KLAMATH RIVER RENEWAL CORPORATION

Parker Thaler
Senior Environmental Scientist – Specialist
Water Quality Certification Program
Division of Water Rights
State Water Resources Control Board (SWRCB)
1001 I Street
Sacramento, CA 95814

January 3, 2018

P.O. Box 100
Sacramento, CA 95812-0100

Mr. Thaler:

This letter serves as a transmittal to accompany the requested portions of the Klamath River Renewal Corporation's Administrative Draft of the Definite Plan for Decommissioning (Definite Plan) for the SWRCB's use in the CEQA and California 401 Water Quality Certification processes.

The Technical Support Document submitted to SWRCB on September 29, 2017 is currently in the process of being refined and updated, as appropriate, in preparation to submit the project Definite Plan to the Federal Energy Regulatory Commission (FERC). The Definite Plan submittal was previously planned for December 31, 2017; however, that submittal has been delayed as indicated in the KRRC's recent filing to FERC. In an effort to keep the CEQA and 401 processes on schedule, and as requested by the SWRCB, this submittal is based on an Administrative Draft version of the Definite Plan and includes a summary of changes since the CEQA Technical Support Document, copies of any new or significantly revised document sections, and a summary of information still under development that will be available at a later date.

As attachments to this transmittal, we are including copies of Sections 3, 4, 7.2, 8.1 and 8.11, and Appendices I, L, and P from the Administrative Draft Definite Plan, as further summarized in Table 1. Table 2 contains a list of information currently under development that will be submitted to the SWRCB on or before March 1, 2018.

Table 1 New Technical Information Provided in Attachment

Definite Plan Section No.	Section Title	Summary
3	Regulatory Overview	Includes an overview of relevant FERC compliance and dam safety processes, water quality permits, endangered species compliance and aquatic resource permits.
4.4	Drawdown Timing	Provides a summary of drawdown timing.
4.5.5	Downstream of Iron Gate (Drawdown Releases)	Includes additional detail concerning river flows in the downstream reach during drawdown.
4.8	Potential for Effects Downstream of the Project	Includes an overview of potential downstream effects related to aggradation, pool depths, lateral migration, water quality, flooding and slope instability.
7.2	Aquatic Resources	Includes new information related to fish population status, fish diseases, total maximum daily load programs, and passage at Keno Dam.
8.1	Supplemental Information Report Overview	Includes a summary of Reclamation's Supplemental Information Report.
8.11	Iron Gate Hatchery	Includes a revised plan for hatchery improvements and operation.
Appendix I	Aquatic Resource Measures	Slightly revised per ongoing coordination with fisheries agencies and stakeholders, and new information related to suspended sediment concentration effects on outmigrating juvenile salmonids.
Appendix L	Cultural Resource Plan	Includes overview of recent work pertaining to cultural resources, in addition to an update on related regulatory processes.
Appendix P	Risk Management Plan	Includes the draft risk management plan for the project, including a detailed risk register.

Table 2 Additional Items to be Provided by March 1, 2018

Name	Notes
Updated Flood Mitigation H-2	Updated information on number of structures and specifics on preliminary design.
Updated Project Construction Schedules	Based on updated project costs
Updated Powerlines and Equipment Demolition	Based on new information provided by PacifiCorp

Please let us know if you have any question or concerns pertaining to the information provided in this submittal. The KRRC looks forward to continuing to work together to move the Project forward toward implementation.

Sincerely,

Mark Bransom
Executive Director
Klamath River Renewal Corporation

423 Washington St. 3rd Floor San Francisco, CA 94111| P: 415-820-4441| www.klamathrenewal.org

AECOM

Klamath River Renewal Project

Definite Plan for Decommissioning Administrative Draft

Submitted to: California State Water Resource Control Board

Submitted by: Klamath River Renewal Corporation

Date: January 2018

Prepared for:

Klamath River Renewal Corporation
Federal Energy Regulatory Commission

Prepared by:

KRRC Technical Representative:

AECOM Technical Services, Inc.
300 Lakeside Drive, Suite 400
Oakland, California 94612

CDM Smith
1755 Creekside Oaks Drive, Suite 200
Sacramento, California 95833

River Design Group
311 SW Jefferson Avenue
Corvallis, Oregon 97333

Kleinschmidt
1500 NE Irving Street, Suite 550
Portland, Oregon 97232

3. Regulatory Overview

This section provides an overview of some of the relevant regulatory processes associated with the Project, with a focus on FERC compliance and dam safety, as well as responses to specific FERC AIRs per Table 1.1-1.

3.1 FERC Compliance and Dam Safety

This section provides an overview of the dam safety program (Program) being developed to allow decommissioning of the Project to be undertaken in a manner that minimizes risk to people, structures, infrastructure, and the natural resources of the Klamath River Basin. It is the intent of the KRRC to substantially develop the Program before the Request for Proposal for construction is issued.

The Program is being developed jointly by the KRRC (as co-applicant) and PacifiCorp (the licensee and co-applicant). The KRRC recognizes that it will be responsible, once the license transfer is complete, for finalizing and implementing the Program; this includes developing the required dam safety plans and confirming that contract documents for the Contractor and Construction Manager are consistent with FERC Engineering Guidelines (FERC 2017).

3.1.1 Board of Consultants

By the Order dated October 5, 2017, FERC directed co-applicants to convene a Board of Consultants ("BOC") to review and assess all aspects of the proposed dam removal process. FERC expressed the following concern.

> *"Uncontrolled flow through a planned breach during removal activities can progress more quickly than anticipated, causing significantly higher discharge through the breach than expected. Removal of material on the downstream slope of an embankment dam can cause an increase in the hydraulic gradient within the embankment. Lowering of the reservoir can create upstream slope instabilities. In addition, the proposed transfer of these developments to the Renewal Corporation raises questions about the adequacy of funding, cost estimates, insurance, and bonding".*

Pursuant to this Order, the KRRC, in consultation with PacifiCorp, is proceeding with identifying members for the BOC, and plans to submit recommendations to FERC per the schedule contained in our December 4, 2017 response letter filing. The BOC will play a significant role in reviewing the dam safety program described below and in evaluating project risks.

3.1.2 Part 12 Requirements

This section provides an overview of the dam safety approach employed by the FERC's Division of Dam Safety and Inspections (D2SI) and the Portland Regional Engineer; the process described is consistent with other FERC regulated dam removals in recent years. A general schedule and approach for the KRRC is suggested.

3.1.2.1 Potential Failure Modes Analysis Background

A Potential Failure Modes Analysis (PFMA) is a dam and project safety evaluation tool developed by FERC to be used in the Part 12, Subpart D, program of dam and safety evaluations for FERC regulated projects. Since initiation of the PFMA program, a PFMA has been performed for all FERC regulated dams that are required to undergo Independent Consultant Safety Inspections as defined in 18 CFR Part 12, Subpart D. Iron Gate, Copco No. 1, and J.C. Boyle fall under these regulations, and Part 12D Reports and PFMAs have been performed accordingly. As Copco No. 2 does not meet the requirements for a Part 12D Independent Consultant's inspection, a PFMA has not been performed for this dam.

3.1.2.2 Supplemental PFMA

For dams that will be undergoing major modifications, remedial work or are scheduled to have substantial changes which can include removal, FERC's Engineering Guidelines indicate that Supplemental PFMAs shall be conducted. One purpose of this Supplemental PFMA is to evaluate the recommended dam removal plan prior to demolition. Thus, Supplemental PFMAs will be performed for Iron Gate, Copco No. 1, and J.C. Boyle, and for the previously unevaluated Copco No. 2.

The KRRC has reviewed dam safety submittals for Powerdale (FERC Project No. 2659) and Condit (FERC Project No. 2342) decommissioning projects, which involved recent FERC regulated dams in the region that share similarities based on size, type, and location. For both examples, a separate Core Team was assembled, and a supplemental PFMA workshop was held.

For the PFMA to be comprehensive, consistent, and complete, the following outline describes the dam safety approach the KRRC will employ when carrying out the Supplemental PFMA.

Step 1: Collection of Background Data

The KRRC will collect all data, removal plans, studies and information on the investigation, design, construction, analysis, performance and operation of the project in preparation for review by the PFMA Core Team. A listing will be made of the data available for review and considered in the PFMA. The list will be included in any PFMA documentation. Data requests made of PacifiCorp in April of 2017 will provide the fundamental background information for the Core Team. Additionally, the Definite Plan will be made available to the Core Team members for review prior to the PFMA session. If any dam safety incident reports exist, they will also be made available to the team for review.

Based on the estimated time to gather all the data, 60 days for FERC Regional Office review, and the time to perform the PFMA workshops, the process should begin one year prior to the planned construction contract award date, and/or negotiation of the guaranteed maximum price. The goal of the proposed PFMA schedule is to complete the session in accordance with FERC Guidelines, provide FERC with adequate time to complete their review and provide any comments to the KRRC without impacting the project schedule.

Studies conducted in preparation for facility removal are relevant to the activities of the Core Team. In particular the PFMA report will incorporate:

- Updated slope stability analysis and any recent surveys of new or previously unidentified landslides along the reservoir rims
- An evaluation of the rock in the area of the planned dam removal and breaching
- A structural evaluation of any facilities needed to support heavy equipment (e.g., cranes) to verify support for anticipated loads

Step 2: Selection of the PFMA Core Team

The Core Team members will have knowledge and experience related to dam safety evaluations and will consist of the applicants' Technical Representatives, FERC Inspector, Facilitator, Independent Consultant (if available), and a geologist or geotechnical engineer. Considering that the Project includes land both in Oregon and California, the state dam safety organizations located in those states will be invited to participate. In addition to the Core Team members, key project staff will be available during the PFMA session so they may answer questions from the Core Team, to clarify operating rules, and provide key site-specific information.

The BOC, discussed in Section 3.1.1, may also have a role in PFMA proceedings. This group is distinct from the Core Team in that they are to provide independent, expert opinions on matters related to their subject area. The Supplemental PFMA process is an opportune time to educate the BOC about the project and discuss risks; their role will be discussed in more detail when the KRRC finalizes their plan for the BOC.

Step 3: Site Visit

Typically, the Core Team is assembled at the time of the review, and depending on the Core Team's familiarity with the Project, a project site visit may be requested by the FERC Portland Regional Office. For a site visit, an advanced review package will be prepared by the Team Leader for the participants to get familiarized with the Project. At the site, the Facilitator will review the basic concepts of the PFMA process for the Core Team, the objectives, and answer any questions the participants may have. The site visit will be performed just before the Core Team conducts a comprehensive review of the background material.

Step 4: Comprehensive Review

The Core Team begins the PFMA session with review of the gathered data on the facilities. The review will take place at a convenient location that allows the Core Team to review all the necessary data and have collaboration on items that may need clarification. This location has not yet been identified.

Step 5: PFMA Session

The Facilitator begins the session by outlining the goals and ground rules, ensures the process is followed, and that the Core Team performs the PFMA following the FERC Engineering Guidelines. The session will then move on to a brief review of the existing PFMs compiled from previous PFMA sessions with an emphasis on dam removal. The group will then focus on potential new failure modes that could occur as part of dam removal.

Step 6: Evaluation of Surveillance and Monitoring

The Core Team members will assess the dam safety surveillance and monitoring plan (DSSMP) for the dams considering potential failure modes and ensure that a DSSMP is developed for any "highlighted" potential failure modes and any selected "not highlighted" potential failure modes.

Step 7: Documentation

The KRRC will document the Major Findings and Understandings and prepares the draft PFMA Report which documents the PFMA session, surveillance and monitoring, and/or risk reduction opportunities identified by the PFMA. The PFMA report should be prepared following the outline contained in FERC's Engineering Guidelines. A draft report will be sent to the Core Team members for review and comment. After receiving the Core Team's comments, the report will be finalized and made part of the Supporting Technical Information Document for reference.

3.1.3 FERC Required Plans and Submittals

Table 3.1-1 indicates the plans and submittals to be provided to FERC, along with responsibilities for development and implementation.

Table 3.1-1 FERC Required Plans and Submittals

Plan Name	Developed by	Submitted by
Coffer Dams	Contractor	See below
• Coffer Dam Design	Contractor	Contractor, for KRRC
• Coffer Dam Certification	KRRC	AECOM, for KRRC
Temporary Construction Emergency Action Plan	Contractor	Contractor, for KRRC
Quality Control Inspection Program (QCIP)	Construction Manger	AECOM, for KRRC
Dam Stability Analysis (Iron Gate and JC Boyle)	KRRC	AECOM, for KRRC
Blasting Plan	Contractor	Contractor, for KRRC
Reservoir Rim Stability Analyses	KRRC	AECOM, for KRRC
Flood Routing Analysis and Inundation Study	KRRC	AECOM, for KRRC
Rock quality evaluation in the areas of planned breaching	KRRC	AECOM, for KRRC

3.1.4 State Dam Safety Agency Coordination

All four projects are regulated by the FERC. However, both Oregon and California have their own state dam safety agencies. In Oregon, the Oregon Water Resources Department (OWRD) regulates dams. OWRD typically defers to FERC's Division of Dam Safety and Inspections for

FERC regulated projects. In California, the Department of Water Resources, Division of Dam Safety (DSOD) is responsible for dam safety regulations. Both of these agencies should be notified of the PFMA schedule and may require detailed coordination to allow their participation if requested.

3.2 Water Quality Permits

Permits under the authority of the Clean Water Act (CWA) would be required for the Project including a Section 404 Individual Permit, Hoopa Valley Tribe Water Quality Permit, Section 401 Water Quality Certifications, and Section 402 National Pollutant Discharge Elimination System (NPDES) permits. This section provides an update on the status of applications and correspondence with the reviewing agencies for these water quality-related permits and approvals. Where anticipated permit issuance dates are discussed, these are target dates only and are contingent on coordination with and completion of the CEQA and NEPA processes, as applicable. Other regulatory approvals may also be sought, and another update will be provided with the Definite Plan.

3.2.1 Section 404 Individual Permit

The Project will result in fill and/or dredging of jurisdictional waters of the United States, including wetlands, within and adjacent to the Klamath River during in-river construction activities. Work in the Klamath River and associated tributaries and wetlands are regulated under Section 404 of CWA. A pre-application meeting was held with the United States Army Corps of Engineers (USACE) on May 25, 2017 and periodic informal updates have been provided to the assigned project manager. The Section 404 permit application is expected to be submitted in 2018, with approval anticipated in 2019 following the issuance of the Section 401 water quality certifications from Oregon and California and the completion of the Endangered Species Act consultation.

3.2.2 Hoopa Valley Tribe Water Quality Permit

Preliminary discussions have been held with the Hoopa Valley Tribal Environmental Protection Agency ("TEPA"), and a meeting with the TEPA was held to discuss implementation of Section 401 under the CWA.

3.2.3 Oregon Department of Environmental Quality Section 401 Water Quality Certification

In Oregon, Section 401 is administered by the Oregon Department of Environmental Quality (ODEQ). The Water Quality Certification will likely include water and sediment quality monitoring requirements, as well as other conservation measures and BMPs, to be implemented during and after dam removal to ensure protection of beneficial uses and compliance with water quality standards.

A 401 Water Quality Certification request was submitted to ODEQ on September 23, 2016. ODEQ began their review of the application and issued a request for additional project information on July 19, 2017. To comply with regulatory review schedules, the KRRC withdrew and resubmitted its request on September 11, 2017. ODEQ acknowledged its receipt of the KRRC's request on September 14, 2017. A response to the request for additional information was submitted to ODEQ on September 30, 2017. This response is the same document that was submitted to the California SWRCB titled California Environmental Quality Act (CEQA) and California and Oregon 401 Water Quality Certifications Technical Support Document ("CEQA Technical Support Document") as described below, and is available at https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/lower_klamath_ferc14803/20170929_krrc_tech_report.pdf. Periodic updates have been, and will continue to be, provided to ODEQ upon request or as otherwise required to fulfill regulatory requirements.

3.2.4 California State Water Resources Control Board Section 401 Water Quality Certification

A 401 Water Quality Certification request was submitted to California, the California State Water Resources Control Board (SWRCB) on September 23, 2016. SWRCB has begun its review of the application and identified information gaps that needed to be filled. On August 24, 2017, SWRCB sent a request for additional information to the KRRC. The KRRC submitted the CEQA Technical Support Document as a response to the state request on September 30, 2017. In addition, to comply with regulatory review schedules, the KRRC withdrew and resubmitted the 401 application on September 11, 2017.

In California, the SWRCB action on the 401 Water Quality Certification must also comply with CEQA. SWRCB has posted a public notice of the application and has held three public scoping meetings. Preparation of a CEQA Environmental Impact Report (EIR) and associated public review processes are expected to extend into spring 2019. Periodic updates have been, and will continue to be, provided to ODEQ upon request or as otherwise required to fulfill regulatory requirements.

3.2.5 Clean Water Act Section 402

Because the Project will disturb more than one acre during construction in both Oregon and California, an NPDES Construction Stormwater General Permits will be required for construction-related stormwater discharges to surface waters in both states.

NPDES permit applications for general construction stormwater discharges are required to be submitted at least 30 days prior to land disturbance commencing. Because the land disturbance is expected to be more than 5 acres, an additional 14-calendar-day public review period also anticipated. It is currently anticipated that the applications will be prepared by the selected dam removal construction contractor during February of the year prior to reservoir drawdown, with submission to each agency planned for the end of March in the year that pre-drawdown construction activities are planned to occur. Approvals would be expected around the end of May of the same year.

3.3 Endangered Species Act Compliance

In 2012, NMFS and the USFWS issued the "Joint Preliminary Biological Opinion on the Proposed Removal of Four Dams on the Klamath River." At that time, USBR was the federal lead agency for the dam decommissioning project. Because the timeline for dam decommissioning was uncertain, the 2012 Biological Opinions (BiOps) were issued as a preliminary statement for project planning purposes. Since 2012, federal lead agency status has been transferred to FERC, and FERC designated the KRRC as the Designated non-Federal Representative for purposes of conducting informal consultation and preparation of a biological assessment (BA). The KRRC is currently updating the prior BA to account for changes in the environmental baseline, species lists, and in the potential project effects on river flows. The KRRC is working informally with NMFS and USFWS to confirm species lists, the definition of the proposed action, effects analysis methods, environmental baseline conditions, and to identify the best available science. The BA will include an evaluation of compliance with Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act and the NMFS review of the BA will include consideration of compliance with this act.

With respect to the other past BiOps referred to in this AIR that were issued in connection with the operation of USBR's Klamath Irrigation Project over the past decade, the KRRC does not have first-hand knowledge of these efforts. Moreover, USBR's operation of the Klamath Irrigation Project, and the Services' review of the same, do not implicate the removal activities the KRRC proposed in the Surrender Application that will be further described in the Definite Plan.

Based on the KRRC's review of public information related to the Klamath Irrigation Project, the KRRC understands that NMFS and USFWS jointly issued in 2013 the "Biological Opinions on the Effects of Proposed Klamath Project Operations from May 31, 2013, through March 31, 2023, on Five Federally Listed Threatened and Endangered Species." This 2013 BiOp supersedes the 2008 and 2010 BiOps. The KRRC also understands from review of public information that USBR is currently working with NMFS and USFWS to develop a new proposed action for the Klamath Irrigation Project, which will include the issuance of a new BiOp related to operation of the Klamath Irrigation Project.

To date, several workshops have been held with agency representatives in support of consultation under Section 7 of the Endangered Species Act and Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act. These workshops have primarily focused on discussing the potential effects the project may have on federally threatened and endangered species currently inhabiting the Klamath River, current and potential mitigation measures that may be implemented to reduce those effects, and the development of a monitoring plan to ensure the effectiveness of proposed mitigation measures. Dates and a brief description of the topics discussed at each workshop are provided below:

- April 28, 2017, Lower Basin Agency Meeting – overview of proposed 2017 project activities including schedule, review and discussion of mitigation measures previously included in BiOp, EIS/EIR, and Detailed Plan specific to threatened and endangered species identified within the 2012 project action area. Attendees included the KRRC, NMFS, USFWS, and CDFW.
- May 23, 2017, Aquatic and Terrestrial Resource Meeting –discussion of concerns specific to aquatic resource relocation and potential mortality rates of spawning and juvenile species, inclusion of Coho salmon into the BiOp, and proposed mitigation measures. This

meeting also included a discussion on proposed survey plans and potential minimization measures for terrestrial species including northern spotted owl and listed plants. Attendees included the KRRC, NMFS, USFWS, CDFW, ODEQ, Northcoast Regional Water Quality Control Board (NCRWQCB), SWRCB, Hoopa Valley, Yurok, Karuk, and Klamath tribes.

- May 24, 2017, USFWS Sucker Mitigation Plan Meeting – Sucker genetics, trapping and relocation, and potential mitigation measures. Attendees included the KRRC, USFWS, and United States Geological Survey (USGS).
- June 13, 2017, Aquatic Mitigation Measures Planning Meeting – discussion on the deficiency of the 2012 Aquatic Resource Mitigation Measures, development and implementation of an effective monitoring plan, and revised Aquatic Resource Mitigation Measures specific to Mainstem Spawning, Outgoing Juveniles, and Pacific Lamprey. Attendees included the KRRC, NMFS, USFWS, CDFW, Hoopa Valley, Yurok, and Karuk tribes.
- June 19, 2017, Aquatic Mitigation Measures Planning Meeting (Suckers) – sampling/salvage of suckers and appropriate methodology, relocation of suckers and permitting options. Attendees included the KRRC, USFWS, USGS, CDFW, Oregon Department of Fish and Wildlife (ODFW), and Klamath tribes.
- July 27, 2017, Agency Visit to Project Site – site visit with a focus on terrestrial resources measures and overview of project components. Attendees included the KRRC, USFWS, CDFW, ODFW, and Oregon Department of State Lands (ODSL).
- August 15, 2017, Aquatic Resources Mitigation Measures review workshop – ongoing discussions pertaining to refinements to the 2012 Aquatic Resource Mitigation Measures, development and implementation of an effective monitoring plan, and revised Aquatic Resource Mitigation Measures specific to Mainstem Spawning, Outgoing Juveniles, and Pacific Lamprey. Attendees included the KRRC, NMFS, USFWS, CDFW, ODFW, ODEQ, SWRCB, Hoopa Valley, Yurok, and Karuk tribes.
- October 26, 2017, Aquatic Resources Planning Workshop – proposed monitoring periods, laboratory experiments for turbidity and suspended sediments, evaluation of spawning habitat and salmonid behavioral response to high sediment loads. Attendees included the KRRC, NMFS, USFWS, CDFW, ODFW, Hoopa Valley, and Yurok tribes.
- October 27, 2017, Terrestrial Resources Coordination Call – updates on terrestrial resources measures development, proposed field survey schedule, species-specific discussions. Attendees included the KRRC, USFWS, CDFW, SWRCB and ODFW.
- November 20, 2017, Terrestrial Resources Coordination Call – updates on terrestrial resources measures, proposed field survey schedule and results of 2017 reconnaissance work, species-specific discussions. Attendees included the KRRC, USFWS, CDFW, SWRCB and ODFW.
- December 6, 2017, Section 7 consultation meeting with NMFS and USFWS – Discussion of needed updates to the dam decommissioning BA including project and baseline changes, schedule, action area, and new species. Attendees included the KRRC, USFWS, and NMFS.

Records of meetings notes from these meetings were included with the December 31, 2017 filing. Additional meetings are proposed in the coming months to confirm field survey needs and protocols, aquatic mitigation measures, adjust minimization measures based on field survey results as needed, and finalize schedule and approach for associated permit applications.

The complete list of terrestrial federal and state-listed, proposed, candidate, and petitioned for listing species that are known to occur or that may occur within the area of potential effect is found in Appendix J. Please note that there are separate tables for special status animals and special status plants in Appendix J.

The changes in terrestrial species status and/or designated critical habitat that have occurred since the 2012 EIS/EIR are shown in Table 3.3-1. There have been no changes in aquatic species status, known occurrences, or designated critical habitat since the 2012 EIS/EIR was published.

Table 3.3-1 Change in Terrestrial Species Status or Designated Critical Habitat

Common Name	*Scientific Name*	Status	Change from Previous EIS/EIR
Conservancy fairy shrimp	*Branchinecta conservatio*	FE	Added to list of species with potential to occur
Vernal pool tadpole shrimp	*Lepidurus packardi*	FE	Added to list of species with potential to occur
Klamath pebblesnail	*Fluminicola sp. 5*	ONHP List 1	Added to list of species with potential to occur
Klamath Rim pebblesnail	*Fluminicola sp.6*	ONHP List 1	Added to list of species with potential to occur
Blue Mountains juga (snail)	*Juga sp. 2*	ONHP List 1	Added to list of species with potential to occur
Scale lanx (snail)	*Lanx klamathensis*	ONHP List 1	Added to list of species with potential to occur
Terrestrial snail	*Monadenia fidelis leonine*	Tracked on CNDDB	Added to list of species with potential to occur
Foothill yellow-legged frog	*Rana boylii*	Petitioned for federal listing, BLM, OSS, CSSC, Request for CA candidate	Change in species status
Oregon spotted frog	*Rana pretiosa*	FT, BLM, OSS, CSSC	Change in species status
Western pond turtle	*Actinemys marmorata*	Petitioned for federal listing, BLM, OSS, ONHP List 2, CSSC	Change in species status
Northern spotted owl	*Strix occidentalis caurina*	FT, OT, ONHP List 1	Change in designated critical habitat
Yellow-billed cuckoo	*Coccyzus americanus*	FT, CE, OSS, BLM	Change in species status
Black-backed woodpecker	*Picoides arcticus*	BLM, OSS, Petitioned for listing under CESA	Change in species status
Tricolored blackbird	*Agelaius tricolor*	Petitioned for federal listing, BLM, CSSC, Candidate for listing under CESA as endangered	Change in species status
Fisher- West Coast DPS	*Martes pennanti (Pekania pennanti)*	BLM, OSS, ONHP List 2, CSSC	Change in species status
Wolverine	*Gulo gulo*	FPT, CT, OT, FP	Change in species status
Gray wolf	*Canis lupus*	FE, CE, ONHP List 2	Corrected species status
Western yellow cedar	*Callitropsis nootkatensis*	Petitioned for federal listing, CNPS List 4.3	Added to list of species with potential to occur

Key:

BLM	Bureau of Land Management sensitive species -species that could easily become endangered or extinct; and/or Survey and Manage Species
CE	California Endangered

CSSC	California Department of Fish and Wildlife Species of Special Concern -not listed under the Federal or California Endangered Species Act but are believed to: 1) be declining at a rate that could result in listing, or 2) historically occurring in low numbers and having current known threats to their persistence
CT	California Threatened
FE	Federal Endangered
FP	Fully protected under the California Fish and Game Code
FT	Federal Threatened
ONHP List 1	Oregon Natural Heritage Program (ONHP) threatened with extinction or presumed to be extinct throughout their entire range
ONHP List 2	threatened with extirpation or presumed to be extirpated from the State of Oregon
ONHP List 3	more information is needed before status can be determined, but may be threatened or endangered in Oregon or throughout their range
OHNP List 4	of conservation concern but not currently threatened or endangered
OT	Listed as threatened by ODFW
OSS	Oregon Sensitive or Sensitive- Critical Species, East Cascades, West Cascades, and Klamath Mountains Ecoregions

3.4 Aquatic Resource Permits

Several aquatic resources permits are discussed under Section 3.2 Water Quality Permits and Section 3.3 Endangered Species Act Compliance. The status of those permits and consultations, including records of correspondence, is discussed in those sections. This section addresses the status of the remaining aquatic resources permits and approvals including Wild and Scenic Rivers Act compliance, Section 10 of the Rivers and Harbors Act, and the California Aquatic Lands Lease.

3.4.1 Wild and Scenic River Act

The Klamath River in Oregon from approximately the J.C. Boyle powerhouse downstream to the California border is designated as a Wild and Scenic River. In California, the river downstream of Iron Gate Dam to the ocean is designated as a Wild and Scenic River. A teleconference call was held between the KRRC Technical Representative and representatives from the National Park Service and the Bureau of Land Management on May 2, 2017 to discuss these Wild and Scenic Rivers Act designations.

3.4.2 Section 10 Rivers and Harbors Act

Section 10 of the Rivers and Harbors Act of 1899 would apply to construction activities in the portions of the Klamath River subject to tidal influence, and may apply to activities from the mouth of the Klamath River to approximately River Mile 38. At this stage of design, it appears no structures will be placed within the Klamath River in the portion regulated under Section 10; however, this will be monitored as the project progresses.

3.4.3 California State Lands Surface and Submerged Waters Lease

The relocation of the City of Yreka water supply line will require an amendment to an existing state lands lease. Both the intake structures on Fall Creek and the pipeline crossing of the Klamath River would trigger an amendment to the lands lease. As several alternatives for the relocation of the water line are still under consideration, there has not yet been any contact with the California State Lands Commission. It is anticipated that an application for a new or revised lease would be made in late 2018, if necessary.

4. Reservoir Drawdown & Diversion Plan

4.1 Introduction

The following reservoir drawdown and streamflow diversion plan is proposed to facilitate the removal of J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams while minimizing flood risks and downstream impacts due to the release of impounded reservoir sediments. The proposed plan results in drawdown of the reservoirs impounded by J.C. Boyle, Copco No. 1, and Iron Gate dams by March 15 of the drawdown year, to minimize downstream impacts resulting from the natural release and transport of impounded sediments. Historical daily and monthly streamflow data downstream of each of the dams can be found in Section 2: Existing Hydrology Conditions in USBR's *Hydrology, Hydraulics, and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration Klamath River, Oregon and California* (USBR 2012c).

Drawdown of the reservoirs will generally take place between January 1 and March 15 of the drawdown year. However, the proposed plan includes early drawdown of Copco No. 1 and delayed cessation of power generation at Copco No. 2. Early drawdown of Copco No. 1 is necessary for the reservoir drawdown to be completed by about March 15 (prior to spring salmonid migration). To offset lost revenue from shutting Copco No. 1 down prior to January 1, generation of power at Copco No. 2 Dam (with sediment-laden flow) could continue for up to four months after January 1 of the drawdown year (or until May 1). This assumes the Copco No. 2 generating equipment will be capable of operating under such conditions. Power generation at Copco No. 1 Dam would end after the reservoir reaches the minimum operating level at reservoir water surface (RWS) elevation 2604.5, which would be nearly 2 months before January 1 of the drawdown year. These operational changes may need to be approved by PacifiCorp if drawdown occurs before January 1, 2020.[8] Reservoir drawdown below the minimum operating level would commence at each dam when power generation has ceased at that dam. The proposed plan assumes power generation at each of the dams would end as shown in Table 4.1-1.

Table 4.1-1 End Date for Power Generation

Location	End Date
J.C. Boyle	January 1 of drawdown year
Copco No. 1	November 1 of year prior to drawdown
Copco No. 2	May 1 of drawdown year
Iron Gate	January 1 of drawdown year

The following sections describe the reservoir drawdown facilities, flood frequency flows, the anticipated drawdown rates (i.e., rate of elevation change and discharge rates) and timing of drawdown, and the portion of discharge associated with specific structures (spillways,

[8] KHSA Section 7.3.5 specifies PacifiCorp has discretion to allow facilities removal prior to January 1, 2020 but the KHSA does not comment on the start date for reservoir drawdown.

diversion tunnels, etc.). Additional information and results beyond those presented here can be found in Appendix F.

The bulleted list below provides a roadmap for specific information related to drawdown:

- Total anticipated discharge (cfs) associated with drawdown for each reservoir is discussed in Section 4.4
- Description of structures used for drawdown operation and associated flows is provided in Section 4.2
- Description of notching at Copco No. 1 is provided in Section 4.2.2 (Option 1 – no longer included)
- Proposed duration and timing of drawdown operations is discussed in Sections 4.4 and 4.5
- Proposed reservoir elevation change per day is provided in Section 4.5
- Description of measures associated with possible tunnel failure is provided in Section 4.7.1
- Additional information concerning the retrofit of the diversion tunnels is provided in Section 4.2
- Slope stability monitoring during and after reservoir drawdown is discussed in Section 4.6
- Measures to implement if slope stability issues are identified are discussed in Sections 4.7.2 and 4.7.3
- Measures to implement to reduce impacts to aquatic species are discussed in Section 4.7.4 and Section 7.2
- Studies conducted to verify reservoir drawdown rates are protective of slope stability and potential flooding are discussed in Section 4.7
- Schedule and sequence for drawdown of all Lower Klamath Project dams is provided in Sections 4.4 and 4.5
- Adaptive strategy for adjusting schedule based on interruptions in drawdown sequence is provided in Sections 4.7.1(tunnel blockage)
- Physical modifications to the dam to facilitate drawdown are summarized in Section 4.2
- Strategies for managing drawdown under low, medium and high flow conditions are provided in Section 4.5
- Drawdown flows in cfs are provided in Section 4.5

4.2 Diversion Facilities

Facilities that will be used for drawing down the reservoirs and diverting Klamath River flows around J.C. Boyle, Copco No. 1, and Iron Gate dams are shown in Table 4.2-1. The major drawdown facilities at J.C. Boyle are the spillway, power intake, and diversion culverts beneath the dam. At Copco No. 1, drawdown facilities have two options: (1) the spillway, diversion tunnel, and dam notches or (2) spillway and a modified diversion tunnel. At Iron Gate, the drawdown would occur via the spillway and a modified diversion tunnel. The penstocks at Copco No. 1 and Iron Gate provide only a minor amount of potential additional diversion, and they are assumed to be closed when power generation ceases, so they are not included in the drawdown modeling.

Table 4.2-1 Facilities to be Used for Reservoir Lowering and Diversion

Location	(a) Diversion Facility	(b) Invert Elevation	(c) Notes
J.C. Boyle Dam			Normal operating elevation 3796.7
	Spillway	3785.2	
	Power Intake	3771.7	
	Power Canal, Tunnel, and Turbines	--	Pass power intake flows through turbines without generating power
	Diversion Culvert – Bay 1	3755.2	
	Diversion Culvert – Bay 2	3755.2	
Copco No. 1 Dam			Normal operating elevation 2609.5
Option 1	Spillway	2597.0	
	Modified Diversion Tunnel	2485.5[1]	
	Notches in Dam	Varies	
Option 2	Spillway	2597.0	
	New Gate in Diversion Tunnel	2485.5[1]	
Iron Gate Dam			Normal operating elevation 2331.3
	Spillway	2331.3	
	New Gate in Diversion Tunnel	2176.3[2]	

[1] Estimated from Drawing 1475.
[2] Drawing 8860 shows the invert at 2173 feet NGVD (2176.3 feet NAVD); Drawing 8862 shows invert at 2175 feet NGVD (2178.3 feet NAVD).

The removal of Copco No. 1 and Iron Gate dams requires the successful completion of modifications to restore and increase the discharge capacity of the existing diversion tunnels for low-level releases. Both require underwater work that would be difficult and will need to be performed the year prior to reservoir drawdown. The design and fabrication of large gates that are the major component of both modifications will also require a significant lead time (up to 10 months for design and fabrication) ahead of installation. No impacts to power generation are expected for the modification work. Measures to modify the diversion facilities are described in the following sections.

A description of the diversion facilities and any modifications that would be required prior to reservoir drawdown are described in the following sections.

4.2.1 J.C. Boyle Reservoir

Water releases for reservoir drawdown at J.C. Boyle will be made through the gated spillway (crest elevation 3785.2), the power canal (intake invert elevation 3771.7), and through the two

9.5- by 10-foot diversion culverts (invert elevation 3755.2) located below the gated spillway (see Figure 4.2-1(B). Modifications of these facilities are not required prior to drawdown. Discharge rating curves for the J.C. Boyle facilities, as well as the stage-storage curve for J.C. Boyle Reservoir, are shown in Figure 4.2-2.

Figure 4.2-1 J.C. Boyle Diversion Facilities (Appendix B)

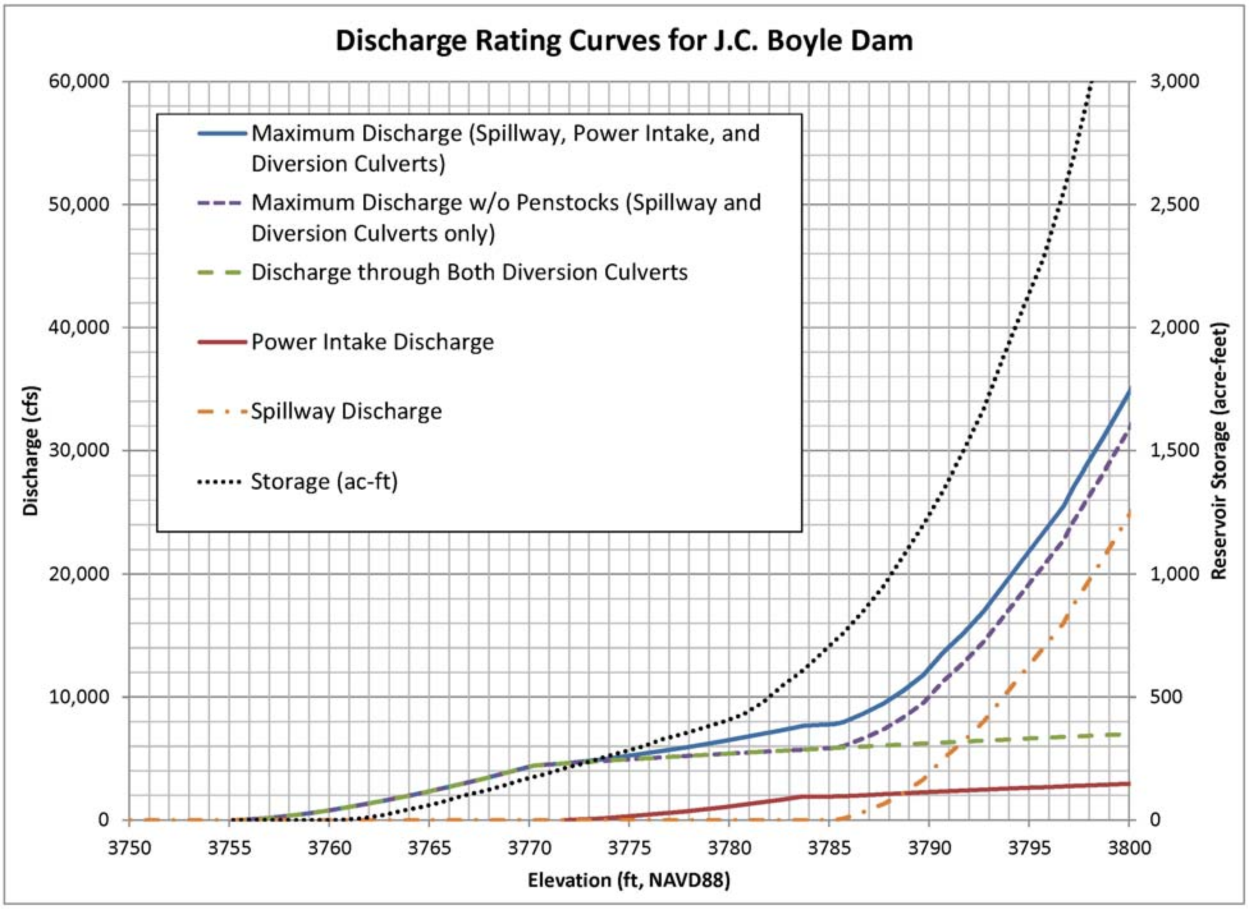


Figure 4.2-2 Discharge Rating Curve and Stage-Storage Curve for J.C. Boyle

4.2.2 Copco Lake

Two options were analyzed for reservoir drawdown at Copco No. 1. Option 1 would make releases through a combination of the diversion tunnel modified to restore operation through three existing 6-foot diameter pipes in the diversion tunnel intake structure, in addition to a series of notches sequentially excavated in the dam. Option 2 would make releases solely through the diversion tunnel modified to restore full use of the tunnel by installing a new large gate at the downstream end of the tunnel and removing the intake structure at the upstream end. Discharge rating curves for the diversion facilities for the two Copco No. 1 options, as well as the stage-storage curve for Copco Lake, are shown on Figure 4.2-3.

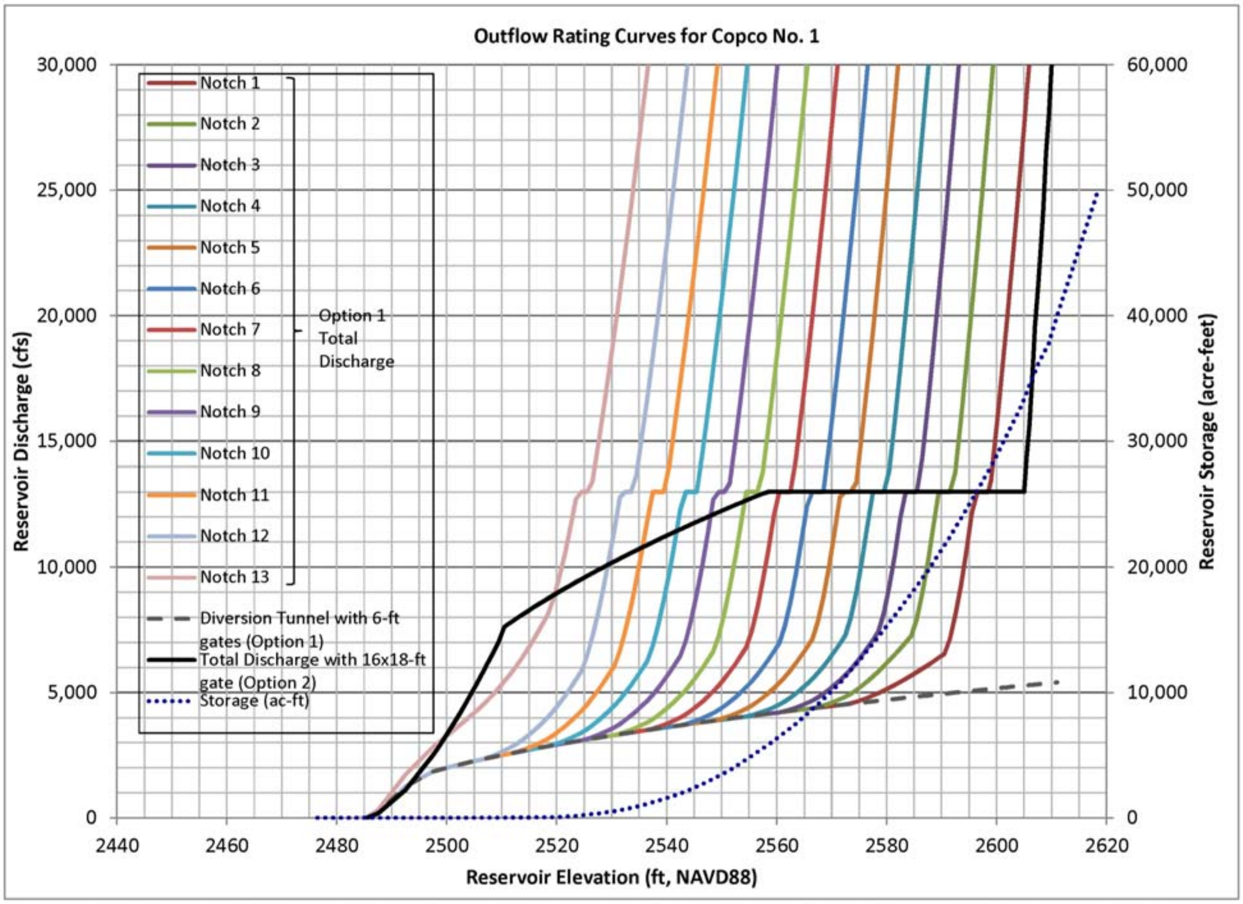


Figure 4.2-3 Discharge Rating Curve and Stage-Storage Curve for Copco No. 1

The following sections provide a more detailed description of the diversion tunnel modifications for Option 1 and Option 2. The modification would be performed the year prior to reservoir drawdown.

4.2.2.1 Option 1 – Diversion Tunnel Modification to Restore Release Capacity

1. Design, fabricate, and deliver three new 6- by 6-foot slide gates.
2. Mobilize barge-mounted crane onto Copco Lake (assume normal RWS elevation 2609.5). Remove deposited sediment from diversion tunnel intake using clamshell or suction dredge, as required.
3. Remove three existing 72-inch flap gates on the upstream face of diversion intake structure (invert elevation 2485.5) under balanced head and no flow conditions, using hard hat divers (124-foot depth) (Figure 4.2-4 (B)). Upstream tunnel should be full of water (due to valve leakage since tunnel was plugged), but should be confirmed.
4. Install three new 6- by 6-foot slide gates with hydraulic operators and remote controls at upstream face of diversion structure using hard hat divers (see Figure 4.2-4(B)).
5. With new upstream slide gates and diversion intake closed, drill drain and air vent holes through concrete tunnel plug from downstream side to unwater tunnel (see Figure 4.2-

5(B)). Remove concrete tunnel plug in dry conditions. Inspect the unlined diversion tunnel for possible reinforcement (lining with shotcrete or concrete) or repairs.

6. Remove (or open) three existing 72-inch butterfly valve disks from downstream side of inlet in dry conditions, after drilling drain and air vent holes through each disk. Determine need for air vent piping and provide as necessary for operation of upstream slide gates.
7. All work in the tunnel would be in compliance with local, state and federal codes and regulations (e.g., Title 29 of the Code of Federal Regulations (29 CFR 1926.800)) and would include safety provision of adequate ground control, flood control, air monitoring, ventilation, illumination, communication, personal protective equipment, access and egress procedures, mechanical equipment, and emergency procedures.

Figure 4.2-4 Copco No. 1 Diversion Modification, Intake Structure (Appendix B)

Figure 4.2-5 Copco No. 1 Diversion Modification, Tunnel (Appendix B)

4.2.2.2 Option 2 – Diversion Tunnel Modification to Increase Release Capacity

1. Design, fabricate, and deliver new 16.5- by 18-foot roller gate.
2. Construct new gate shaft with new gate structure and 16.5-foot by 18-foot roller gate at downstream end of diversion tunnel (see Figure 4.2-6 (B)).
3. Mobilize barge-mounted crane onto Copco Lake (assume normal RWS elevation 2609.5). Remove sediment from diversion tunnel (see Figure 4.2-4(B)) intake using clamshell or suction dredge, as required.
4. Remove three existing 72-inch flap (or "clack") gates on upstream face of diversion intake structure (invert elevation 2485.5) under balanced head and no flow conditions, using hard hat divers (124-foot depth). Upstream tunnel should be full of water (due to valve leakage since tunnel was plugged), but should be confirmed. Install three new 6-foot blind flanges (see Figure 4-2.4(B)) using hard hat divers.
5. With new blind flanges in place, drill drain and air vent holes through concrete tunnel plug from downstream side to unwater tunnel (see Figure 4.2-5(B)). Remove concrete tunnel plug in dry conditions. Inspect the unlined diversion tunnel for possible reinforcement (lining with shotcrete or concrete) or repairs. Line tunnel with shotcrete or concrete, if determined to be necessary.
6. Remove three existing 72-inch butterfly valve disks from downstream side of inlet in dry conditions, after drilling drain and air vent holes through each disk.
7. Close new large gate and fill tunnel upstream of gate with water.[9] Under balanced head and no flow conditions, remove the 6-foot blind flanges at the inlet using hard hat divers.
8. Using hard hat divers, demolish intake structure and install grating to minimize potential for large debris entering the diversion tunnel.

[9] Tunnel filling could be accomplished several ways such as by inserting a small valve into the blind flange or by drilling a small opening into the tunnel adjacent to the intake structure.

9. All work inside the tunnel would be performed in the same manner described for Copco No. 1 (Option 1).

Figure 4.2-6 Copco No. 1 Diversion Modification, New Gate Structure (Appendix B)

4.2.3 Iron Gate Reservoir

Reservoir drawdown at Iron Gate Dam will make releases solely through the diversion tunnel. It will be modified to restore full use of the tunnel by installing a new large gate in place of the current concrete bulkhead and gate. Discharge rating curves for the diversion facilities for Iron Gate Dam, as well as the stage-storage curve for Iron Gate Reservoir, are shown on Figure 4.2-7.

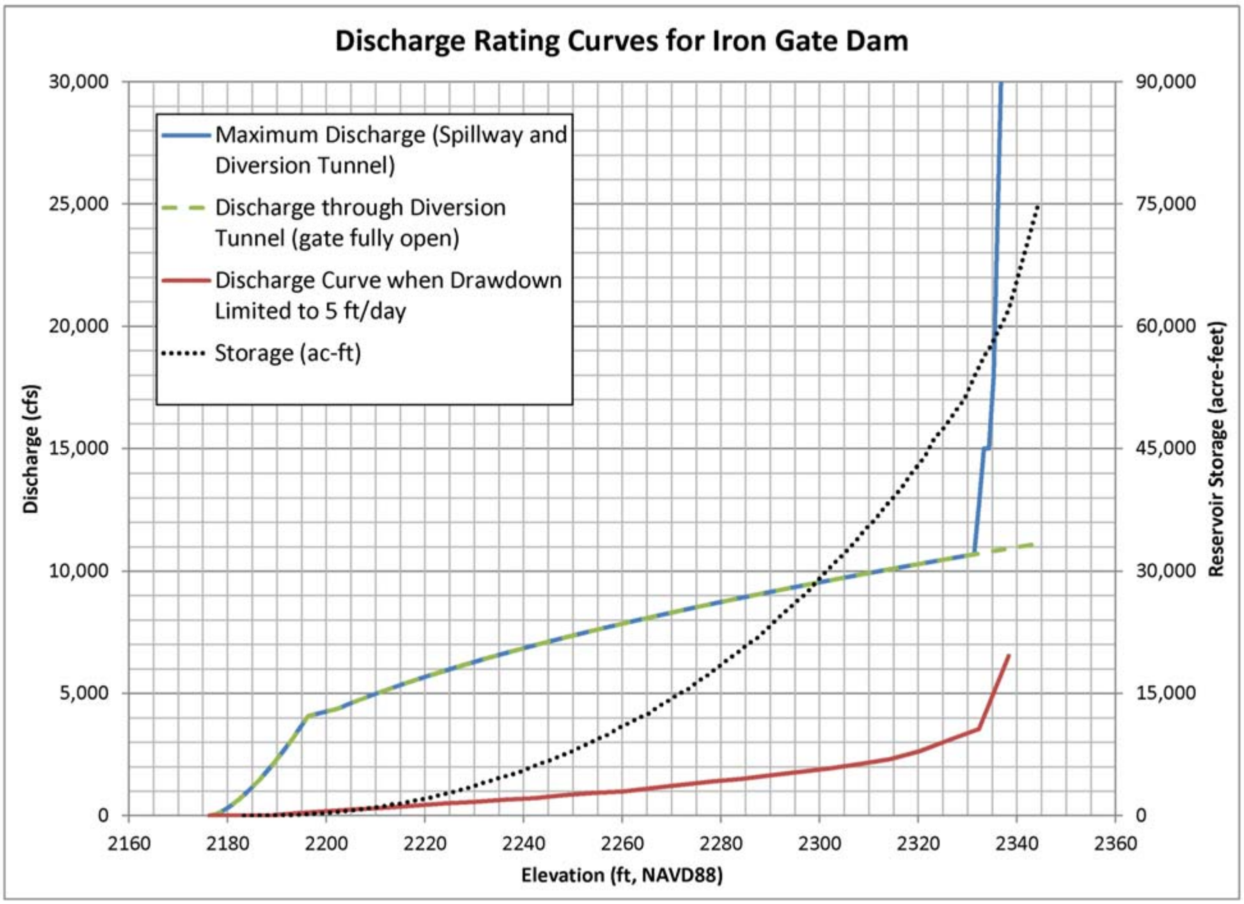


Figure 4.2-7 Discharge Rating Curve and Stage-Storage Curve for Iron Gate

A detailed description of the Iron Gate diversion tunnel modifications includes the following:

1. Design, fabricate, and deliver new 16.5- by 18-foot roller gate.

2. With the existing gate closed, remove downstream stoplog structure and miscellaneous metalwork from downstream tunnel in the dry. Maintain air vent pipe in tunnel crown if needed for final operation. Securely bolt existing blind flange to the reinforced concrete ring downstream of the concrete sluice gates (see Figure 4.2-8(B)) to retain full reservoir head. A preliminary assessment indicates the existing features would be capable of accommodating this loading condition and will be verified prior to construction.
3. Raise upper sluice gate slowly to fill portion of downstream tunnel between the gates and blind flange. Provide air vent and drain valve through downstream concrete ring as necessary. Close air vent when filling has been completed.
4. Mobilize a barge-mounted crane onto the reservoir in June of the year prior to drawdown. Raise the upper sluice gate to top of control tower using the existing hoist and remove using barge-mounted crane. Send hard-hat divers to the bottom of wet-well shaft to install lifting device for lower diversion gate, and to cut welded connection along downstream seal of lower diversion gate. Raise the lower diversion gate to the top of the control tower using existing hoist and remove using barge-mounted crane. Install new 16.5- by 18-foot roller gate into existing slots in gate shaft (with a 160-foot design head) using hard hat divers and barge-mounted crane. Install new gate operator with remote controls. Close new roller gate.
5. With new roller gate closed, drain downstream tunnel using air vent and drain valve provided at the blind flange. Remove blind flange and reinforced concrete ring.
6. Inspect the downstream portion of the diversion tunnel for possible reinforcement (lining with shotcrete or concrete) or repairs (see Figure 4.2-8(B)).
7. All work inside the tunnel would be performed in the same manner described for Copco No. 1 (Option 1) in Section 4.2.2.1.

Figure 4.2-8 Iron Gate Diversion Modification (Appendix B)

4.2.4 Drawdown Controls

The drawdown of Copco No. 1 and Iron Gate reservoirs would be managed through automated gate control systems with operator oversight. Inputs to determine the amount of gate opening at each reservoir would include continuous measurement of reservoir levels by remote sensor. The gate control system would incrementally open (or close) the gate to increase (or decrease) flow through the diversion tunnel to maintain the reservoir drawdown at an approximate constant rate (see Sections 3.2 and 3.3 for drawdown rates recommended to maintain embankment and reservoir rim stability) as the inflows vary due to watershed response to storms or due to changes in drawdown rates of upstream reservoirs.

Once the Copco No. 1 and Iron Gate reservoirs have reached full drawdown, the gates would remain in the full open position to limit reservoir refilling during storm events following March 1 of the drawdown year (or any time after the point that full drawdown is reached, if that occurs sooner). Storm inflows large enough to cause refilling of the reservoir would pass through the spillway (or through a notch in the case of Copco No. 1 notching option).

It was assumed for this analysis that the gates on the diversion tunnels would temporarily be closed during a large storm event once outflow over the spillway reached a pre-determined discharge level. The gates would be allowed to fully open again once discharge over the spillway dropped back below the pre-determined level. At Copco No. 1, this was assumed to be 13,000 cfs (between the 10-year and 20-year events) to help prevent downstream flooding of the Copco No. 2 powerhouse. At Iron Gate Dam, the discharge level was set to 15,000 cfs, which is just above the 10-year peak flow.

The drawdown on J.C. Boyle Reservoir would controlled by the spillway and then the capacity of the power intake. Once the reservoir stabilizes with spillway and intake fully open, the diversion culvert concrete stop logs in the culverts would be blasted, and flow would only be controlled by the capacity of the culverts, which is about 6,000 cfs at the spillway elevation (between the 2 and 5-year events). For storm flows that refill the reservoir before deconstruction, higher discharge rates would be experienced over the spillway.

4.3 Flood Frequency Analysis

Flood frequency analyses were performed at four locations on the Klamath River using the USACE HEC-SSP software (V2.1), following the Bulletin 17B method for Log-Pearson Type III distributions (USGS 1982)[10]. Details of the gages are provided in Table 4.3-1. J.C. Boyle and Copco records correlate well with the Keno data. Therefore, the records at J.C. Boyle and Copco were extended based on linear correlations with USGS gauge data at Keno to allow for a coincident period of analysis. Appendix F provides the correlations used to extend the data. A good correlation with Keno data was not obtained for Iron Gate gage, likely due to significant tributary inflows. Therefore, the historical period of record (1960 to 2017) was used for Iron Gate.

Table 4.3-1 U.S. Geological Survey Streamflow Gaging Stations Analyzed

USGS Gaging Station No.	Station Name	Drainage Area (mi^2)	Latitude	Longitude	Gage Elevation (feet, NGVD29)	Period of Record (Water Years)
11509500	Klamath River at Keno, OR	3,920	42°08′00″	121°57′40″	3,961	1905-1913 1930-2016
11510700	Klamath River below John C. Boyle Power Plant near Keno, OR	4,080	42°05′05″	122°04′20″	3,275	1959-2016
11512500	Klamath River below Fall Creek near Copco, CA	4,370	41°58′20″	122°22′05″	2,310	1924-1961
11516530	Klamath River below Iron Gate Dam, CA	4,630	41°55′41″	122°26′35″	2,162	1961-2016

[10] Log-Pearson Type III distributions are intended to fit the distribution of annual peak flows from natural watersheds (i.e., non-regulated watersheds). The Klamath Basin is highly regulated for irrigation water supplies and fishery flows, but the regulated flows primarily describe low flows (non-storm event flows) as there are no flood control reservoirs in the basin. We found that after ignoring the low flows in the data, the annual peak flow data fit well with the Log-Pearson Type III distribution.

USGS Gaging Station No.	Station Name	Drainage Area (mi^2)	Latitude	Longitude	Gage Elevation (feet, NGVD29)	Period of Record (Water Years)
11520500	Klamath River near Seiad Valley, CA	6,940	41°51’14”	123°13’52”	1,320	1913 - 2016
11523000	Klamath River at Orleans	8,475	41°18’13”	123°32’00”	355.98	1927 - 2016
11530500	Klamath River near Klamath, CA	12,100	41°30’40”	123°58’42”	5.60	1861 - 2016

Flows in the Klamath River are controlled by releases from Upper Klamath Lake and Link River Dam. The operations at Link River Dam could influence the flood frequency curves calculated using the USGS gage data. Plots of the flood-frequency curves were compared before and after censoring peak flow data to determine if there was a low flow threshold below which flows did not fit the distribution well. For all locations except J.C. Boyle, the data visually appeared to fit within the 95 percent confidence limit of the distribution. Therefore, only the J.C. Boyle data were censored. Flows below 3,400 cfs were censored as low flow outliers. The Bulletin 17B procedures adjusted the probabilities to account for the censored data. The results are shown in Table 4.3-2. Plots of the data and distributions can be found in Appendix F.

Table 4.3-2 Annual Flood Frequency Results

Location	2-Year	5-Year	10-Year	20-Year	50-Year	100-Year	200-Year	500-Year
Keno	4,329	6,957	8,830	10,699	13,210	15,156	17,152	19,872
Blw J.C. Boyle [1,2]	4,736	7,719	9,438	10,862	12,405	13,370	14,194	15,104
Blw Fall Creek nr Copco[2]	5,974	9,114	11,340	13,567	16,580	18,937	21,377	24,742
Below Iron Gate	5,942	10,895	14,912	19,295	25,744	31,169	37,106	45,796
Seiad Valley	16,418	34,673	52,002	73,229	108,545	141,806	181,736	246,577
Orleans	61,712	114,819	157,209	202,710	268,332	322,432	380,576	463,907
Klamath	140,056	239,890	313,456	388,200	490,163	570,125	652,719	766,069

[1] Flows below 3,400 cfs were censored as low flow outliers due to the influence of Link River Dam.

[2] The gage record was extended to cover 1932 to 2017 based on the flows measured at the Keno gage.

4.4 Drawdown Timing

The surrender application proposes the simultaneous removal of the four dams with the dewatering periods scheduled to minimize sediment release into downstream areas during critical times for important aquatic species and life stages (e.g., anadromous fish spawning, rearing, and in- and out-migration). The deconstruction period, including site preparation, dewatering, and facilities removal, would occur over about 20 months. The 2012 EIS/EIR prepared in support of the original KHSA states that the drawdown period could vary depending on water year type, with longer drawdowns occurring during wet years and shorter drawdowns during dry years.

To reduce the uncertainty regarding the length of time over which flows with high suspended sediment concentrations would occur and potentially negatively affect aquatic resources, the Definite Plan includes an updated approach to the drawdown at Copco Lake. This updated approach (Option 2 summarized in Section 4.2) dewaters the reservoir via an upgraded diversion tunnel, and no longer relies on dam notching to complete the drawdown. With the dam notching proposed in the 2012 EIS/EIR, wet water years could have caused delays in the notch progression. In wet years, the Contractor would need to wait for the water level to drop below the crest to enable equipment access to the notch area to complete the next notch. These delays can be seen in the modeling results discussed further in Section 4.5.

