lieu of groundwater pumped from the Sacramento Valley groundwater basin. An estimated 32.5 TAF per year of recycled water would be used for irrigation during the growing season (April through October). In a dry year, irrigation demands could be as much as 37.5 TAF per year. An additional 8.75 to 17.5 TAF per year of recycled water would be applied to lands during the non-growing season for wildlife enhancement. In the future, an additional 5.5 TAF per year could also be used for wildlife enhancement purposes. Return flows from irrigation are assumed to be minimal. Reuse of up to 50 TAF per year of recycled water would result in a reduction of up to 50 TAF per year in wastewater outflow to the Sacramento River. The flow rate of the reduction will vary over the year based on annual pattern of wastewater generation. This represents a relatively small change in Sacramento River flow – less than a 0.7 percent decrease in Sacramento River inflow to the Delta.[13]

3. Analysis

This section describes the individual effects of each of the WSIP projects, considers how they interact, and addresses cumulative changes to Delta, Feather River, and Sacramento River flows, and other parts of the SWP system. Note that the volume of the pulse flows will be determined through a process included in an agreement between DWR and CDFW. The pulse flow volumes described below are derived from the modeling assumptions made by project proponents. For the purpose of this analysis they provide a reasonable upper limit of expected volumes of flow.

[13] See Footnote 10.

3.1 Summary of Hydrology Changes for Individual WSIP Projects

Chino Basin Conjunctive Use Environmental Water Storage/Exchange Program

The following changes to hydrology are expected to occur with implementation of the CBEWP:

- Project Additional Groundwater Storage: 15 TAF/year
- Feather River pulse flows: 50 TAF in selected years
- Reduced Delta Exports: 50 TAF in pulse flow years, but likely offset by additional SWP diversions
- Delta Outflow: 50 TAF in pulse flow years

Kern Fan Groundwater Storage Project

The following changes to hydrology are expected to occur with implementation of the Kern Fan Project:

- Delta Exports, Excess Conditions: up to 100 TAF/year when Article 21 is available under excess conditions
- Project Additional Groundwater Storage: up to 25 TAF/year when Article 21 is available under excess conditions
- Feather River pulse flows: 18 TAF in selected years
- Reduced Delta Exports: 18 TAF in pulse flow years, but likely offset by additional SWP diversions
- Delta Outflow: 18 TAF in pulse flow years

Willow Springs Water Bank Conjunctive Use Project

The following changes to hydrology are assumed to occur with implementation of the WSWB:

- Project Additional Groundwater Storage: Information unavailable at this time
- Feather River pulse flows: 28 TAF in selected years
- Reduced Delta Exports: 28 TAF in pulse flow years, but likely offset by additional SWP diversions. Additional information on pre-delivery process may identify Delta export increases.
- Delta Outflow: 28 TAF in pulse flow years

Los Vaqueros Reservoir Expansion Project

The following changes to hydrology are assumed to occur with implementation of the LVE Project:

- Additional Surface Water Storage: 115 TAF
- Sacramento River Diversions: up to 115 cfs (12 TAF/year[14]) at Freeport
- Delta Exports, Balanced Conditions: up to 200 to 300 cfs[15] (58 TAF/year)
- Delta Exports, Excess Conditions: up to 200 to 300 cfs (69 TAF/year)

[14] Freeport diversions would occur during balanced and excess conditions; however, information on Freeport diversions during balanced vs. excess conditions is not available. Therefore, the quantification of Delta exports for balanced and excess conditions include exports for the Old River, Middle River, Rock Slough, and Freeport intakes (i.e., total Delta exports are overestimated by 12 TAF per year).

[15] This range represents either diversion to storage (up to 200 cfs) or direct diversions made to the California Aqueduct (up to 300 cfs).

Sites Reservoir Project

The following changes to hydrology are assumed to occur with implementation of the Sites Project:

- Additional Surface Water Storage: 1,500 TAF
- Sacramento River Diversions: up to 3,900 cfs (60 to 390 TAF/year) during excess conditions
- Sacramento River Releases: up to 1,000 cfs (116 to 382 TAF/year) during balanced conditions. This includes possible releases for exchanges with upstream reservoirs.
- Delta Exports, Balanced Conditions: up to 243 TAF/year from deliveries pumped at Banks and Jones Pumping Plants

Pacheco Reservoir Expansion Project

The following changes to hydrology are assumed to occur with implementation of the Pacheco Project:

- Additional Surface Water Storage: 136 TAF
- Delta Exports: Unknown. San Luis Reservoir will have increased capacity due to the Pacheco Project that will allow some additional SWP and CVP export from the Delta. These exports could occur in balanced or excess conditions.