Relying on the diversion tunnel at Copco No. 1, rather than notching, significantly increases the likelihood that drawdown, or at least an initial drawdown, would occur by the end of February, thus releasing the majority of suspended sediment during that period and reducing the likelihood of high suspended sediment concentrations after March 15. An assessment of the extent to which a wet year effects the drawdown duration is discussed with the modeling results in Section 4.5.

Due to the improvement of the probability of drawdown being completed within the January 1 to March 15 time period, the potential effects on downstream environmental resources by deconstruction implementation during a wet year is considered to be similar to potential effects in a normal water year.

With the updated drawdown approach at Copco No. 1, the probability of an increase in the cost of deconstruction due to the occurrence of a wet year is significantly reduced because drawdown is much less likely affected by high flows. In the proposed construction schedule, the embankment removal at Iron Gate Dam and J.C. Boyle Dam and the concrete removal at Copco would all start in May or June and be completed by October, months when high flows have receded in most years. The embankment removal schedules assume that the minimum embankment height maintained through removal will accommodate a 0.01 chance storm plus 3 feet of freeboard in any given month. If a wet year were to delay the start of embankment or concrete removal to July, the Contractor would increase productivity to complete the removal on time. The cost implications of an unplanned increase in productivity will be captured by the cost analysis included in Section 9.

Based on the discussions and analyses summarized above, the current drawdown schedule minimizes the release of sediment during the previously identified critical times for important species and life stages.

4.5 Reservoir Drawdown Releases

The following sections describe how the diversion facilities will be used to drawdown the reservoirs and release sediment, the timing of the discharges, the range of discharge rates anticipated, the portion of discharge associated with specific structures, and the change in reservoir elevation per day.

Copco No. 2 Dam does not impound a significant volume of sediment and would be removed during the same year as the three larger dams. Drawdown of Copco No. 2 Reservoir would not be necessary until after Copco No. 1 Dam has been breached to final grade. No drawdown rate limitations would apply to the removal of Copco No. 2 Dam.

Reservoir drawdown rates at Iron Gate, Copco, and J.C. Boyle (until diversion culverts are opened) will be limited to 5 feet per day (see Sections 3.2 and 3.3); however, the actual drawdown rates may be less (or negative) during storm periods because of increased inflows to the reservoirs. To provide information on the range of flows that are likely to be released from the reservoirs during drawdown, an analysis of the reservoir drawdown for water years 1961 through 2009 was completed. The purpose of this analysis was to provide information on the following points.

1. Anticipated discharges from each reservoir to the Klamath River in cfs associated with reservoir drawdown operations
2. Description of structures used for reservoir drawdown operations including the flow (cfs) anticipated for each structure during drawdown operations
3. For notching, a description of the dimensions and elevations of the notches
4. Timing of reservoir drawdown operations
5. For each reservoir, confirmation on proposed reservoir elevation change per day

The range of likely additional outflow due to reservoir drawdown is provided in Table 4.4-1. For the modeling, the starting elevations of Iron Gate and Copco No. 1 were assumed to be at the spillway crest on January 1.[11] The starting elevation at J.C. Boyle was assumed to be the normal operating elevation on January 1.

The maximum drawdown rate is set at 5 feet per day until drained, and the minimum drawdown rate assumes it takes 59 days to drain the reservoir (January 1 to February 28). These flows would be in addition to the flows in the river that are released from Keno Reservoir and contributed by tributaries. For comparison, the percent of average and maximum flows in the Klamath River for January and February are also provided in Table 4.4-1.

For J.C. Boyle, the increase in flow to the river due to drawdown is expected to be from less than 1% up to 8%. For Copco No. 1, the increase is expected to be between 2% and 33%, and for Iron Gate the increase is expected to be between 3% and 23%. Note the minimum drawdown rate would likely occur during periods with large storm events, so the increase in flow would be closer to the 1 to 3% range during a storm event (see Column 6 in Table 4.4-1).

[11] Copco Lake drawdown from normal operating elevation is assumed to begin on November 1 (prior to the January 1 drawdown process). The period from November 1 to January 1 is assumed sufficient to draw down from normal operating elevation to the spillway crest elevation (approximately 12.5 feet) with a maximum historic drawdown of 2 feet per day. The Copco Lake modeling starts on January 1 with the reservoir elevation at the spillway crest.

During dry periods the reservoirs can be drawn down quicker, resulting in a larger percent increase in flow to the river, but since the river flows are relatively small, the impacts are not necessarily greater (see column 8 in Table 4.4-1). For comparison, the 2-year flood event at Keno is 4,400 cfs and at Iron Gate is 6,000 cfs. The 5-year flood event at Keno is 7,000 cfs and at Iron Gate is 10,900 cfs. Compared to these flood events, the incremental increase in flow due to reservoir drawdown in minimal.

Table 4.5-1 Range of Release Flows from Reservoirs due to Drawdown

Reservoir	Depth (feet)	Volume (acre-feet)	Minimum average release flow (cfs)[1]	% of Average flow in Klamath River [3]	% of Maximum Flow in Klamath River[4]	Maximum average release flow (cfs)[2]	% of Average flow in Klamath River [3]	% of Maximum Flow in Klamath River[4]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
J.C. Boyle	41.5	2267	19	0.5%	0.1%	191	5%	1%
Copco	111.5	33724	288	8%	1%	762	22%	4%
Iron Gate	155.0	50941	435	12%	2%	810	23%	4%

[1] Minimum assumes 59 days to drain reservoir
[2] Maximum assumes continuous 5 feet per day drawdown
[3] Based on average release from Keno in January and February of 2,270 cfs and additional 1,261 cfs inflow to Iron Gate
[4] Based on maximum release from Keno in January or February of 14,300 cfs and additional 7,388 cfs inflow to Iron Gate

4.5.1 Detailed Modeling

Detailed analysis of the drawdown was conducted using the USACE Hydrologic Engineering Center River Analysis System (HEC-RAS) model (version 5.0.3). The model was used to calculate flows and water levels due to the drawdown of J.C. Boyle Reservoir, Copco Lake, and Iron Gate Reservoir. For modeling stability purposes, the Klamath River was divided into two modeling reaches. Reach 1 covers the J.C. Boyle Reservoir and extends from approximately 1 mile upstream of J.C. Boyle Reservoir to approximately 0.4 miles downstream of J.C. Boyle Dam. Reach 2 extends from approximately 1.5 miles upstream of Copco Lake to approximately 0.6 miles downstream of Iron Gate Dam.

The HEC-RAS model requires inputs for topography/bathymetry, inflow rates, and rating curves for dam outlets. Input sources and data are discussed in the following sections.

4.5.1.1 Topography/Bathymetry

The cross-section bathymetry in the HEC-RAS model was generally obtained from the SRH1-D model provided by the USBR. The data were representative of Scenario 8 in USBR (2012). The bathymetry data extended from above J.C. Boyle to the ocean, however only the data for the two reaches listed above were used.

4.5.1.2 Inflow Rate

Inflow data based on the Klamath Basin Restoration Agreement (KBRA) flows were used as river flows (Keno flows).[12] These flows were obtained from the SRH1-D model input files (USBR 2012c). The data were compared to the measured flows at the USGS gage at Keno (gage no. 11509500, Klamath River at Keno, OR). Figure 4.4-1 compares the USGS measured data at Keno to the SRH1-D data used in the model. As seen in the figure, the Keno flows closely follow the measured flows at the USGS Keno gage but some of the variability has been "smoothed" out as during non-storm periods when the Keno flows are relatively constant by month. During large storms the Keno flows data occasionally have a sharp peak that exceeds the USGS measured flows. These sharp peaks generally last a few days. During the winter (January – April) when drawdown will occur, the flow frequency curve for the flows used in the model and the measured USGS flows are very similar. The data prior to 1969 appears to be time shifted or mislabeled by approximately 1 year.

Water years 1961 through 2009 were simulated in the model. Results are presented for six years representative of the various conditions that could occur during construction (results for the other years are provided in Appendix F). All simulations started on January 1 with J.C. Boyle at normal operating elevation and Copco Lake and Iron Gate reservoirs full to the spillway crest elevation. It is possible that during construction, water levels could be lower or higher depending upon the hydrologic conditions that occurred in the preceding December. The six years selected for discussion are summarized below:

- 1965: Largest storm of record occurred between December 1964 and April 1965 (Corresponds to water year 1966 in the SRH1-D and HEC-RAS output)
- 1970: Years drier than 1970, based on ranking the maximum 15-day volume of flow between January and May at Keno, drained by March 1
- 1973: The median year based on ranking the maximum 15-day volume of flow between January and May at Keno
- 1979: Representative dry year
- 1986: Representative wet year
- 2006: Representative wet year

[12] The 2013 Joint Biological Opinion for USBR's Klamath Project (NMFS and USFWS 2013) modified the flows from the 2010 KBRA. The 2013 Joint Biological Opinion slightly increases the annual average water supply by about 9 thousand acre feet when compared with the KBRA Flows, and it maintains higher minimum summer flows in dry years. The changes to flows in January and February (during drawdown) are negligible. The small changes to flows in the 2013 Joint Biological Opinion will not affect the drawdown of the reservoirs, nor the level of flows released during drawdown. NMFS and USFWS are working on a new Joint Biological Opinion to be released in 2019, which may again alter flows released by USBR's Klamath Project.

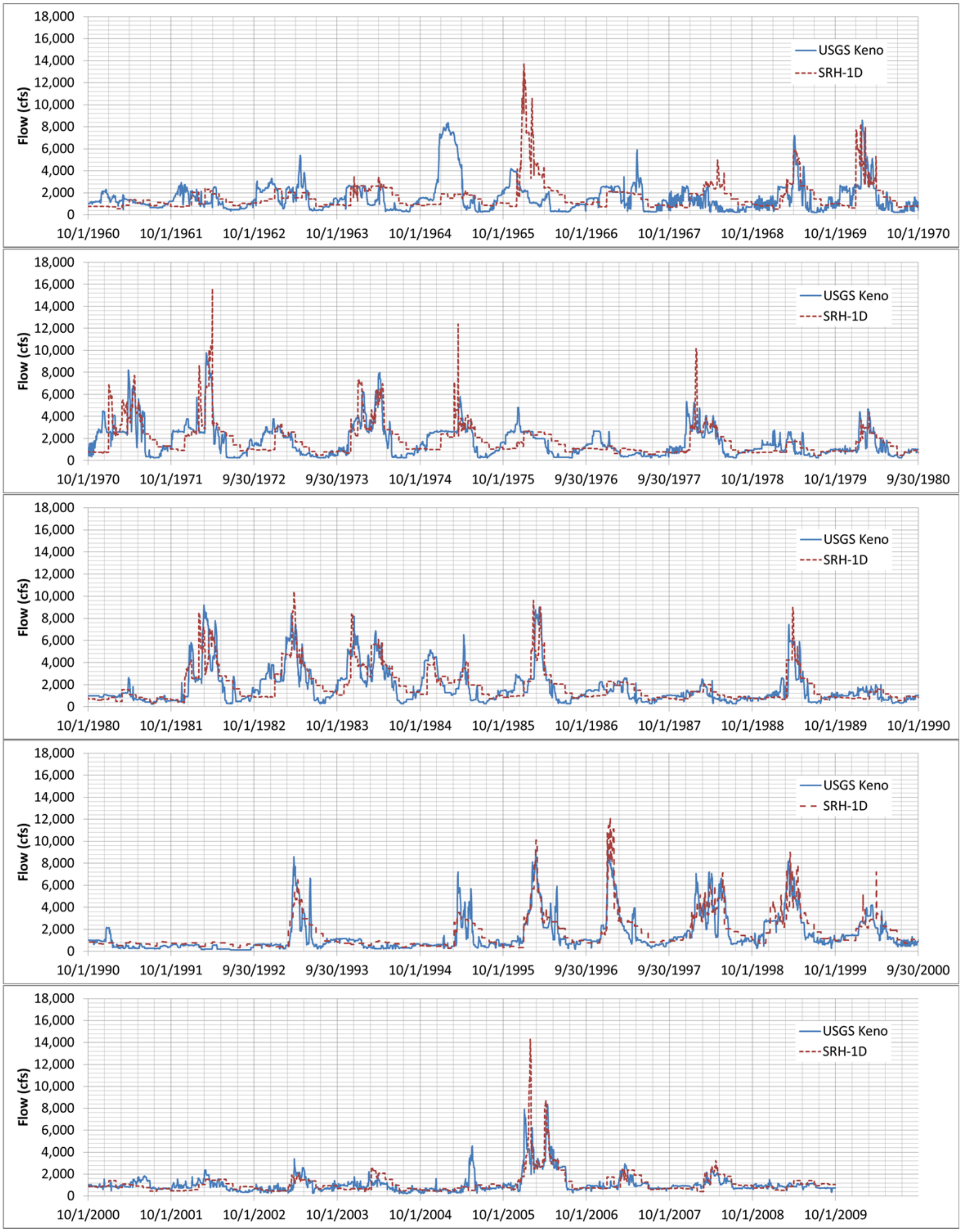


Figure 4.5-1 Comparison of Gaged Flows at Keno to Modeled Flows in SRH-1D

4.5.2 J.C. Boyle Reservoir

4.5.2.1 Drawdown Procedure

The drawdown procedure at J.C. Boyle is summarized in the numbered list below:

1. Reservoir drawdown would begin on January 1 of the drawdown year, by making controlled releases through the gated spillway (crest elevation 3785.2) and the power intake (invert elevation 3771.7). Additional discharges to the river during drawdown using the spillway and power canal would be on the order of the values shown in Table 4.4-1 but these would be short term. Once the reservoir drawdown elevation (dependent on base inflow) stabilizes with both the spillway and power intakes fully open, the reservoir elevation would be held for about a week. However, because of the minimal storage available above the power intake invert, the water level in the reservoir would fluctuate in concert with the changing inflow. The maximum flow through the power intake is about 2,800 cfs. About 25% of years have an average flow in January greater than 2,800 cfs and almost 40% have a maximum flow greater than 2,800 cfs. Flows above about 2,800 cfs will go over the spillway.
2. With the reservoir at the lowest possible level (depending upon inflow) using spillway and power intake, drawdown would continue by removing the concrete stoplogs from one 9.5- by 10-foot bay of the 2-bay diversion culvert (invert elevation 3755.2) by blasting, if necessary.[13] There is relatively little storage below the spillway crest elevation compared to storm volumes, so the elevation will change rapidly with changes in inflow rate. Additional drawdown releases would rapidly increase to a maximum of about 3,000 cfs for a short duration dropping back to near the inflow value over a period of a few hours. For reference, the 2-year and 5-year flow events downstream of J.C. Boyle Dam are 4,736 cfs and 7,719 cfs, respectively. The reservoir elevation would be allowed to stabilize and be held for one to two weeks to allow dissipation of pore pressures in the embankment and the reservoir rim.
3. With the reservoir at the lowest possible level (depending upon inflow), drawdown would continue by removing the concrete stoplogs from the remaining two 9.5- by 10-foot diversion culverts (invert elevation 3755.2) by blasting, if necessary.[14] Additional drawdown releases would rapidly increase to a maximum of 1,000 to 2,000 cfs for a short duration dropping back to the inflow value over a period of about an hour or less. This would provide the maximum reservoir drawdown possible prior to removal of the dam embankment section, except for the natural drawdown resulting from the subsequent reduction of streamflow. The reservoir drawdown should be completed by January 31of the drawdown year, to minimize potential impacts at the downstream dam removal sites. The potential formation of reservoir ice in January at this site is assumed to not impact reservoir drawdown significantly during this period. Reservoir releases at the dam would be maintained below any ice cover.
4. The timing of the removal of the stoplogs from either diversion culvert will take into consideration inflow conditions with a possibility of shifting stop log removal to avoid

[13] For modeling purposes, the 1st culvert is opened on January 14.
[14] For modeling purposes, the 2nd culvert is assumed to be opened on February 1.

contributing additional flow during very high flow conditions. The power intake gate would be closed once the reservoir is drawn down below the intake invert or following removal of the stoplogs from the second bay of the diversion culvert, whichever is earlier, and the canal would be drained through the powerhouse turbines not through the forebay spillway.

4.5.2.2 Results

Figures 4.4-2 through 4.4-7 show results from the HEC-RAS analysis for the six representative years discussed above. Because of the small size of the J.C. Boyle Reservoir, the reservoir will refill partially or completely during a storm until dam removal is complete. The capacity of the two diversion culverts for water levels below the spillway elevation is about 5,700 cfs. About 15% of the years are expected to have a maximum January or February flow that exceeds 5,000 cfs and will result in reservoir refilling and associated flows over the spillway.

During the representative drier years (1973 and 1979, see Figures 4.4-6 and 4.4-7), the reservoir was easily drawn down in January, and it did not refill after that point.

During the wetter year of 2006 and 1986 (see Figures 4.4-3 and 4.4-4), the reservoir was completely drawn down early (January to mid-February), but quickly refilled later in the year when storms occurred. The majority of the accumulated sediment would mobilize during the initial drawdown, and subsequent reservoir filling and drawdown is expected to cause only moderate increases in high suspended sediment (relative to background) (USBR 2012c).

For the wettest year (1966[15], see Figure 4.4-2) the reservoir was mostly drawn down by March, but did not completely drain until April. This is the only wet year that did not allow for complete drawdown before March, so there is a relatively low risk of this occurring during drawdown. In addition, it is likely that the majority of accumulated sediment was evacuated prior to March in that year.

For all water years, any increase in peak outflows flows with drawdown compared to peak flows without drawdown is small due to the relatively limited amount of attenuation associated with the existing reservoir.

It is not anticipated that sediment concentrations resulting from the proposed drawdown procedure and associated hydraulics, would differ from those previously estimated (USBR 2012c).

[15] Largest storm of record occurred between December 1964 and April 1965 in WY1965, but due to the data shift noted in Section 4.4.1.2, this corresponds to WY1966 in the modeling.

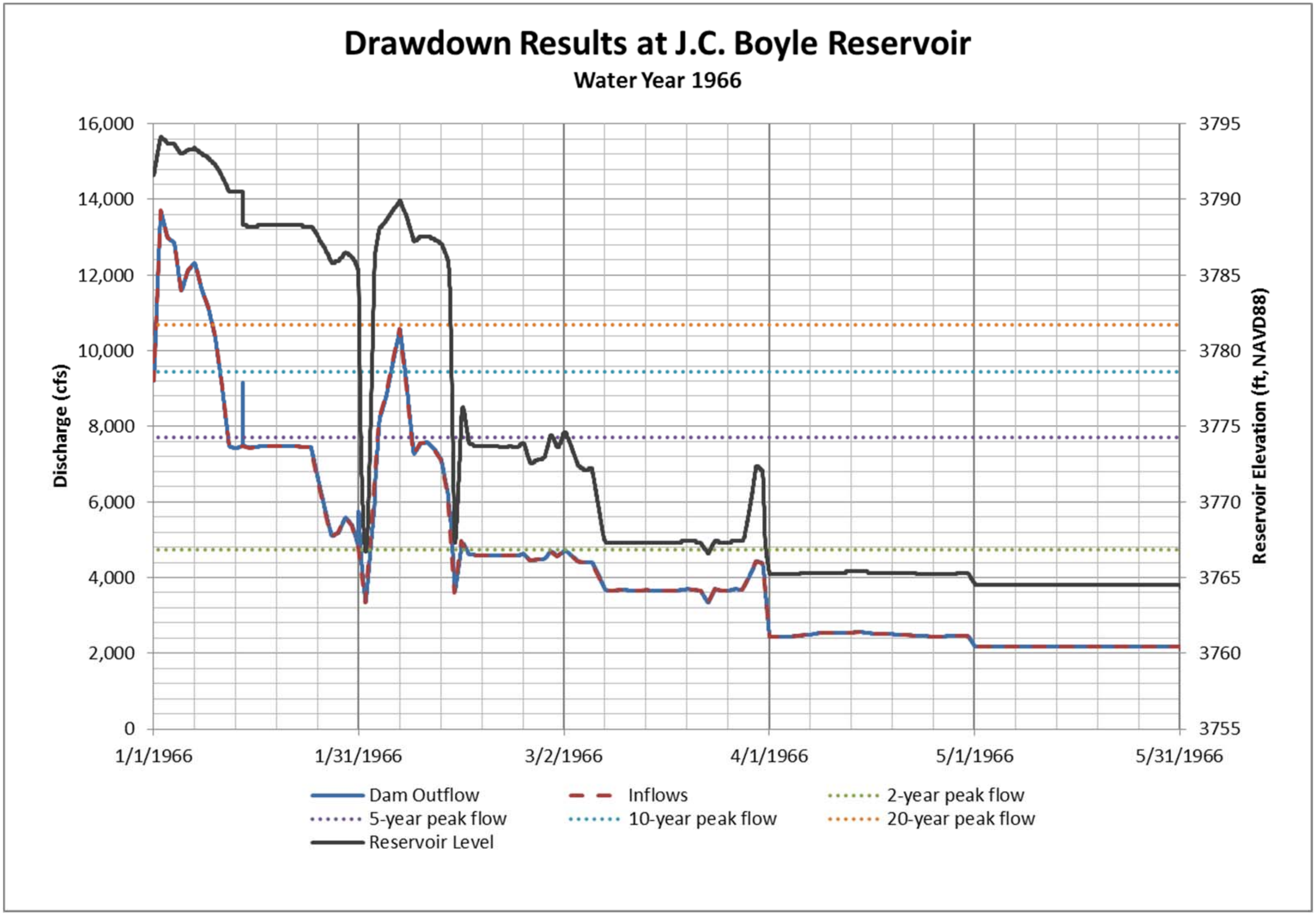


Figure 4.5-2 J.C. Boyle Reservoir Drawdown, Water Year 1966 (Wettest Year)

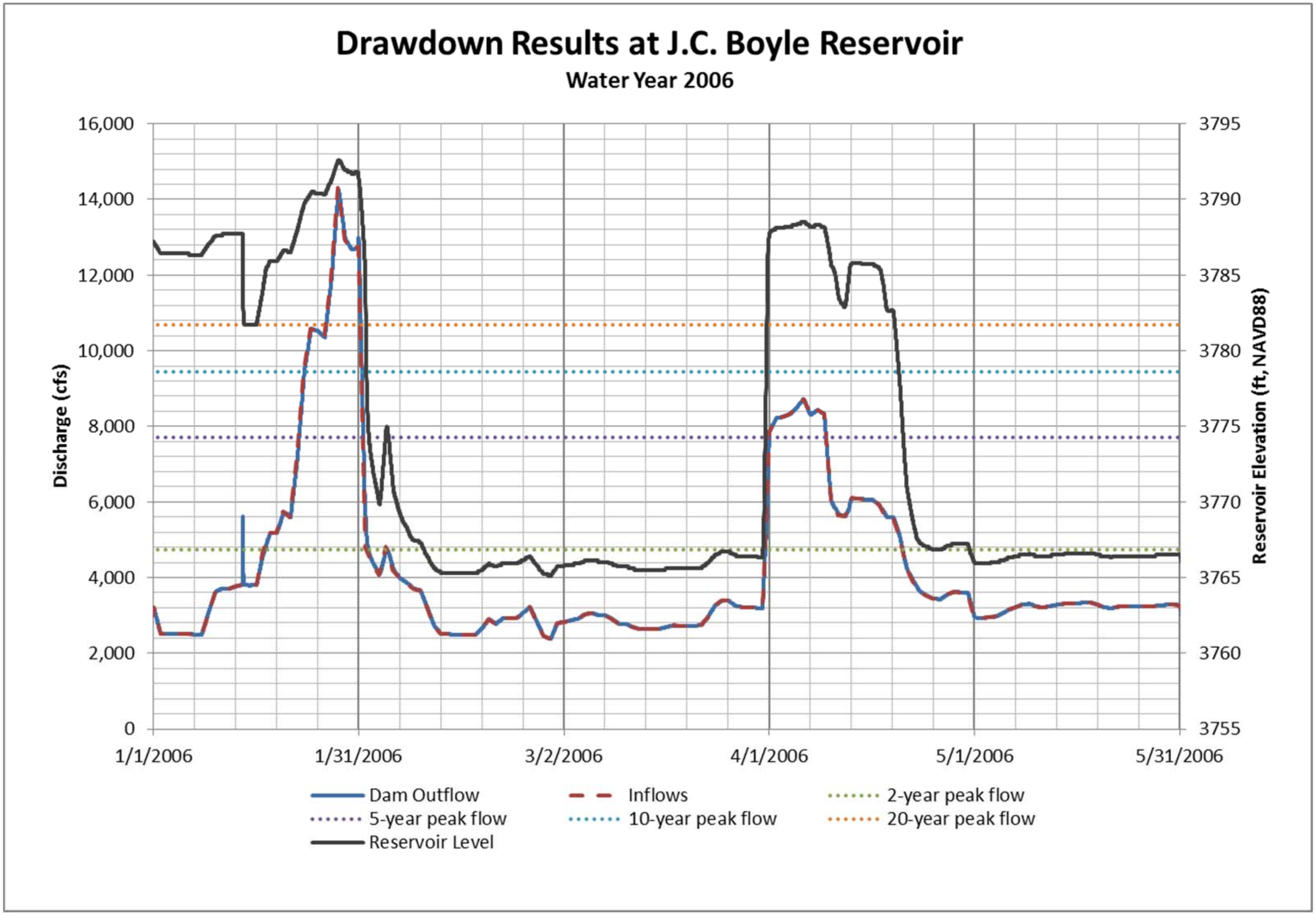


Figure 4.5-3 J.C. Boyle Reservoir Drawdown, Water Year 2006 (Wet Year)

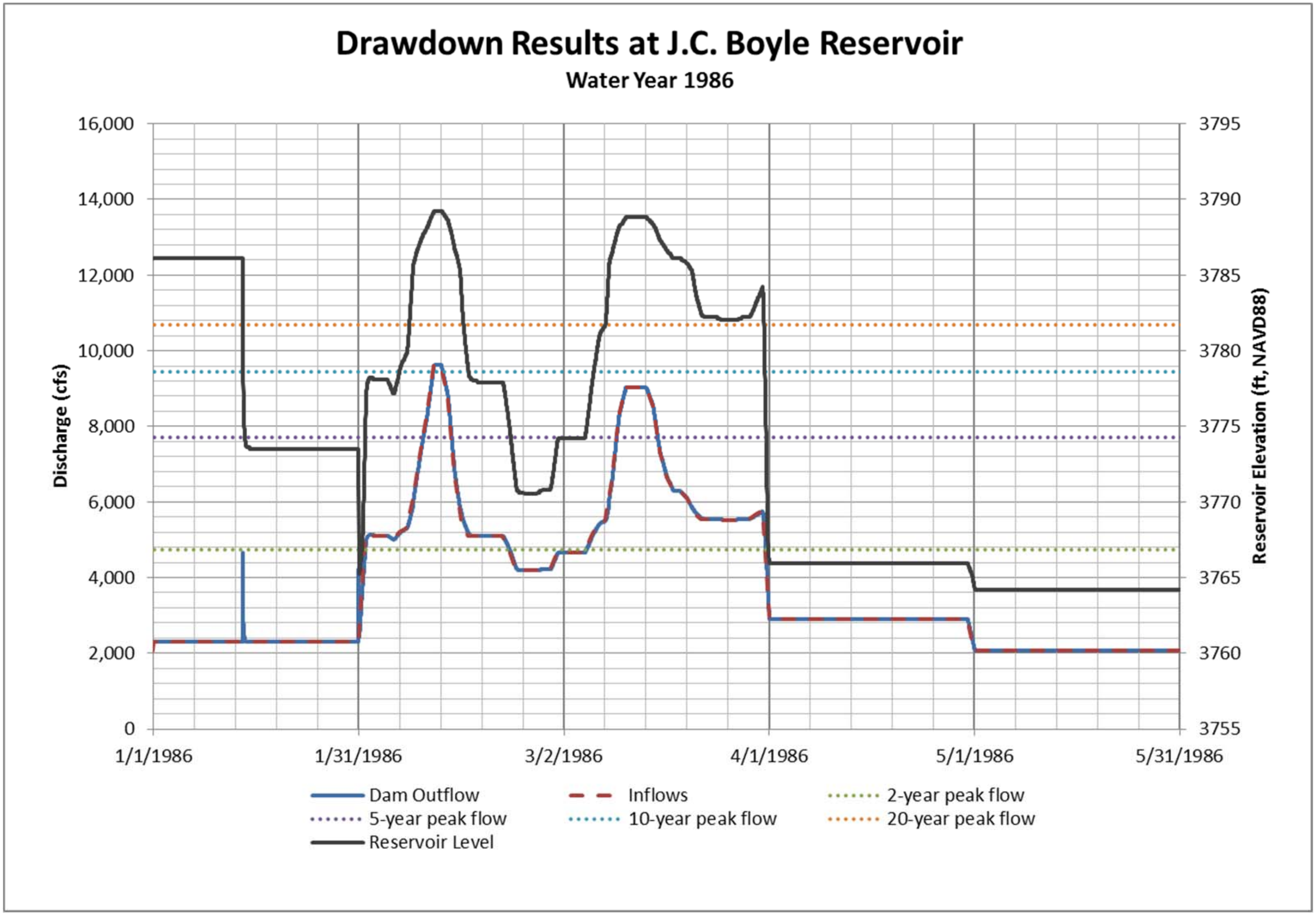


Figure 4.5-4 J.C. Boyle Reservoir Drawdown, Water Year 1986 (Wet Year)

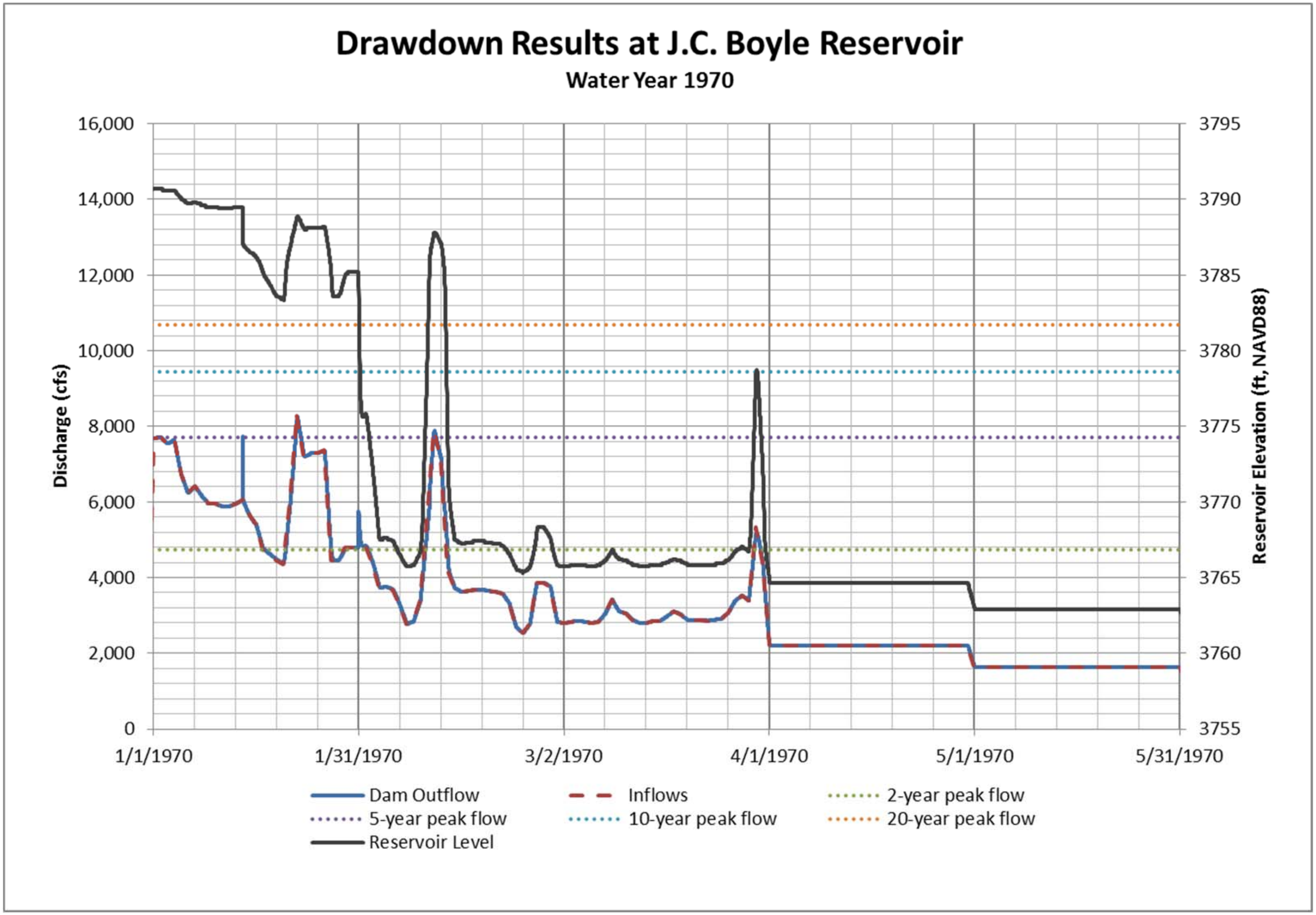


Figure 4.5-5 J.C. Boyle Reservoir Drawdown, Water Year 1970 (Above Normal Year)

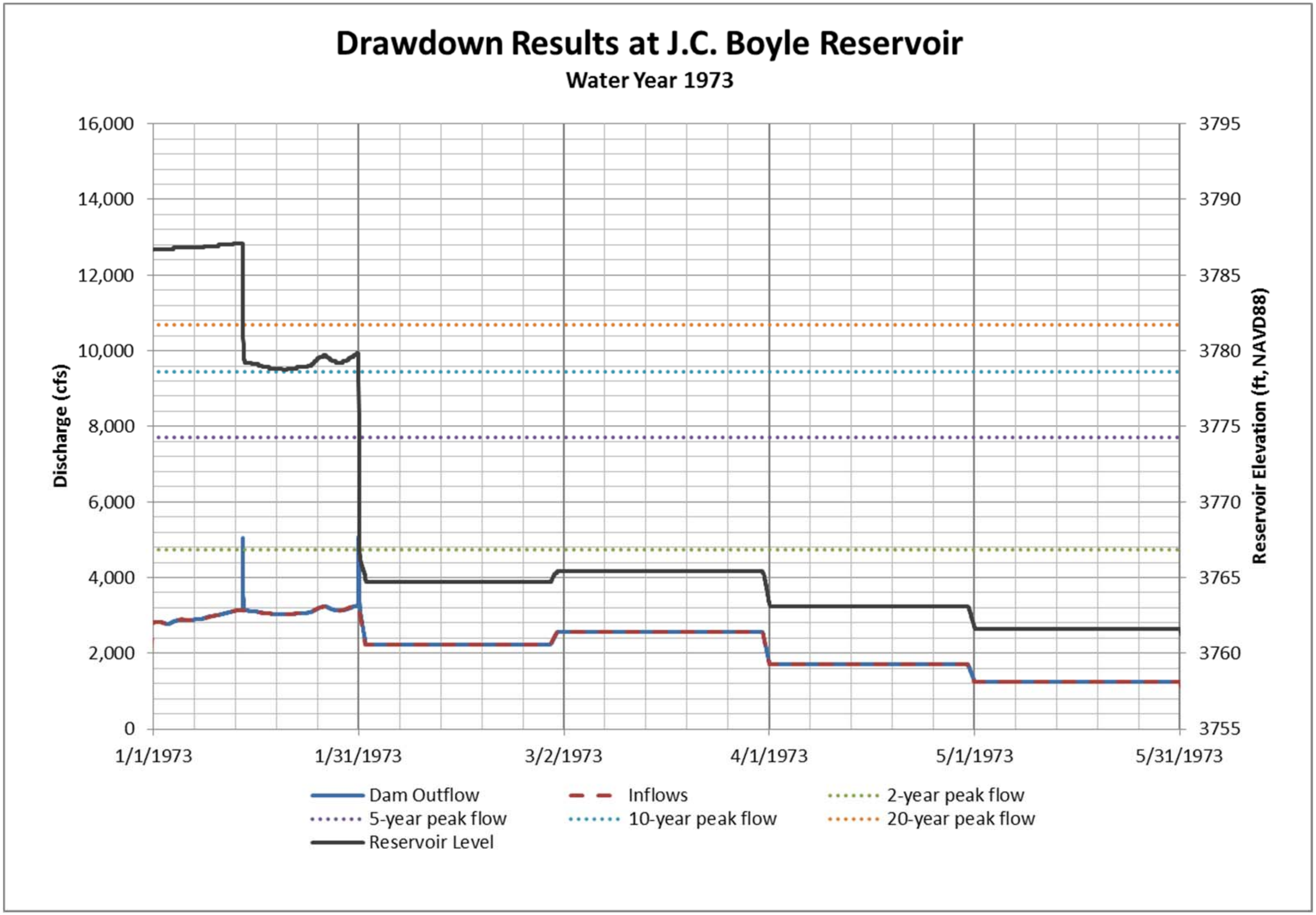


Figure 4.5-6 J.C. Boyle Reservoir Drawdown, Water Year 1973 (Normal Year)

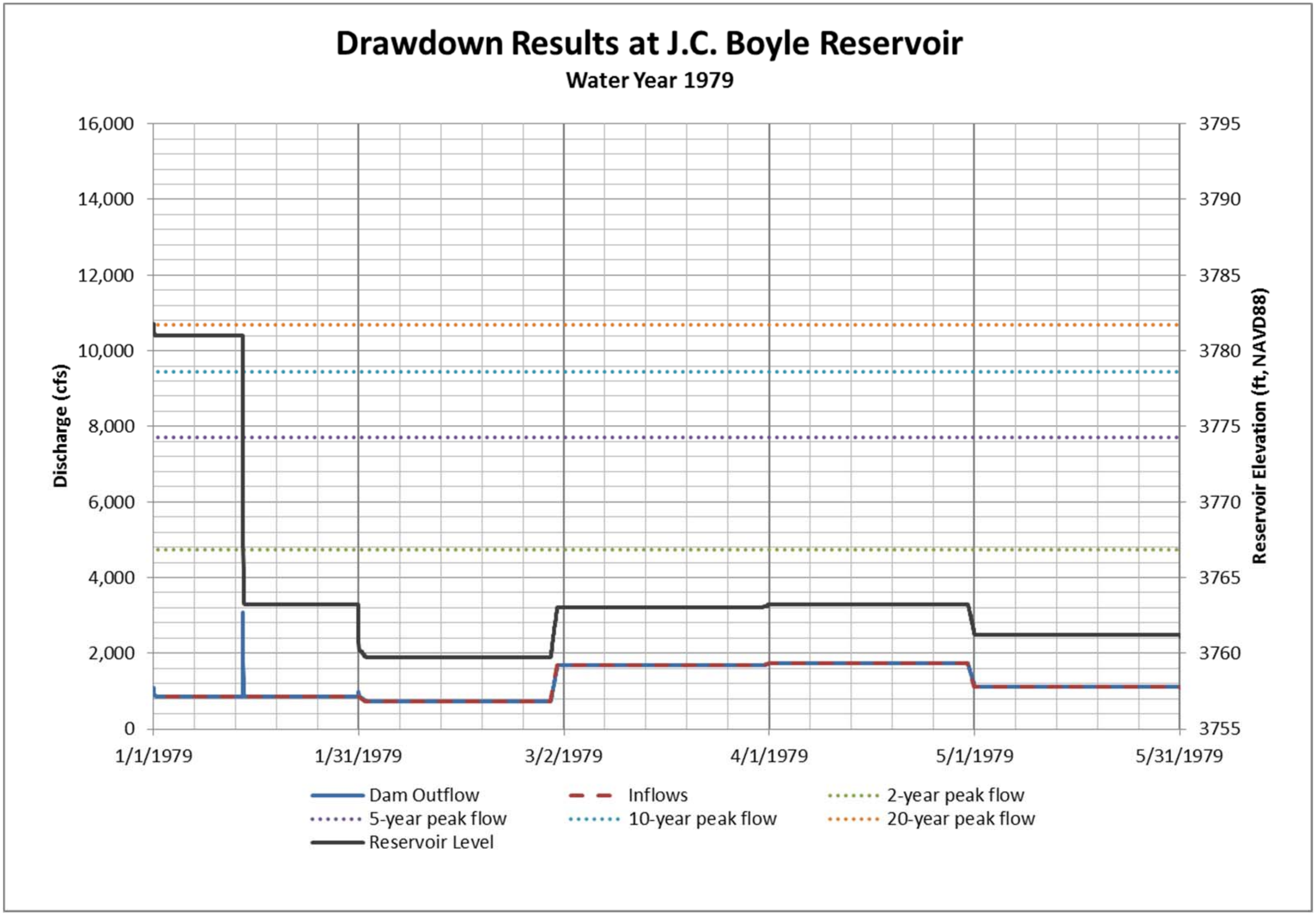


Figure 4.5-7 J.C. Boyle Reservoir Drawdown, Water Year 1979 (Dry Year)

4.5.3 Copco Lake

4.5.3.1 Drawdown Procedure

Drawdown of Copco Lake is discussed separately for the two tunnel modification options described in Section 4.2.2.

Option 1 – Diversion Tunnel Modified to Restore Capacity and Dam Notching:
The drawdown procedure at Copco Lake for Option 1 is summarized in the numbered list below:

1. Begin reservoir drawdown from normal operating elevation 2609.5 feet on November 1in the year prior to the main drawdown by making controlled releases through the gated spillway (crest elevation 2597.0) and from the modified diversion tunnel. Continue releases to the powerhouse for power generation for as long as possible (minimum operating elevation 2604.5), although plant shutdown on November 1 has been assumed. Limit initial reservoir drawdown to the maximum historical drawdown rate of about 2 feet per day. No significant sediment release is expected for this upper range of reservoir levels and rate of drawdown.
2. Once drawdown has begun, remove spillway features using a barge mounted crane (see Section 5.3).
3. Starting January 1 of the drawdown year, make controlled releases from the modified diversion tunnel. Limit reservoir drawdown to a maximum of 5 feet per day to maintain reservoir rim slope stability and to control drawdown releases from both reservoirs upstream of Iron Gate. Due to the limited capacity of the diversion tunnel modified to reuse the three 6-foot openings in the intake structure, the reservoir drawdown rate and reservoir elevation would be highly dependent on reservoir inflows, with full reservoir drawdown by March 1 not possible for about 50 percent of historical flows between 1961 and 2008 (USBR 2012c).
4. To fully draw down the reservoir, notch the concrete dam with a series of 13 notches: an initial 24.5-foot notch, followed by 11 18-foot deep notches (measured from lowered dam crest to notch elevation; sequentially lowering the notches in 6 foot increments), then a final notch of 22 feet down to the channel bed elevation. Proceed with lowering the dam crest in 6 foot lifts as the notching progresses. Bottom width of all notches is 8 feet. Locate the notches at the left abutment of the dam. Control instantaneous reservoir releases and drawdown rates during notching by excavating the notches in stages or by controlling the diversion tunnel discharge. The elevation of the first notch would be 2572.5 ft. The elevation of the final notch would be at elevation 2484.5 (regardless of water year) with the lowered dam crest at elevation 2518.5. Target drawing down the reservoir to RWS elevation 2486.5 (reservoir level maintained by Copco No. 2 Dam) by March 1of the drawdown year, to minimize downstream impacts due to sediment release. Retain Copco No. 2 Reservoir to permit continued power generation at the Copco No. 2 powerhouse.
5. Maximum additional discharge downstream of the dam due to drawdown activities is about 4,000 cfs immediately following opening of a notch (assuming an 18-foot-deep notch with a bottom width of 20 feet) with the additional flow due to drawdown

decreasing as the reservoir level drops in the notch. For reference, the 10-year, 20-year, 50-year, and 100-year flow events downstream of Copco No. 1 are about 11,300 cfs, 13,500 cfs, 16,560 cfs, and 18,950 cfs, respectively.

6. Successful reservoir drawdown using Option 1 is highly dependent on successful dam demolition and notching during January and February. There are several risks associated with Option 1 that need to be considered:

   a. Safety of construction workers operating on very narrow, steep access roads during winter months with wet and icy conditions.

   b. Weather impacts to production that are likely to be worse in the wettest years when reservoir drawdown will rely more notching than in dry years.

   c. During wet years complete drawdown may not occur until notching is complete. If notching is delayed, drawdown will be delayed by an equal amount. [16]

Option 2 – Diversion Tunnel Modified to Increase Capacity (no Dam Notching)

The drawdown procedure at Copco Lake for Option 2 is summarized in the numbered list below:

1. Begin reservoir drawdown from normal operating elevation 2609.5 feet on November 1in the year prior to the main drawdown by making controlled releases through the gated spillway (crest elevation 2597.0) and from the modified diversion tunnel. Continue releases to the powerhouse for power generation for as long as possible (minimum operating elevation 2604.5), although plant shutdown on November 1 has been assumed. Limit initial reservoir drawdown to the maximum historical drawdown rate of about 2 feet per day. No significant sediment release is expected for this upper range of reservoir levels and rate of drawdown.
2. Once drawdown has begun, remove spillway features using a barge mounted crane (see Section 5.3).
3. Starting January 15 of the drawdown year, make controlled releases from the new gate structure. With Option 2, drawdown releases are delayed two weeks after drawdown releases begin at Iron Gate Dam (January 1) to create additional reservoir capacity at Iron Gate, [17] which will better handle drawdown releases from Copco Lake and help attenuate outflows from Iron Gate Reservoir due to storms. Limit reservoir drawdown to 5 feet per day to maintain reservoir rim slope stability and control drawdown releases from both reservoirs upstream of Iron Gate Reservoir.
4. Maximum additional discharge downstream of the dam due to drawdown activities is about 6,000 cfs when the gate is opened on January 15. During other times the increase is generally 1,000 to 2,000 cfs. The total discharge capacity of the new gate structure with the reservoir at the spillway crest elevation 2597.0 feet is about 16,000

[16] For modeling, it was assumed a notch would be delayed if the water level was less than 1 foot below the lowered crest.
[17] Without this delay, Iron Gate Reservoir would often remain full until Copco Lake is drawdown and outflows are decreasing because the increased Copco diversion tunnel capacity is similar to the Iron Gate diversion tunnel capacity.

cfs, but would be limited to 13,000 cfs to not cause high water levels that would impact power production at Copco No. 2 powerhouse.

5. For reference, the 10-year, 20-year, 50-year, and 100-year flow events downstream of Copco No. 1 are 11,300 cfs, 13,500 cfs, 16,560 cfs, and 18,950 cfs, respectively.

4.5.3.2 Results

Figures 4.4-8 through 4.4-13 show the drawdown results for Copco No. 1 for both drawdown options.

In general, Option 1 with notching performs worse than Option 2 in terms of minimizing peak flows and drawdown duration, particularly in wet years. Therefore, it is recommended to proceed with Option 2 for Copco No. 1 drawdown, and the remainder of the results discussion will focus on Option 2.

During the representative dry years (1973 and 1979, see Figure 4.4-12 and 4.4-13), the reservoir was easily drawn down before March 1, and does not refill after that point.

For Option 2during the wetter years of 1966, 2006, 1986, and 1970 (see Figures 4.4-8 and 4.4-11), the reservoir was completely drawn down early (early to mid-February), but in some cases partially refilled later in the year when storms occurred. The majority of the accumulated sediment would mobilize during the initial drawdown, and subsequent reservoir filling and drawdown is expected to cause only moderate increases in high suspended sediment (relative to background) (USBR 2012c).

For Option 2during the wetter years of 1966, 2006, 1986, and 1970 (see Figures 4.4-8 and 4.4-11), flows are higher than what would be expected via the spillway alone (i.e., without drawdown), but the increases are limited to those periods when flows are below the 10-year flood elevation. As discussed above (see Figure 4.4-1), the peak inflows used in the model are occasionally greater than the measured USGS peak flow for that year. In those cases the peak outflow from the reservoir during drawdown may exceed the peak flow recorded by USGS for that year. This is due to the use of larger inflows rather than due to a significant increase in flow in the river due to drawdown.

It is not anticipated that sediment concentrations resulting from the proposed drawdown procedure and associated hydraulics, would differ from those previously estimated (USBR 2012c).

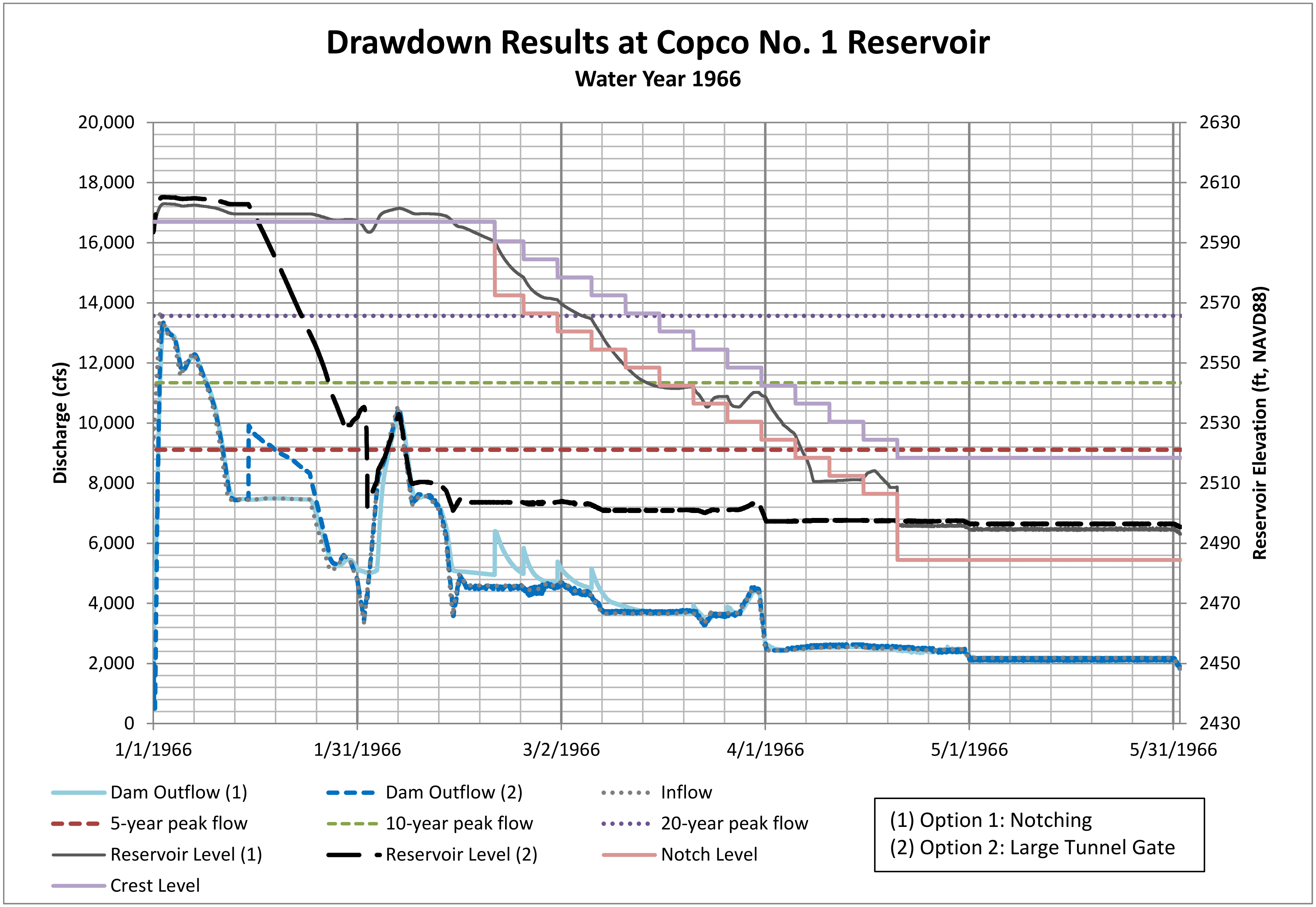


Figure 4.5-8 Copco No. 1 Reservoir Drawdown, Water Year 1966 (Wettest Year)

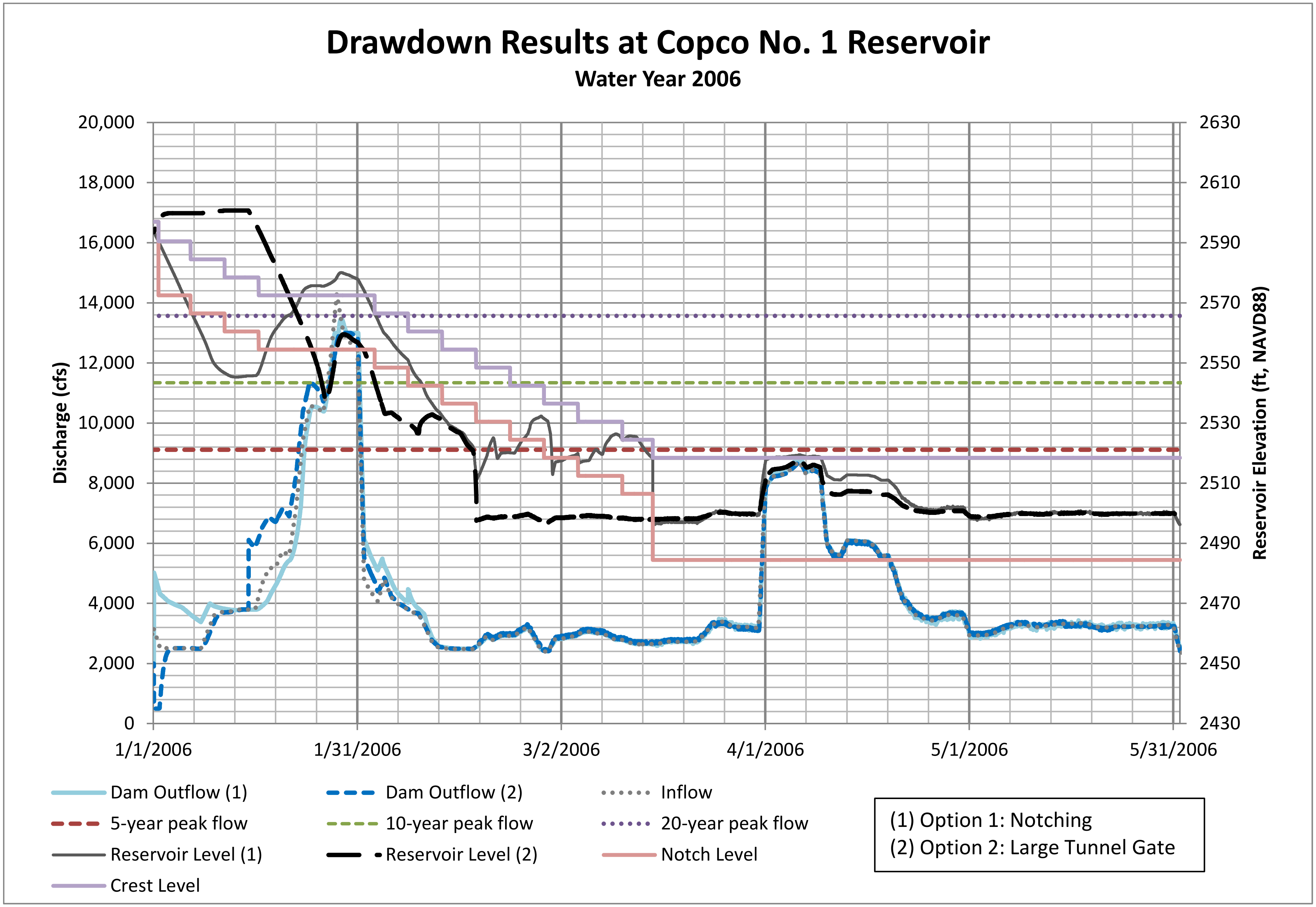


Figure 4.5-9 Copco No. 1 Reservoir Drawdown, Water Year 2006 (Wet Year)

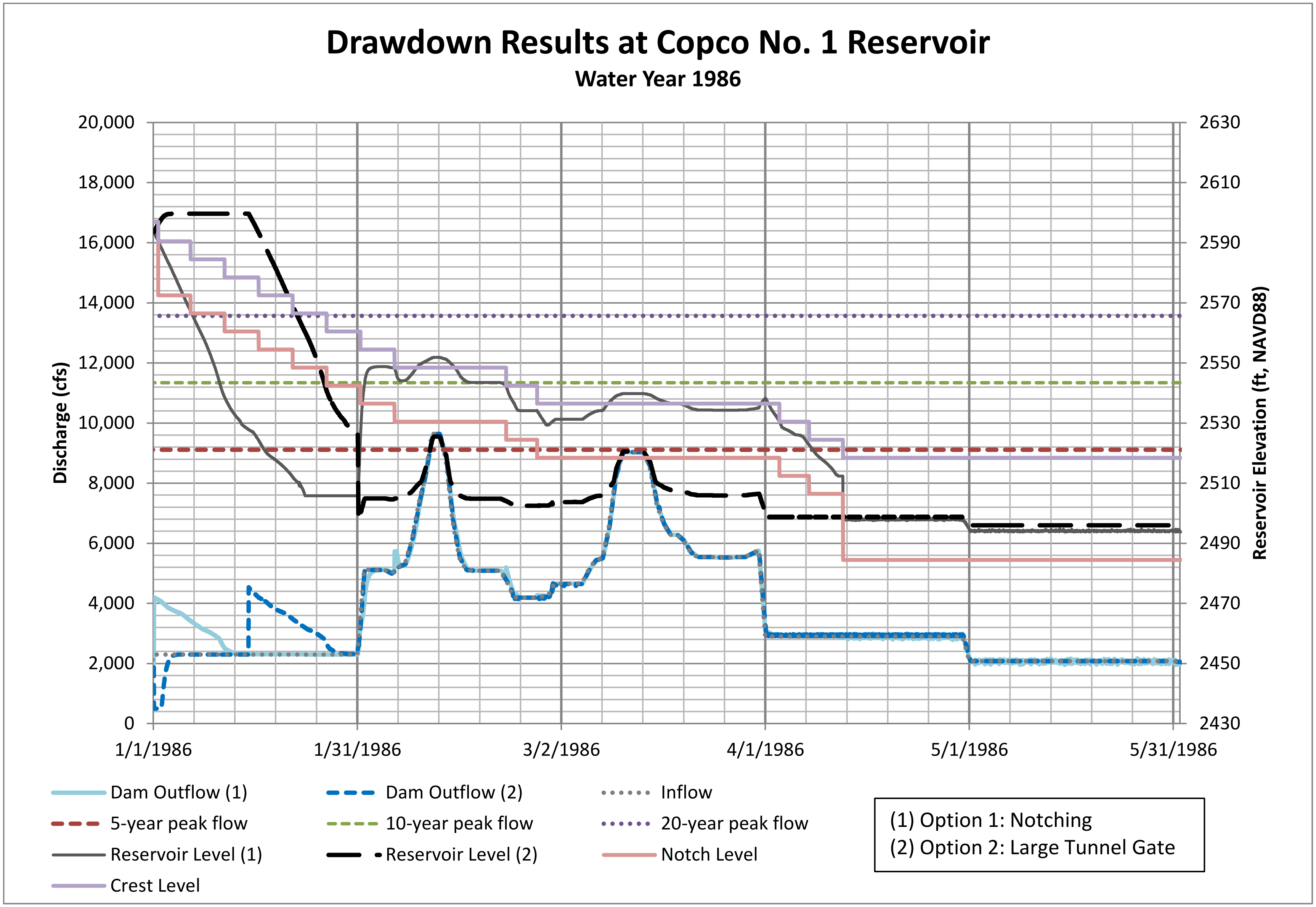


Figure 4.5-10 Copco No. 1 Reservoir Drawdown, Water Year 1986 (Wet Year)