Harvest Water Program

The following changes to hydrology are expected to occur with implementation of the Harvest Water Program:

- Sacramento River reductions: up to 50 TAF/year in both balanced and excess conditions
- Project Additional Groundwater Storage: up to 50 TAF/year in lieu use

3.2 Cumulative Flows

This section considers cumulative changes to Feather River, Sacramento River, and Delta flows due to implementation of the seven WSIP projects. Cumulative flow effects are considered for both excess and balanced conditions. In all cases, water pumped from the Delta is subject to all applicable operational requirements. SWP and CVP operations can be further limited by the capacity in south-of-Delta storage facilities, the pumping capacity at the Delta pumping facilities, and operational constraints for fish and wildlife protection and water quality, as well as other environmental and legal restrictions.

Table 1 provides a summary of expected changes from each of the WSIP projects. The following observations on the cumulative flow effects from these projects can be made based on this information. Analyses are made based on location of projects and seasonality (balanced and excess conditions).

Spring Pulse Flows

CBEWP, Kern Fan Project, and WSWB Project (collectively referred to as the pulse flow projects) include an ecosystem benefit that allows for springtime releases from Lake Oroville in dry and below normal years upon request by CDFW and approval by DWR. The amount of water conveyed in the Feather River, Sacramento River, and Delta would increase by the pulse flow amount, assumed to be 50 TAF, 18 TAF, and 28 TAF, respectively. These amounts are based on modeling for the WSIP applications. CDFW will use an adaptive management framework to make requests to DWR for pulse flow releases from Lake Oroville. The volume and duration of any specific pulse flow is not known at this time and it is likely that pulse flows will differ among years. The pulse flow amount will increase Feather River flows, flow into the Sacramento River, and flow through and out of the Delta. CDFW has submitted an example of a pulse flow based on all three pulse flow projects in operation. The example estimates a maximum pulse flow of 3,000 cfs for 10 days with a ramp down rate of 500 cfs per day.

For the Feather River at the low flow channel, the base flow is estimated to be 1,000 cfs, so a pulse flow of 3,000 cfs increases the flow at this location by 300 percent, but the flow is well within the capacity of the low flow channel. During April to May, spring flows in the Feather River downstream of the Thermalito Afterbay Outlet average about 1,500 cfs in dry years.[16] A spring pulse with an additional 3,000 cfs would increase flows by 200 percent. At the mouth of the Feather River, near its confluence with the Sacramento River, spring flows average about 4,300 cfs in dry years; an additional 3,000 cfs is an increase of 70 percent. In the Sacramento River at Freeport, spring flows average about 14,200 cfs in dry years; an additional 3,000 cfs is an increase of 20 percent. And finally, Delta outflow in the spring of a dry year averages about 14,500 cfs; an additional 3,000 cfs is an increase of 20 percent. The timing of these pulse flows would provide fisheries benefits during migration windows.

Conclusion: Pulse flows have no adverse consequences.

Sacramento River Diversions

The LVE Project (through use of the Freeport diversion) and the Sites Project would increase Sacramento River diversions and the Harvest Water Program would reduce inflow into the Sacramento River.

The Sites Project is by far the largest Sacramento River diversion at 3,900 cfs, which would occur only during excess conditions. The LVE Project Freeport diversion has a capacity of 115 cfs and may divert under excess conditions for the LVE Project. Since the Harvest Water Program reduces Sacramento River inflows by 50 TAF per year on a continuous basis, that amount averages to a reduction of 69 cfs per day. Modeling for the environmental documents show that the Sites Project diversions during wet weather years from January through March, when excess conditions are expected, shows a 3 to 4 percent reduction in flows in the Sacramento River downstream of Red Bluff Diversion Dam. Adding a possible 115 cfs from the LVE Project Freeport diversion and 69 cfs from the Harvest Water Program discharge reduction would change these percentages by no more than 0.6 percent.[17]