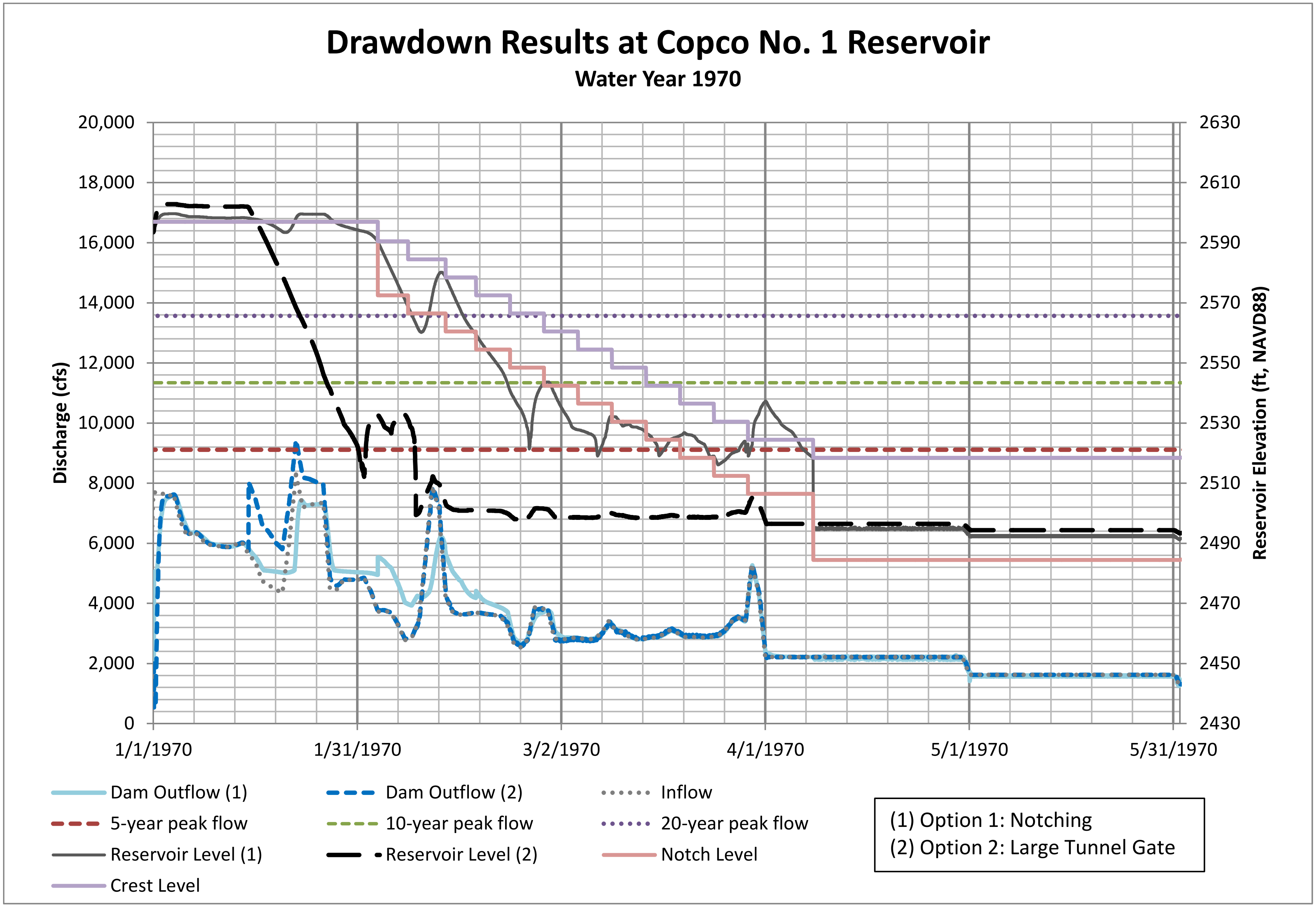


Figure 4.5-11 Copco No. 1 Reservoir Drawdown, Water Year 1970 (Above Normal Year)

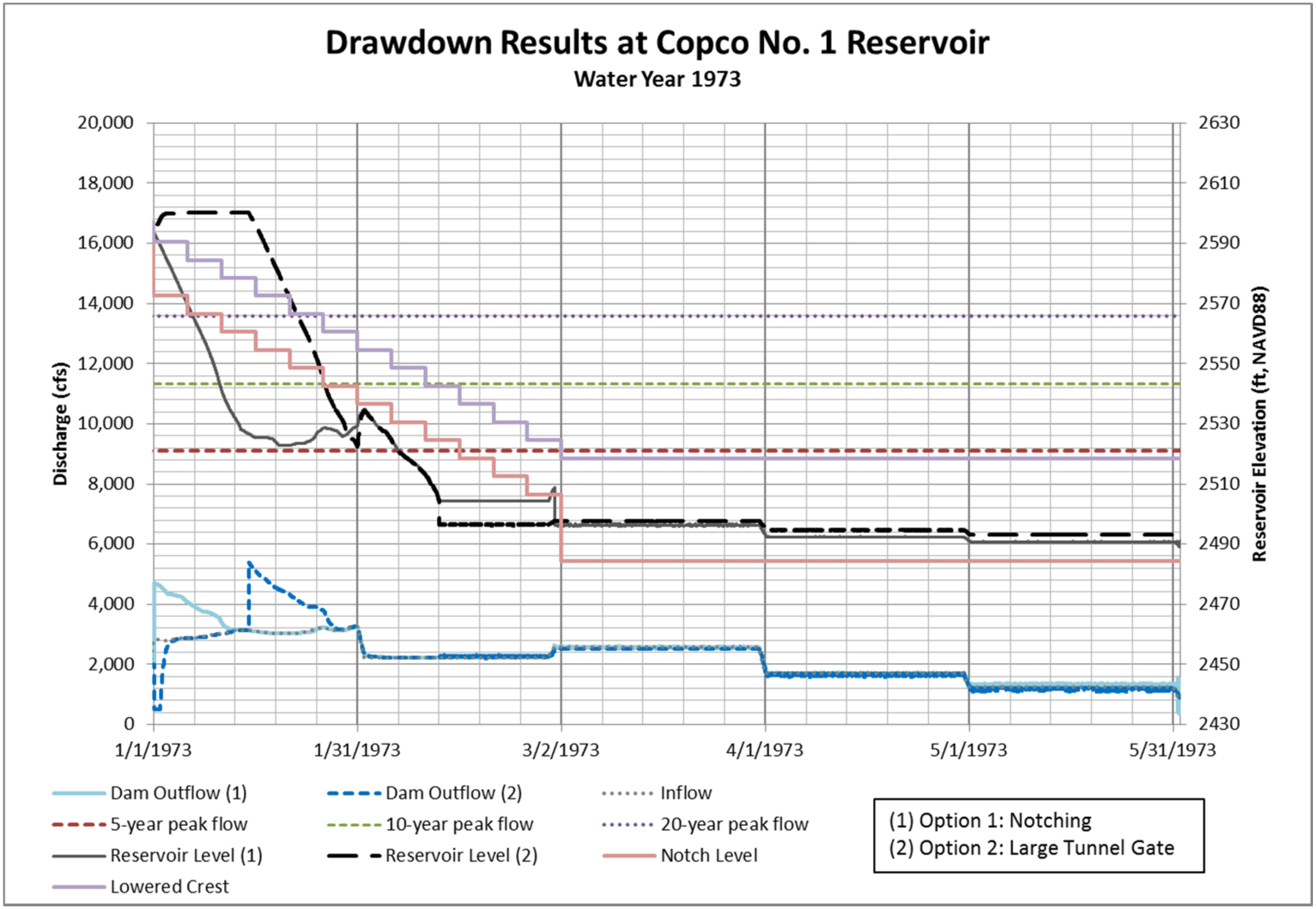


Figure 4.5-12 Copco No. 1 Reservoir Drawdown, Water Year 1973 (Median Year)

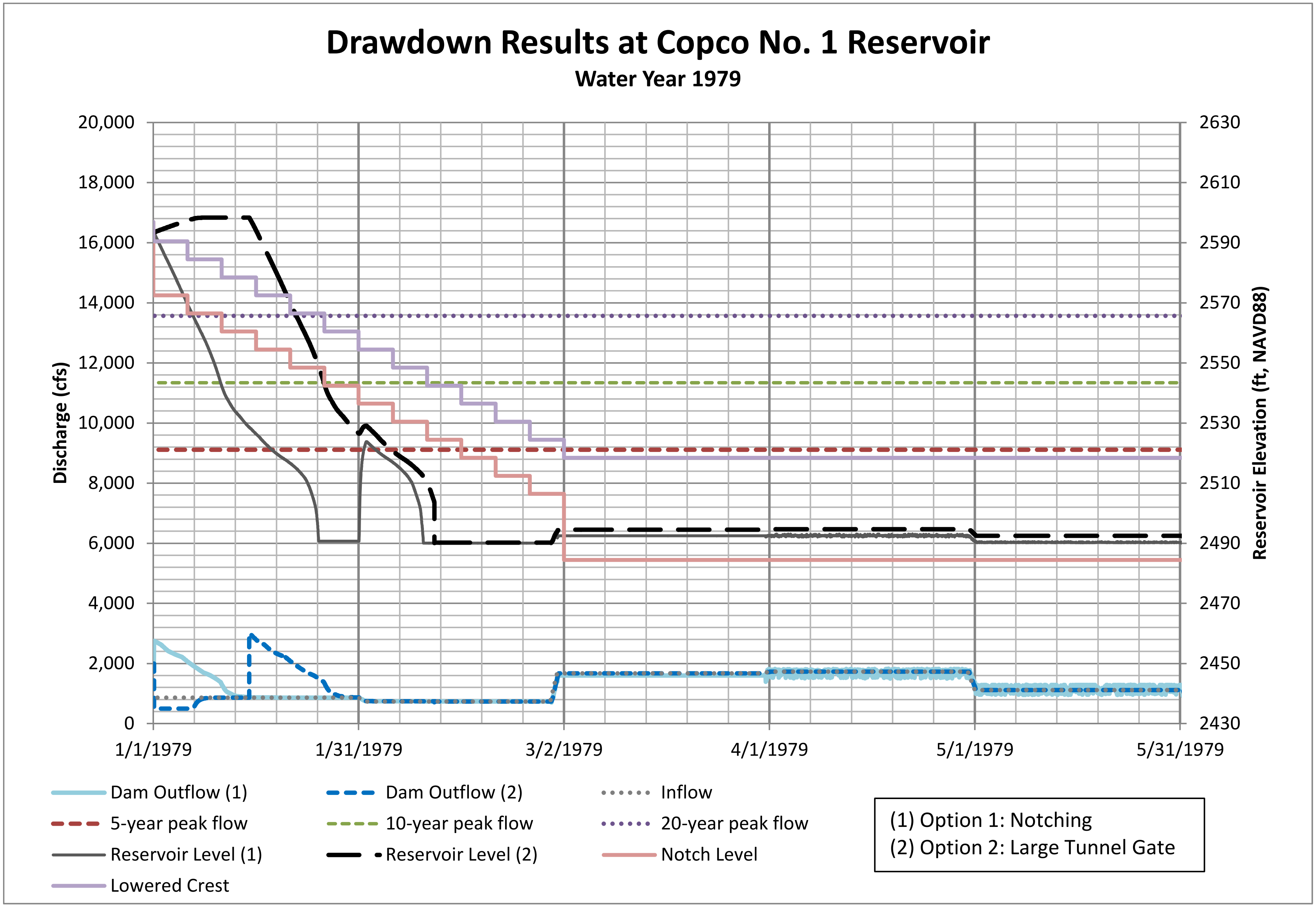


Figure 4.5-13 Copco No. 1 Reservoir Drawdown, Water Year 1979 (Dry Year)

4.5.4 Iron Gate Reservoir

4.5.4.1 Drawdown Procedure

Begin reservoir drawdown from normal operating elevation 2331.3 feet on January 1 of the drawdown year by making controlled releases through the modified diversion tunnel. Limit reservoir drawdown to a maximum of 5 feet per day to maintain reservoir rim slope stability. Maximum additional discharge downstream of the dam due to drawdown activities is about 4,000 cfs . The total discharge capacity of the modified diversion tunnel with the reservoir at spillway crest elevation 2331.3 is about 11,000 cfs. For reference, the 5-year flow event downstream of Iron Gate Dam is 10,900 cfs.

4.5.4.2 Results

Due to their close proximity, the Iron Gate Reservoir drawdown was modeled in conjunction with the Copco Lake drawdown. Figures 4.4-14 through 4.4-19 show results from the HEC-RAS analysis for the six representative years. There are different results at Iron Gate Reservoir depending on which drawdown option at Copco No. 1 Dam is chosen. References to Options 1 and 2 in the plots are the resulting effects at Iron Gate based on either Option 1 or 2 being implemented at Copco No. 1 Dam.

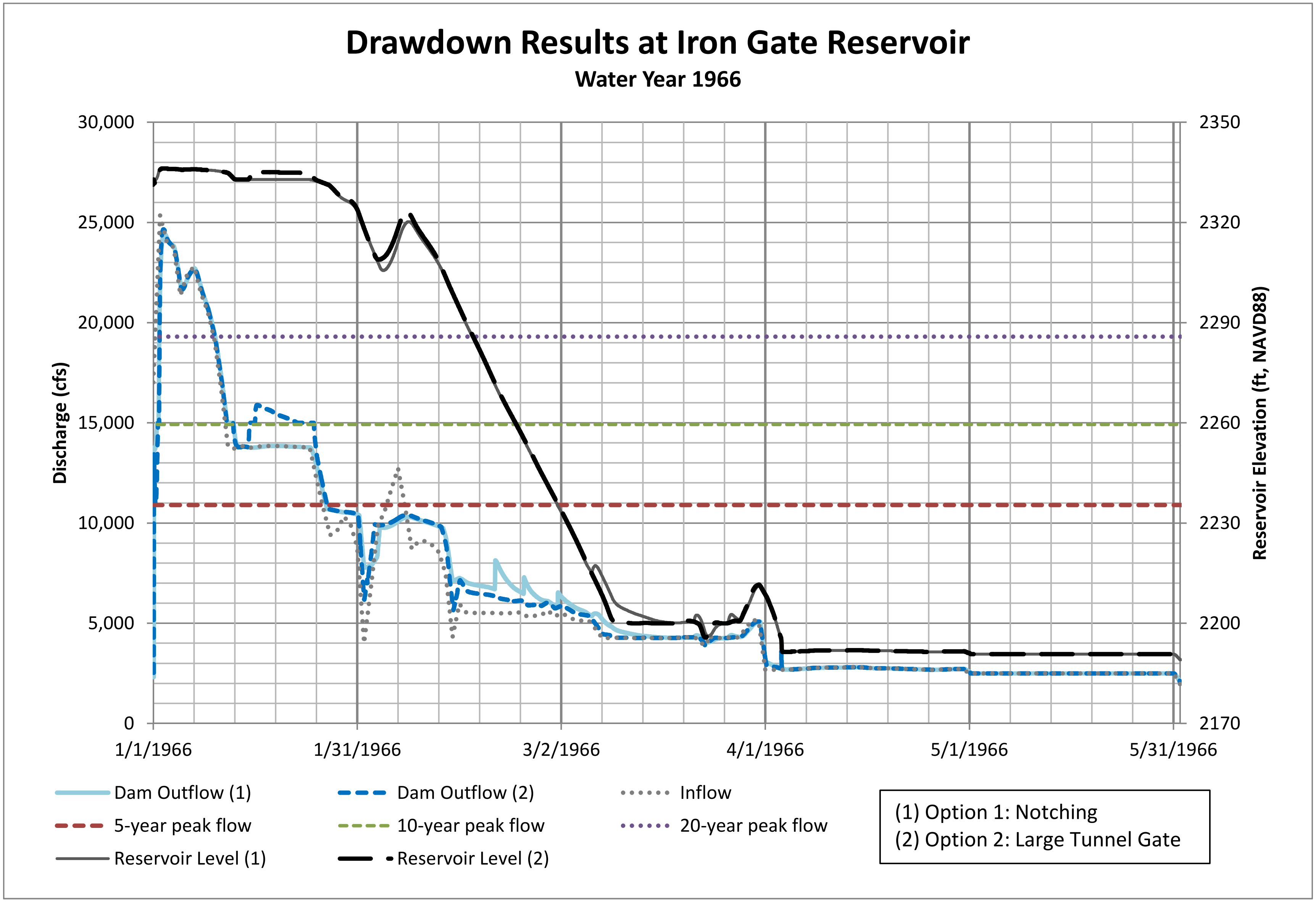
During the representative drier years (1973 and 1979, see Figures 4.4-18 and 4.4-19), the reservoir was easily drawn down by early February, and it did not refill after that point.

During the wetter years of 2006 and 1986 (see Figures 4.4-15 and 4.4-16), the reservoir was completely drawn down my March 1, but partially refilled later in the year when storms occurred. The majority of the accumulated sediment would mobilize during the initial drawdown, and subsequent reservoir filling and drawdown is expected to cause only moderate increases in high suspended sediment (relative to background) (USBR 2012c).

For the wettest year (1966, see Figure 4.4-14) the reservoir was mostly drawn down by March 1, but did not completely drain until mid-March.

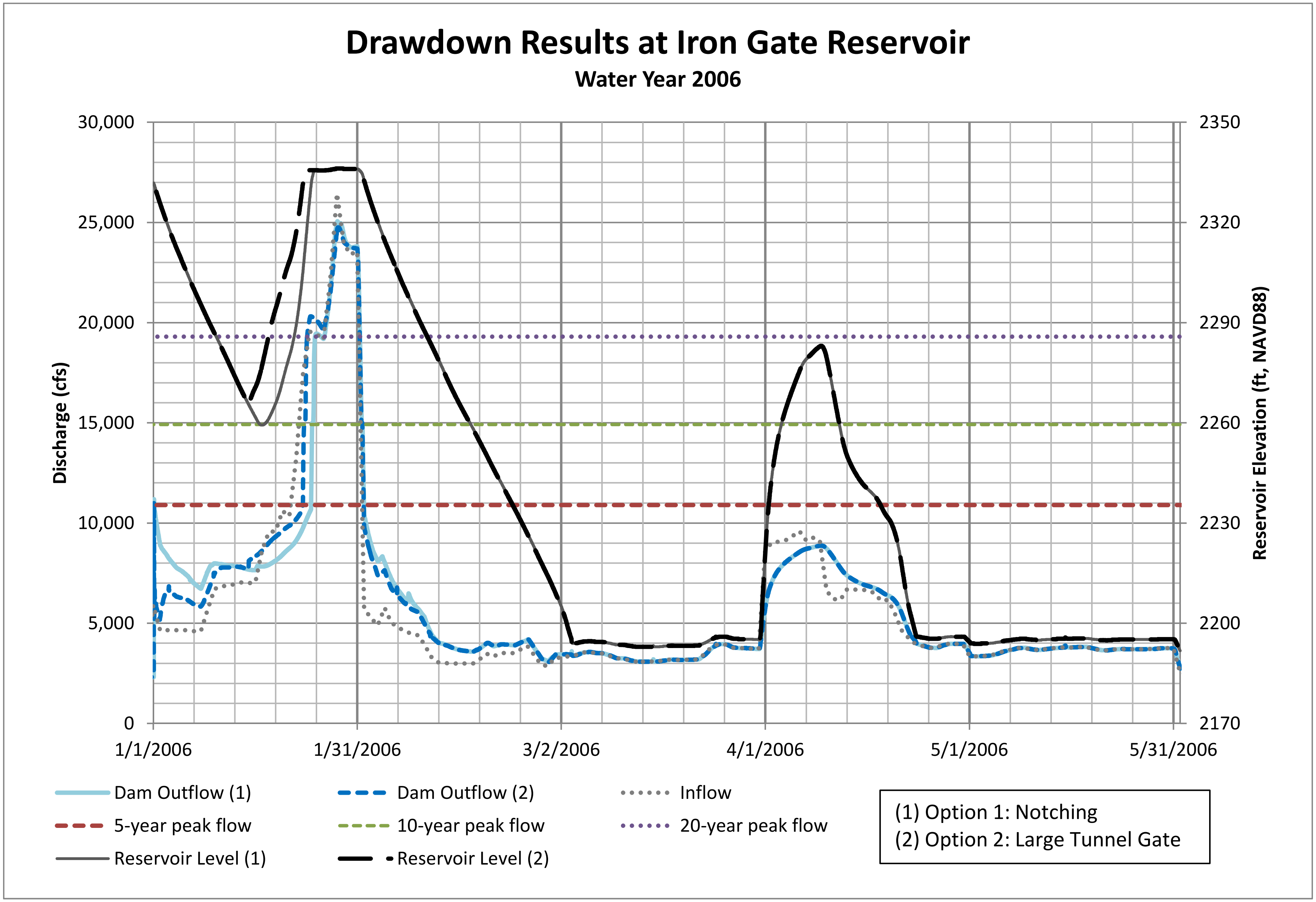
During the wetter years of 1966, 2006, 1986, and 1970 (see Figures 4.4-14 and 4.4-17), flows are higher than what would be expected via the spillway alone (i.e., without drawdown), but the increases are limited to those periods when flows are below the 10-year flood elevation. As discussed above (see Figure 4.4-1), the peak inflows used in the model are occasionally greater than the measured USGS peak flow for that year. In those cases the peak outflow from the reservoir during drawdown may exceed the peak flow recorded by USGS for that year. This is due to the use of larger inflows rather than due to a significant increase in flow in the river due to drawdown.

It is not anticipated that sediment concentrations resulting from the proposed drawdown procedure and associated hydraulics, would differ from those previously estimated (USBR 2012c).



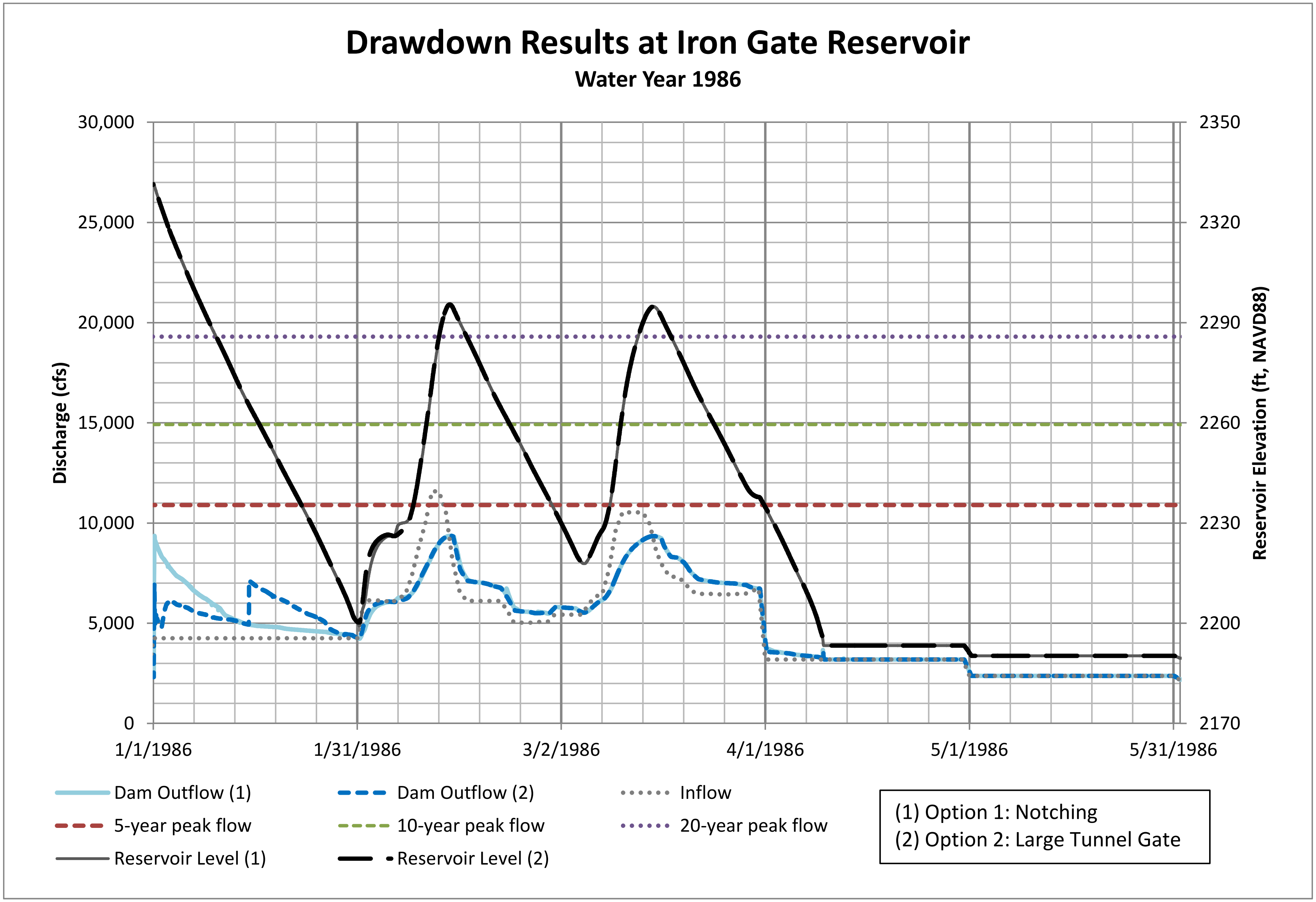
References to Options 1 and 2 in the plots are the resulting effects at Iron Gate based on either Option 1 or 2 being implemented at Copco No. 1 Dam.

Figure 4.5-14 Iron Gate Reservoir Drawdown, Water Year 1966 (Wettest Year)



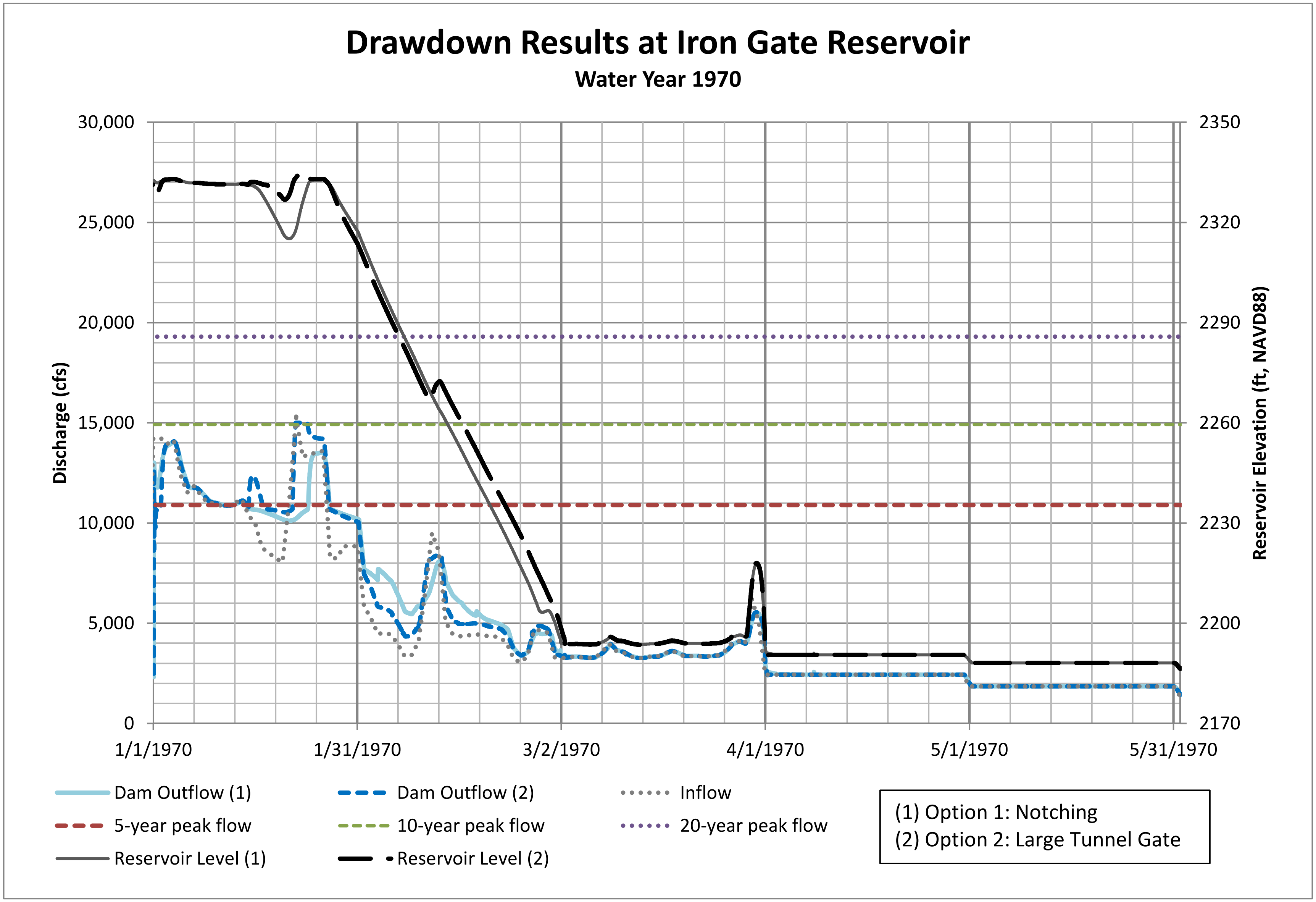
References to Options 1 and 2 in the plots are the resulting effects at Iron Gate based on either Option 1 or 2 being implemented at Copco No. 1 Dam.

Figure 4.5-15 Iron Gate Reservoir Drawdown, Water Year 2006 (Wet Year)



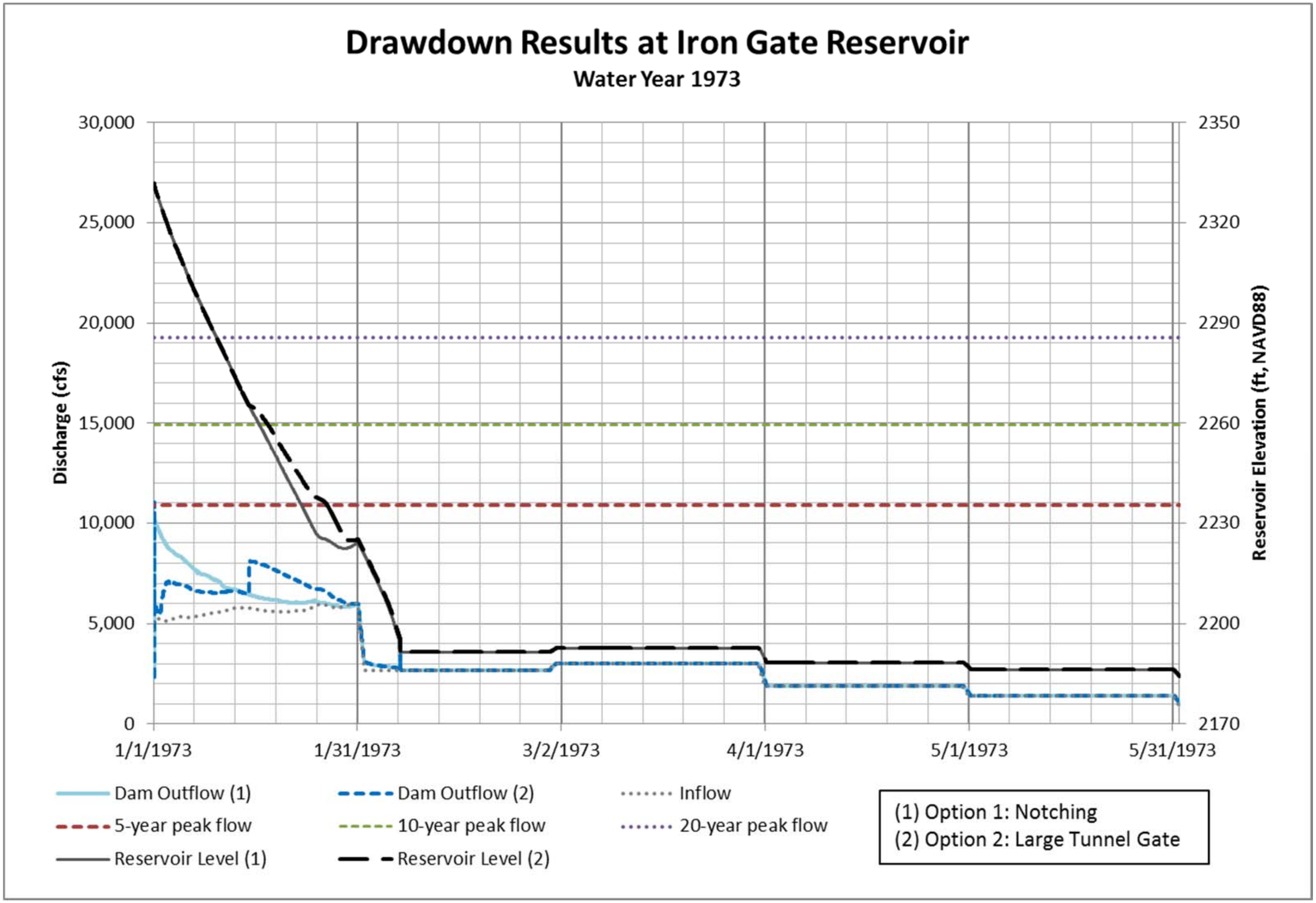
References to Options 1 and 2 in the plots are the resulting effects at Iron Gate based on either Option 1 or 2 being implemented at Copco No. 1 Dam.

Figure 4.5-16 Iron Gate Reservoir Drawdown, Water Year 1986 (Wet Year)



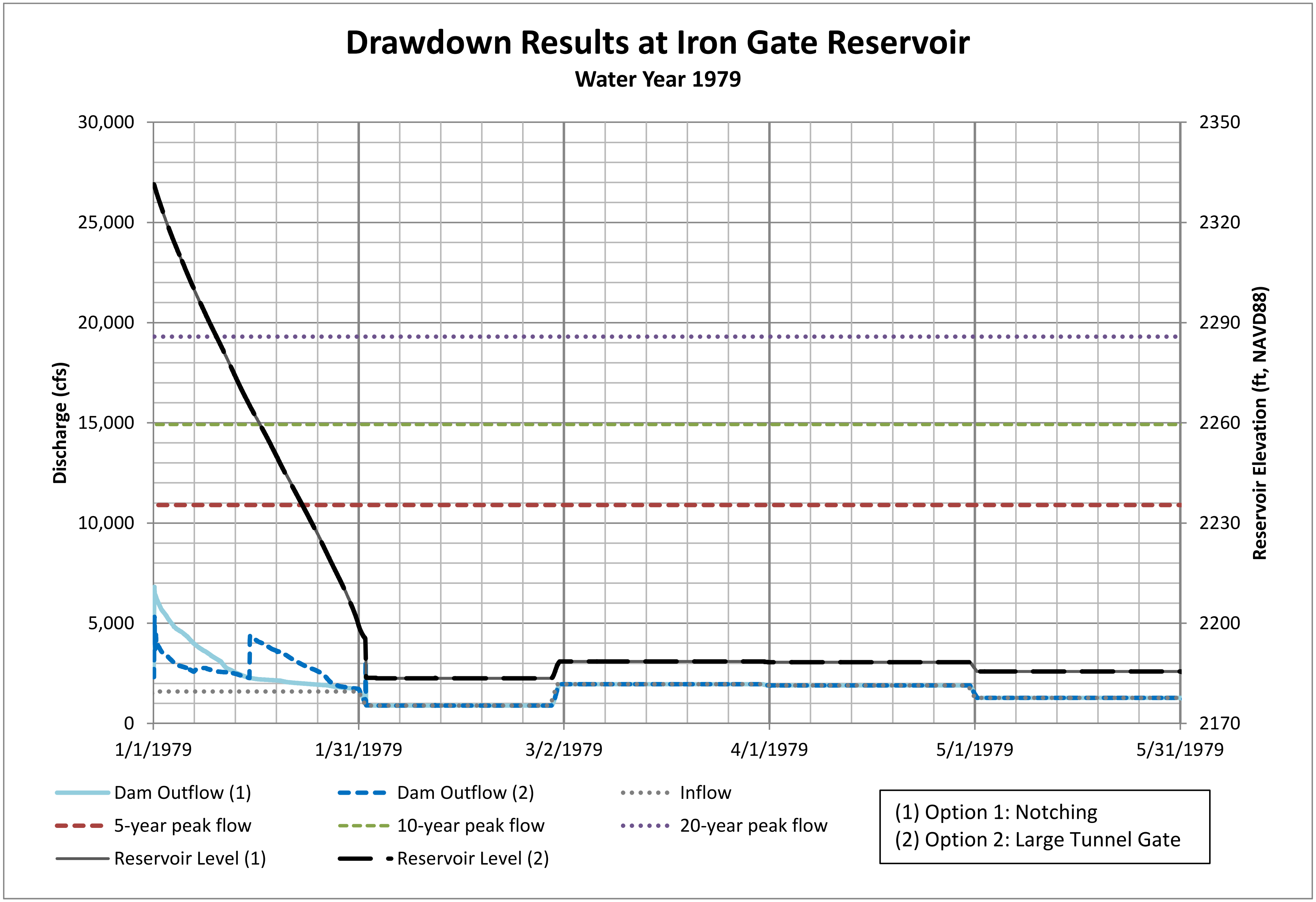
References to Options 1 and 2 in the plots are the resulting effects at Iron Gate based on either Option 1 or 2 being implemented at Copco No. 1 Dam.

Figure 4.5-17 Iron Gate Reservoir Drawdown, Water Year 1970 (Above Normal Year)



References to Options 1 and 2 in the plots are the resulting effects at Iron Gate based on either Option 1 or 2 being implemented at Copco No. 1 Dam.

Figure 4.5-18 Iron Gate Reservoir Drawdown, Water Year 1973 (Median Year)



References to Options 1 and 2 in the plots are the resulting effects at Iron Gate based on either Option 1 or 2 being implemented at Copco No. 1 Dam.

Figure 4.5-19 Iron Gate Reservoir Drawdown, Water Year 1979 (Dry Year)

4.5.5 Downstream of Iron Gate

The response of the river flows at Seiad Valley, Orleans, and Klamath USGS gage station locations to the flows discharged during the reservoir drawdown was analyzed. The analysis shows that the drawdown has negligible effect on peak downstream flows during wet and above normal years for several reasons:

- The proportion of flow contributed by the Klamath River at Iron Gate is smaller than the flows contributed by tributaries downstream.
- The drawdown distributes the flow over a longer time span than a typical storm event and provides attenuation in the reservoir once drawdown is underway.
- The capacity of the Iron Gate spillway, which is activated during storm events in the gage record, is much higher (30,000 cfs and greater) than the capacity of the diversion tunnel being used to control drawdown (11,000 cfs maximum).

For normal years (based on flow rate), the analysis showed that the drawdown can increase flows downstream, especially when the recorded peak flow at Iron Gate is less than the discharge capacity available during drawdown. The increase in flow in normal water years is small compared to the flow magnitude and does not cause flows to exceed the 5-year return interval flow at Iron Gate.

The analysis was completed using model output from the drawdown model described in Section 4.5.1 along with the recorded gage data for the Iron Gate, Seiad Valley, Orleans, and Klamath USGS gages and then comparing the hydrographs for the following water years:

- 1964 (normal)[18]
- 1965 (wettest year on record)[19]
- 1970 (above normal)
- 1974 (above normal)
- 1980 (normal)
- 1985 (normal)
- 1986 (wet)
- 1997 (wet)
- 2000 (normal)
- 2006 (wet)

The determination of wet, above normal, and normal water years was based on ranking the annual maximum 15-day volume of flow at the Keno gage during the January to May months for the years 1961 to 2009 (similar to the rating described in Section 4.4.1).

4.5.5.1 Analysis Timing

During a storm event, the worst flooding occurs during the peak flow, the highest flow in the river channel. To understand the full effects the drawdown could have on downstream flows

[18] Water Year 1964 is model year 1965 due to the data shift described in Section 4.4.1.2.
[19] Water Year 1965 is model year 1966 due to the data shift described in Section 4.4.1.2.

and floods, it is important to understand the effects of drawdown during peak flows of the flood events. For the analysis, the timing of the drawdown peak discharge from the model was aligned with gage record peak recorded at the Iron Gate gage in most of the analysis years. The alignment was done by altering the dates of the drawdown model output until the drawdown peak flow occurred on the same day as the record peak flow. This approach was used because future flood events could occur with timing different than in the historical gage record, and the worst case flooding effects occur during the peak flow. It is important to capture the effects that peak drawdown could have on the peak river flow when referring to flooding effects.

In most of the analysis years, the annual peak flow recorded at Iron Gate occurred concurrently with the annual peaks recorded at Seiad Valley, Orleans, and Klamath USGS gages. In two of the normal years: 1985 and 2000, the annual peak at Iron Gate occurred during a separate and unrelated event from the peaks recorded at Seiad Valley and downstream. In these two years, the recorded annual peaks at Iron Gate occurred months later. Therefore, the timing of the drawdown peak discharge from the model was aligned with the peak recorded at Seiad Valley gage for these two years.

4.5.5.2 Analysis Setup

The analysis involved comparing, on a daily basis, the recorded hydrograph for each year and each location to a synthetic hydrograph created using the drawdown model output. The daily flows and the annual peak flows for each gage location were downloaded from the USGS National Water Information System for the analysis years. To generate more representative hydrographs, the recorded annual peak was substituted for the daily flow value on the day that the peak occurred. This generated the recorded hydrograph.

The synthetic hydrographs were created as follows. For the Iron Gate USGS gage location, the drawdown model output was used to represent the flows during drawdown. For Seiad Valley, Orleans, and Klamath USGS gage locations, the synthetic hydrographs were created by taking the gage record of each location subtracting the flow recorded at the Iron Gate gage on that day and adding the flow from the drawdown model for the same day (after the date shift described above). The recorded and synthetic hydrographs for each gage were then plotted together to show the effect of drawdown.

4.5.5.3 Results

The results of the analysis are provided in Table 4.4-2 and Figures 4.4-20 to 4.4-29.

The water operations model prepared by USBR (2012) generates the input flows to the drawdown model, but these flows are not the same as the USGS record flows (refer to Figure 4.4-1). In a number of years, the operations model has higher peak flows than occurred in the record (analyzed water years 1965, 1986, 1997, 2000, and 2006). This is because of the way the operations model interprets the operations rules as well as that the upstream facilities may not have been operated according to the same rules during the record event. This difference has an effect on the results of the analysis in this section, and needs to be considered when reviewing the results.

The results of the analysis show that in wet and above normal years, drawdown typically decreases or does not change flows downstream of Iron Gate Dam. The significant percent increases occurred in 1997 with a 10% and in 2006 with a 98% increase in flow at Iron Gate. Water year 1997 had 2% or less increases seen further downstream at Seiad Valley and Orleans, while in 2006 larger increases of 18% at Seiad Valley and 6% or less at Orleans and Klamath. For 1997, the increase at Iron Gate shifts the return interval from a 20-year event up to between a 20 and 50-year event. For 2006, the increase at Iron Gate shifts the return interval from between a 10 and 20-year to a 50-year event, and the increase at Seiad Valley in 2006 shifts the return interval from about a 20-year event to between a 20 and 50-year event.

Rather than these increases being the result of the drawdown operation, they are an artifact of the operations model input flows. The operations model shows significantly higher flows in 1997 and 2006 than in the record (Figure 4.4-1) with an increase at Keno of 32% and 80%, respectively[20]; this means that the increase in flows shown in this analysis is entirely or mostly related to the larger input flows from the operations model upstream, rather than from the effect of drawdown releases.

For normal years, the drawdown results in either a decrease or an increase in flows. Even with the largest increases in flow at Iron Gate of 26% in 1964 and 40% in 2000, the drawdown releases remain below a 5-year event, well within the river channel capacity. Water year 2000 is also affected by the increase in inflows from the operations model as compared to the record, a 74% increase in 2000 at Keno. [21]

In all cases the percent change in flows seen at Iron Gate decreases significantly in the downstream direction. At Orleans the largest change was a 7% increase in 2000 to a less than 2-year event, and at Klamath the largest change was a 4% increase in 2006 to an event between a 10 and 20-year return.

[20] Keno 1997 record peak flow is 9,200 cfs, but the operations model has a peak of 12,188 cfs. Keno 2006 record peak flow is 7,930 cfs, while the operations model has a peak of 14,307 cfs.
[21] Keno 2000 record peak flow is 4,200 cfs, while the operations model has a peak of 7,230 cfs.

Table 4.5-2 Comparison of Flows Downstream of Iron Gate Dam with and without Drawdown

Water Year	Water Year Type	Iron Gate Peak Flow					Seiad Valley Peak Flow					Orleans Peak Flow					Klamath Peak Flow				
		Record (cfs)	With Drawdown (cfs)	% Increase ♦	Record Return Interval*	With Drawdown Return Interval*	Record (cfs)	With Drawdown (cfs)	% Increase ♦	Record Return Interval*	With Drawdown Return Interval*	Record (cfs)	With Drawdown (cfs)	% Increase ♦	Record Return Interval*	With Drawdown Return Interval*	Record (cfs)	With Drawdown (cfs)	% Increase ♦	Record Return Interval*	With Drawdown Return Interval*
1964	Normal	4,850	6,121	26%	2-yr	2-yr	20,100	21,371	6%	3-yr	3-yr	59,900	61,171	2%	2-yr	2-yr	162,000	163,271	1%	2-yr	2-yr
1965	Wettest on Record	29,400	24,236	-18%	80-yr	40-yr	165,000	165,598	0%	150-yr	151-yr	307,000	301,836	-2%	82-yr	77-yr	557,000	557,598	0%	89-yr	90-yr
1970	Above normal	14,900	15,000	1%	10-yr	10-yr	56,000	56,804	1%	11-yr	12-yr	175,000	175,804	0%	13-yr	13-yr	331,000	331,804	0%	12-yr	12-yr
1974	Above normal	18,700	15,000	-20%	18-yr	10-yr	126,000	122,300	-3%	72-yr	67-yr	279,000	275,300	-1%	57-yr	55-yr	529,000	525,300	-1%	70-yr	68-yr
1980	Normal	8,580	7,004	-18%	3-yr	2-yr	41,400	40,495	-2%	7-yr	6-yr	121,000	124,706	3%	6-yr	6-yr	234,000	233,095	0%	5-yr	5-yr
1985	Normal	7,970	7,703	-3%	3-yr	3-yr	13,800	15,783	14%	< 2-yr	< 2-yr	64,400	66,383	3%	2-yr	2-yr	149,000	150,983	1%	2-yr	2-yr
1986	Wet	13,900	9,341	-33%	8-yr	4-yr	43,100	41,210	-4%	7-yr	6-yr	278,000	276,110	-1%	57-yr	55-yr	459,000	457,110	0%	38-yr	37-yr
1997	Wet	20,500	22,526	10%	24-yr	32-yr	117,000	119,026	2%	60-yr	62-yr	258,000	260,026	1%	43-yr	45-yr	n/a †	n/a †	n/a †	n/a †	n/a †
2000	Normal	5,190	7,286	40%	2-yr	3-yr	11,300	14,486	28%	< 2-yr	< 2-yr	46,800	49,986	7%	2-yr	2-yr	141,000	139,783	-1%	2-yr	2-yr
2006	Wet	12,400	24,560	98%	6-yr	42-yr	74,000	86,966	18%	20-yr	29-yr	213,000	225,160	6%	23-yr	27-yr	342,000	354,966	4%	13-yr	15-yr

♦ Flow increases in 1997, 2000, and 2006 are an artifact of the operations model input flows. The increase in flows is entirely or mostly related to larger input flows from the operations model upstream, rather than from the effect of drawdown releases.
* Return intervals are approximate whole years based on a regression of the data shown in Table 4.3-2.
† No daily data available at the Klamath gage for Water Year 1997.

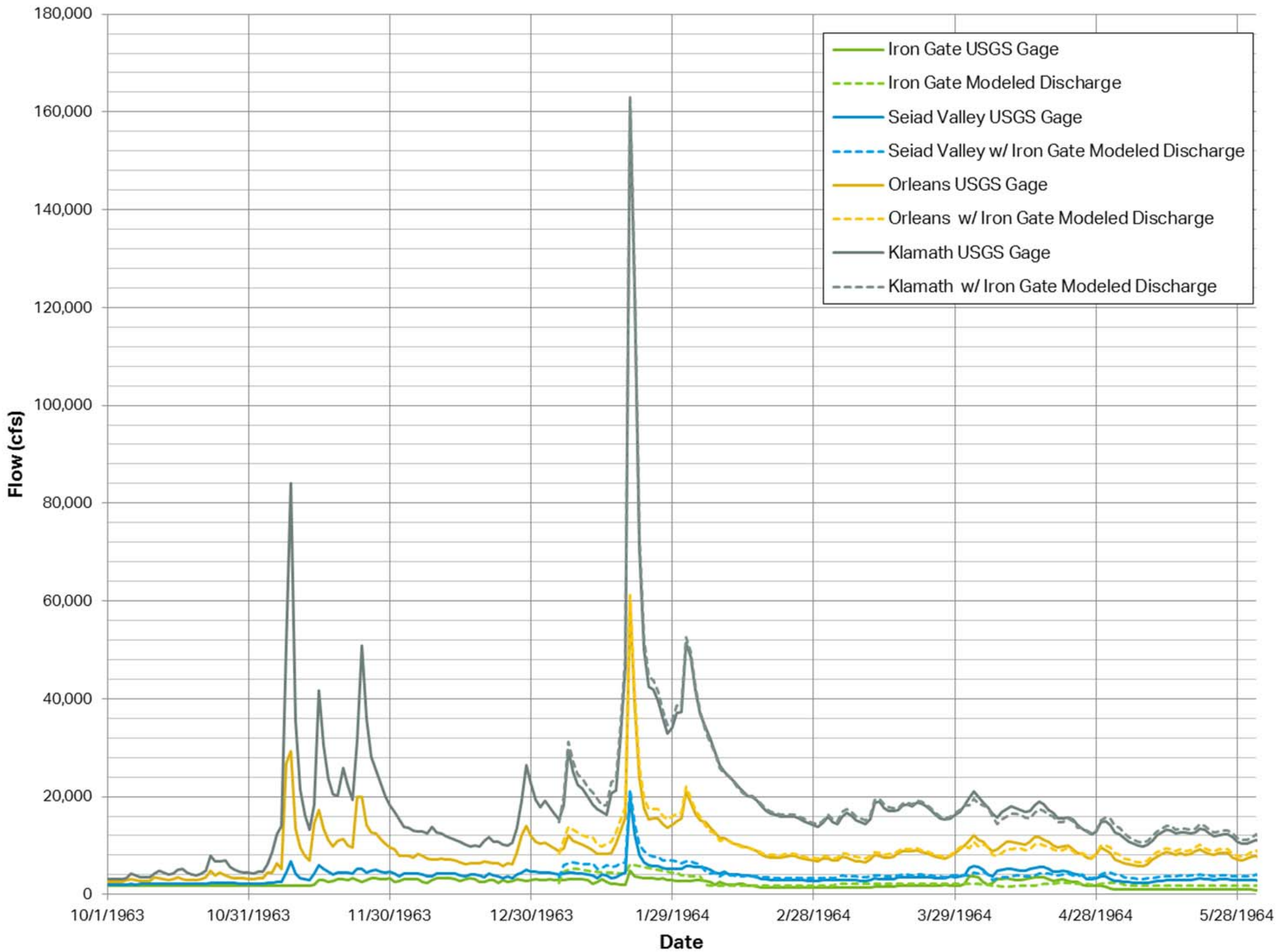


Figure 4.5-20 Comparison of Flows Downstream of Iron Gate Dam – Water Year 1964 (Model Year 1965)

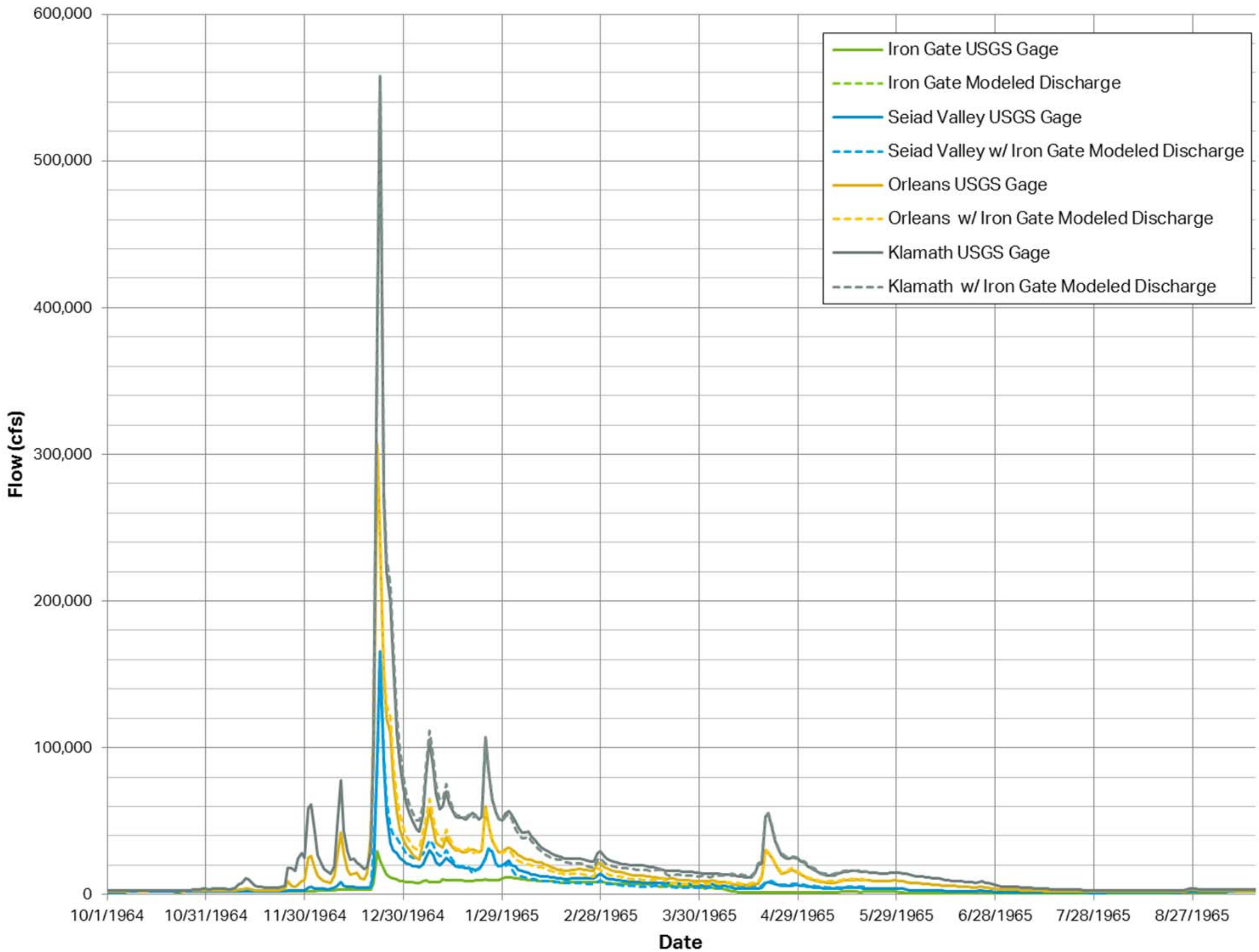


Figure 4.5-21 Comparison of Flows Downstream of Iron Gate Dam – Water Year 1965 (Model Year 1966)

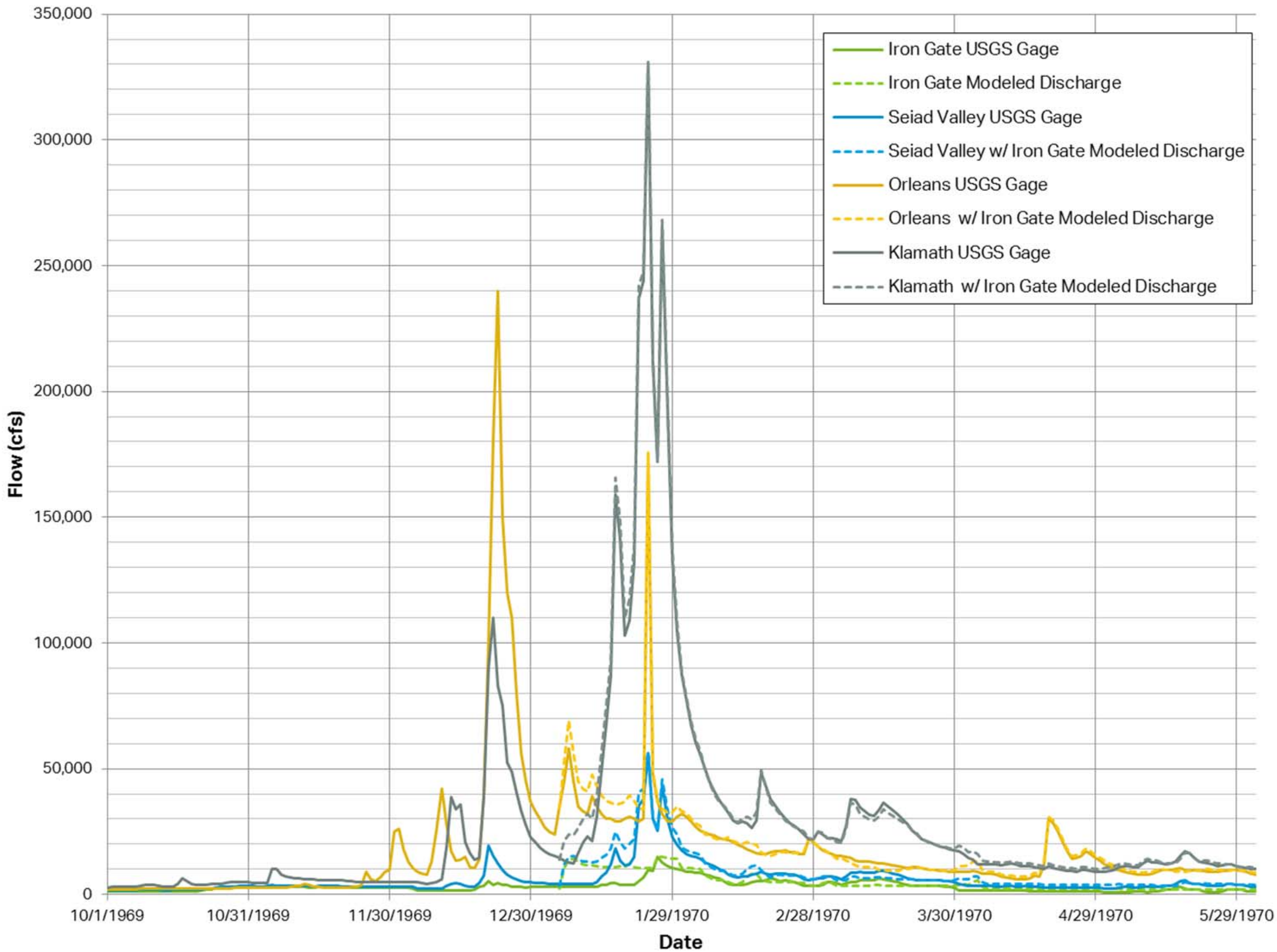


Figure 4.5-22 Comparison of Flows Downstream of Iron Gate Dam – Water Year 1970 (Model Year 1970)

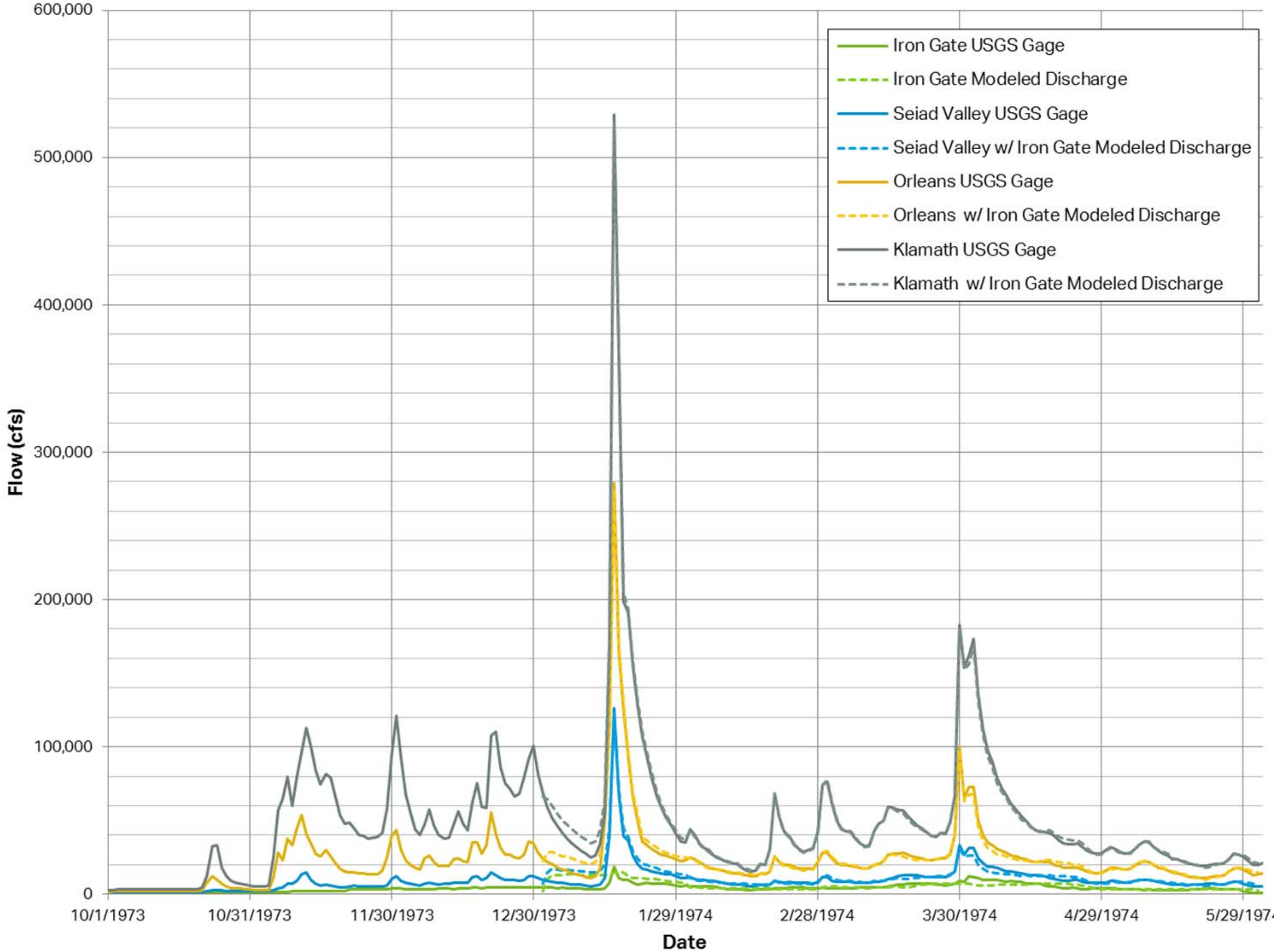


Figure 4.5-23 Comparison of Flows Downstream of Iron Gate Dam – Water Year 1974 (Model Year 1974)