The LVE Project Freeport diversion could also divert in balanced conditions such as for diverting SWP Table A supplies into the LVE Project. This type of relatively small diversion would be scheduled and coordinated through the LVE Project coordination agreements with the SWP and CVP to eliminate any adverse consequences and will be diverted in conformance with all permits and regulations. Any Harvest Water Program reductions in balanced conditions is not substantial (less than 0.7 percent).[18]

From a volume standpoint, the combined effect from these projects are expected to have maximum flow reduction of 452 TAF in a wet or above normal year (390 TAF from the Sites Project, 12 TAF from the LVE Project, and 50 TAF from the Harvest Water Program), a 2 to 3 percent volume reduction when predominately excess conditions are expected.[19] Similarly, flows could be reduced by 122 TAF

[16] Long-term Operations of the CVP and SWP (Reclamation 2019, Appendix D – Modeling, Tables 21-1, 22-1, 29-1, and 41-1).
[17] Flows in the Sacramento River below Red Bluff Diversion Dam in a wet year during January through March average about 28,800 cfs (Reclamation 2019, Appendix D – Modeling, Table 17-1); a reduction of 184 cfs is a decrease of 0.6 percent.
[18] Average annual flow in the Sacramento River at Freeport is 10,400 to 30,900 cfs depending on year type (Reclamation 2019, Appendix D – Modeling, Table 29-1); a reduction of 69 cfs per day would decrease annual flow by no more than 0.7 percent.
[19] Sacramento River flow at Freeport is estimated at 22.4 MAF/yr in wet years, 18.2 MAF/yr in above normal years, 12.2 MAF/yr in below normal years, 11.5 MAF/yr in dry years, and 7.6 MAF/yr in critical dry years (Reclamation 2019, Appendix D – Modeling, Table 29-1).

in drier years (60 TAF from the Sites Project, 12 TAF from the LVE Project, and 50 TAF from the Harvest Water Program), a 1 to 2 percent volume reduction when predominately balanced conditions are expected.[20]

Conclusion: Since the largest diversion, the Sites Project, occurs in excess conditions and is a relatively small percentage of expected Sacramento River flows, there are no adverse consequences anticipated. The LVE Project Freeport diversion is expected to be utilized less frequently than the Delta diversion locations and is a relatively small diversion rate.

Sacramento River Releases

The Sites Project would release flows back to the Sacramento River during balanced conditions. A long-term average annual release of 243 TAF per year could increase Sacramento River flows by approximately 1 to 3 percent.[21] The releases from the Sites project are estimated to be a maximum of 1,000 cfs. The releases will be to local waterways eventually leading to the Sacramento River and the Delta. The environmental documents for the Sites Project show no significant impacts from this level of deliveries. The releases would be scheduled and coordinated through the Sites Project coordination agreements with the SWP and CVP to avoid any substantial adverse consequences and will be diverted in conformance with all permits and regulations.

Conclusion: Releases in balanced conditions are coordinated with the SWP and CVP, so no adverse consequences are expected.

Delta Exports in Balanced Conditions

The pulse flow projects do not increase Delta exports in balanced conditions. An exception may be the WSWB Project whose pre-delivery concept may result in opportunities for the SWP to export some additional water in both balanced and excess conditions to fill newly available SWP storage created by the WSWB Project. However, until WSWB provides a description of the pre-delivery concept, an analysis cannot be conducted.

The pulse flow projects reduce demand for Delta pumping for individual SWP partner contractors who receive their Table A deliveries from the groundwater banks instead of the Delta or San Luis Reservoir. However, the reduced diversions create additional capacity in the SWP system that the SWP can use by increasing exports, so there is no net reduction in Delta exports.

The Sites Project releases water from storage during balanced conditions for delivery to project participants and for exchanges with upstream SWP and CVP reservoirs. Most of the deliveries to project participants will be exported at SWP and CVP export facilities. The LVE Project will also divert water from the Delta during balanced conditions. An example would be export of SWP Table A water for SWP South Bay Aqueduct contractors.

The Pacheco Project results in increased available capacity in San Luis Reservoir that would allow some additional SWP and CVP export from the Delta in both balanced and excess conditions. Information on the amount of increased Delta exports is not available.