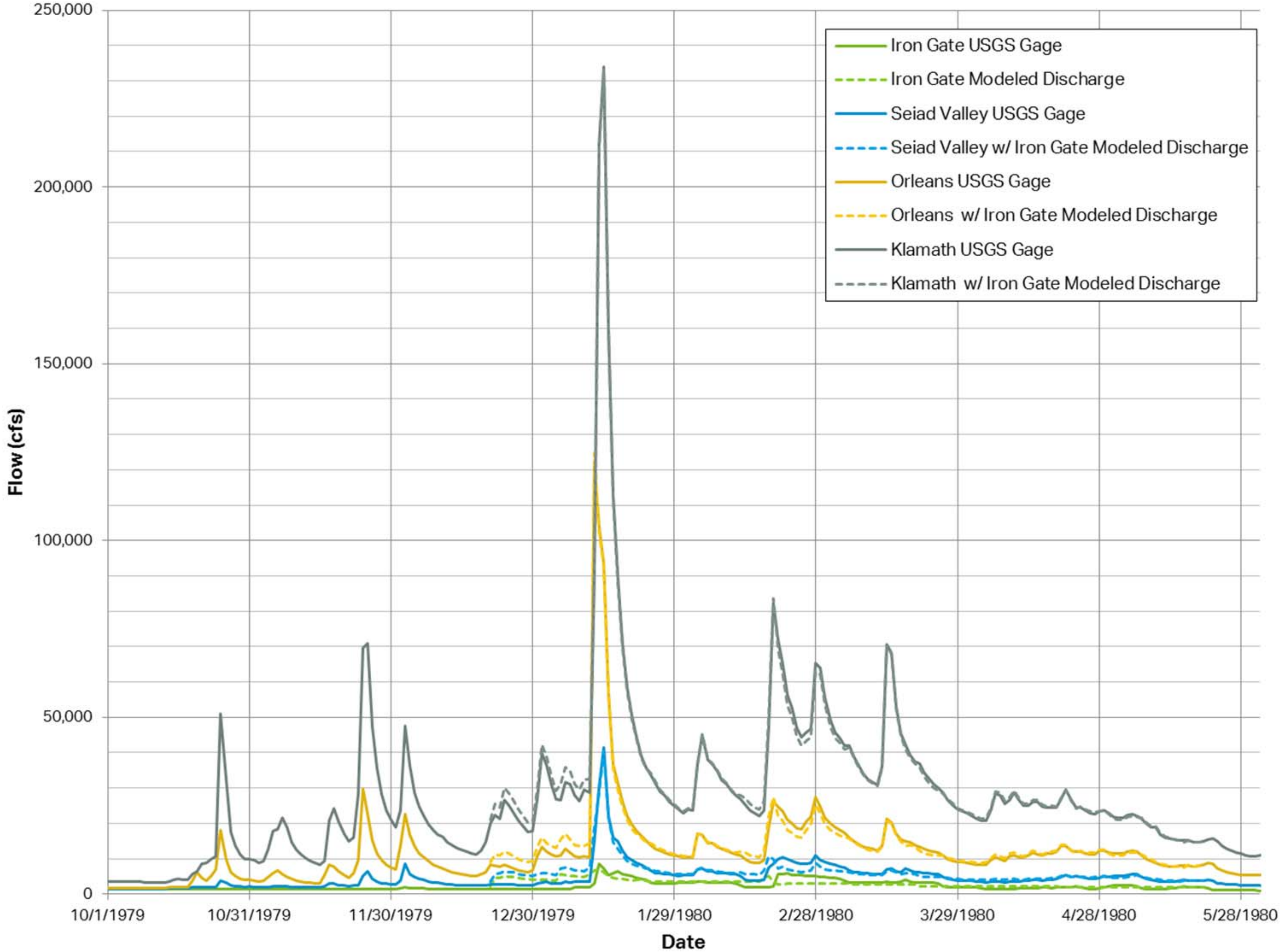


Figure 4.5-24 Comparison of Flows Downstream of Iron Gate Dam – Water Year 1980 (Model Year 1980)

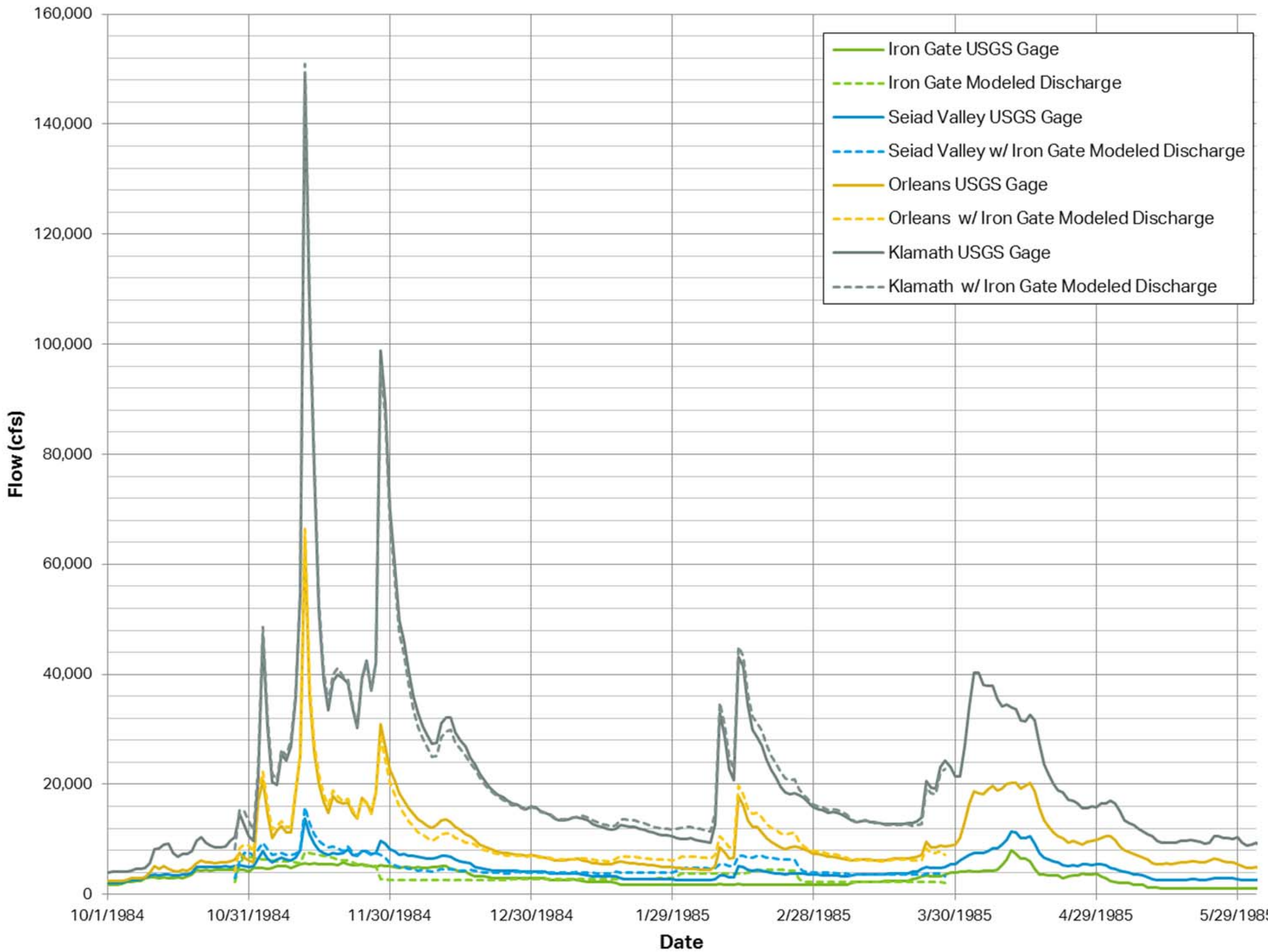


Figure 4.5-25 Comparison of Flows Downstream of Iron Gate Dam – Water Year 1985 (Model Year 1985)

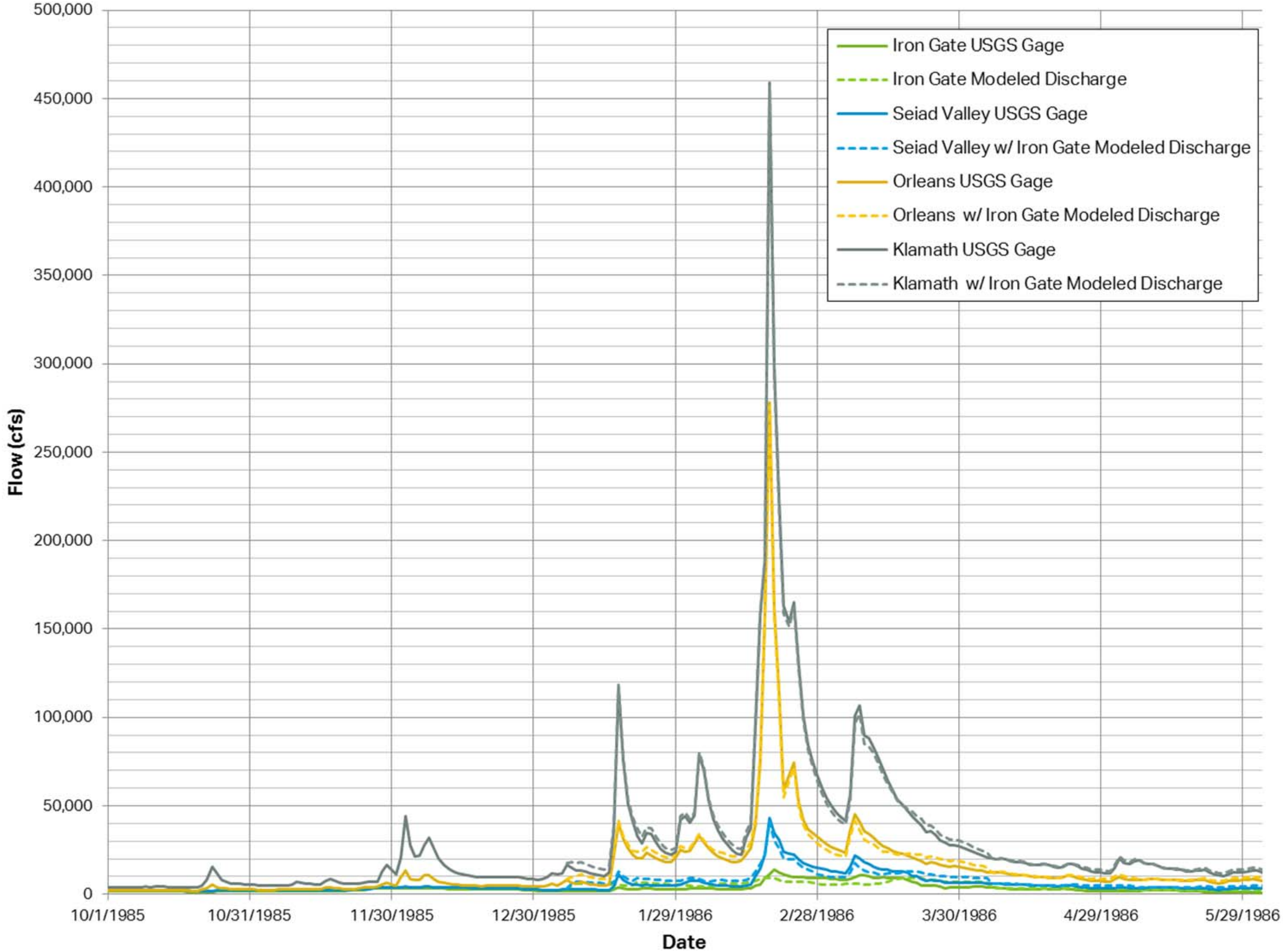


Figure 4.5-26 Comparison of Flows Downstream of Iron Gate Dam – Water Year 1986 (Model Year 1986)

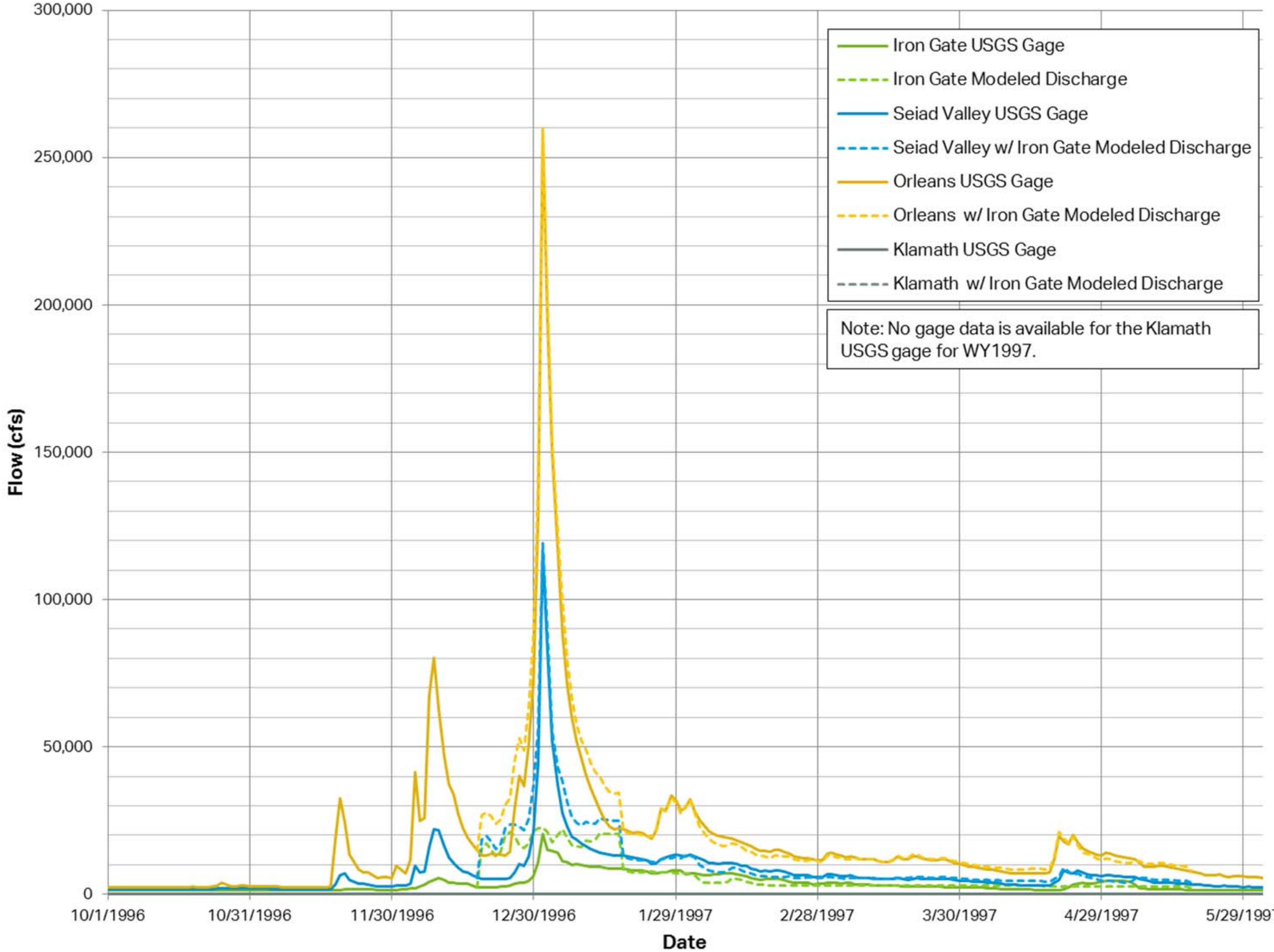


Figure 4.5-27 Comparison of Flows Downstream of Iron Gate Dam – Water Year 1997 (Model Year 1997)

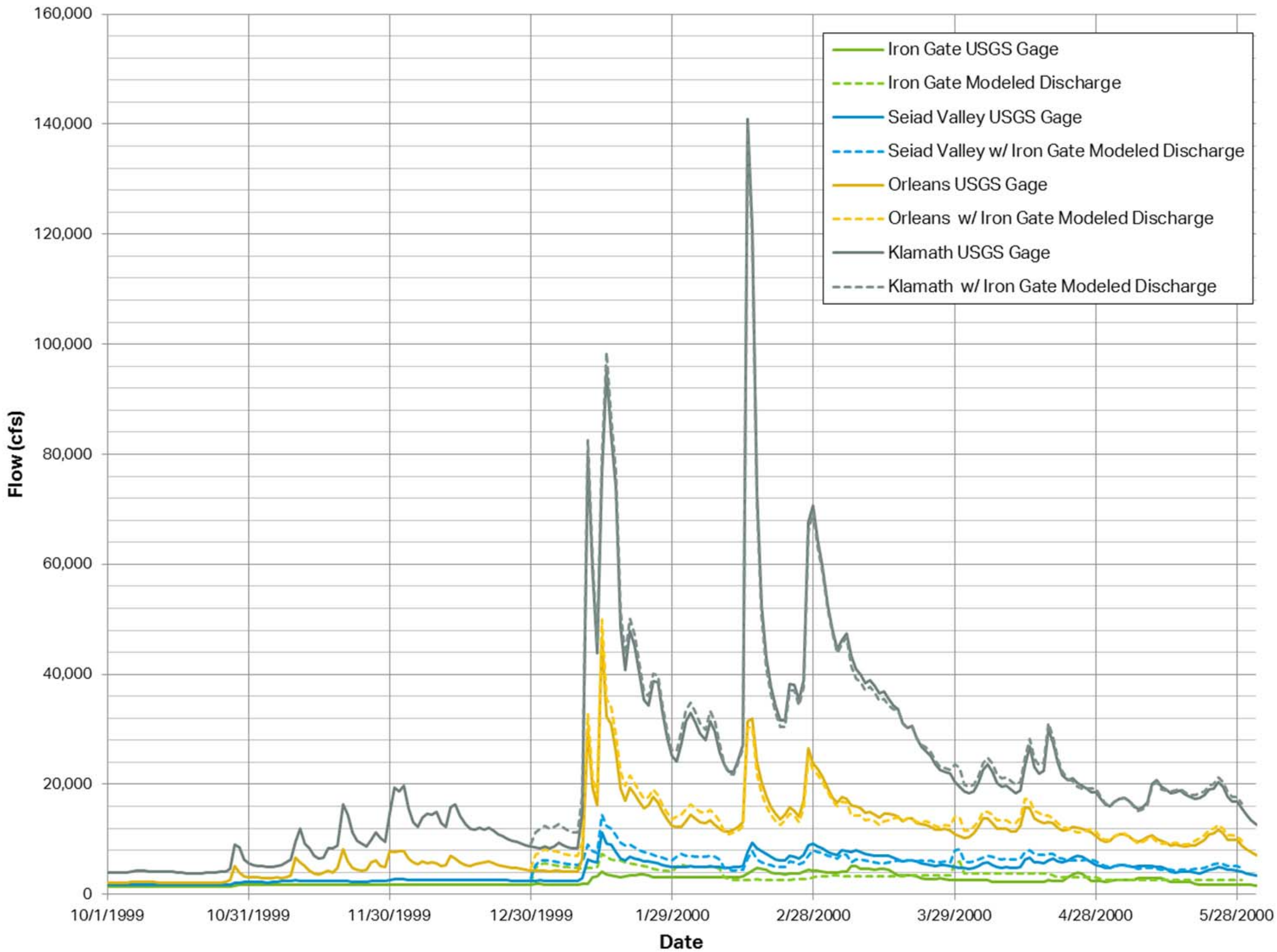


Figure 4.5-28 Comparison of Flows Downstream of Iron Gate Dam – Water Year 2000 (Model Year 2000)

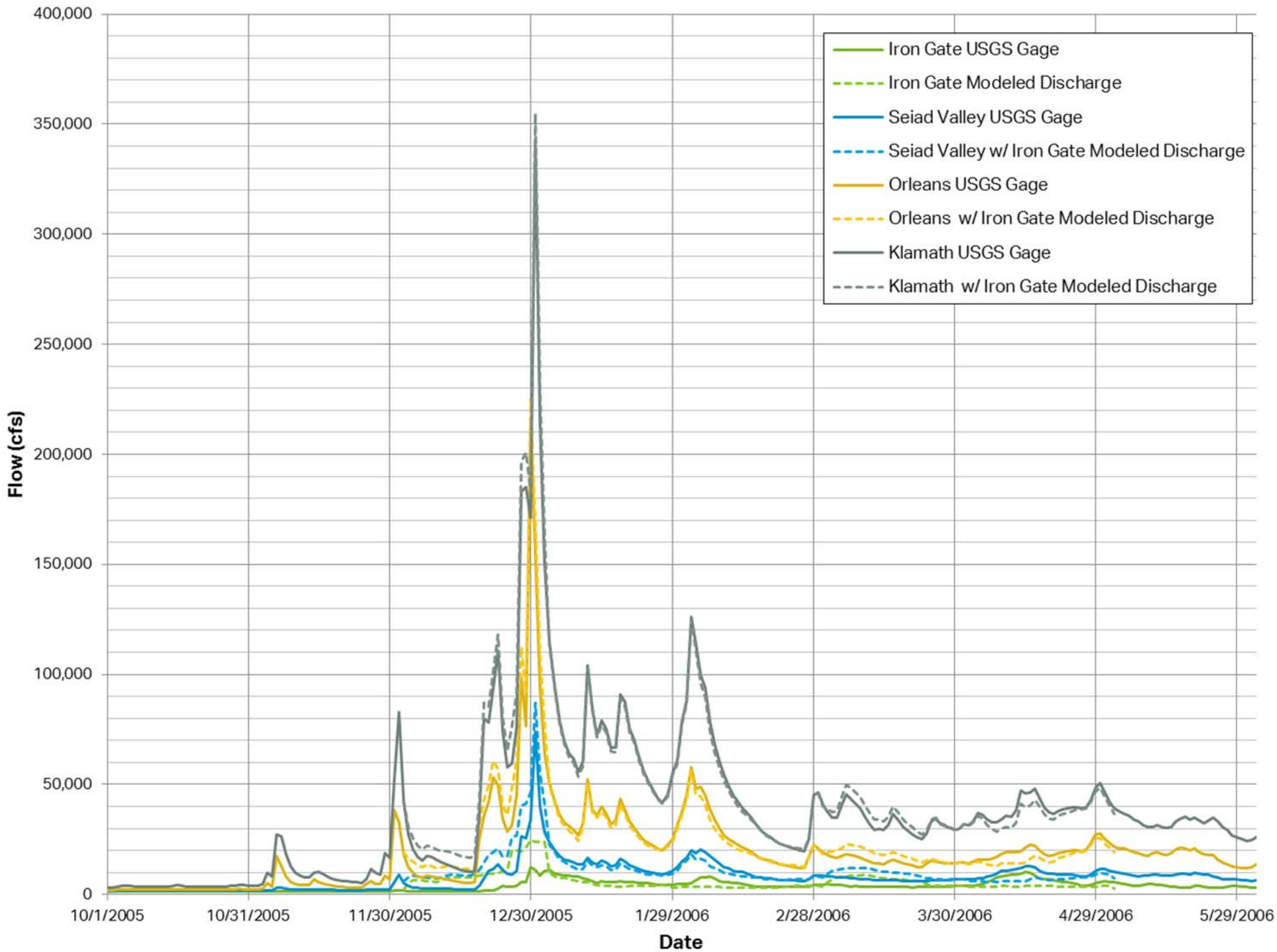


Figure 4.5-29 Comparison of Flows Downstream of Iron Gate Dam – Water Year 2006 (Model Year 2006)

4.6 Monitoring During Reservoir Drawdown

Iron Gate Dam and the embankment section of J.C. Boyle Dam would be monitored during reservoir drawdown for evidence of impending embankment instability significant enough to be indicative of upstream slope failure that would threaten the safety of the embankments. Shallow slumps that may occur on the upstream slope would not represent a significant risk to the safety of the embankments. Monitoring would include daily visual observations of the upstream slope for signs of instability such as cracking or slumping. Survey monuments and a minimum of two inclinometers installed in each embankment during the year prior to reservoir drawdown would be monitored on a daily basis for evidence of deep failures within the upstream shell. Piezometers would also be installed in the upstream shell (a minimum of 2) and the core (a minimum of 2) of the embankments for monitoring during reservoir drawdown to confirm that changes in pore pressure during drawdown are similar to or greater than assumed in the analyses (See Appendix D).

Monitoring of portions of the reservoir rim at each facility, as appropriate, would include daily visual observations for signs of instability such as cracking or slumping. Survey monuments and inclinometers will be installed in areas of particular sensitivity (e.g., near residences and cultural resources) and will be monitored on a daily basis for evidence of potential impending slope failure. After drawdown, monthly visual observations will be completed for 12 months to monitor inclinometers and look for evidence of potential impending slope failure. If no evidence or trends showing slope instability are found after the monitoring discussed above, no additional slope stability monitoring will be completed. Should evidence or trends of slope movement be identified, monthly monitoring shall continue for another 12 months, and an assessment shall be completed to determine the likelihood of slope failure and possible mitigation measures (e.g. slope protection, property acquisition, etc.).

Monitoring during drawdown related to cultural resources is discussed in Appendix L.

4.7 Potential Measures to Implement During Reservoir Drawdown

4.7.1 Blockage of Diversion Facilities

Diversion facility failure or blockage, particularly of the Iron Gate or Copco No. 1 diversion tunnels, during reservoir drawdown could impact the duration of drawdown. Failure modes of the diversion 0tunnels include: debris blocking the tunnel inlet, abutment instability and failure blocking the tunnel inlet, mechanical failure of the operating gate, and tunnel collapse. To mitigate inlet blockages, measures include installing large grates at the inlets and providing a mechanism to clear the grates using barge mounted equipment. Depending on the severity of the blockage or the mechanical failure, reservoir drawdown might have to be suspended and delayed to the following year after repairs are made.

Diversion facility failure or blockage of the Iron Gate diversion tunnel during dam removal would be a serious issue because the dam would no longer have an operable spillway. Mitigation against this occurrence includes conservative design criteria for the modification of the diversion tunnel to make inlet blockage, tunnel collapse, and mechanical gate failure very unlikely. In addition, by the time dam removal starts on June 1, the diversion tunnel will have been in full operation for 5 months demonstrating its operability.

Diversion facility failure or blockage of the Copco No. 1 diversion tunnel during dam removal will not prevent dam removal because flows that would have been diverted through the tunnel would flow through notches or over the lowered dam crest. Flow over the lowered crest at Copco No. 1 Dam would prevent access for further concrete removal; however, the lowered crest is expected to be sufficient for overtopping flows, and does not present a safety hazard.

The project will update the existing Emergency Action Plans (EAPs) for the dams. The EAPs describe the notification process for impending catastrophic dam failure and include flood inundation mapping.

4.7.2 Stability of Embankments

Instability of the upstream slope of the J.C. Boyle or Iron Gate embankment during reservoir drawdown could result in either loss of erosion protection or loss of freeboard due to a slope failure that encompasses a portion of the dam crest. In the case of shallow slumping that disrupts erosion protection, measures include stockpiling riprap materials during the season prior to reservoir drawdown for repairs. Likewise in the unlikely event that a slope failure displaces a portion of the dam crest, measures include stockpiling embankment materials for emergency repairs of the crest of the embankments. The project will update the EAPs for the dams. The EAPs describe the notification process for impending catastrophic dam failure and include flood inundation mapping.

4.7.3 Stability of Reservoir Rim

When discussing reservoir rim stability during drawdown at the various reservoir locations, it is important to differentiate between the potential for deep-seated large landslides, which could impact residences and other resources adjacent to the rim, and shallow slides of material beneath the current water surface, which would only impact resources within the local limited slide footprint.

Based on the assessment included in Appendix E, the potential for deep-seated large landslides that would impact residences or other resources is low at each reservoir. At J.C. Boyle and Iron Gate, the potential is low enough that additional geotechnical investigations and associated stability analyses are not anticipated during detailed design. At Copco Lake, the geology is more complex, and additional reconnaissance and geotechnical investigations are proposed (see Appendix E), along with associated stability analyses, to confirm the preliminary findings.

Should additional investigation and analyses indicate that the potential for deep-seated large landslides are more probable at any locations around Copco Lake, measures would be taken to mitigate that potential impact. Mitigation to strengthen the slopes against instability (flattening or reinforcing) is not practicable because of impacts to those areas from the mitigation itself or because of the cost and uncertainty of success of the slope strengthening. Project purchase of potentially impacted properties and residences (and subsequent demolition) would be considered to mitigate the potential impact, as appropriate. Should unanticipated rim stability issues arise during drawdown and associated monitoring (Section 4.5), adjacent residences could be evacuated while a determination is made concerning long-term stability. If there is no feasible solution to stabilize the slope, Project purchase of potentially impacted properties and residences (and subsequent demolition) would be considered.

Shallow slides of existing material beneath existing reservoir water surfaces are possible during drawdown, and existing resources within these shallow slides could be impacted. See Section 4.8 for measures to address cultural resources that may be exposed or uncovered during reservoir drawdown due to shallow slides.

4.7.4 Measures to Reduce Impacts to Aquatic Species

Section 7.2 and the associated Appendix H discuss measures to implement in and downstream of the Project to reduce impacts on aquatic species listed in the federal Endangered Species Act (ESA), California ESA, and candidate listed species.

4.8 Potential for Effects Downstream of the Project

The sections below discuss potential effects in the river channel downstream of the project, including aggradation at tributaries, pool depths, lateral channel migration, water quality and slope instability. For a discussion of the effects on downstream flows, see Section 4.5.5 above.

4.8.1 Previous Modeling Results and Limitations

Aggradation is expected in the reach between Iron Gate Dam and Bogus Creek because this reach is immediately downstream of Iron Gate Dam and the relatively deep pools in this reach will fill in with coarse sediment. This reach is artificially degraded because of the release of sediment-depleted, clear water flows from the dam. The simulated sediment results in this relatively short reach (0.3 miles) are somewhat unreliable because there was limited survey data in the vicinity of the spillway and hydropower outlets and because this area only had a few cross sections within it. The survey data did not fully capture the depth of the scour holes downstream of the dam, so the model results are not reliable in this reach. The results starting at Bogus Creek are more representative of the anticipated effects.

The results of the two-dimensional model were not used to quantify volumes of eroded reservoir sediment, sediment deposition in the downstream channel, or suspended sediment concentrations. The two-dimensional model was primarily used to help inform USBR's revegetation plan for dam removal at Copco. USBR was interested in the general shape and location of the river channel post dam removal and the modeled shape and location corresponded well to the pre-dam maps. The pre-dam maps were eventually used to determine the most likely location of the post-dam removal channel.

4.8.2 Aggradation and Tributary Confluences

There are likely different responses for tributaries within the reservoir areas and for tributaries downstream of the reservoir. Within the reservoirs, previously deposited reservoir sediment may or may not be eroded during drawdown, depending upon the flows present in the tributaries and in the Klamath. Should barriers form at these locations within the former reservoirs, effort will be taken post-drawdown to remove the barrier and connect the tributary (see Section 6.1.3)

At downstream tributaries, there are several different possibilities for tributary response depending upon the relative balance of Klamath River flow, tributary flow, and sediment concentration. There are naturally-occurring, small depositional features at most tributary mouths along the Klamath River and having some deposition at these locations could take the form of a partial bar rather than fully blocking the tributary mouth and is not necessarily a negative impact.

The only scenario where deposition could fully block a tributary preventing upstream migration would be perhaps during a high flow in the Klamath River with little to no flow in the tributary. This is only considered a possibility for the tributaries between Iron Gate and Shasta River. The dilution of sediment concentrations and relative flow in the tributaries downstream of the Shasta River will prevent complete blockage of the tributary. The suggested plan for dealing with this scenario would be to monitor the tributary mouths between Iron Gate and Shasta River and mechanically excavate the tributary mouth if a blockage occurs after dam removal.

4.8.3 Pool Depths

The reaches below the dams have all been unnaturally depleted of coarse and fine sediment due to the trapping of sediment within the reservoirs. Therefore, there has very likely been some river bed degradation and river bed lowering caused by the depletion of coarse sediment. We do not expect, nor would we want, a return to pre-removal conditions in the pools downstream of the dams. The pools are likely deeper and coarser than they would be under natural sediment supply conditions. There will be an immediate filling of pools after dam removal and an immediate fining of the river bed sediment. After one or two average floods, most of the fine sediment will be removed from the pools and they will return to being dominated by a coarser substrate. However, the full, pre-removal, pool depth will not be recovered and instead it will return to a more natural pool depth. Numerical models are not able to reliably predict the pool-riffle formation and exact depths. An estimate of the bed material response has been provided as part of the USBR (2012) report.

A survey of the river bed downstream of Iron Gate is recommended prior to dam removal, and every year after dam removal for the first three years. Mechanical intervention is not recommended in the main channel of the Klamath River at any substantial scale because the disturbance of the bed could cause more ecological impact than the sediment in the bed. Moreover, as mentioned above, we do not believe that it is reasonable or prudent to want to recover pre-removal pool depths downstream of the dam.

4.8.4 Lateral Migration

Lateral migration is a natural part of all alluvial rivers and cannot be fully controlled throughout a large river. In fact, preventing lateral migration through bank protection can degrade the aquatic habitat of the river by causing channel bed degradation. That being said, the Klamath River is predominantly a bedrock controlled river and naturally has very little migration and bank erosion. USBR (2012) compared mapping of terraces to one performed by Ayres (1999) and found very little difference in the plan form of the river over time. The risk of bank erosion would be higher when coarse sediment and large woody debris is introduced into the channel and deposits, which then forces the river to take a new path. An example of this process is the Elwha dam removals where there has been several locations of bank erosion observed after dam removal. The risk of bank erosion on the Klamath is much smaller for a variety of reasons: there is much less coarse sediment in the reservoirs, the banks are mostly bedrock controlled, and there is no large source of woody debris upstream of the reservoirs because of operations at Link River and Keno Dams. For these reasons, no monitoring or adaptive management associated with downstream lateral migration is proposed.

4.8.5 Water Quality and Suspended Sediment

USBR (2012) performed simulations for a variety of water year types, some of which result in release of suspended sediment after March 15. And effects are discussed in that report. As discussed above in Section 4.4, the updated approach to drawdown at Copco No. 1 significantly reduces the likelihood of a prolonged drawdown and high sediment concentrations. Due to the low probability of a prolonged drawdown, there is minimal risk of any associated negative effects.

4.8.6 Water Quality and Sediment Contaminants

This summary is in reference to contaminant concentration analyses in Klamath River reservoir sediments and aquatic biota, and provides an evaluation of the results with respect to current USACE Sediment Evaluation Framework (SEF) for the Pacific Northwest (USACE, 2016) and U.S. Environmental Protection Agency (EPA) screening levels (SLs). The 2012 EIS/EIR summarizes sediment and aquatic biota testing completed by Camp Dresser and McKee (CDM) during or before 2011, a time period during which the freshwater contaminant screening levels were being reviewed and finalized by the Northwest Regional Sediment Evaluation Team (RSET). Although the 2009 SEF SLs and the EPA Regional Screening Levels (RSLs) were not the only thresholds considered in the 2011 analysis and result, an examination of previous results and conclusions with respect to the most recent SEF SLs and RSLs is necessary to ensure current science and regulatory standards are met.

The following review of the 2011 results under the 2016 SEF SLs and compliance with a Level 2B[22] evaluation confirms the conclusions presented in the 2012EIS/EIR that the reservoir sediments in each reservoir are suitable for unconfined, aquatic disposal and exposure and

[22] A Level 2B assessment includes physical, chemical, biological, and other special evaluations completed to provide more empirical evidence regarding the potential for sediment contamination in the project area to have adverse effects on receptors (RSET 2016).

that contamination risks are unlikely and/or are either lower than with the dams still in place and/or lower than background levels. The marine SLs are relatively unmodified from the 2009 SEF, and the most recent freshwater SLs in the 2016 SEF are typically less protective than standards set forth by, e.g., EPA RSLs and ODEQ Bioaccumulation Screening Level Values (SLVs) for fish consumption. As a result, any revisions to the standards have negligible impact on previous conclusions.

4.8.6.1 Testing Summary

To assess the risk of contamination in biota and humans from the release of reservoir sediments, an evaluation of the sediments from each reservoir was completed in 2011 and generally followed the tiered sediment evaluation framework presented in the 2009 SEF. The results and conclusions are summarized in the 2012 EIS/EIR and Klamath Dam Removal Overview Report for the Secretary of the Interior (SDOR). All steps required for a Level 2B evaluation were conducted, and they included a review of existing information (Level 1), screening assessment of sediment chemistry (Level 2A), bioassays and screening assessment of elutriate chemistry (Level 2B), and an additional examination of reservoir fish tissues. Additionally, concentrations were compared with the protective standards (i.e., low SLs) of the EPA RSLs and ODEQ SLVs for fish consumption. The contamination risk of concentrations in excess of the SLs was evaluated in consultation with several state and federal agencies and with respect to several contaminant exposure pathways from the sediments to biota and humans. The pathways included a “dams remain” option and four dam removal options: in the water column and in deposits in terrace and banks, the river bed, and near-shore marine environment. Additionally, values were compared with known background values for the area.

4.8.6.2 Previous Results

Based on the screening level evaluation, the previous analysis concluded that the risk of contamination to humans and freshwater, marine, and terrestrial biota along the four dam removal pathways was unlikely. In all but one case, contaminant concentrations above standards from the SLs, RSLs, or SLVs were at levels unlikely to cause adverse effects (see SDOR Figure 4.4.9-2). The one contaminant concentration determined to cause potential short-term minor to limited effect on freshwater biota was not a result of comparison with SEF SLs or EPA RSLs. With the exception of nickel in J.C. Boyle and Copco No. 1 and dieldrin in J.C. Boyle, the only contaminants reported in excess of the SEF standards were a result of the reporting limits (RLs) of the laboratory analysis in excess of the SLs, rather than detected concentrations of the contaminants in excess of the SLs. Exceedances based on reporting limits, rather than detected concentrations, included several polynuclear aromatic hydrocarbons (PAHs), phthalates, pesticides, and polychlorinated biphenyls (PCBs), but were generally not in excess of SL2 values.

The only exceedances of the EPA RSLs were the total carcinogenic RSLs for residential soils for arsenic and nickel in each reservoir. The EPA RSL threshold for lifetime exposure to humans to contaminated soils in residential settings for arsenic and nickel are 0.39 and 0.38 mg/kg, respectively, and, although exceeded, the exposure durations will be sufficiently low for exposure to be unlikely to lead to adverse effects. The results of the bioassays only indicated the potential for toxicity of reservoir sediments to benthic biota in J.C. Boyle reservoir, and CDM argued that increased toxicity in a dam removal scenario is unlikely given the dilution of the material. The lab results of contaminant testing for each reservoir are presented in EIS/EIR Appendix C and CDM (2011) Chapter 3 and Appendices A and B.

4.8.6.3 Current Screening Limit Standards and Reassessment of Results

Previous results were reviewed with respect to minor changes in SLs since 2011 and determined that the changes do not alter the previous conclusions. The updated SEF SLs in the current 2016 SEF Table 6-2 are generally similar to previous iterations of SEF SLs. The marine SLs are unchanged from the 2009 SEF with the exception of the pesticide dichlorodiphenyltrichloroethane (DDT), for which the SL was increased. The freshwater SL1 values from the 2016 SEF are generally similar to and typically higher than previous values, so the conclusions in the 20120EIS/EIR regarding SEF SLs are still valid.

We have reassessed the concentrations of the metals arsenic, chromium, nickel, and silver, for which the 2016 SEF SLs are lower than those used by CDM. For arsenic, chromium, and nickel, the lowest freshwater screening levels used by CDM were lower than the SEF SL1 value, so there is no change in the samples designated as exceeding the SLs criteria. Silver was not previously found to exceed any SLs. The standards of the EPA RSLs for the total carcinogenic RSLs for residential soils for arsenic and nickel are more protective than the SEF values, and the RSL values have not changed in a way that alters previous evaluations.

In the 2016 SEF, PAH SLs are defined as summed quantities rather than SLs for each contaminant as with the previous SLs. The maximum PAH RL values from the 2011 analysis are sufficiently low to not exceed the total PAH SL value in the 2016 SEF when summed. For 19 analytes (e.g., some PCBs, volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs)) measured during 2009-2010, RLs were greater than SLs, so it remains undetermined if concentrations exceed revised SLs. However, it was determined that these contaminants were unlikely to contribute to risk of contamination, and this argument is unaffected by any revisions to SLs. The results of the bioassays are not impacted by any new standards or SLs.

4.8.7 Flooding and Slope Instability

The potential for significant flooding and slope instability downstream of Iron Gate Dam due to and during reservoir drawdown activities is considered to be low. This is primarily due to the discharge capacity of the modified Iron Gate diversion tunnel, which is equivalent to a 5-year flood event. If the reservoir refills and spills during an event much larger than the 5-year flood event, this larger event would cause increased downstream flows even without the drawdown because the reservoirs are not used for flood control. For non-flood event periods, flows in the downstream channel would not exceed a 5-year flooding event; therefore, reservoir drawdown is not expected to cause significant erosion or subsequent slope instability. In fact, during reservoir drawdown, Iron Gate Reservoir will actually attenuate larger flood events resulting in lower flood discharges than would occur under existing conditions.

Since drawdown will not result in significant flooding or slope instability, reconnaissance of potentially inundated areas downstream of Iron Gate Dam is not proposed.

7.2 Aquatic Resources

7.2.1 Klamath Population Status Updates

The following section is intended to provide recent context on trends and estimated abundances of anadromous fish populations inhabiting the Klamath Basin downstream of Iron Gate Dam. The information provides an update on population data presented in the 2012 EIS/R. The population review includes spring and fall run Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), and steelhead (*O. mykiss*). Most of the data presented in this section contains the most recent 10 years of available population abundance metrics to provide additional context to the short term trends.

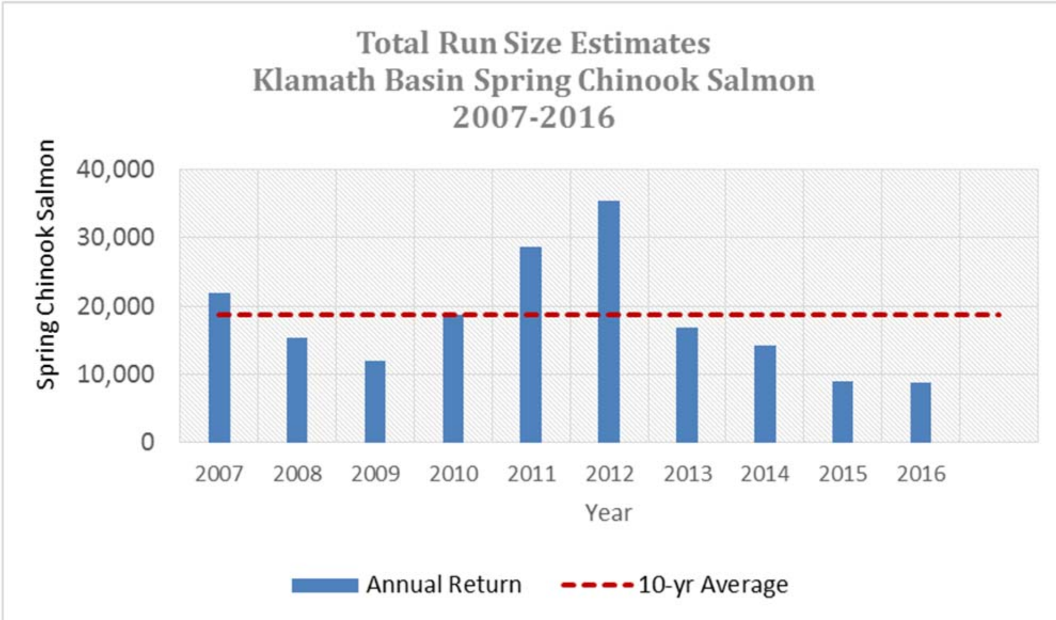
7.2.1.1 Chinook Salmon

Chinook salmon that spawn upstream of the Klamath-Trinity Rivers confluence comprise the Upper Klamath and Trinity Rivers Chinook salmon Evolutionarily Significant Unit (ESU). Populations downstream of the confluence comprise the Southern Oregon /Northern California Coastal Chinook salmon ESU. Neither of these Chinook salmon ESUs are currently listed under the Endangered Species Act. While Chinook salmon continue to be the most abundant salmonid species in the Klamath Basin, recent declines in Chinook salmon populations have had widespread impacts and have led to restrictions on important commercial, recreational, and tribal fisheries that the ESUs have historically supported. Furthermore, recent advances in understanding of genetic structure of Chinook salmon populations could potentially result in creation of a new ESU and may lead to the listing of Klamath River and Trinity River spring Chinook salmon under the ESA.

7.2.1.2 Spring Chinook Salmon

Historically, runs of spring Chinook salmon in the Klamath Basin likely numbered greater than 100,000 (Moyle et al. 2017), and likely outnumbered fall-run Chinook salmon (Spier 1930, Snyder 1931), but spring run Chinook salmon have been extirpated from a large portion of their historical range due to lack of accessible habitats (Hamilton et al. 2005). Since the 2012 EIS/R, the remaining naturally-produced populations of Klamath River spring Chinook salmon in the Salmon River and across the Upper Klamath and Trinity River (UKTR) ESU have continued a precipitous decline (CDFW 2016a).

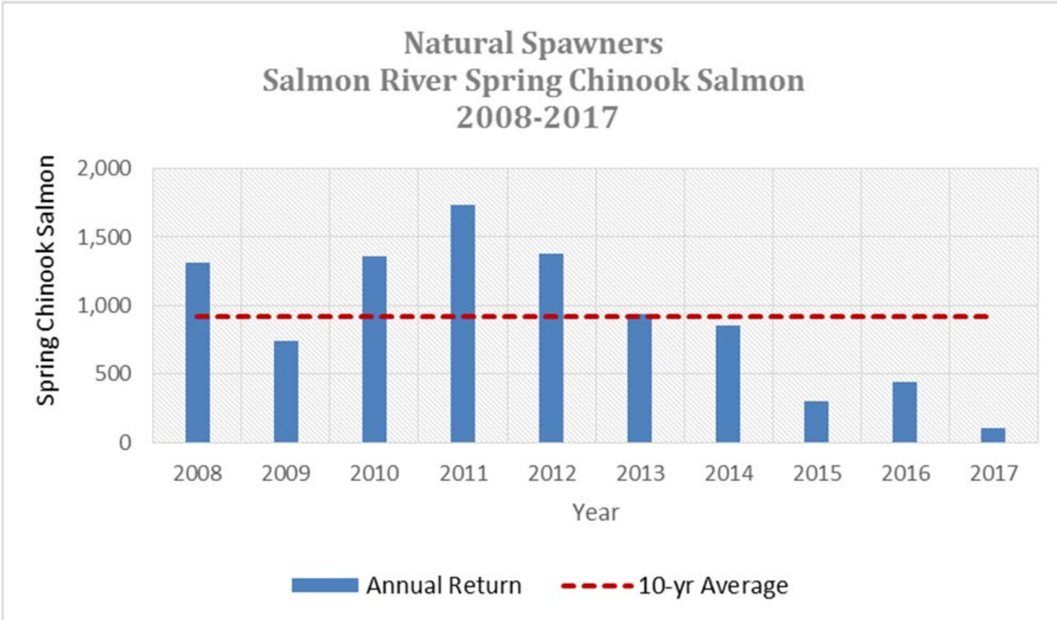
Total run size estimates from 2007-2016 (Figure 7.2-1) including both naturally and hatchery-produced spring Chinook salmon in the Klamath River basin, including the Trinity River, have ranged from a maximum of 35,326 in 2012 to a minimum of 8,815 in 2016, with an average of 18,817.



The recent 10-year average represented by the dotted red line is 18,817 fish.

Figure 7.2-1 Total run size estimates for Klamath Basin spring Chinook salmon from 2007-2016.

Only two viable naturally-spawned populations of wild spring Chinook salmon remain in the entirety of the Klamath Basin, one in the South Fork of the Trinity River, and the other in the Salmon River near Somes Bar, California. Summer holding pool adult counts have been conducted on the Salmon River annually for the past 23 years to estimate the total number of natural spring Chinook spawners available in that system. The contemporary effort includes snorkeling over 80 miles of the Salmon River mainstem, forks, and selected tributaries, and involves participation from federal and state agencies, tribes, watershed councils, and volunteers (CalTrout 2017). These counts show downward trends over time with a maximum of 1,736 spring Chinook salmon in 2011 decreasing to a low of 110 spawners in 2017. The 10-year average is 918 spring Chinook salmon (Figure 7.2-2). The Salmon River represents the last remaining viable natural spawning population of spring Chinook salmon in the Klamath Basin above the confluence of the Trinity River, and the nearest population to historical habitat upstream of Iron Gate Dam.



The recent 10-year average represented by the dotted red line is 918 fish.

Figure 7.2-2 Estimated natural spring Chinook salmon spawners based on summer resting pool counts for the Salmon River from 2008-2017.

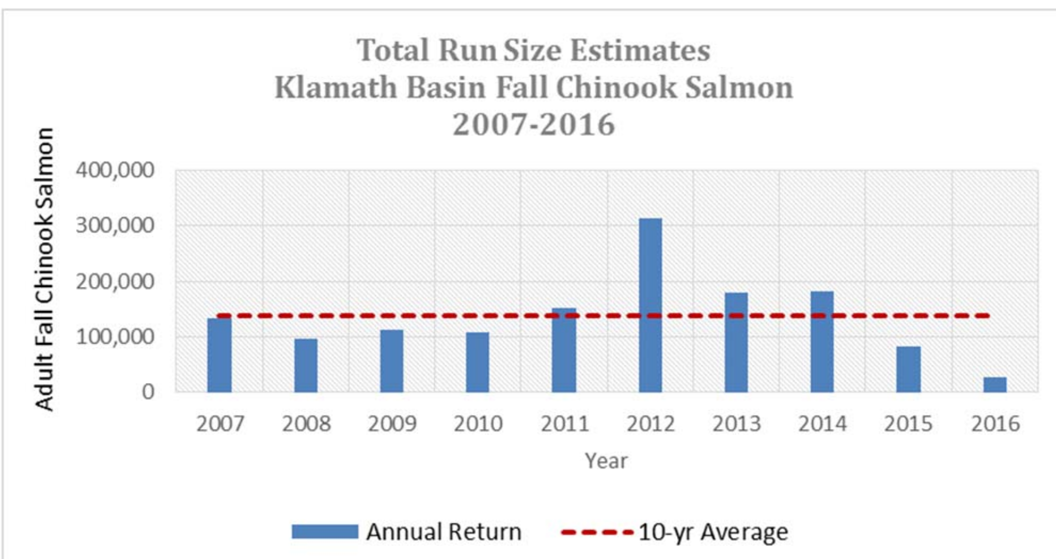
A 2013 status review of the UKTR Chinook salmon ESU conducted by NMFS in response to a petition for listing under the Endangered Species Act concluded that spring and fall run populations of Chinook salmon in the UKTR are included in a single ESU and that the ESU was at a low risk of extinction at the time of that determination (Williams et al. 2013). In their conclusions, the Biological Review Team included several concerns with Upper Klamath populations of spring Chinook salmon which provide additional insight into the overall status of the populations. The Biological Review Team concluded that the relatively few populations of spring Chinook salmon and the low number of spawners within those populations are limited by the availability and condition of currently accessible habitat. Deficient habitat restricts the expression of the spring run life history which typically provides diversity to the ESU. The Biological Review Team also stated that the low numbers of spring Chinook salmon are especially concerning given that the spring run life history was historically equal or larger than the fall run. In addition, the Biological Review Team suggested that the consequences of climate change may exert significant pressure on Chinook salmon populations in the UKTR unless habitat restoration and access to higher-elevation areas is achieved (Williams et al. 2013).

Recently published research by Prince et al. (2017) contests the current UKTR ESU configuration that defines spring and fall run Chinook salmon populations as a single ESU based on overall genetic structure that is primarily defined by geography. This configuration suggests that differences in premature (spring) versus mature (fall) migration timing within the same species and geographic range are replaceable in time frames that are consistent with conservation planning. The newly published research indicates that premature migration is defined by a single genetic variation that diverged approximately 15 million years ago, and that if the premature migration life history is lost in spring Chinook salmon or summer steelhead, it may not be replaceable for perhaps millions of years.

In November 2017, the Karuk Tribe and the Salmon River Watershed Council submitted a petition to NMFS to either list the UKTR Chinook ESU as endangered or threatened, or to create a new ESU for Klamath River spring Chinook salmon based on this new information. Without restored access to historical habitats that support the spring run life history, populations of spring Chinook salmon are expected to remain at a fraction of historical estimates (Moyle et al. 2008). Due to exceptionally low population abundance and the spatial distribution of existing populations being primarily located in the Salmon and Trinity rivers, it's likely that some intervention will be necessary to re-establish spring Chinook salmon populations in the Upper Klamath Basin (Goodman et al. 2011).

7.2.1.3 Fall Chinook Salmon

Run sizes of hatchery and naturally produced fall Chinook salmon in the Klamath Basin vary considerably from year to year. Current estimates of spawning escapement and run size are monitored by a combination of state, federal, and tribal agencies using a variety of methods including redd and carcass surveys, weir counts, and mark-recapture studies. Over 300,000 fall Chinook returned to the Klamath Basin in 2012 representing the largest recorded run since monitoring began in 1978 (CDFW 2016b). Conversely, preliminary data suggest that only approximately 27,000 fall Chinook salmon returned to the basin in 2016, representing the smallest run size during the same time period. The 2015 fall Chinook returns totaled approximately 84,000 which is substantially less than the recent 10-year average of approximately 140,000 fish (Figure 7.2-3).



The recent ten year average is represented by the dotted red line and is 138,878.

Figure 7.2-3 Total run size estimates for the fall Chinook salmon for the Klamath Basin from 2007-2016.

Critical stressors on natural fall run Chinook salmon populations in the basin include water quality and quantity in the mainstem and spawning tributaries. Downstream of Iron Gate Dam, the mainstem Klamath River undergoes seasonal changes in flows, water temperature, dissolved oxygen, and nutrients, as well occasional blooms of *Microcystis aeruginosa*. During outmigration, juvenile Chinook salmon are vulnerable to contracting disease from pathogens, including the bacterium *Flavobacterium columnare*, and myxozoan parasites *Parvicapsula minibicornis* and *Ceratomyxa shasta* (USBR and CDFG 2012).

More recent trends show that the abundance of natural spawners is also variable between years, but have declined sharply since a large return of adult fall Chinook in 2014 (Figure 7.2-4). Estimates of naturally spawned fall Chinook salmon are based on monitoring surveys that include the mainstem Klamath River, the Salmon River basin, the Scott River basin, the Shasta River basin, Bogus Creek, and miscellaneous Klamath River tributaries on and above the Yurok Reservation (CDFW 2016b).

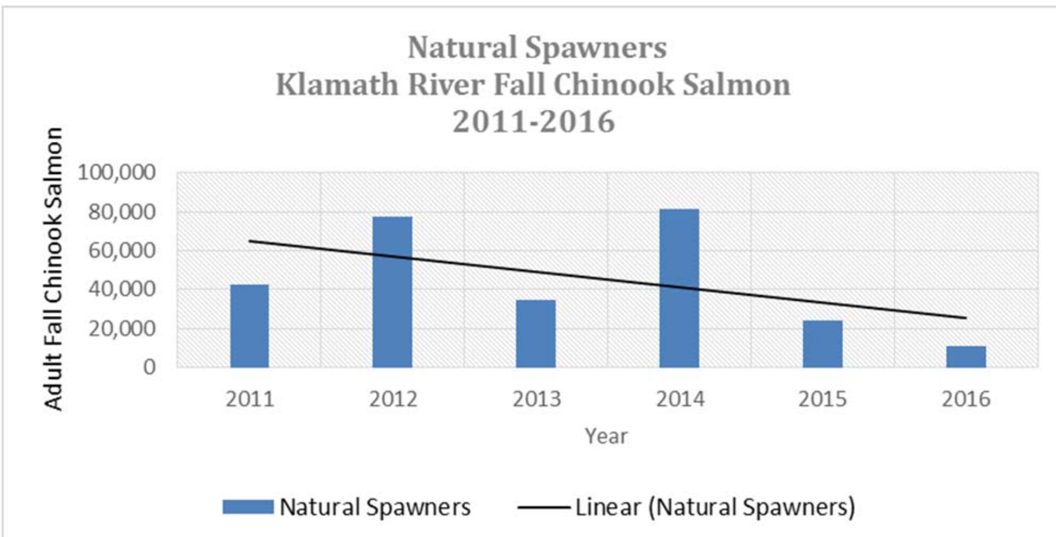


Figure 7.2-4 Natural fall Chinook salmon spawner estimates in the Klamath River and selected tributaries from 2011-2016.

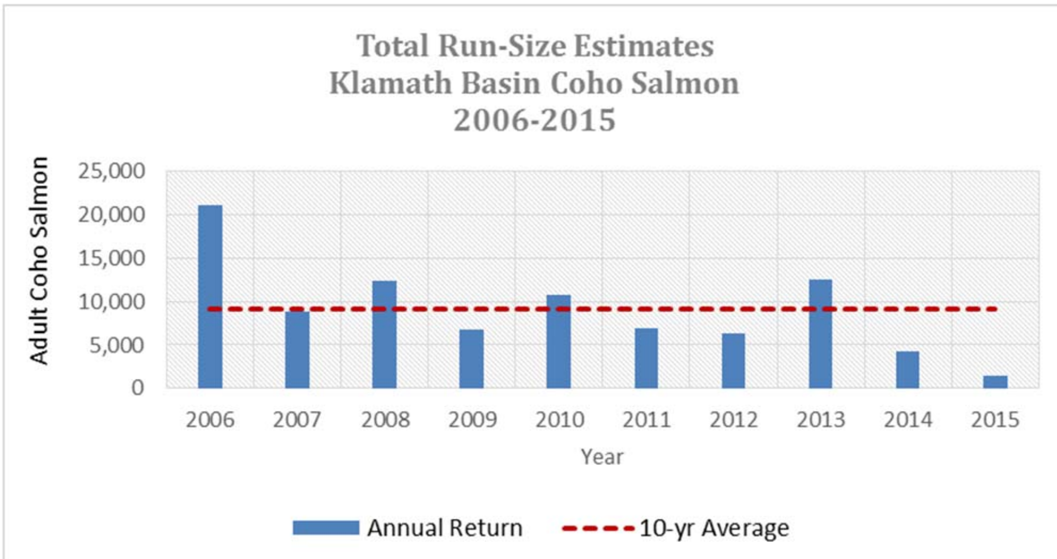
In 2017, the predicted run size was estimated at approximately 12,000 natural spawners, the lowest prediction on record, and substantially less than the 40,700 natural spawner escapement goal. Fisheries managers closed all recreational fishing for Chinook salmon in the Klamath and Trinity rivers for 2017 and tribal and commercial fisheries were severely restricted as well.