Combined Delta exports in balanced conditions for the Sites Project and the LVE Project are 1,300 cfs and approximately 300 TAF per year.[22] For this analysis additional Delta exports resulting from the Pacheco Project are not included. Note that these exports would occur under the same environmental, regulatory, and operational constraints that apply to all SWP supplies. These constraints, which are

[20] Ibid.
[21] Ibid.
[22] Assumed 243 TAF from the Sites Project and 58 TAF from the LVE Project.

protective of fisheries and water quality beneficial uses, would continue to protect fisheries and water quality even with all of the WSIP projects operating at the same time.

Conclusion: Delta exports in balanced conditions are coordinated with the SWP and CVP, so no adverse consequences are expected.

Delta Exports in Excess Conditions

The Kern Fan Project and the LVE Project would increase Delta exports during excess conditions. The Pacheco Project results in increased available capacity in San Luis Reservoir that will allow some additional SWP and CVP exports from the Delta in both balanced and excess conditions; however, information on the amount of increased Delta exports is not available. The WSWB Project pre-delivery concept may result in opportunities for the SWP to export some additional water to fill SWP storage created by the WSWB Project in both balanced and excess conditions. However, until WSWB provides a description of the pre-delivery concept, an analysis cannot be conducted.

Combined Delta exports in excess conditions for the Kern Fan Project and the LVE Project are approximately 169 TAF per year (up to 100 TAF per year from the Kern Fan Project and 69 TAF per year from the LVE Project). Effects on Delta exports from the Pacheco Project and the WSWB Project are unknown at this time.

Exports during excess conditions would cause a small reduction in Delta outflow. The combined effect of the Kern Fan Project and the LVE Project is expected to reduce Delta outflow by 169 TAF per year in wet and above normal years, a 0.6 to 1 percent volume reduction when predominately excess conditions are expected.[23] Combined flows (in cfs) are expected to be a relatively small percentage of Delta outflow during excess conditions.

Note that these exports would occur under the same environmental, regulatory, and operational constraints that apply to all SWP supplies. These constraints, which are protective of fisheries and water quality beneficial uses, would continue to protect fisheries and water quality even with all of the WSIP projects operating at the same time.

Conclusion: Delta diversions during excess conditions are a relatively small percentage of Delta outflow, so no adverse consequences are expected.

4. Conclusions

The three WSIP pulse flow projects provide an environmental benefit in the Feather River and downstream without any identified adverse consequences.

The Sites Project, the LVE Project, and the Kern Fan Project would divert water during excess conditions. The WSWB Project and the Pacheco Project may result in increased exports during excess conditions, but not enough information is available at this time to quantify. For the Sites Project, the LVE Project, and the Kern Fan Project, diversions during excess conditions from the Sacramento River and the Delta would represent a small fraction of the flows during excess conditions. Regulatory requirements and coordination agreements will further protect against any adverse consequences.

The LVE Project would also divert during balanced conditions. Deliveries from the Sites Project would occur in balanced conditions and increase diversion at SWP and CVP Delta pumping plants. Both

[23] See footnote 6.

projects will have operational agreements with the SWP and CVP to coordinate deliveries including consideration of export capacity for the deliveries. This will ensure that the diversions will be made within the existing regulatory framework and would be subject to all applicable permit conditions. The WSWB Project and the Pacheco Project may result in diversions during balanced conditions, but not enough information is available at this time to quantify the changes.

In summary, the movement of water from the seven WSIP project are relatively small compared to overall seasonal flows in the watershed. The regulatory conditions for water projects in the Bay Delta watershed are well known and any project must be designed to function without substantial adverse consequences. The WSIP projects, except the Harvest Water Program, will be integrated by agreement with the SWP and CVP to ensure operations are coordinated and will not violate any regulations or permit terms. From a flow standpoint, the seven WSIP projects can operate successfully assuming operations agreements and permitting are completed.

5. Recommendation

As more information becomes available for the WSWB Project and the Pacheco Project, this memorandum should be updated. Because of the overall minimal changes to the flow regime in the Delta and Sacramento River additional detailed modeling of the cumulative flow effects may not be warranted.

6. References

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Sites Project Documents

Sites Project Authority, 2017. Sites Reservoir WSIP Application, Project Description, Non-Monetized Benefits, Physical Public Benefits, and Modeling Results Compendium. August 2017.