7.2.1.4 Coho Salmon

Coho salmon in the Klamath Basin are a component of the Southern Oregon/Northern California Coast (SONCC) coho salmon ESU, which was listed as federally threatened in 1997.

All nine coho salmon populations within the Klamath basin (i.e., Upper, Middle, and Lower Klamath River populations, Upper and Lower Trinity River populations, Scott, Shasta and Salmon River populations, and the South Fork of the Trinity River population) have declined relative to historical levels (NMFS 2014) some of these populations may not be viable, and all have a moderate or high estimated extinction risk (NMFS 2016).

Estimates for the total run size of naturally and hatchery produced coho salmon for the Klamath Basin between 2006-2015 have ranged from a high of 21,155 (2006) to a low of 1,431 (2015) (CDFW 2016c; Figure 7.2-5). Total run size estimates for 2016 and 2017 were not available at the time of this writing.



The dotted red line represents the recent 10-year average of 9,157 fish.

Figure 7.2-5 Total run size estimate for Klamath Basin coho salmon from 2006-2015.

Estimates of natural spawners in the Klamath River and select tributaries show the variability between different year classes, but illustrate how weak two of the three brood year classes have been with the exception of the 2013 brood year class (Figure 7.2-6). Estimates of naturally spawned coho salmon are based on monitoring surveys that include the mainstem Klamath River, the Salmon River basin, the Scott River basin, the Shasta River basin, Bogus Creek, and miscellaneous Klamath River tributaries below the Yurok Reservation (CDFW 2016c).

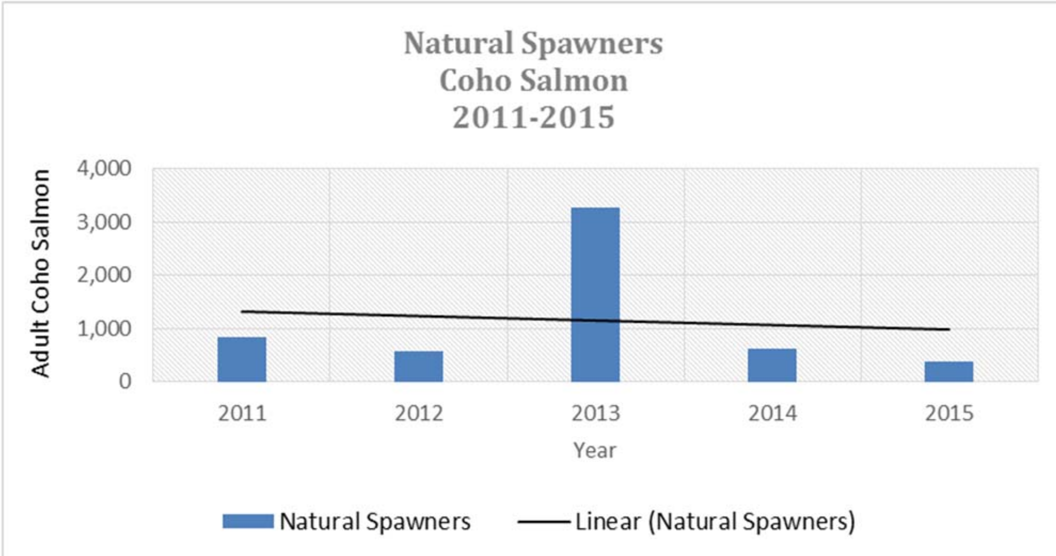
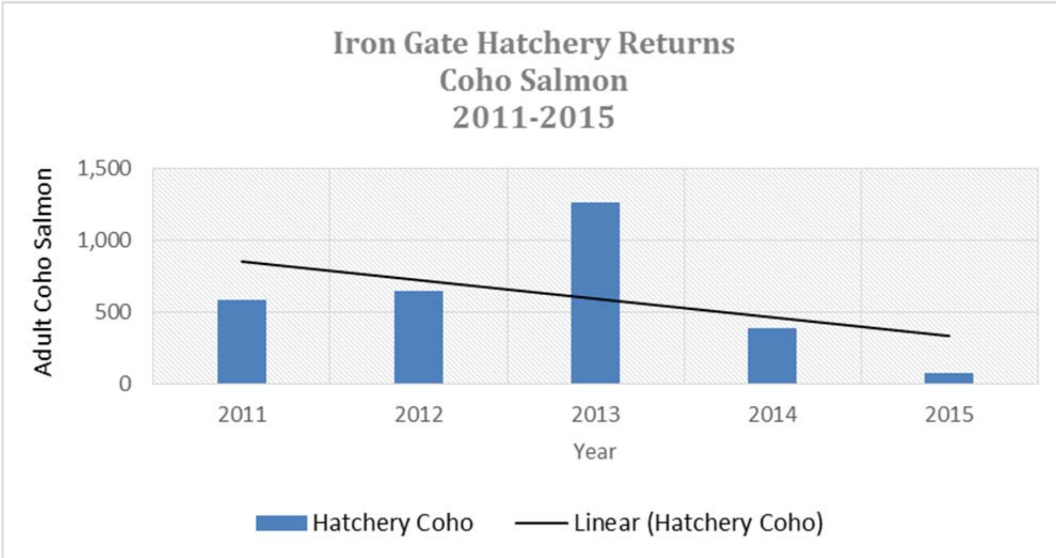


Figure 7.2-6 Estimates for coho salmon natural spawners in the mainstem Klamath River and selected tributaries from 2011-2015.

Hatchery coho production at Iron Gate Hatchery provides additional context to the status of populations within the Klamath River. The Iron Gate Hatchery coho program was initiated in the late 1960s to mitigate for impacts resulting from the construction of Iron Gate Dam, and currently operates to produce a program goal of 75,000 yearling coho salmon (California Hatchery Scientific Review Group 2012). The program currently operates under a Hatchery Genetics Management Plan finalized in 2014 to protect and conserve the genetic resources of the Upper Klamath River coho population unit (CDFW and PacifiCorp 2014).

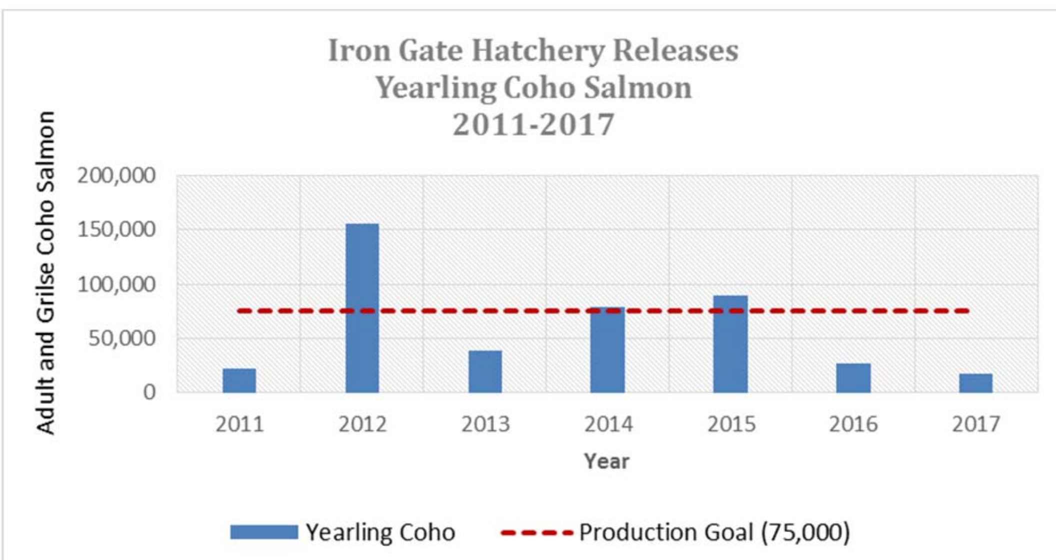
Adult returns to Iron Gate Hatchery between 2011 and 2015 display similar patterns to the estimates of natural spawners, with one year class (2013) substantially stronger than the other two year classes (Figure 7.2-7).



The count of hatchery coho includes adult and grilse (reproductively mature after one ocean year) salmon.

Figure 7.2-7 Returns of coho salmon to the Iron Gate Hatchery from 2011-2016.

Similarly, releases of yearling coho salmon from hatchery production at Iron Gate Hatchery between 2011-2017 have only met production goals in three out of the last seven years (Figure 7.2-8).



The red dotted line represents the IGH production goal of 75,000 yearling coho.

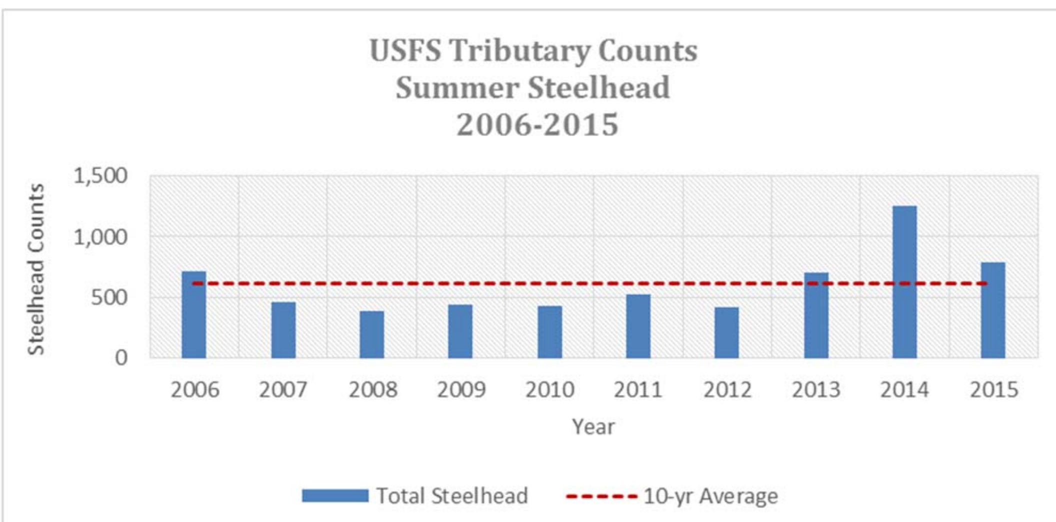
Figure 7.2-8 Yearling coho salmon releases from the Iron Gate Hatchery from 2011-2017.

7.2.1.5 Steelhead

Klamath Basin summer and winter steelhead populations comprise the Klamath Mountain Province ESU. In 2001, NMFS determined the Klamath River Basin steelhead were not warranted for listing under the ESA, despite declining populations (NMFS 2001). Recent research completed by Hodge et al. (2016) identified a total of 38 life history categories at maturity for steelhead in the Klamath River. Klamath River steelhead populations have declined despite having high life history diversity, a characteristic that typically increases population stability.

Recent data on Klamath River Basin steelhead populations outside of the Trinity River are limited. Recent trends in abundance of Klamath River steelhead populations were examined primarily using three datasets; summer steelhead counts from the Orleans and Happy Camp Ranger Districts on tributary streams located of U.S. Forest Service (USFS) lands; video monitoring results from Bogus Creek and the Shasta River; and Iron Gate Hatchery returns, although the Iron Gate Hatchery steelhead program has not operated since 2013 due to low adult returns.

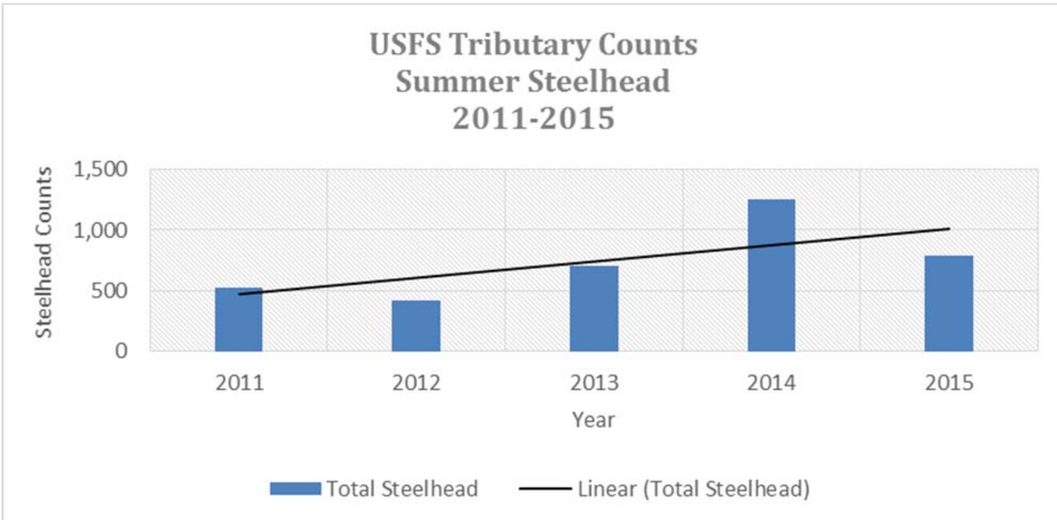
Since 1985, the Klamath Basin Collaborative Partnership has conducted summer steelhead holding counts on tributaries located on or adjacent to lands administered by the USFS Orleans and Happy Camp Ranger Districts in the middle Klamath River. Counts include adults and half pounders, and are a sum of the surveys conducted on Bluff Creek, Red Cap Creek, Camp Creek, Wooley Creek, Dillon Creek, Clear Creek, Elk Creek, Indian Creek, Thompson Creek, Grider Creek, and other small tributaries to the Klamath River located between Aikens Creek and Beaver Creek. Between 2006 and 2015, counts of adult and half pounder summer steelhead have ranged from a low of 384 to a high of 1255 with a recent 10-year average of 612 (Figure 7.2-9).



The dotted red line represents the recent 10-year average of 612 fish.

Figure 7.2-9 Summer steelhead counts on tributaries to the middle Klamath River from 2006-2015.

Between 2011 - 2015, summer steelhead counts in tributaries on USFS administered lands have shown a slight increase with the exception of 2012 (Figure 7.2-10). However these summer steelhead populations likely represent only a fraction of their historical abundance (Moyle et al. 2017), and some populations such as Salmon River summer steelhead have declined significantly in the past several decades (Quiñones et al. 2013).

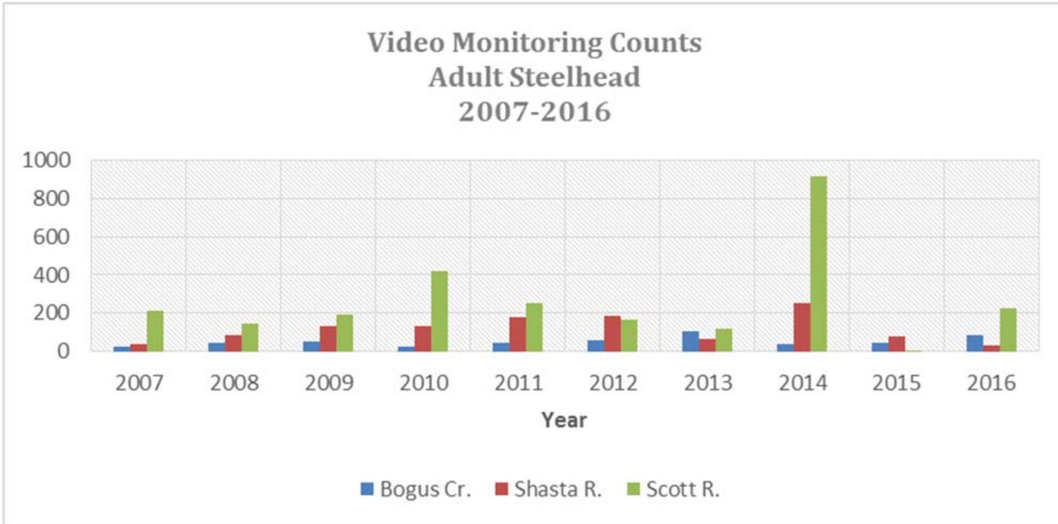


Note Wooley Creek was not surveyed in 2006, and Wooley and Dillon creeks were not surveyed in 2008.

Figure 7.2-10 Counts of holding summer steelhead on tributaries to the middle Klamath River from 2011-2015.

While these data do not provide a basin wide estimate of abundance of summer steelhead populations, they provide some context to the recent trends of these populations on USFS administered lands in the middle Klamath River.

Video monitoring conducted in Bogus Creek and the Shasta and Scott rivers from 2007 to 2016 also provides context to the recent abundance of upper Klamath steelhead populations (Figure 7.2-11). Average returns of adult steelhead counted by video were 53 (Bogus Creek), 117 (Shasta River), and 265 (Scott River) during the 10-year period (CDFW, unpublished data, 2017). However, in many years, video monitoring was terminated in December or January and did not capture the full or peak steelhead migration period. In years where video monitoring or a combination of video counts and SONAR counts covered the full migration period (2013 and 2016 for Bogus Creek and 2012, 2015, and 2016 for Shasta River), total steelhead counted averaged 94 for Bogus Creek and 194 for the Shasta River (CDFW, unpublished data, 2017).

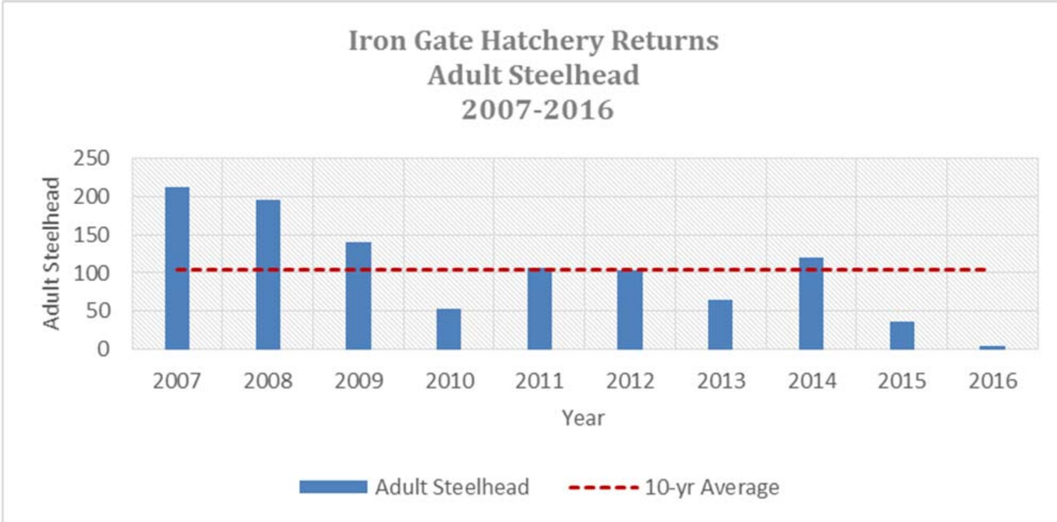


Note that most counts do not represent the peak of full steelhead migration periods.

Figure 7.2-11 Video counts of adult steelhead on Bogus Creek, Shasta River, and Scott River from 2007-2016.

Iron Gate Hatchery has produced steelhead since the early 1960s to mitigate for Iron Gate Dam impacts and to provide recreational fishing and harvest opportunities. Steelhead production has varied substantially over the years, with a high of approximately 643,000 yearlings in 1970 to a low of about 11,000 yearlings in 1997. The 200,000 yearling production goal was met in most years prior to 1991, but has not been achieved since then (California Hatchery Scientific Review Group 2012).

Adult steelhead returns to Iron Gate Hatchery typically ranged between 1,000 to 4,000 fish from the mid-1960s to the late 1980s. Returns declined substantially in 1990 and have steadily declined since (CDFW 2016d). Between 2007 and 2016, adult steelhead returns have ranged from a low of 4 (2016) to a high of 212 (2007) with a recent 10-year average of 104 fish (Figure 7.2-12). These returns have not been adequate to meet production goals for egg take and juvenile releases, and no steelhead have been produced at the Iron Gate Hatchery since 2012 (K. Pomeroy, CDFW, personal communication, 2017).



The dotted red line represents the recent 10-year average of 104 fish.

Figure 7.2-12 Adult steelhead returns to Iron Gate Hatchery from 2007-2016.

7.2.1.6 Summary

The Klamath River Basin historically supported robust and resilient populations spring and fall run Chinook salmon, coho salmon, and steelhead. The remaining populations of anadromous fish in the Klamath River are present at a fraction of their historical estimates, and have declined significantly in abundance and viability over the last century (NMFS 2009). Most recently, and since the development of 2012 EIS/R, these populations have continued to experience further declines in abundance. Coho salmon are the only anadromous salmonid in the Klamath Basin listed under the ESA, the nine coho populations in the basin continue to decline, with most of them being at a high risk of extinction. New research published on Chinook salmon suggests that it may be appropriate to create a separate ESU to distinguish spring-run Chinook from fall-run Chinook in the current Upper Klamath – Trinity River ESU, and that designation would almost assuredly place Klamath Basin spring Chinook salmon on the endangered species list. Fall Chinook salmon runs have demonstrated great variability in year to year run sizes over the last decade with historically large runs in 2012 and 2014, and record low returns in 2015 and 2016. Forecasted predictions for 2017 were for even smaller returns than the record setting low run of 2016, and have led to widespread restrictions on West Coast fisheries. Steelhead populations show variability from year to year and are more difficult to assess than those of coho and Chinook salmon. Some populations such as summer steelhead populations on USFS lands appear to be relatively stable with modest increases over the last few monitoring years, while other populations such as those in the Shasta River and Bogus Creek continuing to decline.

7.2.2 Understanding of Fish Diseases

Fish diseases are widespread in the mainstem Klamath River during certain time periods, and in certain years, disease prevalence has been shown to adversely affect productivity of

Chinook (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*). Since 2012, researchers have focused on developing a better understanding of the life cycle, habitat characteristics, and effects of the myxozoan parasite *Certonova shasta* (previously *Ceratomyxa shasta*; *C. shasta*), and *Parviscapsula minibicornis*, on anadromous salmonids. *P. minibicornis* and *C. shasta* share the same invertebrate host, *Manayunkia speciosa*, and environmental variables such as temperature and flow are expected to affect parasite abundances similarly (Bartholomew and Foott 2010). The following document focuses on *C. shasta* as an indicator of mortality as a result of myxozoan infection in the Klamath River.

7.2.2.1 Certonova Shasta

Life Cycle

The parasite *C. shasta* is endemic to the Klamath Basin and is assumed to have co-evolved with the salmonid species it infects (Som et al. 2016a). The myxozoan parasite has a complex life cycle that includes two hosts and two spore stages. Waterborne actinospores released from the freshwater polychaete worm, *M. speciosa*, infect adult and juvenile salmonids and develop into myxospores that are then released from salmonids and infect the polychaete host.

C. shasta actinospores are released from infected polychaetes into the water column as temperatures rise above 10ºC in late March to early April (Bartholomew and Foott 2010). The actinospores are naturally buoyant and relatively short lived (days to weeks; Bjork 2010). Actinospores die unless they encounter a susceptible fish host. Fish become infected as the spores attach to the gills and travel through the bloodstream to reach the intestine. *C. shasta* infects the intestine of salmonids and can lead to necrosis of intestinal tissue that can be accompanied by a severe inflammatory reaction (enteronecrosis) and mortality (Bartholomew et al. 1989; Bartholomew et al. 2017). Myxospores develop within infected salmonids over a period of 18-25 days and are released into the environment at or soon after fish mortality (Benson 2014). Myxospores are denser than actinospores, allowing them to sink to the channel bed where they are consumed by suspension-feeding polychaetes (Bartholomew and Foott 2010). Consumption of myxospores infects polychaete worms, completing the *C. shasta* life cycle (Som et al. 2016a).

Habitat

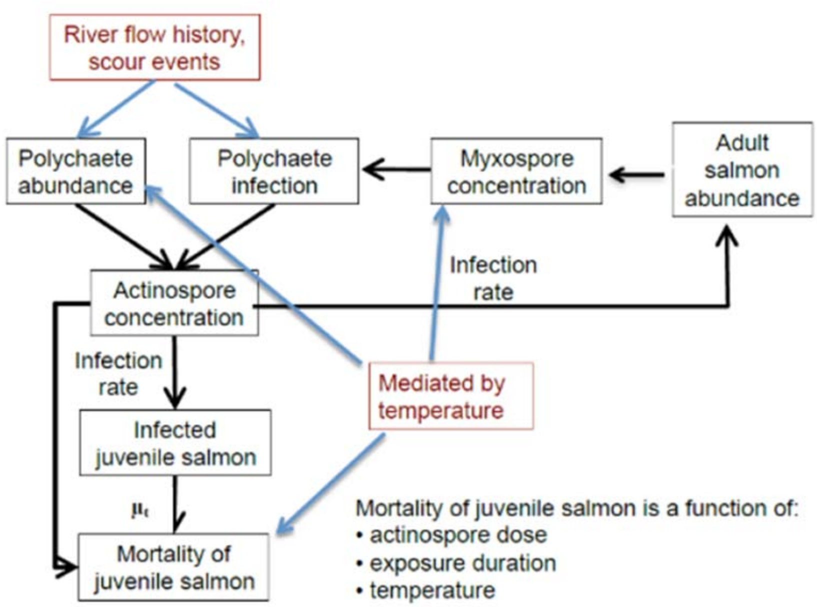
The polychaete worm *M. speciosa* is adapted to life as a semi-sessile benthic invertebrate and inhabits many types of macro and microhabitats. Inhabited macrohabitats include channel habitat such as riffle runs, pools, channel margins, and reservoir inflow zones. Identified microhabitats include channel bed sediment, freshwater sponge, aquatic vegetation, and periphyton (Stocking and Bartholomew 2007). Through laboratory and field studies, researchers have concluded higher flows could directly influence the distribution of polychaetes by restricting habitat use to stable substrates (Som et al. 2016b). However, the mobility of *M. speciosa* and the species' ability to persist after high flow events suggests *M. speciosa* is capable of moving to lower velocity, stable substrate habitats to avoid high flow effects (Alexander et al. 2014). Preliminary test results indicate that infected polychaetes are more likely to occur within a smaller range of peak flow depths and velocities than the general polychaete population, with infected polychaetes more associated with deeper and lower velocity depositional habitat (Som et al. 2016b).

7.2.2.2 Juvenile Salmonid Infection

Annual prevalence of the myxozoan parasite *C. shasta* has been documented in emigrating juvenile salmon populations during spring and early summer in the Klamath River (True et al. 2016). *C. shasta* in out-migrating juvenile salmonids has been well-studied (True 2013; True et al. 2013) and the processes that influence *C. shasta* impacts on Klamath River salmon are increasingly understood.

C. shasta infection of juvenile salmonids causes enteronecrosis, often resulting in death. Fish infected by *C. shasta* may experience enteronecrosis mortality, but are also prone to mortality caused by other pathogens such as *P. minibicornis*. Enteronecrosis may also weaken juvenile salmonids making them more susceptible to predation, and may compromise osmoregulatory systems that are essential for successful ocean entry. *C. shasta*-related mortality has been linked to population declines in fall Chinook salmon in the Klamath River (Fujiwara et al. 2011; True et al. 2013).

C. shasta infection rates of juvenile Chinook salmon are influenced by *C. shasta* spore densities, water temperature, flow rate, and juvenile salmonid residence time in areas of high spore densities (Ray et al. 2014). Figure 7.2-13 includes a conceptual model illustrating the variables and processes influencing *C. shasta* infection and juvenile salmonid mortality. *C. shasta* infections generally progress to clinical enteronecrosis over a 7-18 day period, depending on exposure and the time period fish spend in the infectious zone during their outmigration (True 2013). Mortality may occur between 13 days and 25 days post-exposure to *C. shasta* (Bartholomew et al. 2017).



Source: Foott et al. 2011 cited in Som et al. 2016

Figure 7.2-13 A conceptual model of variables and processes influencing C. shasta infection and mortality of juvenile Chinook salmon.

Studies over the last decade have focused on developing a better understanding of the parasite life cycle and the parasite's effects on juvenile salmonids in the Klamath River. Ray et al. (2014) evaluated in situ juvenile salmonid exposure using sentinel cages. Studies found that increasing parasite concentrations and water temperatures were positively associated with the proportion of juvenile fish that experienced infection and mortality. Spore concentration and water temperature were more important determinants of exposure and mortality of juvenile Chinook and coho salmon, than was river discharge. However, high velocities (Ray and Bartholomew 2013) and elevated flows may dilute spore densities and reduce transmission efficiency (Ray and Bartholomew 2013). Recent low water years associated with the 2013-2014 drought in California provided habitat conditions more favorable to *C. shasta* and *P. minibicornis* proliferation (True et al. 2015) compared to previous and subsequent higher flow years. Although high flow years may disrupt polychaete habitat, elevated flows may also redistribute polychaetes over a longer reach of the Klamath River (Bartholomew et al. 2017).

Table 7.2-1 includes a summary of juvenile Chinook salmon prevalence of infection over 10 years at the Kinsman rotary screw trap location (RM 147.6), located 45 river miles downstream from Iron Gate Dam (RM 192.8). The Kinsman trap is located between the Shasta River and the Scott River, a reach of the Klamath River often referenced as the "infectious zone" (True et al. 2015). The general pattern of annual parasite abundance in the Klamath River downstream from Iron Gate Dam remains relatively consistent from year to year, although the extent of the infectious zone and the magnitude of parasite densities change seasonally and annually (Bartholomew and Foott 2010; Bartholomew et al. 2017). Depending on river conditions (e.g., flow and water temperature) the infectious zone may extend from Iron Gate Dam to downstream of Seiad Valley (True 2013; Bartholomew et al. 2017). While high run-off years may reduce polychaete densities downstream of Iron Gate Dam, the redistribution of polychaetes by high flows may result in the downstream relocation of *C. shasta* 'hot spots' (Som et al. 2016c).

Estimates of the annual proportion of infected Chinook salmon range from 2 percent to 66 percent (Som et al. 2016a). As the release of Iron Gate Hatchery juvenile Chinook salmon overlaps with the period of high infection potential, studies suggest that a high proportion of the Iron Gate Hatchery Chinook salmon stock can become infected with *C. shasta* (Som et al. 2016a). Infected juvenile fish that experience mortality lower in the Klamath River may become another source of myxospores to the lower Klamath River.

Table 7.2-1 Summary of estimates of annual-level C. shasta infection prevalence for wild and/or unknown origin juvenile Chinook salmon passing the Kinsman rotary screw trap site (RM 147.6).

Year	Origin	Prevalence of Infection	Infected Population Estimate Lower Confidence Limit	Infected Population Estimate	Infected Population Estimate Upper Confidence Limit
2005	All	0.41	0.26	0.38	0.47
2007	All	0.28	0.07	0.1	0.15
2008	All	0.6	0.43	0.51	0.58
2009	All	0.5	0.5	0.58	0.66
2010	Wild/Unknown	0.12/0.15	0.02	0.04	0.07
2011	Wild	0.2	0.07	0.11	0.17
2012	Wild/Unknown	0.06/0.00	0.04	0.08	0.14
2013	Wild	0.18	0.03	0.06	0.09
2014	Wild	0.67	0.12	0.18	0.26
2015	Wild/Unknown	0.66/0.96	0.2	0.29	0.39

Note: The lower and upper confidence limits account for the estimation uncertainty in abundance and weekly prevalence of infection rates.
Source: Som et al. (2016a).

7.2.2.3 Spawner Influence on Prevalence of *C. shasta*

Returning adult salmon are exposed to myxospores when fish enter the Klamath River in the fall. Disease progression in adult fish is likely a function of temperature and infectious dose (Bartholomew and Foott 2010). Because adult fish have a low infection threshold, the prevalence of infection is high and infection rates may be high even in years of reduced infectious zone prevalence.

Adult salmonid carcasses play an important role in the lifecycle and prevalence of *C. shasta* in the infectious zone (Som et al. 2016a). Fall Chinook salmon returns to Iron Gate Hatchery and the blockage created by Iron Gate Dam, concentrate spawners and post-spawn carcass densities between Iron Gate Dam and the Shasta River confluence. Myxospore development occurs predominantly in decomposed carcasses rather than in recent post-spawned adults (Som et al. 2016a). Myxospore detection from carcasses ranges from 22 percent to 52 percent, however less than 13 percent of carcasses are significant contributors to myxospores production (produce >500,000 spores). Based on average adult returns to in the Shasta River to Iron Gate Dam reach, Chinook salmon carcasses potentially produce billions of myxospores. Myxospores remain viable in the channel bed sediments through the winter and early spring, and re-enter the water column over the winter when juvenile salmonids begin to emerge from the gravels.

7.2.2.4 Disease Reduction Benefits Associated with Dam Removal

Facilities removal is expected to reduce fish disease impacts to adult and juvenile salmon especially downstream from Iron Gate Dam. Among the salmon life stages, juvenile salmon tend to be most susceptible to *P. minibicornis* and *C. shasta* (Beeman et al. 2008). The main factors contributing to risk of infection by *C. shasta* and *P. minibicornis* include availability of habitat (pools, eddies, and sediment) and microhabitat characteristics (static flow and low velocities) for the polychaete intermediate host; polychaete proximity to spawning areas; increased planktonic food sources from Hydroelectric Reach reservoirs; water temperatures greater than 15°C (Bartholomew and Foott 2010); and juvenile salmonid residence time in the infectious zone (Som et al. 2016a).

Facilities removal will restore natural channel processes including channel bed scour and sediment transport. Annual channel bed scour will disturb the habitat of the polychaete worm that hosts *C. shasta* (FERC 2007). Reducing polychaete habitat will likely increase abundance of smolts by increasing outmigration survival, particularly for juvenile coho salmon (FERC 2007).

Dam removal will also broaden the distribution of adult pre-spawn fall Chinook salmon, reducing crowding and the concentration of disease pathogens that currently occurs in the reach between Iron Gate Dam and the Shasta River (Som et al. 2016a). Lastly, a broader spawning distribution will also influence the distribution of post-spawn adult carcasses that contribute the bulk of the myxospores that enable the *C. shasta* life cycle within the infectious zone. Distributing adult carcasses over a longer reach of the Klamath River corridor will reduce myxospore densities likely leading to lower juvenile salmonid infection rates in the winter and spring rearing period (Som et al. 2016a). However, adult spawning upstream of the Klamath River dam sites could also expand habitat for *M. speciosa* and *C. shasta* effects. Both juvenile outmigrants and returning adult fish could be exposed to *C. shasta* over longer distances with dam removal.

In summary, water temperature and spore concentrations are positively correlated with infection and mortality of juvenile Chinook salmon and coho salmon. High spawner carcass concentrations downstream from Iron Gate Dam, contribute to high myxospore concentrations and the incidence of infection of juvenile fish. The timing of juvenile Chinook salmon from Iron Gate Hatchery and associated water temperatures may substantially contribute to the total myxospore load in the Klamath River. High spore concentrations in the Shasta River to Salmon River reach of the Klamath River, creates an "infectious zone" that increases outmigrating juvenile fish exposure to *C. shasta*.

7.2.3 Total Maximum Daily Load Programs

There are ten US EPA approved Total Maximum Daily Load (TMDL) programs within the Klamath Basin addressing multiple water quality impairments including temperature, nutrients, dissolved oxygen, sediment, and other parameters related to biostimulatory conditions. Programs of TMDL implementation are the direct responsibility of the California North Coast Regional Water Quality Control Board (Regional Water Board) and the Oregon Department of Environmental Quality (ODEQ). The strategic approach to the multiple Klamath Basin TMDLs includes a formal partnership between ODEQ and the Regional Water Board to treat the Klamath Basin as an integrated aquatic ecosystem with a comprehensive program of TMDL implementation. In addition, the Regional Water Board and ODEQ have been participating in a network of Indian tribes, other federal, state and local agencies, non-governmental organizations, and private organizations throughout the Klamath Basin to implement water quality improvement projects and a wide-range of restoration projects. This list of projects includes hundreds if not thousands of projects throughout the Klamath Basin. Example water quality improvement projects include: treatment wetlands, riparian restoration and protection strategies, improved agriculture and timber harvest practices, flow enhancements, among others.

In addition, the Klamath Basin Monitoring Program (KBMP) is coordinating the strategic water quality status and trends monitoring of over forty-five organizations from the headwaters near Crater Lake in Oregon to estuary at the Pacific Ocean in California. KBMP provides an adaptive management framework for participating organizations allowing an evaluation of water quality improvement progress throughout the basin over time.

Recent water quality trend analyses completed for tributaries into Upper Klamath Lake and at the lake's outlet at Link River suggest declining phosphorus concentration trends in the tributaries to Upper Klamath Lake (Walker et al. 2012; Walker et al. 2015). Extensive modelling by USGS indicates that lake algal biomass and thus outflow algal biomass will decline relatively rapidly in response to reductions in phosphorus loading to Upper Klamath Lake (Wherry et al. 2015). This suggests that Upper Klamath Lake is responding in a relatively short time-frame to upper basin water quality improvements that are translated to the Klamath River below Upper Klamath Lake. Therefore, the Upper Klamath Basin has been a focus for water quality improvement projects to meet TMDL objectives.

Recommendations developed at the KHSA Interim Measure 10 Water Quality Improvement Techniques Workshop called for a focus on controlling phosphorus inputs to Upper Klamath Lake from watershed sources in the upper basin (40% reduction target consistent with ODEQ Upper Klamath Lake TMDL). These recommendations have been identified by the Interim Measure 11 Interim Measure Implementation Committee and incorporated into a preferred list of projects funded with $5.4 million provided by PacifiCorp as part of the KHSA. Implementation of the Interim Measure 11 water quality improvement projects will begin in 2018. Also in 2018, USFWS will continue support for the Klamath Basin Restoration Program (KBRP) which provides funds for aquatic and terrestrial habitat restoration actions that provide water quality benefits. A portion of the KBRP funds are intended to address factors such as water quality in Keno that pose potential challenges to successful reintroduction of anadromous fish to the upper basin.

In summary, there are many water quality improvement projects planned by state and federal agencies and Indian tribes throughout the Klamath Basin to achieve the TMDL objectives and thereby improve conditions for anadromous fish reintroduction. Although progress has been made, it is uncertain when these combined efforts will result in improved biostimulatory conditions in critical reaches (e.g., Keno Reservoir), but there is substantial commitment from state and federal agencies and Indian tribes to ensure that the critical water quality improvements are completed to support the reintroduction of salmonids in the Upper Klamath Basin.

7.2.4 Fish Passage and Water Quality at Keno Dam

The ODFW, in conjunction with the Klamath Tribes, is currently in the process of preparing an anadromous reintroduction implementation plan for anadromous fish into the Oregon portions of the Klamath River and its tributaries. The successful upstream passage of adult salmon and steelhead trout that arrive at Keno Dam is an important consideration of the implementation plan. During the initial stages of the reintroduction process, upstream migrant fishes will be allowed to pass unimpeded through the fish ladder at Keno Dam unless water quality conditions in Keno Reservoir exceed a predefined threshold that triggers a decision to actively capture and haul fish upstream to a suitable location for release. Removal of reservoirs would allow cool water tributaries (e.g. Fall, Shovel, Spencer, and Jenny creeks) and cold water from the approximately 225 cfs Big Spring in the JC Boyle by-pass reach to function as thermal refugia for up-migrating salmonids. These cooler water inflows will create thermal diversity in the river in the form of intermittently-spaced patches of thermal refugia and at times, limit the establishment of thermal barriers to upstream migration, as documented to occur in the lower Klamath River (Logomarsino and Hetrick. 2013). Up-migrating fish may hold in in these areas of refugia until water temperature conditions improve to support continued up-migration. Understanding potential adult migratory fish behavior under these conditions will help inform the need and scale of fish capture facilities at Keno Dam.

ODFW has been actively working with PacifiCorp, USBR, and other Klamath Basin fish managers to assess the existing fish passage and potential fish collection at Keno Dam. This includes initiating the aspects of designing and funding the retrofitting of the existing Keno Dam fish ladder to accommodate an adult fish collection facility. The ability to collect adult migrants is projected to be an important component of the anadromous fish reintroduction plan and working to secure the necessary funding for the fish collection facility, along with operational funds, is an ODFW priority. ODFW is working with state and federal agencies to determine funding options and has a high level of confidence the monies will be available in an adequate timeframe to provide collection and upstream transport (if deemed necessary) of upstream migrating adult salmon and steelhead trout. To this end ODFW convened a site meeting of fish biologist and fish passage engineers at the Keno Dam in May of 2017. As a follow-up to this initial site meeting, ODFW and USBR are convening a working group of fish passage and fish collection facility experts in February of 2018 to further address the need, scope, potential design and cost as the basis for working with potential funding sources.

7.2.5 Aquatic Resources Measures

The 2012 EIS/R included aquatic resource (AR) plans to attempt to mitigate the possible short-term (<2 years following dam decommissioning) adverse effects of dam decommissioning. An Aquatic Technical Work Group (ATWG) comprised of the KRRC Technical Representative (KRRC), resource agencies, and tribal fisheries scientists was assembled in 2017 to review the previous AR measures, determine the feasibility and effectiveness of those plans, and to provide input on refined proposed actions that would best meet the intent of the previous AR measures. The ATWG included fisheries scientists representing the CDFW, ODFW, USFWS, NMFS, Yurok Tribe, Hoopa Valley Tribe, Karuk Tribe, and the Klamath Tribes.

Through a series of nine meetings with the ATWG between April 28 and August 15, 2017, review of recent similar dam removal projects, and new scientific information developed since the 2012 EIS/R, KRRC prepared updated AR measures proposed to be implemented as part of the Project. These measures are subject to consultation with aquatic resource agencies and negotiation of the final Biological Opinions for the Project.

The numbered list below summarizes the measures proposed to reduce effects to the associated aquatic resources. The full AR work plans are located in Appendix H, and contain additional detail on background, the latest science, and proposed measures incorporated into the Project. Coordination with the ATWG is continuing and ongoing feedback will be used to refine and finalize the AR measures.

1. **Mainstem Spawning (AR-1)**
   a. **Background:** Short-term effects of dam decommissioning (suspended sediment concentrations and bedload) are anticipated to result in high mortality of fall Chinook salmon and coho salmon embryos and pre-emergent alevins within spawning redds. Additionally, steelhead and Pacific lamprey migrating within the mainstem Klamath River after January 1 of the drawdown year, could be directly affected by high suspended sediment levels.
   b. **Project Measures:** A monitoring and adaptive management plan will be implemented to reduce Project effects on mainstem spawning. Survey and restoration actions included in the adaptive management plan are summarized below:
      i. A two-part monitoring and adaptive management plan will be prepared with input from the ATWG that monitors 1) tributary-mainstem connectivity and 2) spawning habitat availability. Connectivity of tributary-mainstem confluences, four sites in the Hydroelectric Reach and five sites in the 8-mile reach from Iron Gate Dam (RM 192.9) to Cottonwood Creek (184.9), will be evaluated for 2-years from the onset of reservoir drawdown. If present, confluence obstructions will be actively removed during the 2-year evaluation period to ensure volitional passage for adult Chinook salmon, coho salmon, steelhead, and Pacific lamprey.
      ii. The second component of the adaptive management plan is a spawning habitat evaluation of the Klamath River and newly accessible tributaries in the Hydroelectric Reach. A target of 44,100 yd^2 of mainstem spawning gravel is required to offset the effects to 2,100 mainstem-spawning fall Chinook salmon redds. If mainstem spawning gravel availability is less than the target values following reservoir drawdown, spawning gravel augmentation will be completed in the former Klamath River reservoirs and Hydroelectric Reach between Shovel Creek (RM 209.0) confluence and upstream end of Copco Lake (RM 208.0).

         A target of 4,700 yd^2 of tributary spawning gravel is necessary to offset the effects to 179 tributary-spawning steelhead redds. If tributary spawning gravel habitat is less than the target values following reservoir drawdown, the ATWG will convene to prioritize additional habitat restoration actions that will be undertaken to increase the amount of tributary habitat available to compensate for the loss of steelhead redds in the Hydroelectric Reach and associated tributaries (including, but not limited to Jenny Creek, Fall Creek, Shovel Creek and Spencer Creek).

2. **Outmigrating Juveniles (AR-2)**

   a. **Background:** Short-term effects of dam decommissioning (suspended sediment concentrations and bedload) are anticipated to result in mostly sublethal, and in some cases lethal impacts to a portion of the juvenile Chinook salmon, coho salmon, steelhead, and Pacific lamprey that are outmigrating from tributary streams to the Klamath River upstream of Trinity River (RM 43.4) during late winter and early spring of the drawdown year.

   b. **Project Measures:** Surveys and measures proposed to reduce the overall effect on outmigrating juveniles are summarized below:

      i. In December 2018, a mainstem Klamath River seining and trapping effort will be conducted to document the presence of overwintering juvenile coho salmon in the middle and upper reaches of the mainstem Klamath River from approximately the Trinity River confluence (RM 43.4) upstream to Iron Gate Dam (RM 192.9). While low numbers of coho salmon (<500) are anticipated to be encountered, these fish will be particularly vulnerable to the effects of high suspended sediment levels from reservoir drawdown and represent a small, but important life history strategy in the ESA-listed coho population (T. Soto, Karuk Tribe, personal communication, 2017). Targeted areas include low velocity backwater areas and other high-quality rearing habitats.

      ii. The results of the 2018 sampling effort will inform a targeted seining and trapping effort in December prior to reservoir drawdown. Through coordination with the ATWG, salvage and relocation efforts will be done as late in the year as possible to limit any potential impact to the redistribution of fish to off-channel habitats. Seined and trapped juvenile coho salmon and other salmonids will be transported to six existing constructed off-channel ponds in the middle and upper Klamath River (potentially including, but not limited to constructed off-channel ponds located on Seiad Creek, West Grider Creek, Camp Creek, and Stanshaw Creek). Juvenile salmonids placed in ponds will be allowed to volitionally move between the off-channel pond and adjacent tributary or mainstem Klamath River. Up to 500 yearling coho salmon are anticipated to be caught and relocated to off-channel ponds.

      iii. A monitoring and adaptive management plan will be prepared with input from the ATWG to monitor tributary-mainstem connectivity. Tributary-mainstem confluences, four sites in the Hydroelectric Reach and five sites in the 8-mile reach from Iron Gate Dam (RM 192.9) to Cottonwood Creek (RM 184.9), will be evaluated for 2-years from the onset of reservoir drawdown. If present, confluence obstruction will be actively removed during the 2-year evaluation period to ensure volitional passage for juvenile Chinook salmon, coho salmon, steelhead, and Pacific lamprey. Juvenile salmonids are expected to benefit from dam decommissioning by restoring access to at least 13.9 miles of key tributary rearing habitats in the Hydroelectric Reach and several recognized thermal refugia areas including Jenny and Fall creeks.

iv. The second component of the monitoring and adaptive management plan will include monitoring juvenile salmonids and water quality conditions in 13 key tributary confluences between Iron Gate Dam (RM 192.9) and the Trinity River (RM 43.4). The ATWG will convene when tributary water temperatures reach 17°C (7-day average of the daily maximum values) and Klamath River suspended sediment concentration exceeds 1,000 mg/L. Based on ATWG guidance, a multi-day salvage effort for juvenile fish may be conducted at the Shasta and Scott rivers and single day salvage efforts at each other tributary confluence area by a 4-person crew and 2 transport trucks. Salvage effort will be coordinated with the ATWG and will reflect water quality conditions in the tributary confluences, outmigrating juvenile salmonid numbers, and other environmental conditions as necessary.

3. **Fall Pulse Flows (AR-3)**

a. **Background:** Short-term effects of dam decommissioning (suspended sediment concentrations and bedload) are anticipated to result in high mortality of fall Chinook salmon and coho salmon embryos and pre-emergent alevins within redds.

b. **No Additional Measures:** A review of current information regarding Klamath River fisheries and dam decommissioning effects suggests that the use of fall pulse flows would likely be ineffective in reducing the effects of suspended sediment on migrating and spawning salmon, steelhead, and green sturgeon. The uncertainty of storage water availability on the mainstem Klamath River prior to reservoir drawdown, and the natural (unregulated) hydrology of most Klamath River tributaries make implementation and success of this measure unpredictable. The measure may therefore be either infeasible or unnecessary to implement depending on the meteorological conditions prior to dam decommissioning. Fall pulse flows will not be implemented to offset the suspended sediment effects related to the dam decommissioning.

4. **Iron Gate Fish Hatchery (AR-4)**

a. **Background:** Short-term effects of dam decommissioning are anticipated to result in mostly sublethal, and in some cases lethal, impacts to a portion of the juvenile Chinook salmon, coho salmon, steelhead, and Pacific lamprey that are outmigrating from tributary streams to the Klamath River during late winter and early spring of the drawdown year. Deleterious short-term effects are anticipated to be caused by high suspended sediment levels and low dissolved oxygen levels in the Klamath River from Iron Gate Dam (RM 192.9) downstream to Orleans (RM 59.0). Hatchery-produced Chinook and coho salmon juveniles that are released from Iron Gate Hatchery into the Klamath River, could suffer high mortality if juveniles are released during periods of high suspended sediment levels.

b. **No Additional Measures:** Hatchery-reared yearling coho salmon to be released in the spring of the drawdown year could be held at Iron Gate Hatchery or at another facility until water quality conditions in the mainstem Klamath River improve to sublethal levels. Based on the current Iron Gate Hatchery release schedules and suspended sediment predictions in the Klamath River following dam decommissioning, yearling coho salmon releases could be delayed approximately 2 weeks to avoid lethal water quality conditions. Water quality monitoring stations established prior to reservoir drawdown would be used to determine when conditions in the mainstem Klamath River are suitable for the release of hatchery-reared coho salmon.

5. **Pacific Lamprey (AR-5)**

a. **Background:** Short-term effects of the dam decommissioning are anticipated to include high suspended sediment levels, bedload deposition, and low dissolved oxygen concentrations, resulting in predicted high mortality for Pacific lamprey ammocoetes located downstream from Iron Gate Dam.

b. **No Additional Measures:** The 3 km (1.8 mile) reach of the Klamath River downstream from Iron Gate Dam was the focus of Pacific lamprey relocation efforts in the 2012 EIS/R. When the 2012 EIS/R was written, lamprey ammocoete presence downstream from Iron Gate Dam was unknown. Recent surveys (N. Hetrick, USFWS, personal communication, 2017) have found very low numbers of lamprey ammocoetes in the Klamath River between Iron Gate Dam and the Shasta River (approximately 13 river miles). Referenced to as a “dead zone” containing few ammocoetes, this reach is presumably affected by flow management, poor water quality, lack of sandy fines, and high deposition rates of organic material (Goodman and Reid 2015). Dam removal effects to Pacific lamprey ammocoetes in the 3 km reach downstream from Iron Gate Dam are anticipated to be minimal, and therefore, no action is recommended for Pacific lamprey ammocoetes.

6. **Sucker (AR-6)**

a. **Background:** Short-term effects of the dam decommissioning are anticipated to result in mostly sublethal, and in some cases lethal impacts to Lost River and shortnose suckers within Hydroelectric Reach reservoirs. Lost River and shortnose suckers are lake-type suckers and are therefore not anticipated to persist in the Klamath River following restoration of the Hydroelectric Reach reservoirs to free-flowing riverine conditions.

b. **Project Measures:** Surveys and measures proposed to reduce the overall effect on suckers are summarized below:

i. Lost River and shortnose suckers will be sampled in the Klamath River and in Hydroelectric Reach reservoirs in 2018. River sampling will be completed in spring of 2018 and reservoir sampling will be completed in fall of 2018. The purpose of sampling is to document the abundance and genetics of Lost River and shortnose suckers in the Hydroelectric Reach. Sampling will include placing trammel nets in the reservoirs (reservoir sampling) and in Klamath River segments upstream of the reservoirs (river sampling) to determine the abundance. Captured fish will be marked with a passive integrated transponder (PIT) tag, fin clipped for genetic material, measured, and released. Recaptured fish will be used to estimate the sucker population abundance. Fin clips will be used to determine the genetics of the sampled fish. USFWS is currently developing genetic markers for Lost River and shortnose suckers.

ii. Adult Lost River and shortnose suckers in reservoirs downstream from Keno Dam would be captured and relocated to isolated water bodies in the Klamath Basin. The proposed relocation of rescued suckers to isolated waterbodies is to ensure hybridized suckers do not mix with sucker populations designated as recovery populations in Upper Klamath Lake. An estimated 21 days will be required for sampling, and 14 days will be required for salvage and release efforts. We anticipate salvaging and translocating 100 Lost River and 100 shortnose suckers from each of the three Klamath River reservoirs (600 fish total). The number of translocated fish will not exceed 3,000 fish, which is the capacity of the currently identified recipient waterbody (Tule Lake). The salvage effort will likely translocate less than 10 percent of the sucker populations in the respective reservoirs.

7. Freshwater Mussels (AR-7)

a. **Background:** Freshwater mussels in the Hydroelectric Reach and in the Klamath River downstream from Iron Gate Dam (RM 192.9) are anticipated to experience deleterious effects during dam decommissioning due to high suspended sediment levels, bedload movement, and low dissolved oxygen concentrations for extended time periods. Freshwater mussels are sedentary, long-lived, and are typically found in areas of the channel characterized by stable bed conditions and low hydraulic forces.

b. **Project Measures:** Proposed surveys and other measures proposed to reduce the overall effect on freshwater mussels are summarized below:

i. A reconnaissance effort will be completed in 2018 to assess the distribution and density of freshwater mussels in the 8 mile-long bedload deposition reach from Iron Gate Dam (RM 192.9) downstream to the Cottonwood Creek confluence (RM 184.9). The reconnaissance will confirm mussel beds identified in the 2007-2010 surveys and estimate abundance at a subset of the mussel beds in the reach. Habitat conditions from the upstream extent of J.C. Boyle Reservoir (RM 233.0) to Keno Dam (RM 238.2) will also be evaluated during 2018 to determine the habitat availability and capacity for translocated mussels.

ii. Based on the reconnaissance, a portion of the freshwater mussels located between Iron Gate Dam (RM 192.9) and Cottonwood Creek (RM 184.9) will be salvaged and relocated to reduce dam decommissioning effects to the mussel community. Mussel surveys are estimated to take 5 days and the salvage and translocation effort will take 10 days. The percentage of the existing mussel beds that will be salvaged and translocated is predicated on the available habitat in the Klamath River between Keno Dam (RM 238.2) and the upstream extent of J.C. Boyle Reservoir (RM 233.0), and the abundance of mussels between Iron Gate Dam (RM 192.9) and Cottonwood Creek (RM 184.9). Approximately 15,000 to

20,000 mussels are planned for translocation. The proposed number of translocated mussels is likely less than 10 percent of freshwater mussels in the mainstem Klamath River in the Hydroelectric Reach and downstream from Iron Gate Dam.

8. Mitigation Measures

As summarized in Section 7.1 and Table 7.1-1, a number of previously identified Project mitigation measures have been incorporated into the Project itself, to reduce impacts to environmental resources. In many cases, those measures were refined from the previously documented version (USBR 2012b and USBR and CDFW 2012), prior to their inclusion in this report as Project measures or activities. Where measures have been refined, a rationale for the change has been provided.

A number of previously identified Project mitigation measures are proposed to remain as mitigation, although incorporation into the pending SWRCB CEQA EIR would be a function of ongoing impact assessments and determinations by the CEQA lead agency (SWRCB). The following sections provide a description of each of the proposed mitigation measures. In some cases, those measures were refined from the previously documented measure, prior to their inclusion in this report as Project mitigation measures. Where measures have been refined, a rationale for the change has been provided below.

8.1 Supplemental Information Report Overview

The KBRA was terminated in December 2015, after the completion of the 2012 EIS/R, which considered the KBRA in many aspects of the resource evaluations. In 2016, USBR developed the Draft Klamath Facilities Removal EIS/EIR Supplemental Information Report (SIR) to reexamine the 2012 EIS/EIR in light of new information, including updated regulations and data, amendments to the KHSA, the issuance of the 2013 BiOp for operations of USBR's Klamath Project, and the termination of the KBRA. The draft SIR was not finalized before the Federal lead agency changed from USBR to FERC and was, therefore, not published by USBR as a final report. However, the KRRC has reviewed the draft SIR in detail and concurs with its conclusions on changes to impacts, particularly those related to the termination of the KBRA. A summary of the draft SIR findings is provided below. The full reevaluation of the 2012 EIS/EIR is provided in Appendix Q.

The draft SIR found that there would be:

- A relatively small change to the river flows presented in the 2012 EIS/EIR
- A change in the National Historic Preservation Act (NHPA) process
- Improved socioeconomic and environmental justice conditions
- Some changes in cumulative actions
- The termination of the KBRA would lessen the improvements to water quality, aquatic resources (fisheries), resources traditionally used by the tribes, and agricultural and forest resources, but would not change the overall impact conclusions made in the 2012 EIS/R.

The report concluded that

> *"… no significant new circumstances or release of information relevant to the Proposed Action or any of the environmental impacts addressed in the Klamath Facilities Removal Final EIS/EIR have occurred since completion of the document in December 2012. It is the opinion of the interdisciplinary technical*

team that performed the reexamination that a supplemental EIS/EIR is not warranted or required."

8.1.1 River Flows

The expiration of the KBRA and the issuance of the 2013 BiOp resulted in a relatively slight change to the flows presented in the 2012 EIS/EIR. Compared to the KBRA flows, flows included in the 2013 BiOp would decrease by 21 cfs (1.5 percent) below Keno Dam and increase by 12 cfs (about one percent) below Iron Gate, on an average annual basis. The 2013 BiOp flows differ more on a monthly basis than annually, when compared to the KBRA flows; these changes were made primarily to support ESA listed Coho salmon below Iron Gate Dam. Fall months require about 216 cfs more flow, while summer months (June to August) require about 114 cfs less flow over most water year types. The BiOp also maintains higher minimum flows (76 cfs, 9 percent greater) in July and August. These changes in flow requirements and availability were determined to have little to no impact on the conclusions made in the 2012 EIS/EIR on hydrology-related resources, including water quality, flood hydrology, water supply/water rights, and aquatic resources. The greater fall flows prescribed by the 2013 BiOp will likely provide greater benefits to all anadromous fish species below Iron Gate Dam prior to dam removal and above and below Iron Gate Dam following dam removal.

8.1.2 NHPA Process

Due to the change in NEPA federal lead agency from USBR to FERC, the NHPA process was changed. FERC is now responsible for fulfilling the requirements under Section 106 of the NHPA, including but not limited to the continuation of tribal consultation. However, the mitigation measures and agreement by Tribal Preservation Officers, State Preservation Officers, and federal agencies would still be required to resolve adverse effects (as suggested in the 2012 EIS/EIR). Appendix L contains an update on the Project plan for cultural resources.

8.1.3 Socioeconomics

Updated economic data has been made available since the completion of the 2012 EIS/EIR. The draft SIR provided the updated economics for counties surrounding the four dams. Unemployment rates decreased and total personal income increased in some counties, while others were only slightly changed. Therefore, the SIR suggested that improved or similar conditions exist in the regional economy, compared to the 2009 economic data used in the 2012 EIS/EIR, which suggests that the analysis included in the 2012 EIS/EIR related to loss of jobs and loss of tax revenue is still applicable and that the impacts enumerated in the economic analysis for loss of dam operation and maintenance activities at the hydrologic facilities, reservoir recreation, decrease in property values near the reservoirs, and loss of local government revenues can now be more readily absorbed by the regional economy. The economic gains from construction jobs related to dam removal and mitigation remain beneficial to the same extent as described in the 2012 EIS/EIR. Although the socioeconomic base for dam removal has improved, the specific impacts related to dam removal have not changed. The improvement to the regional economy also improves socioeconomic conditions related to environmental justice in the area. However, the termination of the KBRA would slow the realization of environmental justice benefits primarily accruing to the Basin Indian tribes, as presented in the 2012 EIS/EIR because improvements to fisheries and water quality would occur more slowly in the absence of the KBRA. Furthermore, benefits to commercial fishing and in-river fishing would remain beneficial despite the expiration of the KBRA reducing the fish focused restoration and reintroduction actions planned for the upper basins.

8.1.4 Water Availability

Overall, there is an upward trend in water availability for fisheries following dam removal. Flows presented in the 2013 BiOp are similar to those included in the 2012 EIS/EIR (KBRA flows), differing by up to 12 percent on an average annual basis. However, there are other changes that have been made since the 2012 EIS/EIR that could affect the availability of water for release to the Klamath River, including the items following.

8.1.4.1 Groundwater Pumping in the Upper Klamath Basin

Programs enacted since the 2012 EIS/R suggest that groundwater pumping is decreasing or stabilizing. The KBRA and its predecessor agreements included provisions that allowed Klamath Project irrigators to forego receiving Klamath River water for a cash payment but also allowed for substituting surface water with groundwater supply. Until December 2015 this program was managed by the Klamath Water and Power Authority (KWAPA) under the Water User Mitigation Program (WUMP). KWAPA was terminated as an agency in March 31, 2016. In California, the Sustainable Groundwater Management Act will require the sustainable management of groundwater supplies on a basin level. The Klamath Project Tule Irrigation District is leading this effort for the California portion of the Upper Klamath Basin, but generally this portion of the Upper Klamath Basin is not in a state of overdraft. In Oregon, the completion of the Klamath River Basin Adjudication (discussed below) since the 2012 EIS/R now allows the Klamath Tribes to “call” on both surface water diversion and groundwater pumping used for irrigation in the tributaries above Upper Klamath Lake (Sprague, Williamson and Wood rivers) to provide greater instream flow during certain times of the year. Greater surface water flows directly benefit Upper Klamath Lake water levels and indirectly provide additional storage for releases downstream of Link River Dam. Programs enacted since 2012 have either kept surface water in the streams or curtailed groundwater pumping, resulting in greater groundwater discharge to streams to support fisheries.

8.1.4.2 Retirement of Irrigated Agriculture Lands

The KBRA included the concept of retiring agricultural lands by compensating willing irrigators to increase water availability in the Klamath Basin. Since the termination of the KBRA, and its voluntary Water Use Retirement Program, some lands have been retired but not to the level envisioned in the 2012 EIS/EIR, suggesting there would be less water available within the basin. In 2014, the Upper Klamath Basin Comprehensive Agreement (UKBCA) was signed and contained a detailed approach for ensuring up to 30,000 acre-feet of additional water entering Upper Klamath Lake on an average annual basis, primarily through water use retirements in its Water Use Program. The final Water Use Program ledger recorded 5, 278 acre-feet of increased instream flows (Klamath Basin Coordinating Council, undated). The UKBCA is still in effect, and advocates for the program are seeking Federal legislation and funding for the program's continuation.

8.1.4.3 Improvements in Estimating Evapotranspiration from Wetlands around Upper Klamath Lake

In 2013, a report was written that further examined evapotranspiration from wetlands and other open-water sites near Upper Klamath Lake (Stannard et al. 2013). This report documented the efforts taken to increase the understanding of evapotranspiration, including the monitoring of evapotranspiration and the measurements made from May 2008 through September 2010. A three-year annual wetland evapotranspiration value for the wetlands was estimated to be 0.938 meters per year, approximately 22 percent lower than the three-year estimate for the lake (1.145 meters per year). The findings in this report did not greatly differ from those in previous studies. Therefore, it is not anticipated that these improvements in estimating evapotranspiration from the wetlands around Upper Klamath Lake would be a significant factor for changes in water availability in the Klamath Basin.

8.1.4.4 Changes in Klamath Irrigation Project operation

The Klamath Irrigation Project is currently operating in accordance with the 2013 BiOp under which USBR uses the monthly 50 percent exceedance inflow forecasts from the Natural Resources Conservation Service as the basis for Project operations with respect to the Upper Klamath Lake and the Klamath River during the spring-summer irrigation season (USBR 2017). The project also operates consistent with the March 24, 2017 Court Order (Case 3:16-cv-04294-WHO), which requires it to hold up to 50,000 acre-feet of reserve water between April 1 and July 15, 2017 to be used, if necessary, for potential salmonid disease issues in the Klamath River downstream of Iron Gate Dam. In addition to the 2013 BiOp and the Court Order, operation of the project is subject to tribal trust obligations. As discussed in Section 8.1.1, prescribed flows under the 2013 BiOp are not substantially different from flows developed under the KBRA (flows used in the 2012 EIS/EIR).

8.1.4.5 Changes in Lewiston Dam Operations

Since the 2012 EIS/EIR, USBR has operated Lewiston Dam to make cold-water releases into the Trinity River and lower Klamath River, below the confluence with the Trinity River, in late-summer/early-fall to reduce the overall water temperature and the risk of fish disease. In 2016 the Hoopa Valley Tribe requested USBR release not less than 50,000 acre-feet of water from Lewiston Dam to improve fishery conditions in Trinity River and lower Klamath River. The 2016 Environmental Assessment on flow augmentation from Lewiston Dam (USBR 2016) provided that the requests made of USBR in 2016 to supplement flows in the Trinity River downstream of Lewiston Dam and lower Klamath River below the confluence with the Trinity River was included in the proviso in the Trinity River Division Central Valley Project Act of 1955. Therefore, USBR is to provide additional cold-water releases (50,000 acre-feet) from the Trinity River at Lewiston Dam, "if warranted by deteriorating environmental conditions," to support Hoopa Valley and Yurok tribal fisheries.

8.1.4.6 Oregon Water Resources Department’s Completion of Phase One of the Klamath River Basin Adjudication of Water Rights in the Klamath Basin

The Oregon Water Resources Department completed Phase One of the Klamath River Basin Adjudication of water rights in the Klamath Basin in 2013. Phase Two allows for the claimants or contestants who dispute the determination of their claims or contests the opportunity to file exceptions with the Klamath County Circuit Court. The Court will then review the exceptions and issue a water rights decree that would affirm or modify the Final Order of Determination. The Final Order of Determination included the recognition of most of the active Klamath River Basin Adjudication claims. The key finding in the Final Order of Determination was that the most senior claims in the Klamath River Basin Adjudication are held by the United States in trust for the Klamath Tribes (Oregon Water Resources Department 2013). These claims have a priority date of “time immemorial” and have been recognized for the Upper Klamath Lake and certain reaches of its major tributaries. With the most senior claim to waters in the Upper Klamath Lake, the Klamath Tribes have the right to make a “call” on the water, ensuring it remains in the Klamath River tributary streams to support fish, especially in dry years. This could have a major effect on water availability in the Klamath River and result in the reduction of irrigation water supplies.

8.11 Iron Gate Fish Hatchery

The Iron Gate fish hatchery (IGH) facilities are part of the Lower Klamath Project, and modifications or improvements to infrastructure and operation are included to mitigate the Project's impacts to the IGH facility intake and collection facility. Originally created as mitigation for the dam blockage of fish passage, the hatchery's original purpose will go away after the dams and associated passage barriers are removed. The Project will remove all four dams and restore volitional fish passage through the Project river reach, in addition to creating new fish habitat within the restored river and floodplain.

The existing IGH water intake will be affected by the drawdown of Iron Gate Reservoir and subsequent removal of the dam and hydropower infrastructure, and the existing fish collection system (ladder, trap, spawning building, aeration tower, and holding ponds) will be demolished as part of the dam removal.

8.11.1 Existing IGH Facility and Operations

The IGH spawning/trapping facility was constructed in 1962 with additional facilities added in 1966 where it is located approximately ½ mile downstream of Iron Gate Dam, adjacent to the Bogus Creek tributary. The main hatchery complex includes an office, incubator building, rearing/raceway ponds, fish ladder with trap, settling ponds, visitor information center, and four employee residences (see Figure 8.11-1). The collection facility is located at Iron Gate dam and includes a fish ladder consisting of 20 ten-foot weir-pools that terminates in a trap, a spawning building and six 30-foot circular holding ponds.

The IGH operates with a gravity fed, flow-through system that has five discharge points into the Klamath River. The IGH obtains its water supply from Iron Gate Reservoir. Two subsurface influent points at a depth of seventeen feet and seventy feet deliver water to IGH. Up to 50 cfs is diverted from the Iron Gate Reservoir to supply the 32 raceways and fish ladder.

The spawning facility discharges through the main ladder, and steelhead return line. An overflow line drains excess water from the aeration tower. The hatchery facility also has a discharge at the tail race that supplies the auxiliary ladder or fish discharge pipe, and two flow-through settling ponds for hatchery effluent treatment which converge to a single discharge point.

The hatchery produces Chinook salmon, steelhead trout, and coho salmon. Annual average production since 2001 includes approximately 5.1 million Chinook, 80,000 steelhead, and 76,000 coho, although no steelhead have been produced since 2012 (CDFW, 2017),

The hatchery is operated by the CDFW. Per the license, eighty percent of operations and maintenance costs are required to be funded by PacifiCorp, but PacifiCorp currently funds 100 percent of those costs pursuant to the KHSA.

Figure 8.11-1 Iron Gate Hatchery

As mentioned above, as part of the dam removal Project, the existing fish collection facility located at the toe of Iron Gate Dam will be demolished.

Due to the reservoir drawdown and subsequent dam removal, the existing water supply intake will become unusable, as its elevation will be above the water level post-draw down and high suspended sediment concentrations during drawdown. The water supply intake and associated infrastructure will be demolished along with the dam and hydropower facilities.

8.11.2 Existing Fall Creek Hatchery

The Fall Creek Hatchery (FCH) was built in 1919 by the California Oregon Power Company as compensation for lost of spawning grounds due to the construction of Copco No.1 Dam. Six of the original rearing ponds remain (two above Copco road and four below the road). These ponds were last used from 1979 through 2003 to raise 180,000 Chinook salmon yearlings which were released into the Klamath River at Iron Gate Hatchery. Although the raceways remain and CDFW continues to run water through them, they have not produced fish since 2003 when all mitigation fish production was moved to IGH. The facility has retained its water rights but would need substantial renovation to become operational.

8.11.3 Project Description

The proposed Project includes some level of continued operation of the IGH and reopening of the FCH to maintain a level of fish production during drawdown and for eight years following dam decommissioning. Meeting the current fish production mitigation goals shown in Table 8.11-1 will not be possible due to the absence of sufficient year-round cold-water supply for coho and Chinook yearling production following dam removal. For this reason, NMFS and CDFW have developed a hatchery plan that involves the use of both IGH and FCH to produce the revised fish production recommendations listed in Table 8.11-1. This Project proposes to implement that plan in order to mitigate the impact to the existing IGH operations.

As a state and federally listed species in the Klamath River, coho production is the highest priority for NMFS and CDFW, followed by Chinook salmon, which support tribal, sport, and commercial fisheries. Steelhead production is the lowest priority. Due to limited available water and rearing capacity to meet Chinook yearling mitigation goals, and recent low steelhead returns, NMFS and CDFW have recommended that steelhead production be discontinued. Recommended fish production is shown in Table 8.11-1.

Table 8.11-1 Comparison of Previous Mitigation Goals and Revised NMFS/CDFW Production Recommendation

Species/Life Stage	Current Mitigation Goal (at IGH)	Production Recommendation
Coho Yearlings	75,000	75,000 at FCH
Chinook Yearlings	900,000	115,000 at FCH
Chinook Smolts	5,100,000	2,360,000 at FCH 1,040,000 at IGH
Steelhead	200,000	0

Source: NOAA Fisheries and CDFW Technical Staff Recommendation for Klamath River Hatchery Operations in California Post-Dam Removal, December 19, 2017.

The following assumptions are applicable to the NMFS/CDFW production recommendations:

- Hatchery production related to this Project at IGH and FCH will be limited to the eight years following dam removal.
- IGH and FCH must be operational prior to drawdown per the KHSA (KHSA 2016, Section 7.6.6.B).
- Implementation of the KHSA and other actions taken as part of the Klamath Dam Decommissioning project are considered consistent with the North Coast Regional Water Quality Control Board (NRWQCB) “Policy in Support of Restoration in the North Coast Region.” NRWQCB Resolution No.’s R1-2015-0001 and R1-2015-0004 in combination are referred to as the “Restoration Policy”.
- CDFW will employ Best Management Practices to minimize discharge at IGH and FCH.

8.11.3.1 Improvements at IGH

Required water supply to the IGH following dam removal for adult holding and spawning, egg rearing, and approximately 1 million smolts (one raceway) is estimated at 5.5 cfs. Water use efficiency improvements such as water aeration will be evaluated and implemented to reduce water use to the extent feasible. CDFW has proposed using a riparian water right on Bogus Creek to supply IGH. Water diversion from Bogus Creek will be used to operate the IGH hatchery incubation building, one 200-foot adult holding pond, one 400-foot raceway, and the auxiliary fish ladder. Specific diversion rates are as follows:

- 1.5 cfs October through April for the hatchery building
- 2 cfs October through February for one adult holding pond
- 2 cfs End of November through June 15 for a rearing raceway (with mid-pond aeration)

To utilize Bogus Creek water, a pump station and fish screen would be needed on the creek to lift the water approximately 20 vertical feet to the hatchery.

Since the existing fish collection system at Iron Gate Dam will be demolished, it will be necessary to replace the function of this facility. An auxiliary trap and ladder system is currently located at the main IGH facility (see Figure 8.11-1), and will be utilized as the primary capture facility post-drawdown with some improvements such as additional flow and structural modifications to enhance the flow characteristics. Water supply to the auxiliary ladder will come from operational raceways. An existing raceway at the IGH will be modified by deepening for adult holding.

8.11.3.2 Improvements at FCH

FCH would be reopened with new and/or upgraded facilities for raising coho salmon and Chinook salmon within the existing facility footprint and an area adjacent to the upper raceways (see Figures 8.11-2 and 8.11-3). Circular settling tanks would be installed adjacent to the upper raceways with associated plumbing. Care will be taken to locate the circular tanks and associated infrastructure outside of any sensitive cultural resources in the area.

The existing raceways would be refurbished and other infrastructure would be upgraded. Existing developed or disturbed areas nearby will be used for operations (e.g., vehicle parking, pertinent buildings, tagging trailer, etc.). Non-consumptive water diversion from Fall Creek will support hatchery operations and will be returned to the creek, minimizing adverse effects to Fall Creek aquatic resources. Specific assumptions for FCH include:

- FCH production associated with this Project will extend eight years following dam removal
- Up to 10 cfs of flow would be diverted from the existing Fall Creek Diversion below the City of Yreka's intake using CDFW's existing water rights license and PacifiCorp's pre-1914 water right. This intake would require construction of a new fish screen.
- During shutdown of PacifiCorp's Fall Creek Powerhouse, diversion at the City of Yreka's B-diversion off Fall Creek would provide sufficient flow for hatchery operations.
- A new pump station would be required for operations of the circular tanks and gravity feed would be used for existing raceways.

The precise footprint necessary for operations, including associated activities, has not yet been determined but would be contained in the area noted on Figures 8.11-2 and 8.11-3.

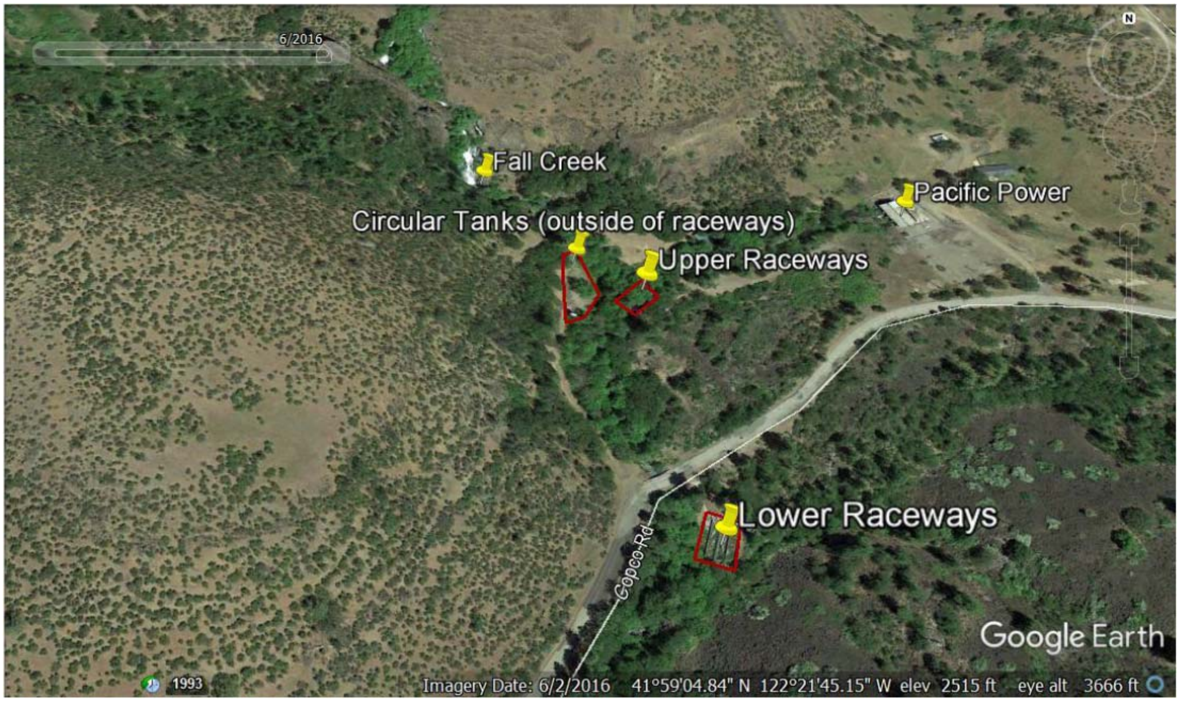


Figure 8.11-2 Map of Fall Creek Hatchery including proposed circular tank footprint

Figure 8.11-3 Photo of proposed location for circular tanks adjacent to upper raceways

Appendix I Aquatic Resources Measures

AECOM

Klamath River Renewal Project

Definite Plan for Decommissioning
Appendix I – Aquatic Resources Measures

Administrative Draft

Submitted to: California State Water Resource Control Board

Submitted by: Klamath River Renewal Corporation

Date: January 2018

Prepared for:

Klamath River Renewal Corporation
Federal Energy Regulatory Commission

Prepared by:

KRRC Technical Representative:

River Design Group
311 SW Jefferson Avenue
Corvallis, Oregon 97333

AECOM Technical Services, Inc.
300 Lakeside Drive, Suite 400
Oakland, California 94612

Table of Contents

Tables

Figures

Appendices

Executive Summary

The Klamath River Renewal Corporation (KRRC) convened an Aquatic Technical Work Group (ATWG) comprised of agency and tribal fisheries scientists to review the aquatic resource (AR) mitigation measures included in the *Klamath Facilities Removal Final EIS/EIR* (2012 EIS/R; U.S. Bureau of Reclamation (USBR) and California Department of Fish and Game (CDFW) 2012), determine the appropriateness of the 2012 AR measures, and develop updated AR measures in accordance with ATWG input.

Through a series of nine meetings with the ATWG between April 28 and August 15, 2017, review of recent similar dam removal projects, and new scientific information that has been developed since the 2012 EIS/R, updated AR measures are proposed to be implemented as part of the Project.

The proposed AR measures include:

AR-1 Mainstem Spawning – A monitoring and adaptive management plan will be developed and implemented to offset reservoir drawdown effects on mainstem spawning of anadromous salmonids and Pacific lamprey. Tributary-Klamath River confluences in the Hydroelectric Reach (i.e., the Klamath River and tributaries from Iron Gate Dam [RM 192.9] to the upstream extent of J.C. Boyle Reservoir [RM 233.0]) and in the Iron Gate Dam to Cottonwood Creek (RM 184.9) reach will be monitored for 2 years post-dam decommissioning to ensure fish passage between tributaries and the Klamath River. Obstructions will be removed to restore volitional passage between the Klamath River and tributaries. A spawning habitat evaluation will also be completed on the Klamath River and four tributaries in the Hydroelectric Reach. If spawning habitat post-reservoir drawdown does not meet target metrics, spawning gravel augmentation on the mainstem and four Hydroelectric Reach tributaries will be completed.

AR-2 Outmigrating Juveniles - To offset reservoir drawdown effects on outmigrating juvenile anadromous salmonids and Pacific lamprey, a sampling, salvage, and relocation effort will be completed to relocate juvenile salmonids, particularly yearling coho salmon, from the Klamath River between Iron Gate Dam and the Trinity River confluence during the fall prior to reservoir drawdown. Through coordination with the ATWG, salvage and relocation efforts will be done as late in the year as possible to limit any potential impact to the redistribution of fish to off-channel habitats. An adaptive management plan will also be developed to assess and restore tributary-mainstem connectivity in the Hydroelectric Reach and the 8-mile reach from Iron Gate Dam downstream to Cottonwood Creek. The second component of the monitoring and adaptive management plan will include monitoring water quality conditions at 13 key tributary confluences. The ATWG will convene when tributary water temperatures reach 17°C (7-day average of the daily maximum values) and Klamath River suspended sediment concentration exceeds 1,000 mg/L. Based on ATWG guidance, a multi-day salvage effort for juvenile fish may be conducted at the Shasta and Scott rivers and single day salvage efforts at each other tributary confluence area by a 4-person crew and 2 transport trucks. Salvage effort will be coordinated with the ATWG and will reflect water quality conditions in the tributary confluences, outmigrating juvenile salmonid numbers, and other environmental conditions as necessary.

AR-3 Fall Pulse Flows – Increasing flows during the fall prior to reservoir drawdown was intended to promote Chinook salmon and coho salmon migration into spawning tributaries to reduce the effect of reservoir drawdown on spawning grounds. Due to water availability uncertainty and typical fall flows, the use of fall pulse flows would likely be ineffective in reducing the effects of suspended sediment on migrating and spawning salmon, steelhead, and green sturgeon.

AR-4 Iron Gate Fish Hatchery – To reduce the number of hatchery-reared juvenile coho salmon exposed to high suspended sediment levels, coho salmon will be released from Iron Gate Hatchery into the Klamath River 2 weeks later than the typical release schedule. Water quality monitoring stations established prior to reservoir drawdown will be used to determine when conditions in the mainstem Klamath River are suitable for the release of hatchery-reared coho salmon.

AR-5 Pacific Lamprey – The 3 km reach of the Klamath River downstream from Iron Gate Dam was proposed for Pacific lamprey ammocoete salvage and relocation in the 2012 EIS/R. Recent surveys have found very low ammocoete abundances between Iron Gate Dam (RM 192.9) and the Shasta River confluence (RM 179.3). Based on the assessment completed by KRRC and reviewed by ATWG, dam removal effects to Pacific lamprey ammocoetes in the 3 km reach downstream from Iron Gate Dam are anticipated to be minimal, and therefore, no action is recommended for Pacific lamprey ammocoetes.

AR-6 Sucker Rescue and Relocation – The dam decommissioning project will result in lethal impacts to Lost River and shortnose suckers inhabiting the Klamath River reservoirs. Since the two sucker species are lake-type suckers, Hydroelectric Reach sucker populations will not persist following the dam decommissioning. An adaptive management plan including sampling, salvage, and relocation of Lost River and shortnose suckers will be conducted in the Hydroelectric Reach reservoirs. Suckers will be translocated to appropriate recipient waterbodies that will ensure the translocated suckers, which are of unknown genetic composition, will not mix with Lost River and shortnose sucker recovery populations in Upper Klamath Lake. Less than 10 percent of the Hydroelectric Reach sucker populations are likely to be salvaged and relocated.

AR-7 Freshwater Mussels – Freshwater mussels located in the 8-mile long from Iron Gate Dam downstream to the Cottonwood Creek confluence, are anticipated to experience high mortality due to suspended sediment concentrations and bedload deposition. KRRC will prepare a reconnaissance, salvage, and translocation plan for approximately 15,000 to 20,000 mussels located in the deposition reach. Less than 10 percent of the freshwater mussel populations inhabiting the Klamath River downstream from Iron Gate Dam are likely to be salvaged and relocated.

1. Introduction

In 2012, the Department of the Interior developed the *Klamath Facilities Removal Final EIS/EIR* (hereafter, "2012 EIS/R"; U.S. Bureau of Reclamation [USBR] and California Department of Fish and Game [CDFG] 2012) to disclose the potential effects of removing four dams on the Klamath River (Project). The 2012 EIS/R identified significant short-term effects to the aquatic biological community. The 2012 EIS/R included aquatic resource (AR) plans to attempt to mitigate the possible short-term adverse effects of dam decommissioning. The Klamath River Renewal Corporation (KRRC) assembled an Aquatic Technical Work Group (ATWG) comprised of resource agencies, and tribal fisheries scientists in 2017 to review the previous AR measures, determine the feasibility and effectiveness of those plans, and to provide input on refined proposed actions that would best meet the intent of the previous AR mitigation measures. The ATWG included fisheries scientists representing California Department of Fish and Wildlife (CDFW), Oregon Department of Fish and Wildlife (ODFW), U.S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA Fisheries, Yurok Tribe, Hoopa Valley Tribe, Karuk Tribe, and The Klamath Tribes.

Through a series of nine meetings between April 28 and August 15, 2017, the KRRC and the ATWG reviewed recent similar dam removal projects and new scientific information that has been developed since the 2012 EIS/R in order to update the 2012 AR measures. Updated AR measures are proposed to be implemented as part of the removal of four dams located on the Klamath River (Project). These measures are subject to consultation with aquatic resource agencies and negotiation of the final Biological Opinions for the Project.

Project effects are anticipated to be short-term in nature, with long-term benefits ultimately outweighing the Project impacts to the aquatic biological community. The aquatic effects will primarily occur from the release of reservoir sediment during reservoir drawdown. The purpose of Appendix H is to review the 2012 EIS/R AR measures, lessons learned from other large dam removal projects, and provide the rationale for revising the AR plans in order to reduce the short-term effects on aquatic resources.

2. Dam Removal Benefits and Effects

This section identifies benefits that have been noted for other dam removal projects in the Pacific Northwest and the anticipated long-term benefits to the Klamath River ecosystem that will occur with Klamath River dam decommissioning.

2.1 Benefits of Recent Dam Removals in the Pacific Northwest

Removal of large dams from rivers in the western United States, has also been completed to, among other things, restore ecosystem processes. Ecosystem response to large scale dam removal projects in Oregon, Washington, California and Montana has been monitored to gain a better understanding of geomorphic and ecological trends following dam removal. The following section provides an overview of recent post-dam removal studies from the Pacific Northwest.

2.1.1 Fish Access to Historical Habitat

Several studies document fish passage benefits associated with restoring access to historical habitat through dam removal efforts. The following references relate fish passage restoration benefits to adult salmon dispersal.

Following the installation of a fish ladder at Landsburg Dam in 2003, both Chinook salmon and coho salmon voluntarily recolonized 33 kilometers (km) of upstream habitat in the Cedar River, Washington, after more than 100 years of extirpation. The total density of salmonids roughly doubled in the mainstem closest to the dam 3 years after ladder installation (Kiffney et al. 2009), while dispersal of anadromous fish into tributary habitats occurred more slowly over the next 5 years (Burton et al. 2013). Both the proportion of all redds found in upstream reaches and the proportion of upstream spawners that were born in those reaches increased over time, demonstrating the successful transition from recolonization to self-sustaining upstream populations (Anderson et al. 2015).

Tule fall Chinook salmon were translocated to upstream reaches of the White Salmon River, Washington in the same year as the removal of the Condit Dam in 2011. Translocations were intended to circumvent the disruption of downstream spawning habitat by temporary sediment flows resulting from dam breaching, while natural migration was allowed in subsequent years. Roughly 10 percent of the Chinook population spawned upstream of the former dam site in the year following removal and both total escapement in the river and the proportion of returning fish born in upstream reaches is increasing over time (Engle et al. 2013; Hatten et al. 2015; Allen et al. 2016; Liermann et al. 2017).

In the Elwha River, Washington, the Elwha Dam and Glines Canyon Dam limited anadromy to the lower Elwha River. Removing the Elwha and Glines Canyon dams provided access to an additional 40 miles of mainstem river habitat as well as tributaries. In 2012, Chinook salmon had access to the area above Elwha Dam for the first time in a century. A total of 203 Chinook redds (396 live and dead adults) were documented upstream of Elwha Dam, with the former Aldwell Reservoir (river kilometer [Rkm] 7.9-12.4) and the main stem Middle Elwha from Rkm 17.2-18.1 (above the former Elwha Dam site) accounting for 44 percent of the redd locations, respectively, in 2012. In 2013, based on SONAR estimates (Denton et al. 2014), the total escapement of Chinook salmon (4,243 adults) approximately doubled over the 20 year average. This doubling resulted in observations of Chinook salmon spawning in all habitats, including the Middle Elwha, with the majority of redds (73 percent) located above the former Elwha Dam (McHenry et al. 2017).

Other work on the Elwha River found that hatchery coho salmon had a very high affinity for the hatchery and spawners released into tributaries upstream of the Elwha Dam produced offspring that returned to the natal release tributaries to spawn as adults (T. Williams, NOAA Fisheries, personal communication 2017). After five years, wild-origin coho salmon made up greater than 50 percent of spawners observed in the tributary with adequate coho spawning and rearing habitat.

At two dam removal sites on the Rogue River in southern Oregon, fall run Chinook salmon used spawning habitat that was formerly inaccessible under reservoirs in the first fall following dam removal. The conversion of former reservoir habitat to riverine habitat, and associated bedload/gravel movement, improved spawning habitat quality in the former reservoir sites. At the former Savage Rapids Dam site, 91 redds were documented within the extent of the former reservoir the first full fall after dam removal. At the former Gold Ray Dam site, 37 redds were documented within the bounds of the former reservoir in 2010, and over twice that many redds were identified within the former reservoir in 2011 (Oregon Department of Fish and Wildlife [ODFW] 2011).

From these previous studies, scientists have found that Chinook and coho salmon exploration of new habitat is an innate component of salmon breeding behavior. Coho salmon movement upstream of a former passage barrier on the Cedar River led to juvenile movement and dispersal which was recognized as an important component of the colonization process (Anderson et al. 2013). Ensuring juvenile passage in the watershed is necessary for juvenile imprinting and the future broadening of adult spawner returns throughout reconnected historical habitats. Additionally, hatchery-origin Chinook salmon have been found to have higher stray rates relative to their wild counterparts (Burton et al. 2013) and as the concept applies to the Klamath River, Iron Gate Hatchery-influenced fall Chinook salmon may rapidly recolonize the Klamath River upstream of Iron Gate Dam. In short, restoring access to lost habitat is a critical conservation strategy (Anderson and Quinn 2007 *cited in* T. Williams, NOAA Fisheries, personal communication 2017).

Beyond the benefits of recolonization for fish populations themselves, recolonization of previously inaccessible reaches also restores the flow of marine-derived nutrients to upstream portions of the watershed resulting in an overall boost to ecosystem nutrient budgets and productivity (Tonra et al. 2015).

2.2 Anticipated Lower Klamath Project Benefits and Effects

The dam decommissioning project will provide long-term ecosystem benefits to the Klamath River Basin. The following anticipated long-term benefits discussion is largely taken from the 2012 EIS/EIR (USBR 2012) and *the Klamath Dam Removal Overview Report for the Secretary of the Interior: An Assessment of Science and Technical Information* (Department of the Interior, U.S. Department of Commerce and National Marine Fisheries Service [NOAA Fisheries] 2013).

2.2.1 Access to Historical Habitat

Iron Gate Dam located at river mile (RM) 192.8 blocks access to the Upper Klamath Basin for three anadromous salmonid species, Pacific lamprey, and freshwater mussels. Facilities removal will restore access to approximately 81 miles of suitable riverine, side channel, and tributary habitat in the Klamath River Hydroelectric Reach (i.e., the Klamath River and tributaries from Iron Gate Dam [RM 192.9] to the upstream extent of J.C. Boyle Reservoir [RM 233.0]; Table 2-1), and 49 tributaries accounting for over 420 miles of historical aquatic habitat throughout the basin upstream of Iron Gate Dam. More specifically, facilities removal will allow access to historical habitat totaling over 75 miles for coho salmon, 300 miles for Chinook salmon (Huntington 2004), and 400 miles for steelhead (Huntington 2004; 2006). In addition to increasing the quantity of available habitat, unique habitats will also be accessible with dam decommissioning. Groundwater-fed areas throughout the Upper Klamath Basin (Table 2-2) are resistant to water temperature increases caused by changes in climate (Hamilton et al. 2011), potentially buffering climate change effects to coldwater salmonids.

Table 2-1 Potential historical habitat availability by species with removal of the Klamath River Hydroelectric Reach dams

Species	Potential Historical Habitat Availability (mi)
Chinook salmon	300
Coho salmon	76
Steelhead	420
Pacific lamprey	>420

Table 2-2 Estimated groundwater discharge (springs) into upper Klamath River systems

River System	Section	Groundwater Flow (cfs)
Lower Williamson River and Tributaries	Mouth of Williamson River up to Kirks Reef	350
Wood River and Tributaries	Crooked Creek Confluence to Headwaters	490
Sevenmile Creek and Tributaries	Crane Creek Confluence to Headwaters	90
Sprague River	South Fork Sprague River to Sprague River	202
Upper Klamath Lake	Spring in Upper Klamath Lake Including Malone, Crystal, Sucker, and Barclay	350
Klamath River	Keno Dam to J.C. Boyle Powerhouse	285
Klamath River and Fall Creek	J.C. Boyle Powerhouse to Iron Gate Dam	128
Total		**1,895**

NOAA Fisheries 2013

Historical anadromous fish population estimates suggest the potential productivity of the Klamath Basin upstream from Iron Gate Dam (RM 192.9). Hamilton et al. (2011) summarized previous spawning surveys and population estimates. The Klamath River and tributaries upstream from Iron Gate Dam historically supported up to 149,000 spawning fall Chinook salmon and up to 30,000 spawning steelhead (Table 2-3).

Table 2-3 Historical and potential production estimates for fall Chinook salmon, coho salmon, and steelhead in the Klamath River Basin

Reach	Species	Median Estimate	Estimate Range	Note
Lower Klamath Basin to Copco Dam	Fall Chinook Salmon		168,000[4] – 175,000[5]	Estimates based on historical spawning escapement and spawning surveys.
	Coho	15,400[4]	20,000[5] – 70,000[5]	122°04'20"
	Steelhead	300,000[5]	221,000[4] – 750,000[5]	122°22'05"
Iron Gate Dam to Copco Dam	Fall Chinook Salmon	2,301[3]	1,113[6] – 18,925[5]	Based on historical spawning data and spawning habitat potential.
	Steelhead	1,144[3]		
Copco Dam to Upper Klamath Lake	Fall Chinook Salmon	10,000[1]	2,2920[2] – 19,207[3]	Based on historical spawning data and spawning habitat potential.
	Steelhead	9,550[3]		

1 FERC 2007

2 Fortune et al. 1966

3 Chapman 1981

4 CDFG 1965

5 Coots 1977

6 FERC 1963

2.2.1.1 Chinook Salmon

Spring Chinook once inhabited the Upper Klamath Basin, and their populations downstream of Iron Gate Dam are currently extremely depressed. Dam decommissioning will benefit spring and fall Chinook salmon by restoring access to over 300 miles of historical habitat (Table 2-4) in the Klamath Basin upstream from Iron Gate Dam (improving water quality, increasing flow variability downstream from Iron Gate Dam, and reducing disease. The spatial diversity and abundance provided by dam removal and re-opening of historic habitat should add to the resilience and viability of this population. Over time, Chinook salmon returns upstream of Keno Dam could be substantial, although fish passage at Keno Dam and habitat quality improvements in the Upper Klamath Basin will be necessary to realize recovery potential.

Table 2-4 Estimated Klamath River mainstem, side channel, and tributary habitat under the Hydroelectric Reach reservoirs, and the number of contributing tributaries in each reservoir

Reservoir	Mainstem Habitat (mi)	Side Channel Habitat (mi)	Tributary Habitat (mi)	Contributing Tributaries (#)
Iron Gate	10.96	-	4.00	52
Copco	11.05	1.99	2.43	18
J.C. Boyle	5.35	-	0.30	10
Total	**27.36**	**1.99**	**6.73**	**80**

Source: Cunanan 2009

2.2.1.2 Coho Salmon

With dam decommissioning coho salmon are expected to rapidly recolonize habitat upstream of Iron Gate Dam, as observed after barrier removal at Landsburg Dam in Washington (Kiffney et al. 2009) and the Elwha River dams in Washington (Liermann et al. 2017). Assuming coho salmon distribution will extend up to Spencer Creek after dam removal, coho salmon from the upper Klamath River population will reclaim approximately 76 miles of habitat: approximately 53 miles in the mainstem Klamath River and tributaries (DOI 2007; NOAA Fisheries Service 2007) and approximately 23 miles currently inundated by the reservoirs (Cunanan 2009).

Coho salmon colonization of the Klamath River between Keno and Iron Gate dams by the upper Klamath coho salmon population would likely improve the viability of SONCC coho salmon by increasing abundance, diversity, productivity and spatial distribution.

2.2.1.3 Steelhead

Dam removal would restore access to over 420 miles of historical steelhead habitat upstream of Iron Gate Dam (Huntington 2004; 2006). Because of their ability to navigate steeper gradient channels and spawn in smaller, intermittent streams (Platts and Partridge 1978), and their ability to withstand a wide range of water temperatures (Cech and Myrick 1999; Spina 2007), steelhead distribution in the basin could expand to a greater degree (over 420 miles; Huntington 2004; 2006) than that of any other anadromous salmonid species. FERC (2007) concluded that implementing fish passage would help to reduce the adverse effects to steelhead associated with lost access to upstream spawning habitats. Hamilton et al. (2011) also concluded that restored access to historical habitat above the dams would benefit steelhead runs.

2.2.1.4 Lamprey

Pacific lamprey is the only anadromous lamprey species in the Klamath Basin, although five other resident lamprey species are also present in the system. Access to habitat upstream of Iron Gate Dam could benefit Pacific lamprey by increasing their range and distribution in the Klamath River Basin, providing additional spawning and rearing habitat upstream and downstream of Iron Gate Dam, and increasing their abundance. Dam decommissioning is anticipated to expand the current range of Pacific lamprey to areas upstream of Iron Gate Dam (FERC 2007). Restoration of natural hydrologic conditions will improve rearing conditions for lamprey ammocoetes that are currently affected by periodic peaking flows that dewater habitat and strand ammocoetes.

2.2.2 Water Quality and Water Temperature

Removal of the reservoirs will decrease the hydraulic residence time from several weeks to less than a day, resulting in improved water quality and a more natural temperature regime. Reservoir removal would also increase the benefits of tributaries and springs such as Fall, Shovel, and Spencer creeks and Big Springs, that will flow directly into the mainstem Klamath River, creating patches of cooler water (see Table 2-2) that could be used as temperature refugia by fish during summer and fall, as well as providing slightly warmer winter water temperatures conducive to the growth of salmonids (Hamilton et al. 2011). Removal of the facilities would result in a 2-10°C decrease in water temperatures during the fall months and a 1-2.5°C increase in water temperatures during spring months (PacifiCorp 2004a; Dunsmoor and Huntington 2006; NCRWQCB 2010a).

Elimination of the thermal lag caused by the existing reservoirs, will result in water temperatures more in sync with historical fish migration and spawning periods for the Klamath River, warming earlier in the spring, and cooling earlier in the fall compared to existing conditions (Hamilton et al. 2011). Warmer springtime temperatures would result in fry emerging earlier (Sykes et al. 2009), encountering favorable temperatures for growth sooner than under existing conditions, which could support higher growth rates and encourage earlier emigration downstream, thereby reducing stress and disease (Bartholow et al. 2005; FERC 2007). In addition, fall Chinook salmon spawning in the mainstem during fall would no longer be delayed (reducing pre-spawn mortality), and adult migration would occur in more favorable water temperatures than under existing conditions. For example, groundwater inputs in the J.C. Boyle Bypass Reach are anticipated to account for 30 to 40 percent of the total summer flow following dam removal. This proportion won't change due to dam removal, however this cold water will become available to anadromous fish and the cold water effects will persist further downstream without the reservoirs. Groundwater inputs will have a positive effect on water temperature, benefiting both anadromous and resident fish and other aquatic organisms in the Klamath River.

In addition to restoring a more natural thermal regime, facilities removal will result in overall increases in dissolved oxygen, increased diel variability in dissolved oxygen, and lower microbial oxygen demand due to decreased organic load. The conversion of an additional 22 miles of reservoir habitat to riverine and riparian habitat would improve water quality by restoring the nutrient cycling and aeration processes provided by a natural channel, as well as from reduced toxic algae blooms that occur annually in the reservoirs.

2.2.3 Hydrograph

With the removal of facilities in the Hydroelectric Reach, Klamath River flows will mimic the natural hydrograph. Fish migration patterns, riparian plant community processes, and sediment and debris transport mechanisms are anticipated to benefit from a more natural hydrograph.

2.2.4 Disease

Fish diseases are widespread in the mainstem Klamath River during certain time periods, and in certain years disease prevalence has been shown to adversely affect productivity of Chinook and coho salmon. High infection rates by the myxozoan parasite *C. shasta* have been documented in emigrating juvenile salmon populations during spring and early summer in the Klamath River (True et al. 2016 *cited in* USFWS 2016), which have been linked to population declines in fall Chinook Salmon (Fujiwara et al. 2011; True et al. 2013). Fish infected by *C. shasta* are also prone to mortality caused by other pathogens such as *Parvicapsula minibicornis*, to predation, and compromised osmoregulatory systems that are essential for successful ocean entry (S. Foott personal communication *cited in* USFWS 2016).

C. shasta infection rates of juvenile Chinook salmon are influenced by *C. shasta* spore densities, water temperature, and juvenile salmonid residence time in area of high spore densities. Table 2-5 includes a summary of juvenile Chinook salmon prevalence of infection over 10 years at the Kinsman rotary screw trap location (RM 147.6), located 45 river miles downstream from Iron Gate Dam (RM 192.8). The Kinsman trap is located between the Shasta River and the Scott River, a reach of the Klamath River often referenced as the "infectious zone" (USFWS 2016).

Table 2-5 Summary of estimates of annual-level C. shasta infection prevalence for wild and/or unknown origin juvenile Chinook salmon passing the Kinsman rotary screw trap site (RM 147.6)

Year	Origin	Prevalence of Infection	Infected Population Estimate Lower Confidence Limit	Infected Population Estimate	Infected Population Estimate Upper Confidence Limit
2005	All	0.41	0.26	0.38	0.47
2007	All	0.28	0.07	0.1	0.15
2008	All	0.6	0.43	0.51	0.58
2009	All	0.5	0.5	0.58	0.66
2010	Wild/Unknown	0.12/0.15	0.02	0.04	0.07
2011	Wild	0.2	0.07	0.11	0.17
2012	Wild/Unknown	0.06/0.00	0.04	0.08	0.14
2013	Wild	0.18	0.03	0.06	0.09
2014	Wild	0.67	0.12	0.18	0.26
2015	Wild/Unknown	0.66/0.96	0.2	0.29	0.39

Source: USFWS 2016

The lower and upper confidence limits account for the estimation uncertainty in abundance and weekly prevalence of infection rates

Facilities removal is expected to reduce fish disease impacts to adult and juvenile salmon especially downstream from Iron Gate Dam. Among the salmon life stages, juvenile salmon tend to be most susceptible to *P.minibicornis* and *C. shasta* (Beeman et al. 2008). The main factors contributing to risk of infection by *C. shasta* and *P. minibicornis* include availability of habitat (pools, eddies, and sediment) and microhabitat characteristics (static flow and low velocieties) for the polychaete intermediate host; polychaete proximity to spawning areas; increased planktonic food sources from Hydroelectric Reach reservoirs; water temperatures greater than 15°C (Bartholomew and Foott 2010); and juvenile salmonid residence time in the infectious zone (USFWS 2016).

Facilities removal will restore natural channel processes including channel bed scour and sediment transport. Annual channel bed scour will disturb the habitat of the polychaete worm that hosts *C. shasta* (FERC 2007). Reducing polychaete habitat will likely increase abundance of smolts by increasing outmigration survival, particularly for juvenile coho salmon life-histories (FERC 2007).

Dam removal will also broaden the distribution of adult pre-spawn fall Chinook salmon, reducing crowding and the concentration of disease pathogens that currently occurs in the reach between Iron Gate Dam and the Shasta River (USFWS 2016). Lastly, a broader spawning distribution will also influence the distribution of post-spawn adult carcasses that contribute the bulk of the myxospores that enable the *C. shasta* life cycle within the infectious zone. Distributing adult carcasses over a longer reach of the Klamath River corridor will reduce myxospore densities likely leading to lower juvenile salmonid infection rates in the winter and spring rearing period (USFWS 2016). In addition, dam removal will eliminate thermal inertia associated with the reservoirs, thereby increasing growth rates of juveniles so they become smolts earlier and migrate from the river prior to disease levels becoming extreme.

2.2.5 Nuisance Algae

Facilities removal would eliminate optimal growing conditions for toxin-producing nuisance algal species, alleviating the transport of high seasonal concentrations of algal toxins to the Klamath River downstream from Iron Gate Dam. Nuisance algae reduction will also decrease the associated bioaccumulation of microcystin in fish tissue for species downstream from the Hydroelectric Reach. While some microcystin may be transported downstream from large blooms occurring in Upper Klamath Lake, the levels are anticipated to be lower than those currently experienced due to the prevalence of seasonal in-reservoir blooms. Overall, bioaccumulation of algal toxins in fish tissue would be expected to decrease in the Klamath River downstream from Iron Gate Dam and would be beneficial.

2.2.6 Sediment and Debris Transport

In the long term, restoration of sediment and debris transport through the Hydroelectric Reach will decrease substrate size and increase the supply of wood debris, an important structural component that influences aquatic habitat diversity. Bedload sediment movement and transport are vital to create and maintain functional aquatic habitat. The river will eventually drive enhanced habitat complexity due to a more natural flow and reconnected bedload transport regime that will mean the restoration of spawning gravels and early rearing habitat downstream from Iron Gate Dam. Pools would likely return to their pre-sediment release depth within one year (USBR 2012), and the river is predicted to revert to and maintain a pool-riffle morphology providing suitable habitat for fall-run Chinook salmon.

In summary, the Klamath Dams decommissioning project will have long-term ecosystem benefits. Primary ecosystem benefits include restored aquatic organism access to historical habitat upstream of Iron Gate Dam (Huntington 2004; 2006); a more natural hydrograph, temperature regime (PacifiCorp 2004; Dunsmoor and Huntington 2006), and nutrient cycling; reduced prevalence of aquatic diseases such as *Ceratomyxa shasta* (Bartholow et al. 2004; Federal Energy Regulatory Commission [FERC] 2007; U.S. Fish and Wildlife Service [USFWS] 2016) and nuisance algae, and restored sediment transport and debris loading (USBR and CDFG 2012).

2.3 Klamath River Species-specific Benefits

The following sections describing the anticipated Klamath River species-specific benefits are largely taken from NOAA Fisheries (2013).

2.4 Anticipated Klamath River Dam Decommissioning Short-term Effects

Short-term effects from the dam decommissioning to the biological community include high suspended sediment concentrations (Greig et al. 2005, Levasseur et al. 2006; USBR 2011), high bedload transport and deposition, and low dissolved oxygen concentrations (Reclamation and CDFG 2012). Effects are anticipated to impact both mobile and sedentary organisms (e.g., freshwater mussels and lamprey ammocoetes), with the greatest effects on sedentary organisms that are unable to seek refuge from poor water quality. The following sections provide more details on anticipated short-term reservoir drawdown effects presented in the 2012 EIS/R (USBR and CDFG 2012).

2.4.1 Suspended Sediment Effects

The dam decommissioning project could release up to 1.2 - 2.9 million metric tons of fine sediment (sand, silt, and finer) downstream from Iron Gate Dam (RM 192.9) over a two-year period (USBR 2011). Suspended sediment concentrations are expected to exceed 1,000 mg/l for weeks, with the potential for peak concentrations exceeding 5,000 mg/l for hours or days depending on hydrologic conditions during reservoir drawdown (USBR and CDFG 2012). The downstream transport of this sediment, currently stored in reservoir deposits, is anticipated to affect downstream habitats as both suspended sediment and bedload. Biological effects may impact salmonids and Pacific lamprey through gill abrasion and clogging, decreased forage efficiency, and other behavioral effects like delayed migration timing. Deposition of suspended sediments is anticipated to impact salmonid spawning grounds by smothering incubating eggs (Greig et al. 2005; Levasseur et al. 2006), impeding intergravel flow thereby affecting egg and fry development, and impacting fry emergence due to gravel clogging. Fine sediment deposition in slower off-channel habitats may also block connectivity between the Klamath River and off-channel habitats such as mainstem side channels, important habitats for juvenile fish rearing and coho salmon spawning.

2.4.2 Bedload Effects

Bedload mobilized by the dam decommission project is anticipated to affect the Klamath River between Iron Gate Dam (RM 192.9) and Cottonwood Creek (RM 184.9). Bedload deposition is anticipated to result in the burial of spawning habitat, freshwater mussel beds, and lamprey ammocoete rearing areas. Dam-released sediment will also increase the proportion of sand in the channel bed, thereby decreasing salmonid fry and lamprey ammocoete survival. The bed material within the reservoirs and from Iron Gate Dam to Cottonwood Creek is expected to have a high content (30 to 50 percent) of sand immediately following reservoir drawdown until a flushing flow moves the sand sized material out of the reach (USBR 2012). A sufficient flushing flow of at least 6,000 cfs and lasting over several days to weeks is expected to be necessary to return the Klamath River bed composition to one dominated by cobble and gravel with a sand content less than 20 percent. After the flushing flow, the river bed is expected to maintain fractions of sand, gravel, and cobble similar to natural conditions, and be sufficient to support biological communities that use the former effected reach. suitable for Pacific lamprey.

2.4.3 Dissolved Oxygen Effects

Release of reservoir sediments is also anticipated to result in depressed dissolved oxygen concentrations that will affect the biological community in the affected reach. Due to high organic concentration of the reservoir sediments, dissolved oxygen depletion is anticipated to result from the microbial breakdown of released organics. Direct effects of low dissolved oxygen levels include fish mortality, reduced growth and impaired development, reduced swimming performance, altered behavior, and reduced reproductive potential. Mobile fish will likely seek out areas of higher dissolved oxygen and improved water quality downstream of the affected reach, in tributaries and tributary confluence areas with the Klamath River, and in areas with faster flowing water with a higher rate of oxygen transfer at the water-air interface. Less mobile organisms are unable to move from impaired water quality so are more susceptible to low dissolved oxygen effects.

2.4.4 Effects Analysis

Hydraulic and sediment modeling was completed to predict flow and sediment transport characteristics in part to predict potential biological effects associated with the dam decommissioning (USBR 2011; Section 8 and 9). Modeling results are very sensitive to watershed hydrology, both in flow magnitude and runoff pattern (USBR 2011). To account for the range of potential effects that could occur during the dam decommissioning project, two scenarios were analyzed with the goal of predicting the potential impacts to fish that have either a 50 percent (effects likely to occur) or 10 percent (unlikely to occur, or worst-case) probability of occurring (USBR and CDFG 2012; Vol. I, Section 3.3).

Due to the uncertainties associated with biological response to the anticipated high suspended sediment concentrations levels and low dissolved oxygen over extended time periods, the KRRC evaluated the 2012 EIS/R worst-case scenario effects for developing the updated AR plans. The 2012 EIS/R considered short-term (less than 2 years) and long-term (more than 2 years) effects to Klamath River aquatic species. Short-term effects were determined to be either significant or less-than-significant for the species covered by the AR plans (Table 2-6). Mitigation was anticipated to reduce short-term effects for fall Chinook salmon and Lost River and shortnose suckers (from significant to less-than-significant), but did not change the determination of significant project effects for the other species. The dam decommissioning was anticipated to have long-term benefits for all aquatic species (except green sturgeon) including those determined to have significant short-term effects (2012 EIS/R Vol. I, pp. 3.3-129 to 3.3-177).

Table 2-6 2012 EIS/R included proposed mitigation actions for species anticipated to experience short-term effects from the dam decommissioning project

Species	Short-term Effects Determination	Mitigation Proposed	Short-term Effects Determination After Mitigation	Proposed Mitigation Effective	Long-term Effects Determination
Fall Chinook Salmon	Significant	Yes	Less-than-significant	Yes	Beneficial
Coho Salmon	Significant	Yes	Significant	No	Beneficial
Steelhead	Significant	Yes	Significant	No	Beneficial
Pacific Lamprey	Significant	Yes	Significant	No	Beneficial
Lost River & Shortnose Suckers	Significant	Yes	Less-than-significant	Yes	Beneficial
Green Sturgeon	Significant	Yes	Significant	No	Less-than-significant
Freshwater Mussels	Significant	Yes	Significant	No	Beneficial

Source: USBR and CDFG 2012

3. AR-1 Mainstem Spawning

The objective of AR-1 is to address dam decommissioning effects on anadromous fish that migrate and spawn in the mainstem Klamath River and its tributaries. The original 2012 EIS/R AR-1 plan focused on trapping and hauling adult migratory anadromous salmonids and Pacific lamprey and relocating fish to areas of the basin less affected by dam decommissioning effects. The updated AR-1 includes implementation of a monitoring and adaptive management plan to monitor and ensure habitat connectivity and spawning habitat availability. The adaptive plan includes: 1) monitoring and ensuring tributary-mainstem connectivity at select tributaries in the Hydroelectric Reach and in the 8-mile long bedload deposition reach between Iron Gate Dam (RM 192.9) and Cottonwood Creek (RM 184.9); and 2) survey/quantification of spawning habitat in the Klamath River and tributaries in the Hydroelectric Reach from Iron Gate Dam to Keno Dam, and augmenting spawning gravel if existing spawning habitat is less than the area to support 2,100 Chinook redds on the mainstem and 179 steelhead redds in Hydroelectric Reach tributary streams. The updated AR-1 represents the best available actions and opportunities to offset Chinook salmon and coho salmon spawning redds lost during reservoir drawdown, and migrating adult steelhead and Pacific lamprey affected by reservoir drawdown.

3.1 Proposed Updated AR-1

Based on a review of the original AR-1 presented in Section 3.2, input from the ATWG, and recent fisheries literature, the KRRC concluded that an updated AR-1 is necessary to offset the anticipated short-term effects of dam decommissioning on mainstem Chinook salmon and coho spawning, and migrating adult steelhead and Pacific lamprey migration. The updated AR-1 includes the development and implementation of a monitoring and adaptive management plan with on-going input from the ATWG. The plan includes monitoring and ensuring tributary-mainstem connectivity and spawning habitat availability. The monitoring and adaptive management plan has two specific actions.

- **Action 1**: Tributary-mainstem confluences, four sites in the Hydroelectric Reach and five sites in the 8-mile reach from Iron Gate Dam (RM 192.9) to Cottonwood Creek (184.9), will be evaluated for 2-years from the onset of reservoir drawdown. If present, confluence obstructions will be actively removed during the 2-year evaluation period to ensure volitional passage for adult Chinook salmon, coho salmon, steelhead, and Pacific lamprey.
- **Action 2**: A spawning habitat evaluation of the Hydroelectric Reach and newly accessible tributaries following reservoir drawdown will be completed. A target of 44,100 yd^2 of mainstem spawning gravel will be required to offset the effects to 2,100 mainstem-spawning fall Chinook salmon redds. If mainstem spawning gravel availability is less than the target values following reservoir drawdown, spawning gravel augmentation will be completed in the former Klamath River reservoirs and Hydroelectric Reach. A target of 4,700 yd^2 of tributary spawning gravel is required to offset the effects to 179 tributary-spawning steelhead redds. If tributary spawning gravel habitat is less than the target values following reservoir drawdown, the ATWG will convene to prioritize additional habitat restoration actions that will be undertaken to increase the amount of tributary habitat available to compensate for the loss of steelhead redds.

The proposed actions are intended to ensure adult salmonid and Pacific lamprey access to mainstem and tributary spawning habitat in the Hydroelectric Reach following dam decommissioning. The following sections provide additional detail on the proposed actions.

3.1.1 Action 1: Tributary-Mainstem Connectivity

The following sections provide information on the monitoring and adaptive management plan pertaining to tributary-mainstem connectivity.

3.1.1.1 Tributary-Mainstem Connectivity Monitoring

To ensure that spawning habitat is accessible following reservoir drawdown, fish passage monitoring and adaptive actions will occur at the confluence areas of key Klamath River tributaries and side channels upstream and downstream of Iron Gate Dam. Tributary confluences in the Hydroelectric Reach may be affected by sediment deposits and debris obstructions as the reservoir are drawdown. Tributary deltas may create fish passage barriers that would limit upstream migration of anadromous salmonids and Pacific lamprey.

Based on hydraulic and sediment transport modeling completed by USBR (Section 9.2.1.4; 2011), sediment deposition during reservoir drawdown is predicted from Bogus Creek (RM 192.4) downstream to Cottonwood Creek (RM 184.9). From Bogus Creek downstream to Willow Creek (RM 187.8), approximately 1.5 feet of sediment deposition is anticipated. From Willow Creek downstream to Cottonwood Creek, deposition of less than 1 foot is expected. Areas downstream of Cottonwood Creek are expected to have only minor deposition with deposits less than 0.25 feet (USBR 2011). No additional deposition is predicted in the Bogus Creek to Cottonwood Creek reach following dam decommissioning.

Species that would be potentially affected by obstructed tributary connections include steelhead and Pacific lamprey during the winter and spring of the drawdown year, and Chinook salmon and coho salmon in the fall of the drawdown year. Further, depending on erosion rates of reservoir sediments, tributary confluence areas in the reservoir areas may not create volitional fish passage conditions following drawdown.

Tributary confluences to be monitored in the 2-year period following dam decommissioning include Bogus Creek, Dry Creek, Little Bogus Creek, Willow Creek, and Cottonwood Creek. Tributaries in the Bogus Creek to Cottonwood Creek reach were selected as they are recognized as influential tributaries (e.g., historical fisheries importance or important freshwater sources) in the mid-Klamath River (Soto et al. 2008). Hydroelectric Reach tributaries to be monitored include Spencer Creek (RM 230.5), Shovel Creek (RM 209.0), Fall Creek (RM 198.9), and Jenny Creek (RM 196.8). These tributaries were selected based on having historical or potential habitat for adult salmonids (Huntington 2006).

3.1.1.2 Tributary Connectivity Maintenance

Tributary obstructions that limit fish passage will be remedied through appropriate manual or mechanical means. Example removal methods may include removing sediment using hand tools or hydraulic equipment. Removed material will be placed in the mainstem Klamath River downstream of the tributary confluence or on the adjacent floodplain. The Project restoration plan allows for incorporation of engineered roughness elements at tributary connection points, as appropriate.

3.1.2 Action 2: Spawning Habitat Evaluation

The following sections provide information on the monitoring and adaptive management plan pertaining to mainstem and tributary spawning habitat availability.

3.1.2.1 Spawning Habitat Target Metrics

Spawning gravel area targets for Chinook salmon and steelhead were developed based on typical spawning redd dimensions for the two species and the anticipated loss of Chinook salmon redds and adult steelhead due to reservoir drawdown. Fortune et al. (1966) used 21 square yards (yd^2) and 26 yd^2 of suitable gravel per Chinook salmon redd and steelhead redd, respectively, to calculate spawning potential in areas of the Klamath River and selected tributaries upstream of Iron Gate Dam (Table 3-1). Based on an anticipated loss of 2,100 Chinook salmon redds downstream from Iron Gate Dam and a 21 yd^2 area per redd, 44,100 yd^2 of spawning gravel is necessary to offset the loss of 2,100 Chinook salmon redds. Based on recent winter steelhead counts, an estimated 358 adult steelhead representing 179 spawning redds will be affected by dam decommissioning. Applying Fortune et al. (1966) steelhead redd dimensions, 4,700 yd^2 of tributary spawning habitat will be needed to offset the loss of 358 winter steelhead.

Table 3-1 Anticipated redd loss due to project effects for fall Chinook salmon and winter steelhead, surface area per redd, and the anticipated spawning habitat area needed to address redd loss for fall Chinook salmon and steelhead adult production

Metric	Fall Chinook Salmon	Winter Steelhead
Anticipated redd loss due to project effects	2,100	179[1]
Surface area per spawning redd (yd^2)	21	26
Spawning habitat area to address redd loss (yd^2)	44,100	4,700

[1]Updated anticipated winter steelhead loss based on peak steelhead return of (631 in 2001) to Iron Gate Hatchery between 2000-2016 (CDFW 2016). Expected mortality calculated using the methodology contained in the 2012 EIS/R (631*0.80*0.71=358). The 358 adult steelhead were converted to 179 redds that would be lost due to adult steelhead mortality

3.1.2.2 Spawning Habitat Monitoring

To quantify the available spawning habitat upstream of Iron Gate Dam, field surveys and remote sensing efforts will be implemented following reservoir drawdown. Boat or aerial surveys will be conducted on the mainstem Klamath River between Iron Gate Dam (RM 192.9) and Keno Dam (RM 238.2) during the summer following reservoir drawdown to determine the amount of mainstem spawning habitat in the Hydroelectric Reach suitable for immediate spawning.

Tributary streams will be walked from their mouths to the first natural fish passage barrier to estimate amount of available spawning habitat following reservoir drawdown (Table 3-2 The area of available spawning habitat will be estimated from the mouth to the first natural barrier. If artificial (manmade) fish passage barriers are located during the tributary reach reconnaissance, they will be noted as potential restoration actions to increase the availability of tributary spawning habitat.