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Regional San, 2021. Petition for Change Mitigation Implementation Plan Summary, Draft Technical Memorandum. June 17, 2020 (Updated May 7, 2021)

Table 1. Resulting Changes from the WSIP Projects

Location or Type	CBEWP	Kern Fan Project	WSWB Project	LVE Project	Sites Project	Pacheco Project	Harvest Water Program
Additional Surface Reservoir Storage	--	--	--	115 TAF	1,500 TAF	136 TAF	--
Additional Groundwater Storage	15 TAF/yr	up to 100 TAF/yr (up to 25 TAF/yr for project use)	unknown	--	--	--	up to 50 TAF/yr in lieu use
Feather River Pulse Flows	50 TAF assumed	18 TAF assumed	28 TAF assumed	--	--	--	--
Sacramento River Diversions or Reductions	--	--	--	up to 115 cfs (12 TAF/yr[1]) in diversions @ Freeport	up to 3,900 cfs (60-390 TAF/yr) diversions in excess conditions	--	up to 50 TAF/yr in reduced wastewater discharge
Sacramento River Releases	--	--	--	--	up to 1,000 cfs (243 TAF/yr avg., 116-382 TAF/yr) in balanced conditions	--	--
Delta Exports, Balanced Conditions	export unchanged	export unchanged	unknown	200-300 cfs (58 TAF)	up to 1,000 cfs (243 TAF/yr) from deliveries	some additional due to increased capacity available in San Luis Reservoir	--
Delta Exports, Excess Conditions	--	up to 100 TAF/yr	none	200-300 cfs (69 TAF/yr)	--	some additional due to increased capacity in San Luis Reservoir	--

[1] Freeport diversions would occur during balanced and excess conditions; however, information on Freeport diversions during balanced vs. excess conditions is not available. Therefore, the quantification of Delta exports for balanced and excess conditions include exports for the Old River, Middle River, Rock Slough, and Freeport intakes (i.e., total Delta exports are overestimated by 12 TAF per year).

From: Laurie Warner Herson [laurie.warner.herson@phenixenv.com]
Sent: 6/30/2021 1:49:28 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Spranza, John [john.spranza@hdrinc.com]
Subject: RE: Sites - TCCA Presentation for Tomorrow

Thanks -it was so long ago I forgot what was in it ☺

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Wednesday, June 30, 2021 1:43 PM
To: Spranza, John <john.spranza@hdrinc.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: RE: Sites - TCCA Presentation for Tomorrow

Almost forgot to mention – nice job on the presentation Laurie!

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Alicia Forsythe
Sent: Wednesday, June 30, 2021 1:42 PM
To: John Spranza (john.spranza@hdrinc.com) <john.spranza@hdrinc.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: Sites - TCCA Presentation for Tomorrow

Hi Laurie and John – The TCCA presentation for tomorrow is located here:

https://sitesreservoirproject.sharepoint.com/:f:/r/EnvPlanning/Meetings/TCCA?csf=1&web=1&e=7QnXPE

Can you both take a look and let me know what you think?

John, please look carefully at the Water Quality Slide (7) along with the Funks releases slides (18 and 19).

Any other issues, policies, approaches that you all think Jeff might be concerned about? I was going to mention 404 jurisdictional as something we need to tackle next but wasn't going to put it in the slides as its not an EIR/EIS issue.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Kevin Spesert [kspesert@sitesproject.org]
Sent: 6/30/2021 3:21:31 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: RE: Sites - TCCA Presentation for Tomorrow

Looks good…I don't have suggestions…think you have it all covered.

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Wednesday, June 30, 2021 1:51 PM
To: Kevin Spesert <kspesert@sitesproject.org>
Subject: FW: Sites - TCCA Presentation for Tomorrow

Kevin – See below. Would appreciate your review of the presentation also if you have a chance. Trying to anticipate the issues / concerns that Jeff will have in our meeting tomorrow.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Alicia Forsythe
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Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Jerry Brown [jbrown@sitesproject.org]
Sent: 6/30/2021 5:03:01 PM
To: Marcia Kivett [MKivett@sitesproject.org]
CC: Kevin Spesert [kspesert@sitesproject.org]; Alicia Forsythe [aforsythe@sitesproject.org]
Subject: Re: Leg Outreach July Cmte Mtg

No all streamed to page. Less is better. Include pic.

Sent from my iPhone

On Jun 30, 2021, at 4:57 PM, Marcia Kivett <MKivett@sitesproject.org> wrote:

Let me know if you want 1 page per person. Their bios are fairly short.

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Wednesday, June 30, 2021 7:39 AM
To: Kevin Spesert <kspesert@sitesproject.org>; Marcia Kivett <MKivett@sitesproject.org>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Leg Outreach July Cmte Mtg

As part of this meeting I'd like to send the group a bio sheet containing a brief bio for each of the State Board members.

Marcia – Can you assist with putting this together. Pull from their website?

Kevin – Can you make sure this gets included in the packet? Also, the agenda for this item needs to cover:

1. The bios, any questions or comments
2. The fact that we are scheduling briefings with each member prior to the August release of the EIR. Our attendees for these meetings will include the chairs, me and Ali. The content will be update on project status and preview of water rights application. We are seeking to learn any concerns or issues they might have as individual state board members.

Thanks
<Water Board Members.docx>

From: Jerry Brown [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=A8920DB143E14E1D860C65947428D1E7-JBROWN]
Sent: 6/30/2021 5:03:02 PM
To: Marcia Kivett [MKivett@sitesproject.org]
CC: Kevin Spesert [kspesert@sitesproject.org]
Subject: Re: Leg Outreach July Cmte Mtg

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Sent from my iPhone

On Jun 30, 2021, at 4:57 PM, Marcia Kivett <MKivett@sitesproject.org> wrote:

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From: Jerry Brown <jbrown@sitesproject.org>
Sent: Wednesday, June 30, 2021 7:39 AM
To: Kevin Spesert <kspesert@sitesproject.org>; Marcia Kivett <MKivett@sitesproject.org>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>
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Thanks
<Water Board Members.docx>

From: Laurie Warner Herson [laurie.warner.herson@phenixenv.com]
Sent: 6/30/2021 6:55:50 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]
CC: Linda Fisher (linda.fisher@hdrinc.com) [linda.fisher@hdrinc.com]
Subject: Re: Sites May 2021 Bimonthly Schedule Update

There is no reason for the schedule to slip - I think Linda sent corrections to Cathy. We should still show the final in June with July certification and the ROD in August.