Table 3-2 Hydroelectric Reach tributaries to be assessed for existing

Tributary	Tributary Confluence Location at the Klamath River (River Mile)	Tributary Length to First Barrier (miles)
Jenny Creek	196.8	1.0
Fall Creek	198.9	1.2
Shovel Creek	209.0	2.7
Spencer Creek	230.5	9.0

3.1.2.3 Response to Spawning Habitat Availability

KRCC will prepare a report summarizing the spawning habitat surveys and outline and prioritize actions to augment spawning habitat if the existing spawning habitat amounts to less than the 44,100 yd^2 of mainstem and 4,700 yd^2 of tributary spawning habitat targets in the Hydroelectric Reach. KRRC will consult with ATWG for input on potential spawning gravel augmentation locations in the mainstem and on other tributary habitat restoration actions in tributaries to increase the availability of spawning habitat. Currently, if existing spawning habitat does not meet targets, spawning gravel augmentation will be completed in the mainstem Klamath River between Shovel Creek (RM 209.0) and the upstream extent of Copco Reservoir (RM 208.0). Mainstem gravel would be added at a rate of 7.0 cy (21 yd^2 x 1 ft depth) per compensatory mainstem redd. Augmented gravel is anticipated to be redistributed with subsequent high flows, broadening potential spawning habitat over larger areas of the treated mainstem reaches. Tributary spawning habitat restoration actions to be completed in Jenny Creek, Shovel Creek, Fall Creek, and/or Spencer Creek could include removal of artificial fish passage barriers, or placement of large woody debris to trap and retain spawning gravels. Spawning gravel augmentation will be prioritized based on anticipated spawning habitat benefits. Through coordination with the ATWG and consistent with other monitoring efforts, gravel augmentation will be done in an adaptive manner (over time with evaluation), to ensure the augmented gravel is not negatively impacting habitat essential for other life stages of salmonids.

In summary, the updated AR-1 includes development and implementation of a monitoring and adaptive management plan. The plan will direct the evaluation of tributary-mainstem connectivity in the Hydroelectric Reach and the Klamath River deposition reach between Iron Gate Dam and Cottonwood Creek. Tributary confluences will be monitored for 2-years following dam decommissioning and tributary obstructions that block fish passage will be addressed over the 2-year period. Mainstem and tributary spawning habitat in the Hydroelectric Reach will be monitored post-reservoir drawdown and will be augment with supplemental spawning gravel or enhanced through additional restoration actions if spawning habitat area metrics are not met by existing habitat conditions following reservoir drawdown.

3.2 Summary of the 2012 EIS/R AR-1, Dam Removal Benefits and Effects, and Recent Fisheries Literature

The following sections review the components of the 2012 EIS/R AR-1 measure, anticipated dam removal effects and benefits on AR-1 species, and recent fisheries literature relative to mainstem spawning. This information is presented in support of the updated AR-1 measure.

3.2.1 AR-1 Affected Species

Species identified in AR-1 include:

- Coho salmon (*Oncorhynchus kisutch*) – Southern Oregon/Northern California Coastal (SONCC) evolutionary significant unit (ESU): Federally Threatened; California Threatened; Tribal Trust Species
- Chinook salmon (*O. tshawytscha*) – Upper Klamath-Trinity Rivers ESU - Fall Run: California Species of Special Concern; Tribal Trust Species
- Chinook salmon (*O. tshawytscha*) – Upper Klamath-Trinity Rivers ESU – Spring Run: California Species of Special Concern; Tribal Trust Species
- Steelhead (*O. mykiss*) – Klamath Mountains Province distinct population segment (DPS) – Summer Run: California Species of Special Concern; Tribal Trust Species
- Steelhead (*O. mykiss*) – Klamath Mountains Province DPS – Winter Run: Tribal Trust Species
- Pacific lamprey (*Entosphenus tridentatus)*: California Species of Special Concern; Tribal Trust Species

3.2.2 Anticipated Dam Decommissioning Effects on AR-1 Species

Short-term effects of dam removal (from both suspended sediment and bedload movement) were predicted to result in high mortality of fall Chinook salmon and coho salmon embryos and pre-emergent alevin within redds that are constructed in the mainstem Klamath River downstream from Iron Gate Dam (RM 192.9) in the fall of prior to reservoir drawdown (USBR and CDFG 2012). Approximately 2,100 fall Chinook salmon redds and approximately 13 SONCC coho salmon redds were predicted to be affected during reservoir drawdown. Additionally, steelhead and Pacific lamprey migrating within the mainstem Klamath River after December 31 prior to the reservoir drawdown year are anticipated to be directly affected by suspended sediment. Table 3-3 includes the likely and worst-case effects to adult anadromous fish species downstream from Iron Gate Dam.

Table 3-3 2012 EIS/R anticipated effects summary for migratory adult salmonids and Pacific lamprey

Species	Life Stage	Likely Effects	Worst Effects
Coho Salmon	Adult Spawning	Loss of 13 redds (0.7-26%)1	Loss of 13 redds (0.7-26%)1
Chinook Salmon - Fall	Adult Spawning	Loss of 2,100 redds (8%)1	Loss of 2,100 redds (8%)1
Steelhead - Summer	Migrating Adults	No anticipated mortality	Loss of 0-130 adults (0-9%)1
Steelhead - Winter	Migrating Adults	Loss of up to 1,008 adults	Loss of up to 1,988

		(14%)1	adults (28%)1
Pacific Lamprey	Adult Migration and Spawning	High mortality (36%)2	High mortality (71%)2

Source: USBR and CDFG 2012

[1] Range of potential year class loss based on the average number of redds associated with the evaluated population(s).
[2] The 2012 EIS/R predicted Pacific lamprey mortality based on mortality models developed for suspended sediment impacts to salmonids. Model output did not include the number of predicted Pacific lamprey mortalities.

The following sections include descriptions of species-specific effects adapted from the 2012 EIS/R (USBR and CDFG 2012; Vol. I, pp. 3.3-129 to 3.3-168).

3.2.2.1 Coho Salmon

The wide distribution and use of tributaries by both juvenile and adult coho salmon will likely protect the population from the worst effects of the dam decommissioning. However, direct mortality is anticipated for redds and smolts from the upper Klamath River, mid-Klamath River, Shasta River, and Scott River population units. No mortality is anticipated for the Salmon River, Trinity River, and Lower Klamath River populations under the most likely or worst-case scenarios. Based on substantial reduction in the abundance of a year class in the short-term, the effect of the dam decommissioning was found to be significant for the coho salmon from the Upper Klamath River, Mid-Klamath River, Shasta River, and Scott River population units.

Based on spawning surveys conducted from 2001 to 2005 (Magneson and Gough 2006), 6 to 13 redds could be affected during reservoir drawdown. The anticipated loss of redds from the Upper Klamath River coho salmon population unit was based on the peak count of redds surveyed in all years (13 redds counted in 2001). Mainstem Upper Klamath River coho redd surveys completed between 2001 and 2016 yielded 6 redds on average and no redds in 2009. A total of 38 mainstem redds were documented between 2001-2005, with two-thirds of those redds being found within 12 miles of the dam (NMFS 2010). Many of the redds anticipated to be affected by the dam decommissioning are thought to be from returning hatchery fish (NOAA 2010). To preserve existing genetic characteristics and to reduce the threat of demographic extinction, under the Iron Gate Hatchery's hatchery genetic management plan (HGMP), all adult coho salmon not used as broodstock have been returned to the Klamath River to spawn naturally since 2010. Many of these hatchery-origin adult coho salmon stray into Bogus Creek and the Shasta River to spawn while the remainder are thought to spawn in the Klamath River below Iron Gate Dam. Therefore, based on the range of escapement estimates in Ackerman et al. (2006), 13 redds could represent anywhere from 0.7 to 26 percent of the naturally returning spawners in the Upper Klamath River Population Unit, and likely much less than 1 percent of the natural and hatchery returns combined (Magneson and Gough 2006; USFWS, unpublished data, 2017).

3.2.2.2 Chinook Salmon – Fall Run

Fall Chinook salmon use the mainstem Klamath River for spawning, rearing, and as a migratory corridor. Direct mortality is predicted for fall Chinook salmon redds and some smolts. The effect of suspended sediment concentrations on juvenile fall Chinook salmon from the dam decommissioning is expected to be relatively minor because of variable life histories, the large majority of age-0 juveniles that remain in tributaries until later in the spring and summer, and because many of the fry that out-migrate to the mainstem come from tributaries in the mid-or lower Klamath River, where suspended sediment concentrations resulting from the dam decommissioning are expected to be lower due to dilution from tributaries.

Suspended sediment is predicted to result in 100 percent mortality of fall Chinook salmon eggs and fry spawned in the mainstem Klamath River during the fall prior to the reservoir drawdown year. Much of the overall effect on fall Chinook salmon will depend on the relative proportion of mainstem spawners during the fall prior to the reservoir drawdown year. Based on redd surveys using a mark and re-sight methodology from 1999 through 2009 (Magneson and Wright 2010), an average of 2,100 redds from hatchery and naturally returning adults are constructed in the mainstem Klamath River and represents approximately 8 percent of the total, basin-wide escapement (USBR and CDFG 2012).

3.2.2.3 Steelhead – Summer and Winter

High suspended sediment concentrations resulting from the dam decommissioning are anticipated to affect winter steelhead migrating during the winter and spring of the drawdown year, particularly for the portion of the population that spawns in tributaries upstream of the Trinity River (RM 43.4). For that portion of the population, effects are anticipated on adults, run-backs, half-pounders, any juveniles rearing in the mainstem, and out-migrating smolts. However, the broad spatial distribution of steelhead in the Klamath Basin and their flexible life history suggests that some steelhead will avoid the most serious effects of the dam decommissioning by remaining in tributaries for extended rearing, rearing farther downstream where suspended sediment concentrations should be lower due to dilution, and/or moving out of the mainstem into tributaries and off-channel habitats during winter to avoid periods of high suspended sediment concentrations.

Additionally, the life history variability observed in steelhead means that, although numerous year classes will be affected, not all individuals in any given year class will be exposed to project effects. Some portion of the progeny of those adults that spawn successfully would also rear in tributaries long enough to not only avoid the highest suspended sediment concentrations, but may also not return to spawn for up to 2 years, when suspended sediment resulting from the dam decommissioning should be greatly reduced. The high incidence of repeat spawning among summer steelhead, ranging from 40 to 64 percent (Hopelain 1998) should also increase that population's resilience to dam decommissioning effects. Dam decommissioning modeling results suggest the loss of up to 1,988 winter steelhead redds and up to 130 summer steelhead redds (however, see updated steelhead population data in Section 3.2.3).

3.2.2.4 Pacific Lamprey

Dam decommissioning would have short-term effects on Pacific lamprey related to high suspended sediment concentrations, bedload sediment transport and deposition, and impaired water quality (particularly low dissolved oxygen levels). Overall, because multiple year classes of Pacific lamprey rear in the mainstem Klamath River at any given time, and since adults will migrate upstream over the entire year, including the reservoir drawdown period when effects from the dam decommissioning will be most pronounced, effects on Pacific lamprey adults and ammocoetes are anticipated to be substantial. However, because of their wide spatial distribution and varied life history, most of the population, (which is distributed from at least California along the Pacific Rim to Japan; Goodman and Reid 2012), would not be affected by the dam decommissioning. In addition, Pacific lamprey are considered to have low fidelity to their natal streams (FERC 2006), and may not enter the mainstem Klamath River if environmental conditions are unfavorable during the reservoir drawdown period. Migration into the Trinity River and other lower Klamath River tributaries may also increase during the reservoir drawdown period because of poor water quality in the upper Klamath River. Low site fidelity and a prevalence of tributary ammocoetes also increases the potential for Pacific lamprey recolonization of mainstem habitats following dam decommissioning.

3.2.3 2012 EIS/R AR-1 Actions

The 2012 EIS/R AR-1 plan (Vol. I, pp. 3.3-242 to 3.3-243) directed the capture and relocation of adult spawning condition salmonids and Pacific lamprey to mitigate dam decommissioning effects. A weir and trap system was proposed for installation directly upstream of the Shasta River (RM 179.3), where the mainstem Klamath River is narrow enough to effectively trap migrating salmonids. This location was also specified to ensure that fish returning to key tributaries downstream of, and including the Shasta River, would not be interrupted. The weir was proposed to be installed at the beginning of the fall migration and fished past the initial dam drawdown period until high flows would require the trap be dismantled. Trap operation would occur intermittently to allow volitional passage of fish upstream of the trap location and would coincide with pulses of fish moving through the system. Trapped fish would then be transported and released either into under-seeded tributaries downstream of Iron Gate Dam (e.g., Scott River [RM 145.1]), or into tributaries or the mainstem Klamath River upstream of J.C. Boyle Reservoir (RM 233.0) if consistent with post-dam decommissioning management goals.

If necessary, additional surveys in the mainstem Klamath River downstream of Shasta River were proposed to locate coho salmon spawning in the mainstem. Any identified adult coho salmon and Chinook salmon, steelhead, or Pacific lamprey could be captured using dip nets, electrofishing, or seines and transported to tributary habitat. Spawning surveys would be conducted in December prior to reservoir drawdown, immediately prior to the first release of sediment associated with dam removal.

3.2.4 KRRC Review of AR-1 for Feasibility and Appropriateness

The KRRC assessed the feasibility and appropriateness of AR-1 through multiple planning meetings held with the ATWG between May and August 2017. During these meetings, new information on Klamath River fisheries was presented and information on other dam removal projects conducted in the western United States was reviewed to understand how the aquatic ecosystem might respond as discuss above. Major concerns discussed by KRRC and ATWG regarding the 2012 AR-1 included:

- Feasibility of a weir and trap system during high flows and winter conditions.
- High anticipated mortality associated with trapping, handling, hauling, and releasing adult spawning condition fall Chinook salmon and coho salmon.
- Impacts to wild fish populations inhabiting streams used to relocate captured fish.

- Adult coho salmon location at time of the reservoir drawdowns.
- Chinook salmon with a high hatchery influence would be most affected by the reservoir drawdowns.
- 2012 EIS/R baseline population estimates and effects uncertainty.

The following sections provide additional information regarding AR-1 feasibility and appropriateness, based on fisheries literature and ATWG input.

3.2.4.1 Weir and Trap System Feasibility

The 2012 EIS/R proposed weir and trap location was above the Shasta River confluence (RM 179.3) with the Klamath River. AR-1 guidance anticipated that the weir would be removed periodically to allow for passage of coho salmon and fall Chinook salmon above the weir to the upper Klamath River and its tributaries, and Iron Gate Hatchery (RM 192.4). The KRRC and ATWG concluded that fall rains will increase river flows and will require weir and trap removal from the river. Periods of increasing flow would also likely correspond with the greatest quantities of fish moving into the upper Klamath River. The weir system would likely not be operational during the reservoir drawdown period when winter-spring steelhead and Pacific lamprey migration increases with high flows. Therefore, the weir system would be ineffective at mitigating effects to migrating winter steelhead and Pacific lamprey during periods of high flows.

The KRRC and ATWG concluded that it would likely be infeasible to trap and haul the large number of fish that could be encountered in the upper Klamath River in an efficient, safe, and cost-effective manner, and that if fish were relocated into tributary streams downstream of Iron Gate Dam prior to reservoir drawdown, there was a high probability that many of those fish would re-enter the Klamath River and spawn in the affected area. The number of returning coho salmon and fall Chinook salmon in the fall prior to reservoir drawdown will depend on several factors including year class strength, ocean conditions, ocean and lower river fisheries, and Klamath River water quality conditions during the spawning migration. While the number of fish that return to Iron Gate Hatchery (RM 192.4) vary widely, the average number of fish returning to the Klamath River upstream of the Shasta River confluence (RM 179.3) is substantial (Table 3-2) and would make trapping efforts intensive. For example, to trap the typically small numbers of natural origin coho salmon or winter steelhead upstream of the Shasta River confluence, there would be substantial effort to handle and sort large numbers of spawning condition hatchery fall Chinook salmon that may not be relocated. Given poor water quality conditions typical during the late summer migration, intensive fish handling, sorting, and transport could result in significant stress and mortality of the target species, as described below.

Ultimately, the KRRC concluded that trapping using a weir style system, handling, and hauling a substantial portion of the typical returns to the upper Klamath River would be ineffective. There have also not been similar efforts conducted on other large dam removal projects to provide more certainty with this action.

Table 3-4 Fall Chinook salmon, coho salmon, and winter steelhead return metrics for Iron Gate Hatchery from 2000 to 2016

Return Metric	Fall Chinook Salmon	Coho Salmon	Winter Steelhead
Maximum Return	72,474	2,573	631[1]
Average Return	20,229	855	242
Minimum Return	8,176	70	4

Source: CDFW 2016

[1] The peak winter steelhead return to Iron Gate Hatchery from 2000 to 2016 was 631 fish. Using the 2012 EIS/R calculation method, 80 percent of fish returning to Iron Gate Hatchery migrate upstream after December 15th. Under the worst-case scenario, 71 percent of mortality is predicted to occur due to the dam decommissioning project. The 2012 EIS/R used a dataset published in 1994 (Busby et al. 1994) that included larger winter steelhead returns than have occurred over the last 27 years.

3.2.4.2 Mortality Associated with Trapping, Handling, Hauling, and Releasing Adult Spawning-condition Fall Chinook Salmon and Coho Salmon

The KRRC and ATWG concluded that spawning condition coho salmon and Chinook salmon will begin to reach the proposed weir location at RM 179.3 in late summer and early fall when water quality conditions are generally poor and fish are susceptible to pre-spawn mortality due to stress and/or disease. Fish would potentially be more susceptible to disease and parasites associated with low flows, high water temperatures, and fish crowding. Given the expected condition of pre-spawn fish and poor water quality, the added stress associated with trapping, handling, hauling, and releasing captured fish is expected to result in high mortality of translocated fish.

Fish condition at the time of trapping influences mortality potential (Keefer et al. 2010). Primary injury and mortality events prior to fish transport are often associated with debris accumulation in the trap box, fish reaction to anesthesia, handling stress, and over-crowding in the trap box. Fish in overcrowded transport tanks may expire due to low oxygen concentrations and warm water temperatures. In a trap and haul study on the San Joaquin River in California, adult fall Chinook salmon were trapped and transported in November. Of the 119 fish that were handled, 4 percent of fish died prior to transport and 8 percent died during transport (Bigelow et al. 2013). A trap and haul study that evaluated effects on adult, sexually mature fall Chinook salmon reported mortality of 19 percent (Geist et al. 2016), substantially higher than a comparison experiment using adult rainbow trout (Mesa et al. 2013 *cited in* Geist et al. 2016). In a study of transport and pre-spawn mortality of adult fall Chinook salmon in the Willamette River, Keefer et al. (2010) found that adult spring Chinook salmon that were captured, transported, and out-planted above barrier dams in the Willamette River, Oregon was 48 percent, ranging from 0 to 93 percent for individual release groups. Mortality rates strongly correlated with fish condition and water temperature.

Delayed post-release, pre-spawn mortality has also been detected in other projects, with mortality likely related to transport stress rather than water quality or disease issues which would manifest in more rapid (hours) or longer term (weeks) mortality, respectively (Mann et al. 2011).

In summary, the KRRC concluded the potential handling mortality and reduced spawning success associated with an intensive trap and haul program could result in significant losses of fall Chinook salmon and coho salmon and counter the expected benefits of a trap and haul effort.

3.2.4.3 Impacts to Wild Fish Populations Inhabiting Relocation Streams

The KRRC and ATWG expressed concerns regarding the relocation of fall Chinook salmon and coho salmon that are highly influenced by Iron Gate Hatchery genetics to tributaries potentially inhabited by wild fish with limited hatchery influence. The KRRC and ATWG also concluded that there would be few viable options for recipient tributary streams based on genetics and disease concerns.

The original AR-1 was in part intended to assist in the reintroduction of anadromous salmonids upstream of Iron Gate Dam. Contrary to ODFW's draft reintroduction plan (2008), ODFW is currently developing a reintroduction strategy for anadromous fish reintroduction to the Upper Klamath Basin (T. Wise, ODFW, personal communication). The strategy, while in development, is expected to rely primarily on natural recolonization of the Klamath River and associated tributaries downstream from Upper Klamath Lake, and tributaries in the Upper Klamath Lake watershed. CDFW is likewise concerned with introducing transplanted coho salmon and fall Chinook salmon of unknown genetics and disease condition into wild populations that spawn in the Klamath River and tributaries.

Chinook salmon exhibit substantial population genetic structure across the species' geographic range including the Klamath River Basin (Kinziger et al. 2013). Chinook salmon in the Klamath River Basin exhibit a complex genetic structure defined primarily by basin geography. The Iron Gate Hatchery (RM 192.4) has a profound influence on Klamath River fall Chinook salmon in the vicinity of the hatchery. Kinziger et al. (2013) found the proportion of naturally spawning fall Chinook salmon of Iron Gate Hatchery origin decreased with distance from the hatchery. Natural origin Chinook sampled in Bogus Creek (RM 192.4), Shasta River (RM 179.3), and the Scott River (RM 145.1) had decreasing proportions of hatchery genetics with increasing distance from the hatchery. Fall Chinook salmon spawning between Iron Gate Dam (RM 192.9) and the Shasta River (RM 179.3) exhibit the greatest introgression of Iron Gate Hatchery fish genes. The influence of Iron Gate Hatchery genetics on fall Chinook salmon is greatly diminished by the Scott River (RM 145.1).

In light of these considerations, relocating fall Chinook salmon from downstream of Iron Gate Dam to Klamath River tributaries would be restricted to tributaries between Iron Gate Dam and the Shasta River to minimize genetic effects to tributary populations. However, moving fish with a higher proportion of hatchery-influenced genetics farther from the hatchery has the potential to extend the hatchery's introgressive influence to downstream fall Chinook salmon populations that are outside of the direct influence of Iron Gate Hatchery (Kinziger et al. 2013). Additionally, streams between Iron Gate Dam (RM 192.9) and the Shasta River (RM 179.3) that support fall Chinook spawning are currently limited by water availability and quality during the fall spawning migration period.

In summary, the KRRC and ATWG concluded that relocating fall Chinook salmon and coho salmon of unknown genetic composition to the Klamath River upstream of Iron Gate Dam or to under-seeded tributaries near Iron Gate Dam presents an unacceptable genetic risk (and possibly disease risk) to other populations potentially dominated by wild fish.

3.2.4.4 Adult Coho Salmon Location at Time of the Reservoir Drawdowns

The KRRC and ATWG concluded that since coho salmon primarily spawn in Klamath River tributaries, adult coho salmon will largely be unaffected by poor water quality conditions associated with reservoir drawdown in the mainstem Klamath River. Additionally, it is believed that the small numbers of coho that do spawn in the mainstem river are mostly of hatchery origin (NOAA 2014). Expected mortality associated with trapping, handling, hauling, and releasing adult coho salmon would stress fish that would not be affected by reservoir drawdown if these fish were instead allowed to reach their spawning tributaries (e.g., Bogus Creek). The reservoir drawdown schedule was also in part developed to account for coho salmon entry into tributaries to minimize dam decommissioning effects. Attempting to capture small numbers of mainstem spawning coho salmon would likely impact greater numbers of coho than would be impacted by dam removal activities.

Overall, the KRRC and ATWG concluded a trap and haul program as prescribed in the 2012 EIS/R would negatively affect coho salmon that would otherwise migrate to their native tributary streams in the upper Klamath River.

3.2.4.5 2012 EIS/R Baseline Population Estimates and Project Effects Uncertainty

Effects to adult fish outlined in the 2012 EIS/R included approximations and assumptions that were based on limited data on Klamath River anadromous salmonids and Pacific lamprey populations; incorporated a conservative analysis of fish avoidance behavior to the anticipated water quality conditions; and in part included a worst-case scenario analysis of dam removal effects on adult salmonids and Pacific lamprey. The following sections provide updated population information for winter steelhead and Pacific lamprey, and identify project effects uncertainty that should be considered in updating the effects determinations.

Steelhead Population Update

Steelhead data for the Klamath River Basin upstream of the Trinity River are limited. Population data for winter steelhead in the 2012 EIS/R were based on Iron Gate Hatchery returns published in 1994 (Busby et al. 1994). In a strong return year based on the 1994 dataset, 3,500 adult winter steelhead returned to Iron Gate Hatchery (USBR and CDFG 2012). The 2012 analysis estimated that there would be 71 percent mortality to 80 percent of those fish based on run timing and effects of suspended sediment. Using updated winter steelhead counts for the Iron Gate Hatchery from 2000 to 2016 (Table 3-2), the peak and average numbers of adult winter steelhead returning to Iron Gate Hatchery were 631 and 242 steelhead, respectively. In 2016, steelhead returns to the hatchery were zero (CDFW 2016). If returns to Iron Gate Hatchery are indicative of the broader winter steelhead population, the precipitous decline suggests a lower number of winter steelhead are likely to be impacted during facilities removal and therefore an updated winter steelhead loss and mitigation number should be established for addressing effects to adult winter steelhead. Using the same methodology contained in the 2012 EIS/R, but applied to the 2000-2016 steelhead return data, effects to steelhead would result in a loss of 358 and 138 steelhead on a peak and average year, respectively.

Video monitoring conducted in Bogus Creek and the Shasta River by CDFW between 2007 and 2016 also provides context to the recent abundance of upper Klamath steelhead populations. Average returns of adult steelhead counted by video were 53 and 102 steelhead for Bogus Creek and the Shasta River, respectively, during the 10-year period. However, many of those years video monitoring was terminated in December or January and did not capture the full steelhead migration period. In years where video monitoring or a combination of video counts and SONAR counts covered the full migration period (2013 and 2016 for Bogus Creek and 2012, 2015, and 2016 for Shasta River) total steelhead counted averaged 94 for Bogus Creek and 194 for the Shasta River (CDFW, unpublished data, 2017). Likewise, no steelhead have been produced at Iron Gate Hatchery since 2012 (K. Pomeroy, CDFW, personal communication, 2017). These numbers are indicative of the low returns of hatchery and natural origin steelhead in the upper Klamath River.

Pacific Lamprey Population Update

Recent genetic analysis of Pacific lamprey suggests no significant population structure exists across populations or regions, indicating a high degree of historical gene flow even across expansive distances of the northern Pacific Rim (Goodman and Reid 2012). Weak population structure and low site fidelity may reduce the short-term effects to Pacific lamprey identified in the 2012 EIS/R. Because the metapopulation is now believed to be relatively undifferentiated across the species' range, the percentage of adult and larval Pacific lamprey that will be affected by the dam decommissioning relative to the population as a whole will be insignificant.

Project Effects Uncertainty

Studies suggest that high suspended sediment concentrations (Newcombe and Jensen 1996; Chapman et al. 2014; Kjelland et al. 2015) and low dissolved oxygen concentrations (Bjorn and Reiser 1991; Washington Department of Ecology [WDOE] 2002; Carter 2005) affect adult salmonid behavior. Adult salmonid behavioral changes to high suspended sediment concentrations include avoidance of turbid waters in homing adult anadromous salmonids. Physiological effects of high turbidity include physiological stress and respiratory impairment, damage to gills, reduced tolerance to disease and toxicants, reduced survival, and direct mortality (Newcombe and Jensen 1996). Concentration and duration of elevated suspended sediment, as well as other factors including water temperature, disease, and river flow, influence the effect of suspended sediment on salmonids.

The effects of low dissolved oxygen levels, eutrophication, or turbidity on natural populations of Pacific lamprey adults and ammocoetes are unknown. Adult steelhead and Pacific lamprey entering the Klamath River during reservoir drawdown and dam removal would encounter poor water conditions and would be expected to avoid poor water quality by either entering tributary streams or using habitats less affected by high suspended sediment concentrations (e.g., tributary confluences or off-channel areas). For instance, in 2012 during dam deconstruction on the Elwha River, a high proportion (44 percent) of Chinook salmon redds were documented in two clear water tributaries (Indian Creek and Little River), while surveys conducted following dam removal activities (2014-2016) resulted in over 95 percent of Chinook redds constructed in the mainstem river. The high proportion of tributary spawning by fall Chinook salmon in 2012 suggests that these streams provided refugia from the effects of dam removal (McHenry et al. 2017). There is increasing evidence that fish will modify their behavior to avoid areas of high suspended sediment concentrations levels immediately following dam removal, thereby reducing the impact of reduced water quality on their populations. This is consistent with ecological and evolutionary theories that predict that fish evolve behaviors to avoid episodic events resulting is poor water quality, such as landslides, fires, and other naturally occurring processes.

The approach presented in the 2012 EIS/R to determine the anticipated effects assumed that fish would not exhibit any of these behavioral responses and instead suffer mortality by voluntarily remaining in areas that had lethal concentrations of suspended sediment for extended periods of time.

Effects to adult fall Chinook salmon are muted by the fact that any cohort is made up of several age classes of adult spawners. Adult returns the year following dam removal will be comprised of age-2, 3, and 4 fish that will be in the ocean during the dam decommissioning process. Benefits of dam decommissioning that are expected to be evident the first year following dam decommissioning include increased mainstem and tributary spawning habitat, reduction in disease-induced mortality, and reduction or elimination of redd-superimposition in spawning areas downstream of Iron Gate Dam (N. Hetrick, USFWS, personal communication, 2017). The improved conditions for fall Chinook salmon following dam decommissioning will bolster multiple age classes in the short and long-term, producing larger overall adult run sizes even with the anticipated short-term effects of the dam decommissioning.

3.3 AR-1 Summary

The Klamath River dam decommissioning project is anticipated to have significant short-term effects, but long-term benefits for fall Chinook salmon, coho salmon, winter steelhead, and Pacific lamprey. The 2012 EIS/R AR-1 mitigation plan included installing a weir and trap system on the Klamath River immediately upstream from the Shasta River confluence. The trap was proposed to be operated periodically to trap and haul fish for release into under-seeded tributaries upstream and downstream from Iron Gate Dam. The ATWG highlighted several concerns associated with the 2012 AR-1 plan, including trapping feasibility, handling mortality, potential genetic and disease effects of relocated fish on wild populations, disruption of adult coho salmon migration to spawning tributaries, and uncertainty of anticipated effects of the Project on adult salmonids and Pacific lamprey. The ATWG stated that these concerns could result in the original AR-1 mitigation effort being ineffective at reducing the Project’s impacts and potentially introducing additional risks to adult anadromous salmonids and Pacific lamprey populations. Therefore, the ATWG determined that additional options in the form of an updated AR-1 are warranted.

The updated AR-1 plan, includes the development and implementation of a monitoring and adaptive management plan to offset the dam decommissioning effects on mainstem spawning. AR-1 actions include a 2-year tributary confluence monitoring effort and addressing sediment and debris obstructions that block volitional upstream passage from the Klamath River into tributaries. The second action includes a spawning habitat evaluation on the Klamath River and tributaries in the Hydroelectric Reach. If existing spawning habitat conditions do not meet target metrics, spawning gravel augmentation will be completed on both the mainstem and key tributaries in the Hydroelectric Reach.

4. AR-2 Juvenile Outmigration

The objective of AR-2 is to address dam decommissioning effects on juvenile anadromous fish in the Klamath River downstream from Iron Gate Dam. The original 2012 EIS/R AR-2 plan focused on trapping and hauling juvenile anadromous salmonids and Pacific lamprey from 13 key tributaries prior to juvenile entry into the mainstem Klamath River during dam decommissioning. Trapped fish would be hauled and released into the Klamath River downstream from the Trinity River confluence where suspended sediment concentrations will be diluted by tributary inputs to sublethal concentrations. The updated AR-2 includes three actions including: sampling and salvaging yearling coho salmon from the Klamath River from Iron Gate Dam (RM 192.9) downstream to the Trinity River confluence (RM 43.4), and relocating captured fish to constructed off-channel ponds prior to reservoir drawdown; monitoring and ensuring tributary-mainstem connectivity; and monitoring juvenile salmonids and water quality conditions at the 13 key tributaries, and salvage and relocating juvenile salmonids if water quality thresholds are exceeded. The updated AR-2 actions are the best opportunities to offset juvenile anadromous fish losses during reservoir drawdown.

4.1 Proposed Updated AR-2

Based on a review of the original AR-2 presented in Section 4.2, input from the ATWG, and recent fisheries literature, the KRRC concluded an updated AR-2 is necessary to offset the anticipated short-term effects of dam decommissioning on outmigrating juvenile fish. The updated AR-2 includes three actions targeting juvenile salmonids.

- **Action 1**: Sampling and salvage of overwintering juvenile coho salmon from the Klamath River between Iron Gate Dam (RM 192.9) and the Trinity River (RM 43.4) confluence prior to reservoir drawdown. Up to 500 juvenile coho salmon are anticipated to be caught and relocated to off-channel ponds in order to protect this small, but important life history strategy in ESA-listed coho salmon population. Relocation efforts will be conducted in late December after fall redistribution period, in consultation with ATWG.
- **Action 2**: A monitoring and adaptive management plan will be prepared with input from the ATWG to monitor tributary-mainstem connectivity. Tributary-mainstem confluences, four sites in the Hydroelectric Reach and five sites in the 8-mile reach from Iron Gate Dam (RM 192.9) to Cottonwood Creek (RM 184.9), will be evaluated for 2-years from the onset of reservoir drawdown. If present, confluence blockages will be actively removed during the 2-year evaluation period to ensure volitional passage for juvenile Chinook salmon, coho salmon, steelhead, and Pacific lamprey. Juvenile salmonids are expected to benefit from dam decommissioning by restoring access to at least 13.9 miles of key tributary rearing habitats in the Hydroelectric Reach and several recognized thermal refugia areas including Jenny and Fall creeks.
- **Action 3:** The third action of the monitoring and adaptive management plan will include monitoring juvenile salmonids and water quality conditions in 13 key tributary confluences between Iron Gate Dam (RM 192.9) and the Trinity River (RM 43.4). Tributary water temperatures and mainstem suspended sediment concentrations will be monitored beginning March 1 of the drawdown year. If water quality triggers are exceeded, juvenile salmonids will be salvaged from the tributary confluences and relocated to cool water tributaries and existing off-channel ponds.

The proposed actions are intended to reduce Project effects on juvenile salmonids and Pacific lamprey during reservoir drawdown. The following sections provide additional detail on the proposed actions.

4.1.1 Action 1: Mainstem Salvage of Overwintering Juvenile Salmonids

The following sections provide information pertaining to mainstem salvage of overwintering juvenile salmonids, particularly yearling coho salmon.

4.1.1.1 Reconnaissance

Up to 15 sites between Iron Gate Dam (RM 192.9) and the Trinity River (RM 43.4) will be sampled during November and December of 2018 to determine the presence and relative abundance of yearling coho salmon. While low numbers of yearling coho salmon (<500) are expected to be encountered, these fish would be particularly vulnerable to the effects of elevated suspended sediment concentrations from reservoir drawdown and represent a small, but important life history strategy in the ESA-listed coho salmon population (T. Soto, Karuk Tribe, personal communication, 2017). Juvenile coho salmon overwintering downstream of the Trinity River will not be targeted for sampling or salvage efforts as water quality conditions associated with the reservoir drawdown period are expected to be similar to existing conditions (USBR and CDFG 2012). Sites above the Trinity River that will be sampled include the Bulk Plant backwater and floodplain channel, Independence Creek floodplain channel, Sandy Bar Creek floodplain channel, and a number of mainstem backwater pools, confluence areas, and alcoves. Final site selection for the reconnaissance effort will be determined in consultation with ATWG.

4.1.1.2 Overwintering Juvenile Salmonids Salvage and Relocation

Following the reconnaissance effort, an overwintering yearling coho salmon relocation effort will be conducted in December prior to reservoir drawdown. Through coordination with the ATWG, salvage and relocation efforts will be done as late in the year as possible to limit any potential impact to the redistribution of fish to off-channel habitats. In addition, fish will not be captured and relocated from areas that have tributary or ground water accretions that would provide refuge from high suspended sediment loads

The number of sites will be based on the results of the 2018 reconnaissance effort although it is anticipated that up to 15 sites will be seined and trapped. A two-day effort with a 4-person crew and transport truck is anticipated at each site. The expected total catch of overwintering juvenile coho salmon in mainstem and off-channel habitats of the Klamath River is expected to be less than 500 individuals based on previous sampling efforts conducted by the Yurok Tribe and Karuk Tribe (Hillemeier et al. 2009). Seined and trapped juvenile coho salmon would be transported to six existing off-channel ponds located on Seiad Creek (RM 131.9), West Grider Creek (RM 131.8), Stanshaw Creek (RM 77.1), and Camp Creek (RM 57.4). Other native fish captured during the seining and trapping effort, such as juvenile steelhead and juvenile Chinook salmon will also be relocated to the same off-channel ponds unless the numbers of relocated fish exceeds the capacity of those habitats, in which case, salmonids other than coho salmon will be placed into tributary streams adjacent to the salvage locations. Capacity of existing habitat area will be evaluated prior to relocation efforts. Fish relocated to off-channel ponds will be allowed to volitionally move between ponds and tributary streams.

4.1.2 Action 2: Tributary-Mainstem Connectivity Monitoring

The following sections provide information on the monitoring and adaptive management plan pertaining to tributary-mainstem connectivity.

4.1.2.1 Tributary-Mainstem Connectivity Monitoring

To ensure that rearing habitat is accessible following reservoir drawdown, fish passage monitoring and adaptive actions will occur at the confluence areas of key Klamath River tributaries and side channels upstream and downstream of Iron Gate Dam. Tributary confluences in the Hydroelectric Reach may be affected by sediment deposits and debris obstructions as the reservoir are drawdown. Tributary deltas may create fish passage barriers that would limit upstream migration of anadromous salmonids and Pacific lamprey.

Based on hydraulic and sediment transport modeling completed by USBR (Section 9.2.1.4; 2011), sediment deposition during reservoir drawdown is predicted from Bogus Creek (RM 192.4) downstream to Cottonwood Creek (RM 184.9). From Bogus Creek (RM 192.4) downstream to Willow Creek (RM 187.8), approximately 1.5 feet of sediment deposition is anticipated. From Willow Creek downstream to Cottonwood Creek, deposition of less than 1 foot is expected. Areas downstream of Cottonwood Creek are expected to have only minor deposition with deposits less than 0.25 feet (USBR 2011). No additional deposition is predicted in the Bogus Creek to Cottonwood Creek reach following dam decommissioning.

Species that would be potentially affected by obstructed tributary connections include outmigrating Chinook salmon, coho salmon, steelhead and Pacific lamprey during and following reservoir drawdown. Further, depending on erosion rates of reservoir sediments, tributary confluences in the reservoir areas may not meet fish passage conditions following drawdown.

Tributary confluences to be monitored in the 2-year period following dam decommissioning include Bogus Creek (RM 192.4), Dry Creek (RM 190.9), Little Bogus Creek (RM 189.8), Willow Creek (RM 187.8), and Cottonwood Creek (184.9). Tributaries in the Bogus Creek to Cottonwood Creek reach were selected as they are recognized as influential tributaries (e.g., historical fisheries importance or important freshwater sources) in the mid-Klamath River (Soto et al. 2008). Hydroelectric Reach tributaries to be monitored include Spencer Creek (RM 230.5), Shovel Creek (RM 209.0), Fall Creek (RM 198.9), and Jenny Creek (RM 196.8). These tributaries were selected based on having historical or potential habitat for adult salmonids (Huntington 2006).

4.1.2.2 Tributary Connectivity Maintenance

Unnatural tributary obstructions that limit volitional fish passage will be remedied through appropriate manual or mechanical means. Example removal methods may include removing sediment using hand tools or hydraulic equipment. Removed material will be placed in the mainstem Klamath River downstream of the tributary confluence or on the adjacent floodplain. The Project restoration plan allows for incorporation of engineered roughness elements at tributary connection points, as appropriate.

4.1.3 Action 3: Rescue and Relocation of Juvenile Salmonids and Pacific Lamprey from Tributary Confluence Areas

The following sections provide information on the monitoring and adaptive management plan pertaining to salvage and relocation of juvenile salmonids from tributary confluence areas.

4.1.3.1 Tributary and Mainstem Water Monitoring and Juvenile Fish Salvage

A monitoring and adaptive management plan will include monitoring juvenile salmonids and water quality conditions in 13 key tributary confluences between Iron Gate Dam (RM 192.9) and the Trinity River confluence (RM 43.4). Tributaries to be monitored include Bogus Creek (RM 192.4), Dry Creek (RM 190.9), Cottonwood Creek (RM 184.9), Shasta River (RM 179.3), Humbug Creek (RM 173.9), Beaver Creek (RM 163.3), Horse Creek (RM 149.5), Scott River (RM 145.1), Tom Martin Creek (RM 144.6), O'Neil Creek (RM 139.1), Walker Creek (RM 135.2), Grider Creek (RM 132.1), and Seiad Creek (RM 131.9).

Water temperatures in tributary streams will be monitored beginning March 1 of the drawdown year. If water temperatures reach 17°C (7-day average of the daily maximum values), the ATWG will convene to to discuss and agree upon appropriate measures to minimize impacts to juvenile salmonids. If the ATWG determines a juvenile salvage effort is necessary, the salvage effort would include capturing fish from confluence areas, loading them to aerated transport trucks, and relocating them to cool water tributaries including, but not limited to the Seiad Creek complex (RM 131.9). The following considerations should be discussed with the ATWG prior to the final decision on salvage:

- Fish that are using confluence areas may be exhibiting behavioral responses to avoid high suspended sediments, and may not require salvage
- Stress and mortality associated with moving fish
- Effects moving fish can have upon straying of adults
- Unknown capacity of areas where fish are being moved

The Seiad Creek complex includes constructed off-channel ponds and connected cool water tributary channels. The complex provides juvenile salmonids with a variety of habitats that they can choose to use. If the number of salvaged fish exceeds the capacity of the Seiad Creek complex, juvenile salmonids may also be relocated to Beaver Creek (RM 163.3), Cade Creek (RM 110.9), Elk Creek (RM 107.2), Tom Martin Creek (RM 144.6), and Sandy Bar Creek (RM 77.8) as well as constructed off-channel ponds located on West Grider Creek (RM 131.8), Camp Creek (RM 57.4), and Stanshaw Creek (RM 77.1). A multi-day salvage effort will be conducted at the confluence of the Shasta and Scott rivers and single day salvage efforts will be conducted at other tributary confluence areas by a 4-person crew and 2 transport trucks. Multiple days may be necessary at the Shasta and Scott River confluences based on juvenile salmonid abundance in the two tributaries. The final salvage plan details will be determined through close coordination with the ATWG.

4.2 Summary of the 2012 EIS/R AR-2, Dam Removal Benefits and Effects, and Recent Fisheries Literature

The following sections review the components of the 2012 EIS/R AR-2 measure, anticipated dam removal effects and benefits on AR-2 species, and recent fisheries literature relative to juvenile salmonid outmigration. This information is presented in support of the updated AR-2 measure.

4.2.1 AR-2 Affected Species

Species identified in AR-2 include:

- Coho salmon (*Oncorhynchus kisutch*) – Southern Oregon/Northern California Coastal (SONCC) evolutionary significant unit (ESU): Federally Threatened; California Threatened; Tribal Trust Species
- Chinook salmon (*O. tshawytscha*) – Upper Klamath-Trinity Rivers ESU - Fall Run: California Species of Special Concern; Tribal Trust Species
- Chinook salmon (*O. tshawytscha*) – Upper Klamath-Trinity Rivers ESU – Spring Run: California Species of Special Concern; Tribal Trust Species
- Steelhead (*O. mykiss*) – Klamath Mountains Province distinct population segment (DPS) – Summer Run: California Species of Special Concern; Tribal Trust Species
- Steelhead (*O. mykiss*) – Klamath Mountains Province DPS – Winter Run: Tribal Trust Species
- Pacific lamprey (*Entosphenus tridentatus)*: California Species of Special Concern; Tribal Trust Species

4.2.2 Anticipated Dam Decommissioning Effects on AR-2 Species

Short-term effects of dam removal are expected to result in mostly sublethal, and in some cases lethal, impacts to a portion of the juvenile Chinook salmon, coho salmon, steelhead, and Pacific lamprey that are outmigrating from tributary streams to the Klamath River during late winter and early spring of the drawdown year. Deleterious short-term effects are expected to be caused by high suspended sediment concentrations and low dissolved oxygen levels in the Klamath River from Iron Gate Dam (RM 192.9) downstream to Orleans (RM 59.0). Under the worst-case scenario, lost juvenile production in the Upper Klamath River, Middle Klamath River, Shasta River, and Scott River, includes the loss of up to: 669 fall Chinook salmon smolts, 6,536 coho smolts, 11,207 age-1 steelhead, 9,412 age-2 steelhead (USBR and CDFG 2012). Table 3-1 includes the likely and worst-case effects to anadromous outmigrating juveniles downstream from Iron Gate Dam.

Table 4-1 2012 EIS/R anticipated effects summary for outmigrating juvenile salmonids and Pacific lamprey ammocoetes

Species	Life Stage	Likely Effects	Worst Effects
Coho Salmon	Outmigrating Smolts	Loss of 2,668 (3%)	Loss of 6,536 (8%)
Chinook Salmon - Fall	Type III Smolts	Loss of 0-189 (<0.02%)	Loss of 0-669 (<0.07%)

Steelhead	Age-1+ Rearing1	Loss of up to 8,200 (14%)	Loss of up to 11,207 (19%)
	Age-2+ Rearing	Loss of up to 6,893 (13%)	Loss of up to 9,412 (18%)
Pacific Lamprey	Ammocoetes	High mortality (52%)2	High mortality (71%)2

Source: USBR and CDFG 2012

[1] Under existing conditions there is 20 percent mortality predicted for Age-1+ rearing.

[2]The 2012 EIS/R predicted Pacific lamprey mortality based on mortality models developed for suspended sediment impacts to salmonids. Model output did not include the number of predicted Pacific lamprey mortalities.

The following sections include descriptions of species-specific effects adapted from the 2012 EIS/R (USBR and CDFG 2012; Vol. I, pp. 3.3-129 to 3.3-168).

4.2.2.1 Coho Salmon

The wide distribution and use of tributaries by both juvenile and adult coho salmon will likely protect the population from the worst effects of the dam decommissioning. However, direct mortality is anticipated for redds and smolts from the upper Klamath River, mid-Klamath River, Shasta River, and Scott River population units. No mortality is anticipated for the Salmon River, Trinity River, and Lower Klamath River populations under the most likely or worst-case scenarios. Based on substantial reduction in the abundance of a year class in the short-term, the effect of the dam decommissioning was found to be significant for the coho salmon from the Upper Klamath River, Mid-Klamath River, Shasta River, and Scott River population units.

Age-1 juveniles that have either successfully over-summered or moved from tributaries into the mainstem in fall could be exposed to much higher suspended sediment concentrations in the mainstem during the winter of facility removal than under existing conditions, and may suffer mortality rates of up to 52 percent under a worst-case scenario (USBR and CDFG 2012). However, many juveniles in the mainstem Klamath River appear to migrate to the lower river to rear and may avoid adverse conditions in the mainstem by using tributary or off-channel habitats during winter, thus reducing their exposure and potential mortality (Hillemeier et al. 2009; Soto et al. 2009), consistent with the observation that juvenile salmonids avoid turbid conditions (Sigler et al. 1984; Servizi and Martens 1992). This strategy may be even more pronounced under elevated suspended sediment concentrations expected as a result of the dam decommissioning project. Overall, it is not known how many juveniles rear in the mainstem during winter, but it is assumed to be a small (<1 percent) proportion of any of the coho salmon populations (USBR and CDFG 2012).

Coho salmon smolts from the cohort prior to reservoir drawdown are expected to outmigrate to the ocean beginning in late February, although the majority of coho smolts typically outmigrate to the mainstem Klamath during April and May (Wallace 2004). During migrant trapping studies from 1997 to 2006 in tributaries upstream of and including Seiad Creek (Horse Creek, Seiad Creek, Shasta River, and Scott River), 44 percent of coho smolts were captured from February 15 to March 31, and 56 percent from April 1 through the end of June (Courter et al. 2008).

Smolts outmigrating in early spring (prior to April 1), are likely to suffer up to 60 percent mortality under the 2012 EIS/R worst-case scenario (USBR and CDFG 2012). Based on modeled population estimates presented in Courter et al. (2008), the anticipated 60 percent mortality would represent a loss of up to 6,536 smolts from the Upper Klamath River, Shasta River, Scott River, and Middle-Klamath River coho populations.

Smolts outmigrating in late spring (after April 1) would be exposed to lower suspended sediment concentrations, and may experience only slightly worse physiological stress and reduced growth rates compared with existing conditions, even under the worst-case scenario (USBR and CDFG 2012).

4.2.2.2 Chinook Salmon – Fall Run

Fall Chinook salmon use the mainstem Klamath River for spawning, rearing, and as a migratory corridor. Effects of suspended sediment concentrations on juvenile fall Chinook salmon from dam decommissioning are expected to be relatively minor because of varied life histories. During juvenile salmonid outmigration trapping conducted at Big Bar on the Klamath River between 1997-2000, very few Chinook were captured before the beginning of June (USFWS 2001). The large majority of age-0 juveniles (Type I outmigrants) remain in tributaries until later in the spring and summer when water quality conditions are expected to be improved relative to late winter and early spring. Type II outmigrants typically rear in tributaries before outmigrating to the mainstem Klamath River and estuary in fall (Sullivan 1989). Additionally, many of the fry that outmigrate to the Klamath River originate in tributaries in the mid or lower Klamath River, where suspended sediment concentrations resulting from the dam decommissioning are expected to be lower due to dilution from tributaries (USBR and CDFG 2012). Based on trapping data from Big Bar, approximately 63 percent of Chinook smolts are Type I outmigrants and 37 percent are Type II outmigrants (USFWS 2001).

A small proportion of juvenile Chinook salmon typically remain to rear in the spawning tributaries until outmigrating in late winter and early spring as yearlings (Type III outmigrants). Although fish exhibiting this life history trait would be most susceptible to the effects of suspended sediment concentrations, these fish represent a very small proportion (<1 percent of all production) of the Klamath River fall Chinook salmon population (USFWS 2001). Based on outmigrant trapping in the mainstem Klamath River at Big Bar, around 942,829 Chinook salmon smolts outmigrate each spring, including both hatchery and naturally produced fish (USFWS 2001). Only 31 Type III outmigrating smolts were captured over 4 years, representing approximately 0.1 percent of the total catch. Based on yearly abundance estimates, this equates to approximately 943 total Type III smolts per year (USFWS 2001). Under the 2012 EIS/R worst-case scenario, mortality rates of up 71 percent are predicted during the dam decommissioning, equating to 669 smolts, or approximately 0.07 percent of the total fall Chinook salmon smolt production. Type I and Type II juvenile outmigrants are expected to experience only sublethal effects (USBR and CDFG 2012).

4.2.2.3 Steelhead – Summer and Winter

Juvenile steelhead rear in the mainstem Klamath River, Klamath River tributaries, and the estuary. Since most (>90 percent) juvenile steelhead smolt at age-2, those juveniles leaving tributaries to rear in the mainstem will be exposed to elevated suspended sediment concentrations resulting from the dam decommissioning through both winter and spring (USBR and CDFG 2012). Based on captures in tributaries and the mainstem, approximately 40 percent of the population rears in tributaries until age-2 (USFWS 2001), and will only be susceptible to mainstem water quality conditions during outmigration. The approximately 60 percent of the rearing population that outmigrates from tributaries as age-0 or age-1 fish, and rears for extended periods in the mainstem upstream of Trinity River, would likely be exposed to much higher suspended sediment concentrations than under existing conditions, with mortality rates up to 100 percent under the worst-case scenario (USBR and CDFG 2012).

Despite these anticipated mortality rates, the broad spatial distribution of steelhead in the Klamath Basin and their flexible life histories suggest that some steelhead will avoid the most serious effects of dam decommissioning by remaining in tributaries for extended rearing, rearing farther downstream where suspended sediment concentrations is expected to be lower due to tributary dilution, and/or moving out of the mainstem into tributaries and off-channel habitats to avoid periods of high suspended sediment concentrations. From past studies, many of these juveniles avoid conditions in the mainstem by using tributary and off-channel habitats during winter, which would reduce their exposure to poor water quality during dam decommissioning (Hillemeier et al. 2009; Soto et al. 2009), consistent with the observation that juvenile salmonids avoid turbid conditions (Sigler et al. 1984; Servizi and Martens 1992). Most smolts migrate prior to the fall, so many juveniles should already be in the estuary or ocean when initial pulses in sediment occur after December 31 prior to reservoir drawdown, or they may migrate out of the mainstem later in the winter after suspended sediment concentrations decrease.

Life history variability observed in steelhead means that, although numerous year classes will be affected, not all individuals in any given year class will be exposed to project effects. Some portion of the progeny of those adults that spawn successfully in winter and spring of the reservoir drawdown year would also rear in tributaries long enough to not only avoid the highest suspended sediment concentrations, but may also not return to spawn for up to 2 years, when suspended sediment resulting from the dam decommissioning should be greatly reduced. The high incidence of repeat spawning among summer steelhead, ranging from 40 to 64 percent (Hopelain 1998), should also increase that population's resilience to dam decommissioning effects.

4.2.2.4 Pacific Lamprey

Dam decommissioning would have short-term effects on Pacific lamprey related to suspended sediment concentrations, bedload sediment transport and deposition, and impaired water quality (particularly dissolved oxygen). Overall, because multiple year classes of Pacific lamprey rear in the mainstem Klamath River at any given time, and since adults will migrate upstream over the entire year, including January of the reservoir drawdown year when effects from the dam decommissioning will be most pronounced, effects on Pacific lamprey adults and ammocoetes are anticipated to be substantial. However, because of their wide spatial distribution and varied life history, most of the population, (which is distributed from at least California along the Pacific Rim to Japan [Goodman and Reid 2012]), would not be affected by the dam decommissioning. Effects of suspended sediment on lamprey ammocoetes are not well understood and for the 2012 EIS/R analysis were based on using the same anticipated effects for juvenile salmonids. This likely overestimates any effects to lamprey ammocoetes since their preferred rearing strategy is to burrow in fine sediments mixed with organic matter. While some of the actions listed in the proposed updated AR-2 below have the potential to benefit Pacific lamprey ammocoetes, (i.e., tributary connectivity and habitat restoration) no specific actions have been developed to specifically target Pacific lamprey for relocation from the areas affected by bedload or high suspended sediment concentrations. Additional discussion of Pacific lamprey ammocoetes effects is provided in AR-5.

4.2.3 2012 EIS/R AR-2 Actions

The 2012 EIS/R AR-2 plan (2012 EIS/R, Vol. I, pp 3.3-243 to 3.3-245) included water quality monitoring to evaluate Klamath River suspended sediment concentrations. If pre-determined water quality thresholds were triggered, a network of 17 screw traps located on 13 key tributaries would be operated to capture downstream migrants prior to their entry into the mainstem Klamath River. Captured juveniles would be transported and released at sites downstream of the Trinity River or other locations with suitable water quality.

4.2.4 KRRC Review of AR-2 for Feasibility and Appropriateness

The KRRC assessed the feasibility and appropriateness of AR-2 through multiple planning meetings held with the ATWG between May and August 2017. During these meetings, new information on Klamath River fisheries was presented and information on other dam removal projects conducted in the western United States was reviewed to understand how the aquatic ecosystem might respond as discuss above. Major concerns discussed by KRRC and ATWG regarding the 2012 AR-2 included:

- Trapping feasibility and efficiency.
- Potential mortality associated with trapping, handling, hauling, and releasing juvenile salmonids.
- Potential imprinting and straying issues.
- 2012 EIS/R baseline population estimates and effects uncertainty.

The following sections provide additional information regarding AR-2 feasibility and appropriateness based on fisheries literature and ATWG input.

4.2.4.1 Trapping Feasibility and Efficiency

A wet winter season, such as experienced between January and May 2017, could prevent the installation and operation of rotary screw traps in any of the prospective tributaries due to persistent high flows. Additionally, capture efficiencies for juvenile salmonids in rotary screw traps is highly variable and depends on many factors such as stream width, depth, flow conditions, and time of day of operation. Capture efficiencies of juvenile salmonids using rotary screw traps are typically very low, and would result in a small proportion of the downstream migrants being captured for relocation and release. For example, trapping efficiencies on various salmonids calculated by the USGS during monitoring efforts for the recent Condit Dam removal on the White Salmon River in Washington State ranged from 0 - 10.6 percent (Allen and Connolly 2011). Trapping efforts for juvenile Chinook salmon on Blue Creek in the Klamath Basin by the Yurok Tribe resulted in trapping efficiencies ranging from 0.5 - 51.3 percent, but trapping efficiencies of greater than 10 percent were not achieved until stream flows dropped in mid-June (Antonetti and Partee 2013). By mid-June, water quality conditions in the Klamath River following dam removal are expected to have returned to background condition and further remediation actions are not expected to be necessary (USBR and CDFG 2012).

The ATWG concluded the level of effort, cost, and likely low capture efficiencies do not support the installation of screw traps for capturing outmigrating juvenile fish during dam decommissioning. The ATWG also concluded the concurrent operation of 17 screw traps during spring high flows is not feasible or safe given potential flow conditions and the remoteness of some tributaries.

4.2.4.2 Potential Mortality Associated with Trapping, Handling, Hauling, and Releasing Juvenile Salmonids

The KRRC and ATWG concluded that although mortality on juvenile salmonids associated with trap and haul operations are typically low, these numbers are based on a variety of environmental factors and logistical considerations and can be highly variable (Serl and Morrill 2010). Transporting juvenile salmonids causes stress in smolts (Barton et al. 1980; Specker and Schreck 1980; Matthews et al. 1986), which may reduce survival if fish are directly released into natural environments (Kenaston et al 2001). In some cases, the mortality associated with screw trapping, handling, trucking, and releasing may exceed the expected mortality associated with dam decommissioning. For instance, under the worst-case scenario, high suspended sediment concentrations and low total DO could result in the direct mortality of up to 669 fall Chinook salmon smolts, less than 1 percent of production (USBR and CDFG 2012). Mortality associated with trapping, handling, transport, and release efforts could potentially result in a similar or greater loss of fall Chinook salmon smolts. The ATWG suggested that outmigrating juvenile fish are well-adapted to avoid lethal sediment concentrations and will likely employ avoidance behaviors to minimize exposure to lethal suspended sediment concentrations and DO levels. The ATWG concluded that large scale efforts aimed at trapping, handling, and releasing juvenile salmonids were likely to cause unnecessary harm to juvenile salmonids.

4.2.4.3 Potential Imprinting and Straying Issues

The KRRC and ATWG expressed concerns regarding how handling and transport of juvenile salmonids may affect imprinting processes resulting in future straying of returning adults. Juvenile imprinting is influenced by natal stream water chemistry and the juvenile fish's physiological state during rearing and outmigration (Keefer and Caudill 2014). Juvenile fish with extended freshwater residency times, or long-distance migrations, almost certainly experience multiple imprinting events that contribute to homing success of adult spawners. Transporting juvenile fish has been shown to disrupt this 'sequential imprinting' process, and several studies on coho salmon (Solazzi et al. 1991) and Atlantic salmon (Gunnerød et al. 1988; Heggberget et al. 1991) have shown that adult homing success is inversely related to transport distance from rearing sites (Keefer and Caudill 2014).

Therefore, the capture, transport, and release of juvenile fish downstream of the Trinity River could compromise the imprinting process for relocated juvenile fish. Insufficient imprinting to natal streams or the loss of spatially distinct imprinting events during outmigration could potentially increase adult straying rates during future returns and result in the loss of genetic integrity in distinct populations. Future, elevated stray rates could result in a more homogenous distribution of fish returning to the lower Klamath River and also hinder the natural recolonization of areas upstream of Iron Gate Dam.

Overall, the ATWG concluded a screw trap-based trapping program as prescribed in the 2012 EIS/R would be a costly, potentially dangerous effort with uncertain benefits. Tributary trapping could also negatively affect juvenile salmonids by disrupting imprinting processes, causing higher mortality than allowing fish to volitionally leave tributaries, and potentially increasing future returning adult stray rates.

4.2.4.4 2012 EIS/R Baseline Population Estimates and Project Effects Uncertainty

Effects to juvenile fish outlined in the 2012 EIS/R included approximations and assumptions that were based on limited data on Klamath River anadromous salmonids and Pacific lamprey populations; incorporated a conservative analysis of fish avoidance behavior to the anticipated water quality conditions; and in part included a worst-case scenario analysis of dam removal effects on adult salmonids and Pacific lamprey. The following sections provide updated population information for coho salmon and Pacific lamprey, and project effects uncertainty that should be considered in updating the effects determinations.