> On Jun 30, 2021, at 6:46 PM, Alicia Forsythe <aforsythe@sitesproject.org> wrote:
>
> Hi Laurie and Linda - I am just glancing at this. This schedule update shows the Final EIR/EIS schedule slipping to October 2022. Were you aware of this? If so, what is driving this?
>
> Ali
>
> ----------------------
> Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org<mailto:aforsythe@sitesproject.org> | www.SitesProject.org<https://urldefense.proofpoint.com/v2/url?u=http-3A__www.sitesproject.org_&d=DwMFAg&c=euGZstcaTDllvimEN8b7jXrwqOf-v5A_CdpgnVfiiMM&r=5lDi_dRX9hZUr3uaaaVnGL7X3t7keCUI33rc_MkofTH8fiDFwXqWpRnG7poqY5i5&m=6zEpv1lmWZzdhLydADdOJifRZRgLD8l7aGNx6hkGWC4&s=DrzIBoWPQo5Pdi_YzSUDjnBnKiOVB8gFSS8NO9fWjNI&e=>
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>
> From: Marcus Maltby <mmaltby@BrwnCald.com>
> Sent: Tuesday, June 15, 2021 5:00 PM
> To: Jerry Brown <jbrown@sitesproject.org>; Alicia Forsythe <aforsythe@sitesproject.org>; Joe Trapasso <jtrapasso@sitesproject.org>; Kevin Spesert <kspesert@sitesproject.org>; laurie.warner.herson <laurie.warner.herson@phenixenv.com>; Spranza, John <john.spranza@hdrinc.com>; Heydinger, Erin <erin.heydinger@hdrinc.com>; conner <conner@cmdwest.com>; Westcot, Cathy <cathy.westcot@hdrinc.com>; Luu, Henry <henry.luu@hdrinc.com>; JP Robinette <jrobinette@brwncald.com>
> Cc: Jeff Campbell <jeff@projectcontrolscubed.com>
> Subject: Sites May 2021 Bimonthly Schedule Update
>
> Hello All,
>
> Please see attached final May 2021 Bimonthly Schedule Update. An Executive Summary highlighting key updates is also attached with the following major takeaways:
>
> 1. Of the 14 major deliverables scheduled to be delivered within the current work plan, 1 deliverable has gained time, 3 deliverables have completed, and 10 deliverables maintained schedule. No deliverables lost time during this update period.
> 2. The Final EIR/EIS deliverable has extended its deliverable date from April 13, 2022 to August 1, 2022 which results in a critical path shift from CWC Determination of Feasibility to the Final EIR/EIS deliverable.
> 3. Preliminary risks have been identified for tracking purposes and are provided in the attached pdf. This list is only preliminary and will be expanded on as the project further develops.
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> All schedule reports, in .pdf and .xer format, are archived on the Sites Sharepoint site at the following location:
> Bimonthly Schedule Updates<https://urldefense.proofpoint.com/v2/url?u=https-3A__nam04.safelinks.protection.outlook.com_-3Furl-3Dhttps-253A-252F-252Fsitesreservoirproject.sharepoint.com-252Fprojectcontrols-252FWork-252520Plans-252FForms-252FSchedule-252520updates.aspx-253FnewTargetListUrl-253D-25252Fprojectcontrols-25252FWork-252520Plans-2526viewpath-253D-25252Fprojectcontrols-25252FWork-252520Plans-25252FForms-25252FSchedule-252520updates.aspx-2526viewid-253D2817b09d-2D76d8-2D4798-2Da8e5-2Dec16d21f942f-2526id-253D-25252Fprojectcontrols-25252FWork-252520Plans-25252FSchedules-25252FBimonthly-252520Updates-26data-3D04-257C01-257Cmmaltby-2540BrwnCald.com-257C0e729f782cfa42e523fb08d8fb1541a0-257Ccb2bab3d7d9044ea9e31531011b1213d-257C0-257C0-257C637535416321040873-257CUnknown-257CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0-253D-257C1000-26sdata-3DtsKjCkYgfQJ64jAGwSNNGKyhQs9OTwVJXLu-252Bhf8XH-252BE-253D-26reserved-3D0&d=DwMFAg&c=euGZstcaTDllvimEN8b7jXrwqOf-v5A_CdpgnVfiiMM&r=5lDi_dRX9hZUr3uaaaVnGL7X3t7keCUI33rc_MkofTH8fiDFwXqWpRnG7poqY5i5&m=6zEpv1lmWZzdhLydADdOJifRZRgLD8l7aGNx6hkGWC4&s=hy4rs9Opd07YuOM_3NZDAJshVOmmQmYx9z6j3zazO08&e=>
>

> Thanks,
>
> Marcus Maltby, PE*
> Brown and Caldwell
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>

From: Fisher, Linda [Linda.Fisher@hdrinc.com]
Sent: 6/30/2021 7:16:57 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Laurie Warner Herson [laurie.warner.herson@phenixenv.com]
Subject: RE: Sites May 2021 Bimonthly Schedule Update

I will have to check with Cathy because it looks like the updates weren't incorporated. Here is how it should be, which is consistent with what Cathy confirmed today and what Laurie indicated:

EIR-210 Preparation of Admin. Final EIR/EIS should be April 13, 2022
EIR 212 Authority/Reclamation/Integration Review of Admin. Final EIR/EIS should be 2-3 weeks after EIR-210 and the remaining tasks should be linked logically
EIR-250 Final EIR/EIS should end August 1 (since July 31 is a Sunday)

The schedule report also doesn't show all of the Final EIR/EIS steps, which makes it hard to follow, so I will let Cathy know that they need to show all of the tasks.

Linda Fisher, M.S.
D 916.817.4962 M 530.400.3212

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From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Wednesday, June 30, 2021 6:46 PM
To: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Fisher, Linda <Linda.Fisher@hdrinc.com>
Subject: FW: Sites May 2021 Bimonthly Schedule Update

Hi Laurie and Linda – I am just glancing at this. This schedule update shows the Final EIR/EIS schedule slipping to October 2022. Were you aware of this? If so, what is driving this?

Ali

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Cc: Jeff Campbell <jeff@projectcontrolscubed.com>
Subject: Sites May 2021 Bimonthly Schedule Update

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Thanks,

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