Coho Salmon Smolt Population Estimates and Outmigration Timing

KRRC reviewed updated smolt trapping data collected by USFWS and CDFG between 2010 and 2015 on the upper mainstem Klamath River and 2010-2016 on the Scott and Shasta Rivers to determine the typical outmigration timing for age-1+ coho salmon smolts. KRRC also reviewed travel time data to see how quickly juvenile fish typically outmigrate in the spring to avoid long exposure to background suspended sediment concentrations effects.

For rotary screw traps and frame nets operated at the Bogus, I-5, and Kinsman sites on the mainstem Klamath River between 2010 and 2015, 63 percent of age-1+ coho migrated after Julian week 13 (last week in March) (Gough et al. 2015; David et al. 2016; and David et al. 2017). Between 2010 and 2016, 93 percent of age-1+ coho salmon captured by rotary screw trap on the Shasta River outmigrated after the end of March, and on the Scott River, 70 percent of age-1+ coho salmon smolts outmigrated after the end of March during the same time period (Jetter and Chesney 2016). Peak outmigration timing beginning in early April on the Shasta River, typically coincides with decreased flows marked by the start of the irrigation season and is consistent with findings from previous studies (Chesney et al. 2009; Adams 2013; Adams and Bean 2016) from CDFW 2016.

Once in the Klamath River, coho salmon smolts appear to move downstream rather quickly. For example, Wallace (2004) reported that numbers of coho salmon smolts in the Klamath River estuary peaked in May, the same month as peak outmigration from the tributaries (Stillwater Sciences 2010). Radio telemetry studies conducted on wild and hatchery coho salmon smolts in the Klamath River between 2006 and 2009 found a wide variety of travel times for coho salmon smolt outmigrating from Iron Gate Dam to the gaging station near the Klamath River estuary (Beeman et al. 2012). The minimum travel time was 3.77 days and the maximum travel time to reach the estuary was 54.44 days with median values over the 4-year study ranging between 15.11 and 25.93 days. However, the longest residence time for any single reach was from the Iron Gate Dam release site to the Shasta River as tagged fish remained near the release site until they were ready to begin the downstream migration to the Pacific Ocean. Once fish passed the Shasta River, travel times in any individual reach were less than 2 days and coho salmon smolts usually took less than 1 week to fully migrate to the gaging station near the Klamath River estuary (Beeman et al. 2012). Courter (2008) assumed that all fish from a given cohort would migrate to the estuary in 2 weeks, and this assumption is also consistent with travel rates documented by Stutzer et al. (2006). Assuming that juvenile fish outmigrating from tributary streams will either outmigrate rapidly to the Klamath River estuary or will move between clean water tributary areas, it is anticipated that no outmigrating smolts will be exposed to suspended sediment for greater than seven contiguous days.

Minimum travel times presented in Beeman et al. (2012) indicate that juvenile coho salmon could migrate downstream of the highest suspended sediment concentrations effects zone fairly quickly. The 2012 EIS/R analysis assumed coho salmon smolts would be exposed to high suspended sediment concentrations for 20 days during the highest suspended sediment concentrations period (prior to April 1). This assumption resulted in a very high mortality estimate for coho salmon smolts (USBR and CDFG 2012).

Further, because smolt abundance data from all tributaries within the Upper Klamath, Middle-Klamath, Salmon River, and Lower Klamath River populations were not available for the 2012 EIS/R analysis, smolt production estimates modeled by Courter et al. (2008) were used to predict the number of smolts emigrating to the Klamath River from each population. Modeled smolt production estimates were based on tributary habitat conditions and smolt production data for other populations. Recent trends in adult returns to tributaries, the Klamath River, and Iron Gate Hatchery indicate that coho salmon populations continue to decline, and that these modeled estimates are likely higher than current actual population sizes.

In a study of juvenile coho salmon use of thermal refugia along the Klamath River, juvenile coho began to enter thermal refugia as water temperature reached 19°C, numbers of coho salmon present increased up to about 22°C to 23°C, and then declined dramatically as temperatures exceeded 23°C (Sutton and Soto 2012). These results suggest that 23°C is the upper thermal tolerance limit, with either lethal effects to juvenile coho salmon or temperature- related stress that causes the fish to move to different habitats.

By updating the current understanding of coho salmon population estimates and typical juvenile coho salmon outmigration timing from Klamath River, Shasta River, and Scott River coho salmon populations, and by adjusting the potential duration of exposure to reflect typical downstream migration rates, anticipated effects to age-1+ coho salmon smolts may result in substantially lower coho salmon smolt mortality estimates, and in most cases, only result in sub-lethal effects.

Pacific Lamprey Population Update

Recent genetic analysis of Pacific lamprey suggests no significant population structure exists across populations or regions, indicating a high degree of historical gene flow even across expansive distances of the northern Pacific Rim (Goodman and Reid 2012). Weak population structure and low site fidelity may reduce the short-term effects to Pacific lamprey identified in the 2012 EIS/R. Because the metapopulation is now believed to be relatively undifferentiated across the species' range, the percentage of adult and larval Pacific lamprey that will be affected by the dam decommissioning relative to the population as a whole will be insignificant.

Project Effects Uncertainty

Studies suggest that high suspended sediment concentrations (Newcombe and Jensen 1996; Chapman et al. 2014; Kjelland et al. 2015) and low dissolved oxygen concentrations (Bjorn and Reiser 1991; Washington Department of Ecology 2002; Carter 2005) affect salmonid behavior. Juvenile salmonid response to high suspended sediment concentrations includes behavioral changes such as avoidance of turbid waters, and physiological responses such as stress and respiratory impairment, damage to gills, reduced tolerance to disease and toxicants, reduced survival, and direct mortality (Newcombe and Jensen 1996). Concentration and duration of elevated suspended sediment, as well as other factors including water temperature, disease, and river flow, influence the effect of sediment on salmonids.

The effects of low dissolved oxygen levels, eutrophication, or turbidity on natural populations of Pacific lamprey ammocoetes are unknown. Juvenile salmonids and juvenile Pacific lamprey emigrating from tributaries to the Klamath River that encounter poor water conditions are expected to avoid poor water quality by either remaining in tributary streams or using habitats less affected by high suspended sediment concentrations (e.g., tributary confluences and off-channel areas). Many juveniles in the mainstem Klamath River appear to migrate to the lower river to rear and may avoid adverse conditions in the mainstem by using tributary or off-channel habitats during winter, thus reducing their exposure and potential mortality (Hillemeier et al. 2009; Soto et al. 2009), consistent with the observation that juvenile salmonids avoid turbid conditions (Sigler et al. 1984; Servizi and Martens 1992).

The approach presented in the 2012 EIS/R to determine the anticipated effects to outmigrating juveniles assumed that fish would not exhibit any of these behavioral responses and instead suffer mortality by voluntarily remaining in areas that had lethal suspended sediment concentrations for extended periods of time.

4.3 Suspended Sediment Concentration Effects on Outmigrating Juvenile Salmonids

4.3.1 Introduction

This section includes a additional information related to the effects of suspended sediment concentrations on outmigrating juvenile salmonids. Development of this section involved a review of recent juvenile salmonid outmigration data for the Klamath River and select tributaries, comparison of outmigration periods to anticipated suspended sediment concentrations from U.S. Bureau of Reclamation (USBR) sediment modeling, and assessment of potential juvenile salmonid avoidance behaviors related to high suspended sediment concentrations.

Results of our additional analysis suggest juvenile Chinook salmon, coho salmon, and steelhead generally outmigrate from tributaries to the Klamath River after peak suspended sediment concentrations are anticipated to occur. However, early outmigrating juvenile Chinook salmon and coho salmon from the Shasta River and Scott River are most susceptible to anticipated suspended sediment concentrations associated with reservoir drawdown. Fish may reduce their exposure to high suspended sediment levels by seeking clear water tributary confluences, entering clear water tributaries and off-channel ponds, and expediting their downstream migration. Measures to further reduce suspended sediment impacts to early outmigrating salmonids include implementing an adaptive monitoring and salvage plan. The KRRC may also consider initiating reservoir drawdown 2-4 weeks earlier than the current proposed schedule to further minimize effects to early outmigrating Chinook salmon and coho salmon. However, initiating an earlier drawdown would also potentially affect the later portion of the adult coho spawning migration. Additional discussion with the fisheries agencies is warranted if an earlier drawdown is possible.

4.3.2 Klamath River and Tributaries Updated Screw Trap Data and Suspended Sediment Effects

The following section provides an overview of the screw trap and suspended sediment concentration analysis KRRC completed to assess potential reservoir drawdown effects to outmigrating juvenile salmonids.

4.3.2.1 Screw Trap Data

Screw trap data provided by U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife (CDFW), Yurok Tribe, and Karuk Tribe (referenced as “acquiring entity”) were reviewed and summarized. The screw trap data analysis focused on 2008 to 2015, and provides an updated data set extending the period of record for screw traps data reviewed in preparation of the 2012 EIS/R (USBR and CDFG 2012). Screw trap data from the Klamath River and tributaries to the Klamath River (Table 4-2) were reviewed to assess juvenile salmonid outmigration timing and relative abundance. Reported data include both juvenile outmigration population estimates and trap catch numbers. Outmigration estimates were generally provided by the acquiring entities for juvenile fall Chinook salmon due to the sufficient abundance of individuals in the mainstem and tributaries. Outmigration estimates are computed by multiplying the number of caught fish by a correction factor that approximates trap efficiency. Compared to trap catch numbers, outmigration estimates are a better representation of the potential number of outmigrating juvenile salmonids from the watershed upstream from the trap location.

Trap catch represents the actual number of fish captured during trap operation. Trap catch numbers do not include a correction for stream flow or trap efficiency so trap catch numbers are a less reliable predictor of outmigration timing and population size. Trap catch is reported for Chinook salmon, coho salmon, and steelhead. Coho salmon and steelhead catches were generally insufficient for calculating outmigration population estimates. Trap catch data are reviewed to provide a relative indication of juvenile salmonid outmigration timing and magnitude, but data are less reliable for predicting juvenile abundance compared to population estimates. Population estimates and trap catch data are reported by Julian Week to improve data comparability over time and to also compare trap data with suspended sediment concentrations. Figure 4-1 includes a map with highlighted trap and water and suspended sediment modeling stations.

Table 4-2 Juvenile outmigration trap information and reporting data for Klamath River and tributary traps.

Reach	Trap Location	Trap Type	Acquiring Entity	Reporting Data
Upper Klamath River	Mainstem downstream from Bogus Creek[1] (RM 191.2)	Net frame	USFWS	Chinook (age-0) estimates Coho (age-0 and age-1+) catch Steelhead (age-0 and age-1+) catch
	Shasta River[2] (Confluence at RM 179.3)	RST*	CDFW	Chinook (age-0) estimates Coho (age-0 and age-1+) estimates Steelhead (age-0 and age-1+) estimates
	Mainstem at Kinsman Creek (RM 147.6) [1]	RST	USFWS	Chinook (age-0) estimates Coho (age-0 and age-1+) catch Steelhead (age-0 and age-1+) catch
	Scott River[2] (Confluence at RM 145.1)	RST	CDFW	Chinook (age-0) estimates Coho (age-0 and age-1+) estimates Steelhead (age-0 and age-1+) estimates
Middle Klamath River	Salmon River[3] (Confluence at RM 66.4)	RST	Karuk Tribe	Chinook (age-0+) catch Coho (age-0+) catch Steelhead (age-0+) catch
	Trinity River[4] (Confluence at RM 43.4)	RST	USFWS	Chinook (age-0+) catch Coho (age-0+) catch Steelhead (age-0+) catch
Lower Klamath River	Blue Creek[5] (Confluence at RM 16.0)	RST	Yurok Tribe	Chinook (age-0) estimates Coho (age-0 and age-1+) catch Steelhead (age-0 and age-1+) catch

*Rotary screw trap
[1]Gough et al. 2015; [2]Jetter et al. 2016; [3]Karuk Tribe, unpublished data, 2017; [4]Harris et al. 2016; [5]Yurok Tribe, unpublished data, 2017

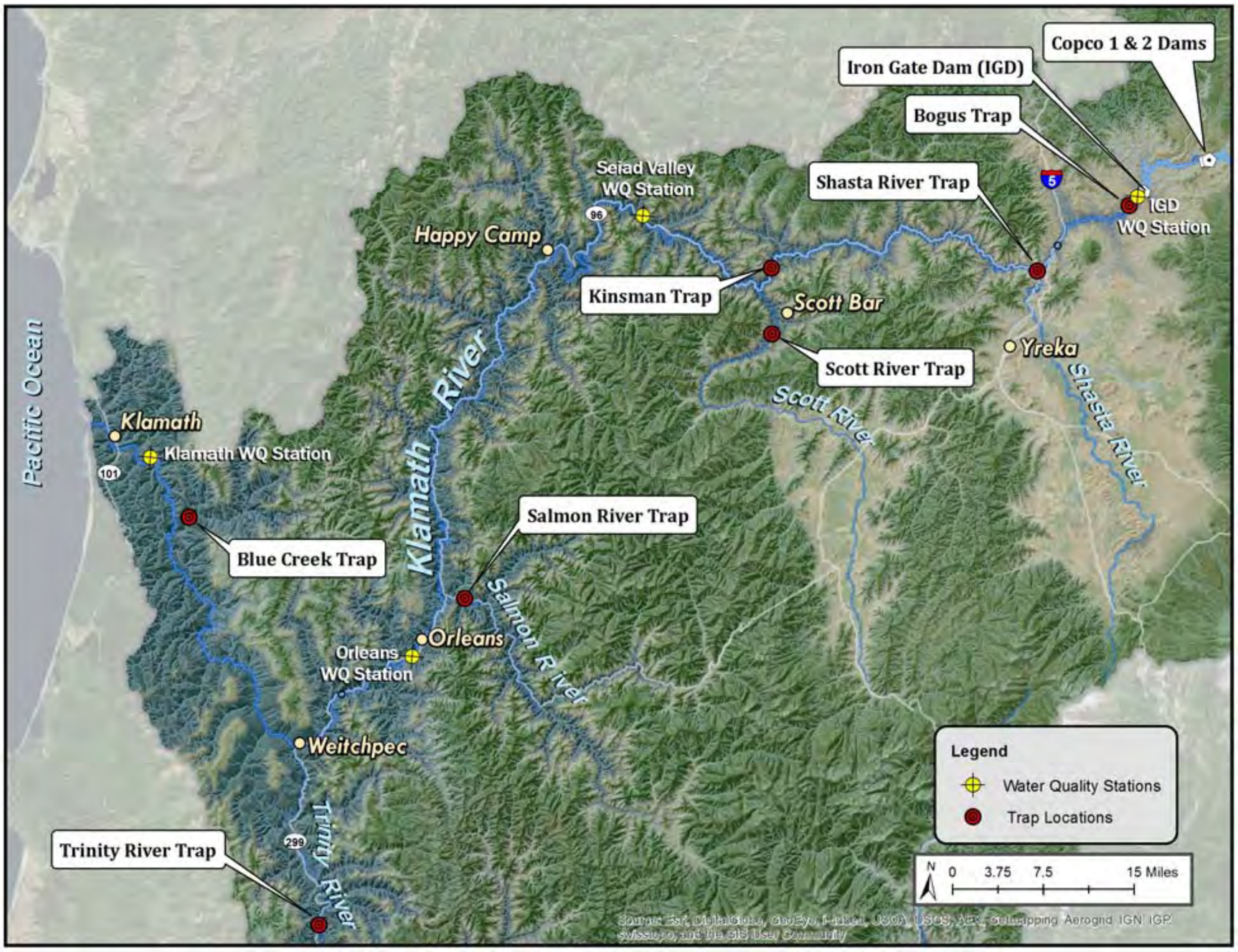


Figure 4-1 Screw trap and suspended sediment modeling stations on the Klamath River.

4.3.3 Suspended Sediment Concentration Analysis

USBR provided KRRC with the suspended sediment modeling output summarized in USBR's (2011) hydrology, hydraulics, and sediment report. KRRC replicated Reclamation's summary suspended sediment concentration graphs associated with sediment modeling for representative dry (2001), median (1976), and wet (1984) years at the four reporting stations: Iron Gate Dam, Seiad Valley, Orleans, and Klamath (see Figure 4-1 and Figure 4-2). Reservoir drawdowns are planned to begin January 1 of the dam removal year. Suspended sediment concentrations rise to an early to mid-February peak and then decline through the fall. Concentrations are generally highest for dry year scenario with other scenarios having lower relative suspended sediment concentration values (Table 4-3). Suspended sediment concentrations generally decrease in a downstream direction as inflows from clear water tributaries dilute suspended sediment concentrations in the Klamath River.

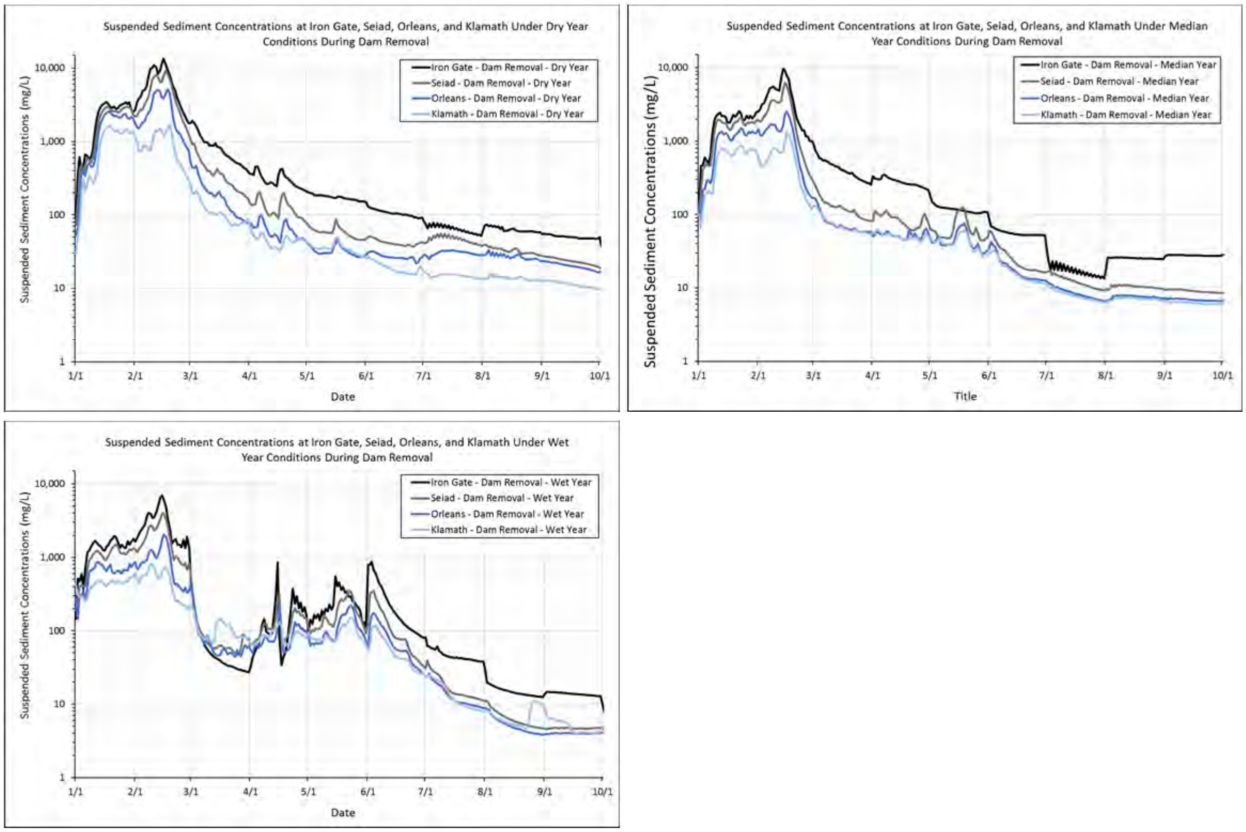


Figure 4-2 Modeled suspended sediment concentrations associated with reservoir drawdown and dam removal. Modeling output is presented for the Klamath River at Iron Gate, Seiad Valley, Orleans, and Klamath modeling stations. Graphs include dry year (2001, upper left), median year (1976, upper right), and wet year (1984, lower left).

Table 4-3 Suspended sediment modeling output stations and summary results. Suspended sediment concentrations related to juvenile salmonid mortality are also included for reference. A 2-week exposure to 1,000 mg/L concentration is associated with predicted 0-20 percent mortality, and 2-week exposure to 3,000 mg/L is associated with 20-40 percent mortality.

Suspended Sediment Modeling Station	Approximate Location (river mile)	Wet Year / Dry Year Peak SSC (mg/L)	Wet Year / Dry Year Cumulative Days with SSC above 1,000 mg/L	Wet Year / Dry Year Cumulative Days with SSC above 3,000 mg/L
Iron Gate Dam	192.9	6,988 / 13,385	54 / 57	12 / 33
Seiad Valley	131.9	3,999 / 9,223	41 / 50	4 / 19
Orleans	59.0	2,046 / 5,157	11 / 45	0 / 11
Klamath	2.5	819 / 1,670	0 / 28	0 / 0

4.3.3.1 Juvenile Salmonid Suspended Sediment Exposure

The following sections present information on juvenile salmonid outmigration rates in the Klamath River and suspended sediment exposure effects.

Juvenile Salmonid Outmigration Travel Time

In order to better predict potential effects of elevated suspended sediment concentrations on outmigrating juvenile salmonids, KRRC reviewed past studies and analyzed Klamath River juvenile salmonid outmigration rates and timing. Past Klamath River studies found juvenile salmonid outmigration rates are influenced by tributary and Klamath River water temperatures, smolt growth rates, and other environmental cues.

Wallace (2004) reported coho salmon smolts in the Klamath River estuary peaked in May, the same month as peak outmigration from the tributaries (Stillwater Sciences 2010). Radio telemetry studies conducted on wild and hatchery coho salmon smolts in the Klamath River between 2006 and 2009 found a wide range of travel times for coho salmon smolts outmigrating from Iron Gate Dam to the gaging station near the Klamath River estuary (Beeman et al. 2012). The minimum and maximum travel time were 3.8 and 54.4 days, respectively, with median values over the 4-year study ranging between 15.1 and 25.9 days. However, the longest residence time for any single reach was from the Iron Gate Dam release site to the Shasta River as tagged fish remained near the release site until they were ready to begin the downstream migration to the Klamath estuary. Once fish passed the Shasta River, travel times in any individual reach were less than 2 days and coho salmon smolts usually took less than 1 week to fully migrate to Klamath estuary (Beeman et al. 2012). Courter (2008) assumed that all fish from a given cohort would migrate to the estuary in 2-weeks, and this assumption is also consistent with travel rates documented by Stutzer et al. (2006). Based on the literature review, a 2-week outmigration period is believed to be a conservative period for juvenile salmonid exposure to elevated suspended sediment concentrations in the Kamath River. We also anticipate that outmigrating salmonids will have access to, and will choose to use clean water locations such as clear water tributary confluences, off-channel ponds and tributaries, and spring seeps during their outmigration, reducing exposure times. Additionally, suspended sediment concentrations will be substantially diluted by tributary inputs including the Trinity River (RM 43.4).

4.3.3.2 Juvenile Salmonid Suspended Sediment Exposure Effects

Newcombe and Jensen (1996) created “look-up tables” to predict response severity to suspended sediment exposures of varying durations and concentrations. Predicted severity-of-ill effects scores or indices were developed from empirical data gathered from numerous dose-response studies. Based on review of these data, juvenile salmonids exposed to concentrations of approximately 1,100 mg/L for 2-weeks have a severity-of-ill-effects score of 10, and may experience mortality rates between 0 and 20 percent. Expected mortality rates increase to between 20-40 percent as suspended sediment concentrations approach 3,000 mg/L.

While these predicted severity scores are helpful for evaluating the potential effects to juvenile fish, there is considerable variability between the effects to different species under different conditions as documented in the numerous studies synthesized by Newcombe and Jensen (1996). For instance, the authors reviewed an unpublished study where coho fry that were exposed to suspended sediment at a concentration of 5,471 mg/L for 96 hours in water at 18.7°C sustained a mortality rate of 10 percent, while similarly exposed steelhead experienced no mortality.

Servizi and Martens (1992) found that a stress response is dependent on a combination of factors including magnitude, frequency, and duration of exposure, as well as environmental factors such as particle size and water temperature. For example, effects to juvenile steelhead and coho salmon held in 18.7°C water, may have exacerbated the effects of suspended sediment on coho since temperatures of 19°C are considered suboptimal and juvenile coho salmon typically begin to seek cold water refugia at that threshold (Stenhouse et al. 2012). Likewise, Noggle (1978) found seasonal differences in salmonid tolerance to suspended sediment. In Noggle's study, bioassays conducted in summer produced lethal concentrations and 50 percent mortality (LC50) of exposed fish at less than 1,500 mg/l, while bioassays in autumn produced LC50 values in excess of 30,000 mg/l. Servizi and Martens (1991) found that underyearling coho salmon survived higher concentrations of suspended sediment at 7°C (22,700 mg/L) than at either 1°C or 18°C.

Based on literature reviewed in Newcombe and Jensen (1996), a 2-week exposure period to suspended sediment concentrations above 1,000 mg/L may result in up to 20 percent mortality of exposed fish, while a 2-week exposure to levels over 3,000 mg/L may result in 20-40 percent mortality of exposed fish. For comparison, parasite infection rates of outmigrating juvenile Chinook salmon from the upper Klamath River may be upwards of 60 percent in some years (Som et al. 2016).

4.3.3.3 Outmigration and Suspended Sediment Concentration Results

The following section presents a review of select screw trap data and suspended sediment concentration results. All outmigration and suspended sediment data are presented by Julian week (Table 4-4). Outmigration histograms represent weekly average number of outmigrants based on the sampled time period, generally 2008 to 2015. Salmon River outmigrant data are presented for two representative years rather than as multi-year averages. Juvenile outmigration variability plots presented in Appendix A, illustrate the plasticity of outmigration timing. Outmigration timing is influenced by flows, water temperature, and other environmental factors.

Table 4-4 Julian week correspondence with months of the year.

	Month											
Julian Week	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1-9												
9-17												
17-26												
26-35												
35-44												
44-52												

Upper Klamath River

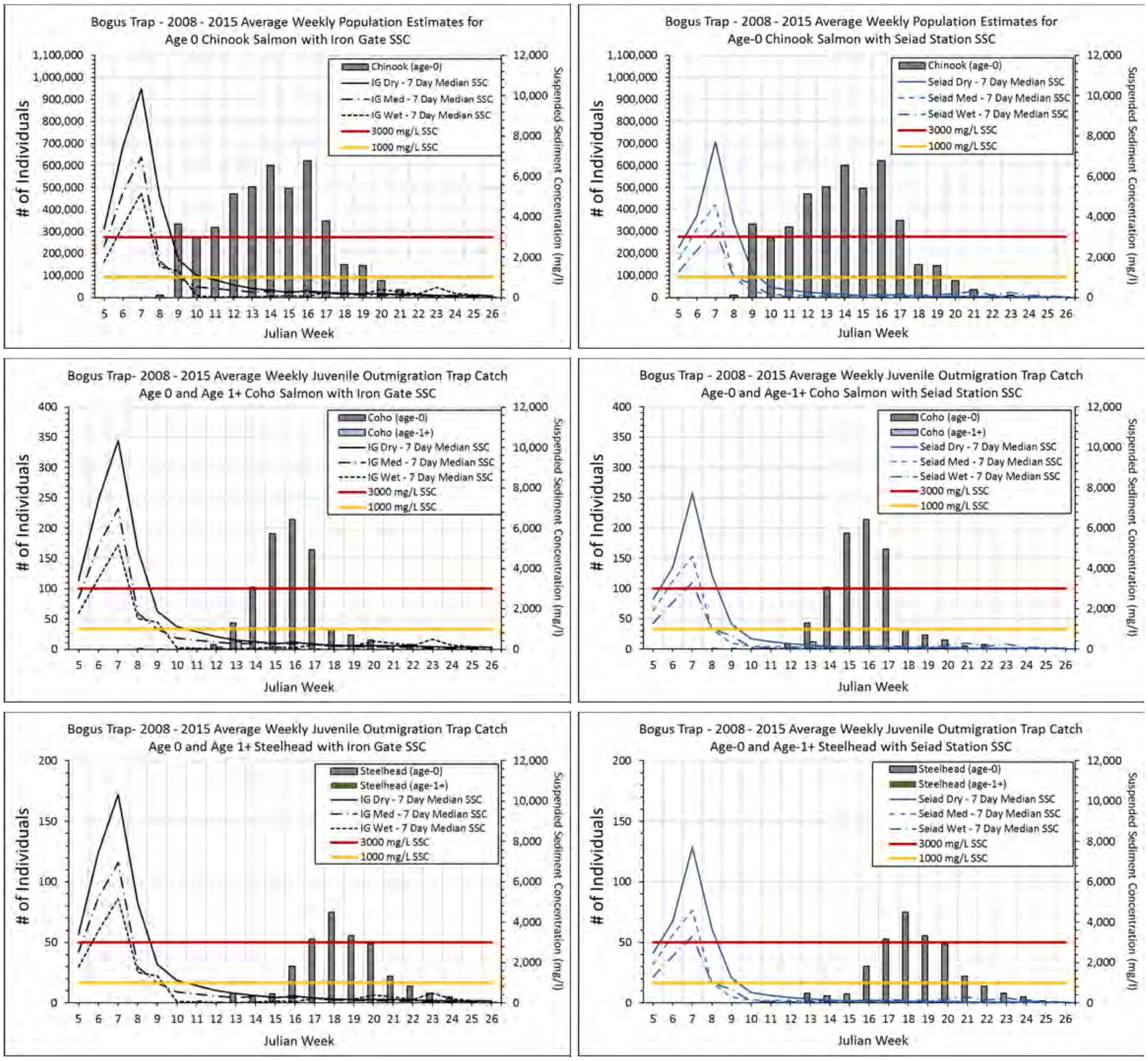
Outmigration trap data for the Klamath River, Shasta River, and Scott River and suspended sediment concentrations for the Iron Gate Dam and Seiad Valley reporting stations are presented in the following section. Because the outmigration traps are located between Iron Gate Dam and the Seaid Valley reporting stations, juvenile salmonids entering the Klamath River closer to Iron Gate Dam will experience the highest concentrations while fish entering or moving downstream in the Klamath River closer to Seaid Valley will experience suspended sediment concentrations diluted by tributary and spring inputs. Inclusion of both reporting stations provide the range of modeled concentrations anticipated to affect the upper Klamath River reach.

Graphs also include 1,000 mg/L and 3,000 mg/L mortality thresholds outlined in the previous report section. Fish outmigrating when the modeled suspended sediment concentrations exceed the mortality thresholds, may experience mortality likelihoods associated with the respective thresholds.

Klamath River – Bogus Trap Results

USFWS maintains the Bogus Creek trap located on the Klamath River downstream from Bogus Creek. The net frame trap samples outmigrants from Bogus Creek and the mainstem Klamath River. The Chinook salmon (age-0) outmigration window based on the sample period is from late February through June with an average peak in early to mid-April (Figure 4-3). On average, only the earliest outmigrants would experience suspended sediment concentrations above the 1,000 mg/L and 3,000 mg/L thresholds. Based on the reviewed trap data, most of the outmigrating juvenile Chinook salmon will move past the Bogus Creek trap location after the peak suspended sediment concentrations.

Trap catch results for outmigrating coho salmon and steelhead suggest these species tend to outmigrate from Bogus Creek and the mainstem Klamath River upstream of the Bogus trap later than Chinook salmon juveniles. Peak coho salmon and steelhead outmigrations are from early to mid-April, after suspended sediment concentrations have dropped below 1,000 mg/L.



The left column of plots includes the Iron Gate Dam suspended sediment concentrations, the right column includes the Seiad Valley concentrations. Outmigrating Chinook salmon appear to be the most vulnerable to peak suspended sediment concentrations. Coho and steelhead outmigrants are expected to outmigrate after peak suspended sediment concentrations.

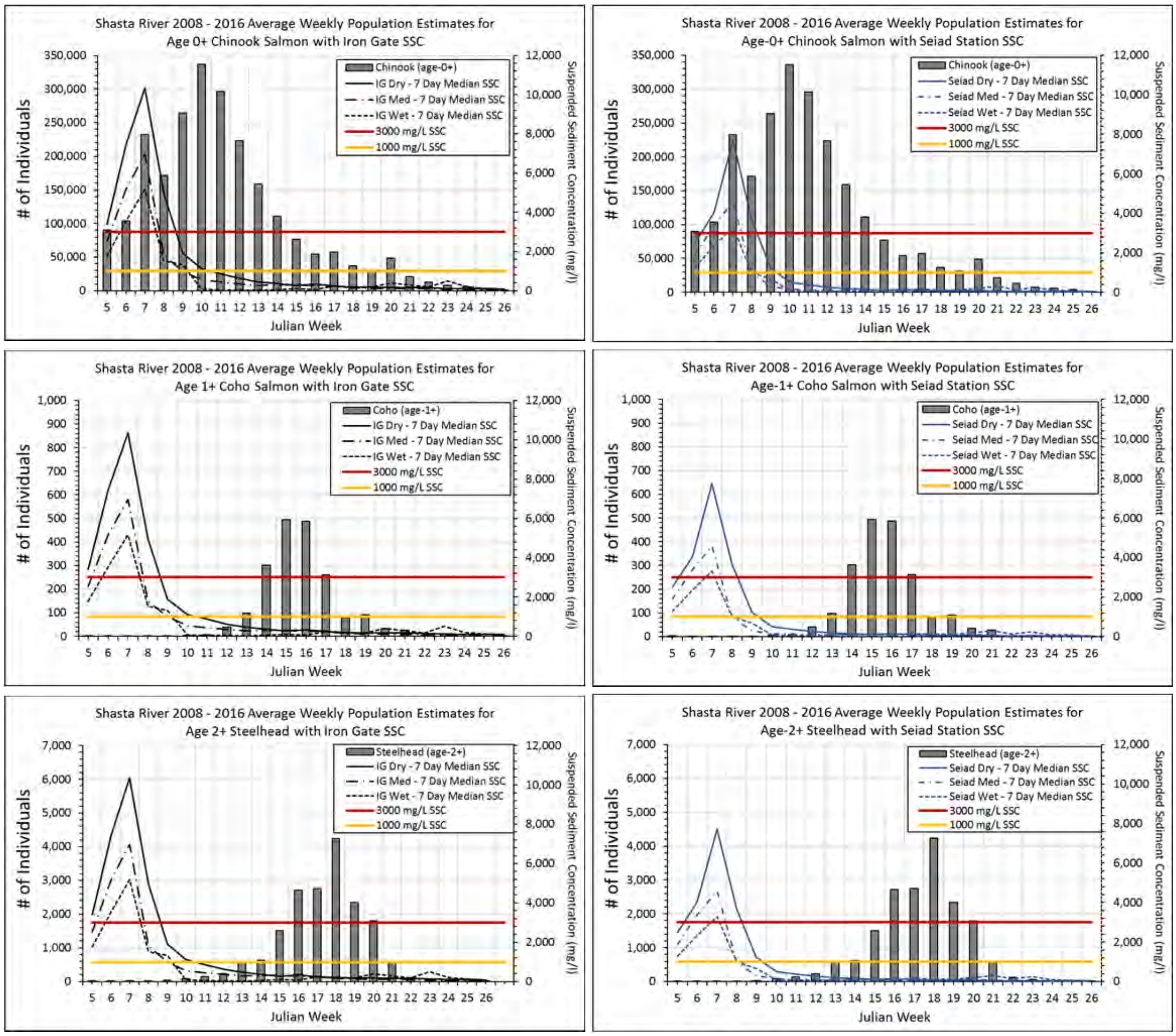
Figure 4-3 Bogus trap on the Klamath River outmigration plots include Chinook salmon age-0 outmigration estimate (top), coho salmon age-0 and age-1+ trap catch (middle), and steelhead age-0 and age-1+ trap catch (bottom).

Shasta River Trap Results

CDFW maintains the Shasta River rotary screw trap located near the Shasta River-Klamath River confluence. Chinook salmon (age-0+) outmigration from the Shasta River tends to occur earlier than in downstream tributaries and the mainstem Klamath River (Figure 4-4). On average, the outmigration begins in January and peaks in early March, overlapping with anticipated declining peak suspended sediment concentrations. Early Chinook salmon outmigrants entering the Klamath River would experience elevated sediment through mid-

March. Results suggest the early portion of the Chinook salmon outmigration will be subjected to potentially lethal suspended sediment due to the concentration and exposure duration.

Population estimates for outmigrating coho salmon and steelhead suggest these species tend to outmigrate from the Shasta River later than Chinook salmon juveniles. Peak coho salmon and steelhead outmigrations are from mid to late April and are likely influenced by declining flows and rising water temperatures associated with onset of irrigation season. Coho salmon and steelhead outmigration patterns suggest that most fish outmigrate after suspended sediment concentrations have dropped below 1,000 mg/L.



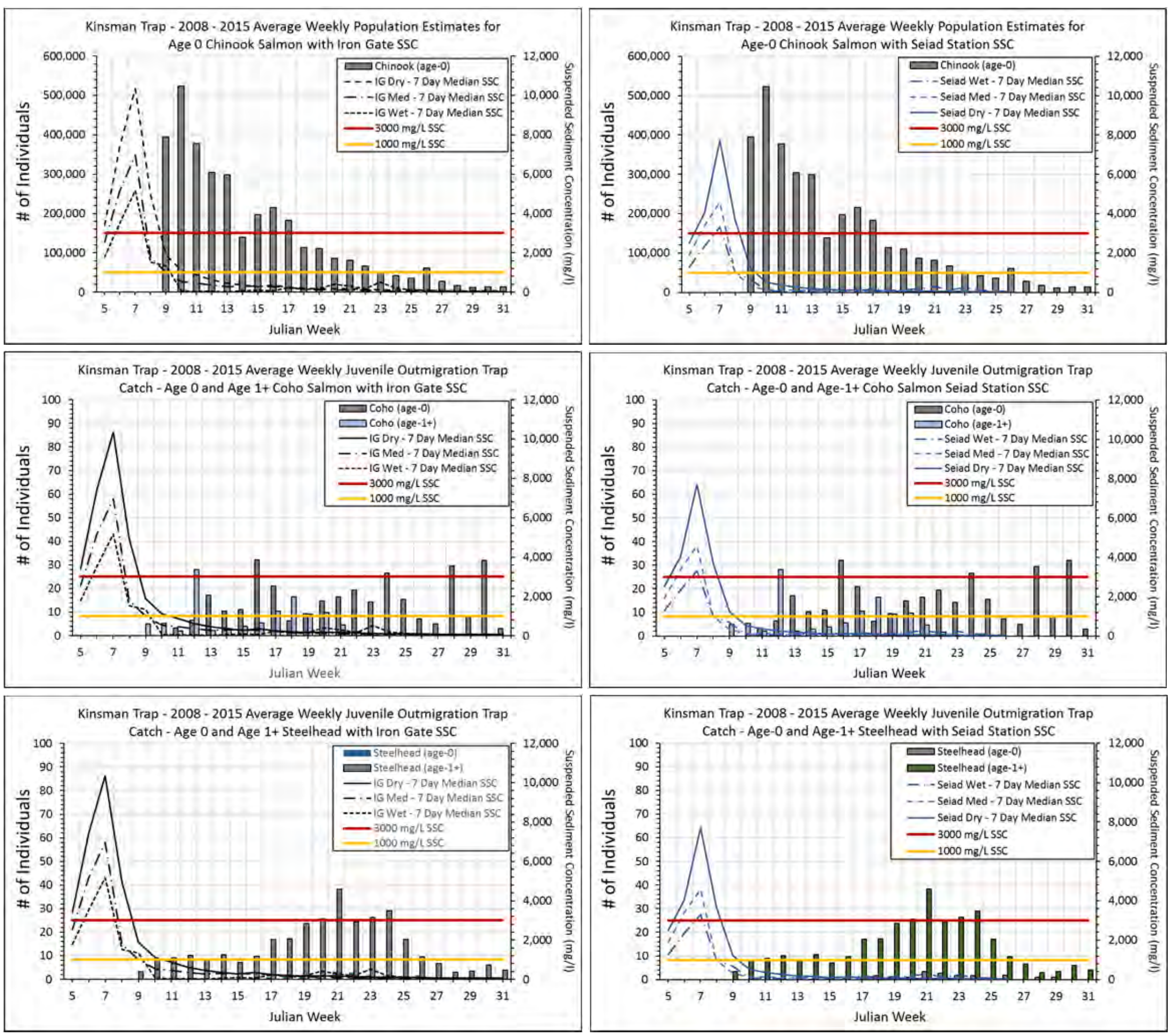
The left column of plots includes the Iron Gate Dam suspended sediment concentrations, the right column includes the Seaid Valley concentrations. Outmigrating Chinook salmon appear to be the most vulnerable to peak suspended sediment concentrations in the Klamath River. Coho salmon and steelhead outmigrants are expected to outmigrate after peak suspended sediment concentrations are below 1,000 mg/L.

Figure 4-4 Shasta River trap outmigration plots include Chinook salmon age-0+ outmigration estimate (top), coho salmon age-1+ outmigration estimate (middle), and steelhead age-2+ outmigration estimate (bottom).

Klamath River – Kinsman Trap Results

USFWS maintains the Kinsman Creek trap located on the Klamath River just upstream of the Kinsman Creek-Klamath River confluence and approximately 2.5 miles upstream of the Scott River-Klamath River confluence. The timing and magnitude of juvenile Chinook salmon in the Kinsman trap suggest the influence of early outmigrants from the Shasta River. Over the period of record reviewed by KRRC, the Kinsman trap does not begin operation until the beginning of March and likely misses the early Shasta River outmigrants entering the Klamath River (Figure 4-5). Therefore, early outmigrating Chinook salmon in the Klamath River would be subjected to elevated suspended sediment concentrations. However, the peak of the Chinook salmon migration reaches the Kinsman trap location after peak sediment concentrations.

Trap catch results for outmigrating coho salmon and steelhead suggest these species tend to outmigrate from areas upstream of the Kinsman trap later than Chinook salmon juveniles. Coho salmon and steelhead outmigrate through the summer and mainly outmigrate after suspended sediment concentrations are projected to drop below 1,000 mg/L.

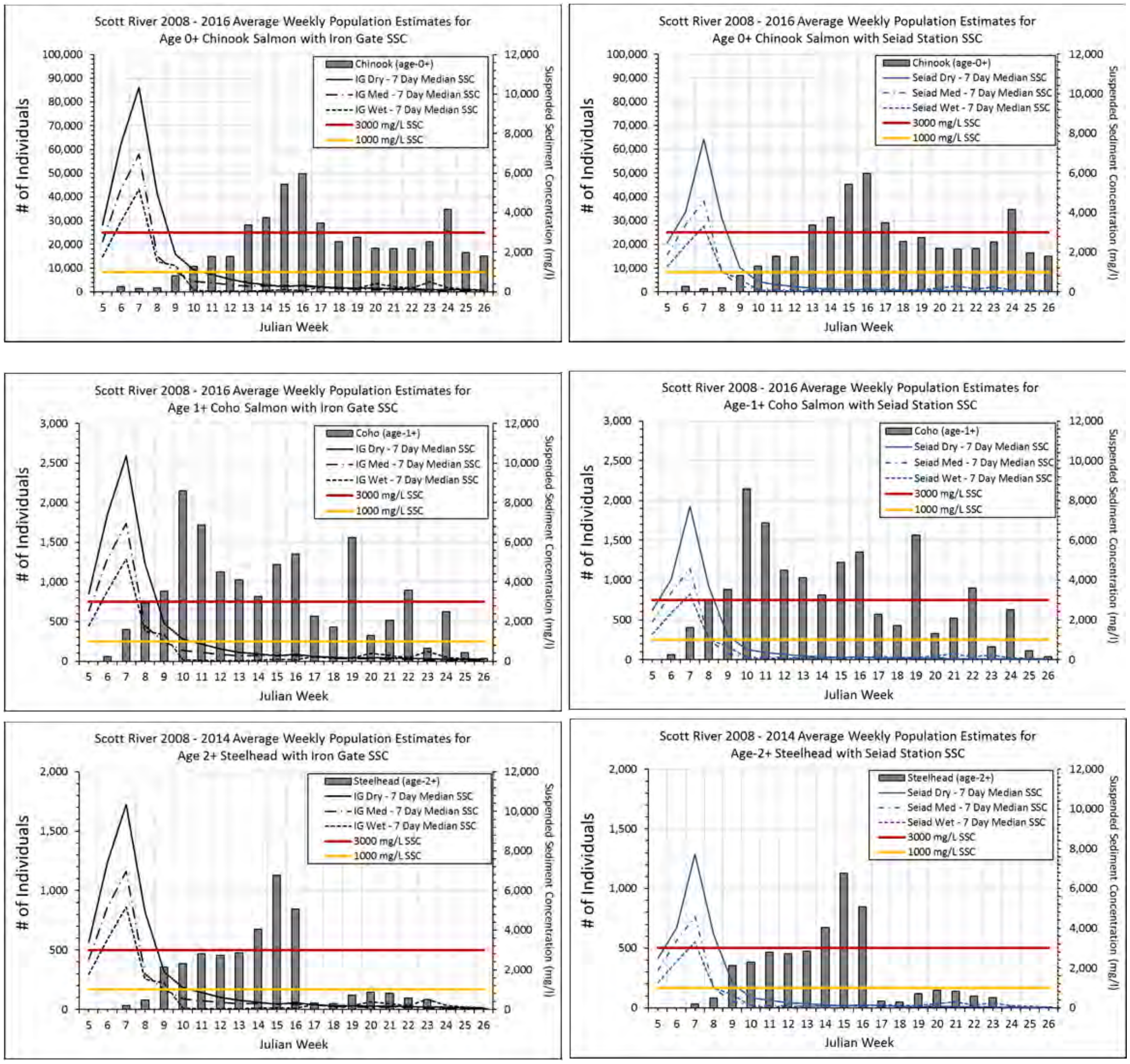


The left column of plots includes the Iron Gate Dam suspended sediment concentrations, the right column includes the Seiad Valley concentrations. Outmigrating Chinook salmon appear to be the most vulnerable to peak suspended sediment *concentrations. Most coho and steelhead outmigrants are expected to outmigrate after peak suspended sediment concentrations.*

Figure 4-5 Kinsman trap on the Klamath River outmigration plots clockwise from upper left include Chinook salmon age-0 outmigration estimate (top), coho salmon age-0 and age-1+ trap catch (middle), and steelhead age-0 and age-1+ trap catch (bottom).

Scott River Trap Results

CDFW maintains the Scott River rotary screw trap located 4.75 miles upstream of the Scott River-Klamath River confluence. Chinook salmon (age-0+) outmigration from the Scott River occurs in mid-April (Figure 4-6) and is more similar to the mainstem Klamath River outmigrants than to the outmigration timing for the Shasta River. The Scott River Chinook salmon outmigration, on average, occurs over a longer period of time with lower abundance relative to the Shasta River Chinook outmigration. Few Chinook salmon outmigrate during the period of peak suspended sediment concentrations.



The left column of plots includes the Iron Gate Dam suspended sediment concentrations, the right column includes the Seiad Valley concentrations. Outmigrating coho salmon appear to be proportionally more vulnerable to peak suspended sediment concentrations, with approximately 25 percent of the average outmigrants subjected to concentrations above 1,000 mg/L.

Figure 4-6 Scott River trap outmigration plots clockwise from upper left include Chinook salmon age-0+ outmigration estimate (top), coho salmon age-1+ outmigration estimate (middle), and steelhead age-2+ outmigration estimate (bottom).

Population estimate results for outmigrating coho salmon and steelhead suggest these species' outmigration periods overlap with outmigrating Scott River Chinook salmon more so than the level of species overlap in the Shasta River. Although at lower abundance levels relative to Scott River Chinook salmon, Scott River coho and steelhead juvenile outmigration amounts to several thousand fish. The earliest outmigrating fish (late February to early March) will likely be subjected to elevated suspended sediment concentrations as sediment levels taper from the peak. Coho and steelhead outmigration patterns suggest that most fish may outmigrate after suspended sediment concentrations have dropped below 1,000 mg/L.

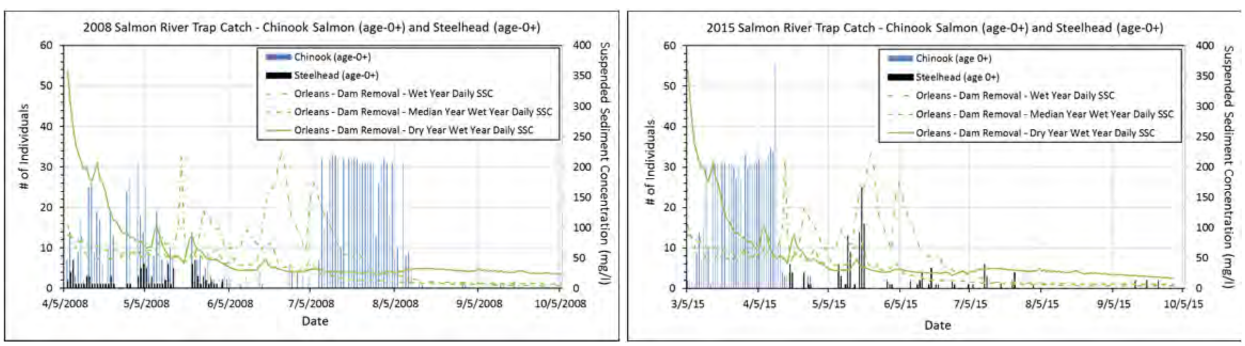
Middle Klamath River

Data are provided for two traps in the middle Klamath River.

Salmon River Trap Results

The Karuk Tribe maintains a screw trap on the Salmon River at RM 0.96. The Salmon River joins the Klamath River at RM 66.4. Suspended sediment concentrations for the Orleans modeling station and Chinook (age-0+) and steelhead (age 0+) trap catch data for 2008 and 2015 are presented in Figure 4-7. The presented years 2008 and 2015 are representative of the outmigration timing for Chinook and steelhead on the Salmon River. The second grouping of Chinook salmon outmigrants from July through September in 2008 is characterized by larger juveniles compared to the earlier April to June outmigration period. The 2015 trap catch data suggest a dominant early juvenile Chinook salmon outmigration under severe drought conditions and few later outmigrants. There were low numbers of outmigrating juvenile steelhead in both years. Coho salmon outmigrants were not included in the analysis due to low trap catch numbers.

Anticipated suspended sediment concentrations at the Orleans station are below the 1,000 mg/L and 3,000 mg/L mortality thresholds and most Chinook salmon and steelhead juveniles migrate to the lower Salmon River when anticipated suspended sediment concentrations in the Klamath River are less than 500 mg/L. Based on the timing of juvenile Chinook salmon and steelhead entry into the Klamath River and the anticipated suspended sediment concentrations at entry, we do not expect outmigrating fish from the Salmon River to experience lethal conditions. We also anticipate outmigrants will reach the Klamath estuary in less than a week, minimizing their exposure to suspended sediment concentrations.



Anticipated suspended sediment concentrations from the Orleans station are also presented. Suspended sediment concentrations during the outmigration period are less than the mortality thresholds of 1,000 mg/L and 3,000 mg/L.

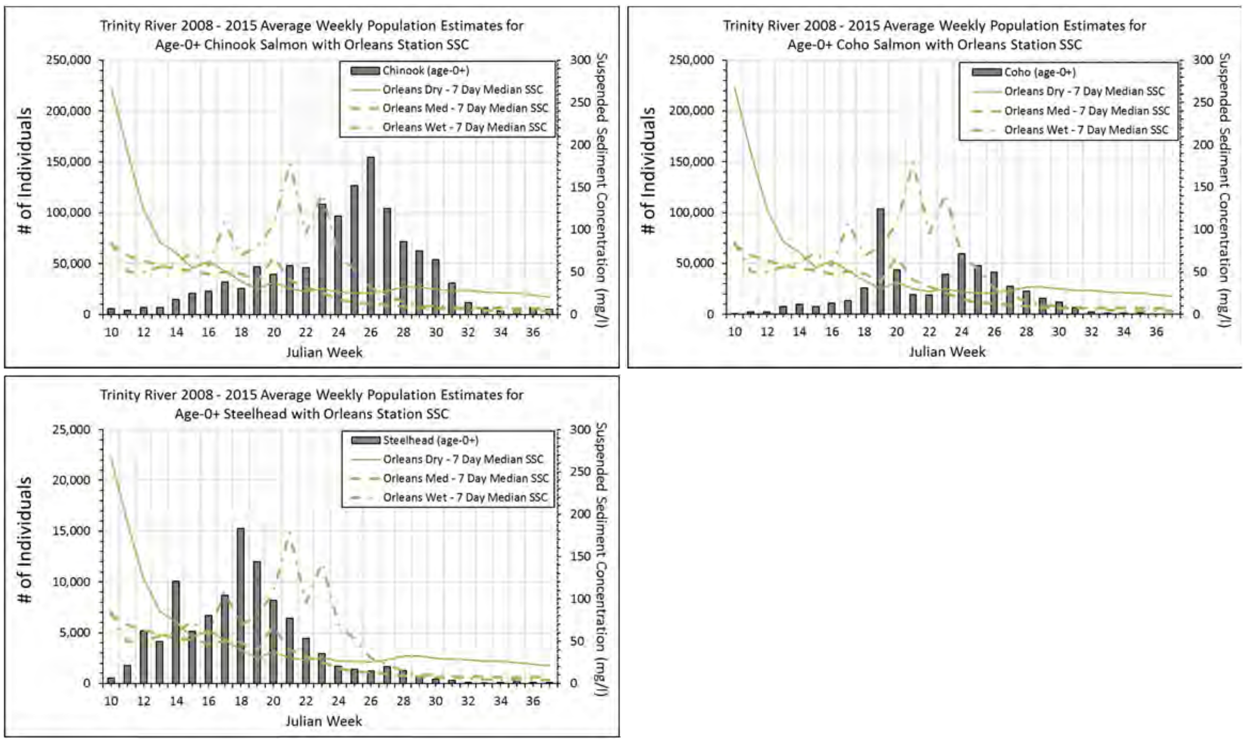
Figure 4-7 Salmon River trap catch outmigration plots for Chinook salmon (age-0+) and steelhead (age-0+) for 2008 (left) and 2015 (right).

Trinity River near Willow Creek Trap Results

USFWS maintains a screw trap on the Trinity River at RM 21.1. The Trinity River joins the Klamath River at RM 43.4. Suspended sediment concentrations for the Orleans modeling station and Chinook salmon (age-0+), coho salmon (age-0+), and steelhead (age 0+) population estimates based on 2008 to 2015 screw trap data are presented in Figure 4-8. Steelhead peak outmigration is earlier than Chinook and coho salmon outmigration timing.

The outmigration values include both hatchery and naturally-produced juveniles and age-0 smolts comprise the majority of the sampled outmigrants.

Anticipated suspended sediment concentrations at the Orleans station are below the 1,000 mg/L and 3,000 mg/L mortality thresholds and most fish migrate through the lower Trinity River when Klamath River suspended sediment concentrations are less than 300 mg/L. Based on outmigration timing to the Klamath River (assuming juvenile fish continue to outmigrate to the Klamath River after they bypass the Trinity River trap location) and the anticipated suspended sediment concentrations at entry, we do not expect outmigrating fish from the Trinity River to experience lethal conditions in the Klamath River. We also anticipate outmigrants will reach the Klamath estuary in less than a week, minimizing their exposure to elevated suspended sediment.



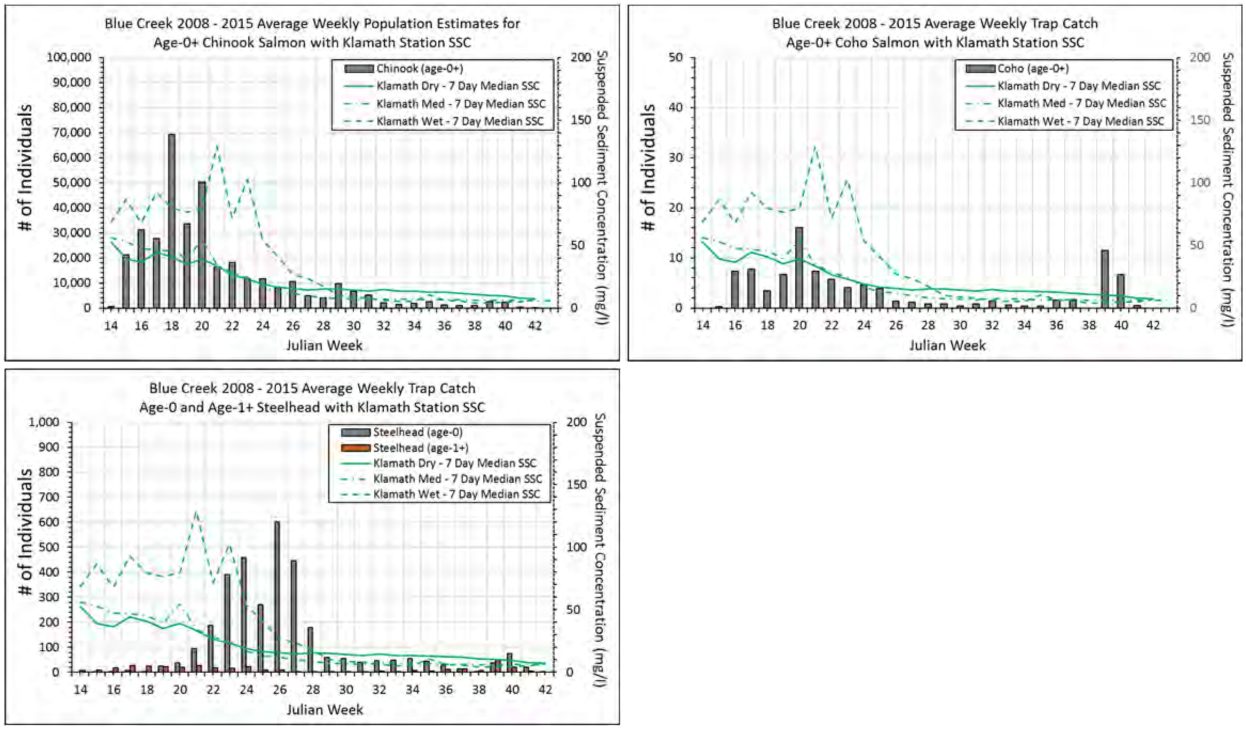
Anticipated suspended sediment concentrations from the Orleans station are also presented. Suspended sediment concentrations during the outmigration period are less than the mortality thresholds of 1,000 mg/L and 3,000 mg/L.

Figure 4-8 Trinity River trap outmigration plots for Chinook salmon age-0+ (upper left), coho salmon age-0+ (upper right), and steelhead age-0+ (lower left).

Lower Klamath River

The Yurok Tribe maintains a screw trap at RM 2.0 on Blue Creek, the largest tributary to the lower Klamath River. Blue Creek supports the largest anadromous fish populations in the sub-basin, and the tributary is considered to be a salmon stronghold by the Yurok Tribe (Antonetti and Partee 2013). Blue Creek joins the Klamath River at RM 16.0. Suspended sediment concentrations for the Klamath modeling station and population estimates for Chinook salmon (age-0+), and trap catch data for coho salmon (age-0+), and steelhead (age-0 and age-1+) for 2008 through 2015 are presented in Figure 4-9.

Anticipated suspended sediment concentrations at the Klamath station are below the 1,000 mg/L and 3,000 mg/L mortality thresholds. Outmigration timing for juvenile salmonids is generally during anticipated elevated suspended sediment concentrations less than 300 mg/L. We do not anticipate negative effects from suspended sediment concentrations on outmigrating juvenile salmonids in the Lower Klamath River based on low sediment concentrations and the close proximity of Blue Creek to the Klamath estuary.



Anticipated suspended sediment concentrations from the Klamath station are also presented. Suspended sediment concentrations during the outmigration period are less than the mortality thresholds of 1,000 mg/L and 3,000 mg/L.

Figure 4-9 Blue Creek trap outmigration plots include Chinook salmon age-0+ outmigration estimate (upper left), coho salmon age-0+ trap catch (upper right), and steelhead age-0 and age-1+ trap catch (lower left).

4.3.3.4 Outmigration and Dissolved Oxygen

The release of organic-based sediments during reservoir drawdown is anticipated to affect dissolved oxygen levels in the Klamath River downstream from Iron Gate Dam (Stillwater Sciences 2011). The highest predicted oxygen demand levels will be associated with peak suspended sediment concentrations that are anticipated to occur during February of the drawdown year. Despite the relatively high predicted biological oxygen demand, dissolved oxygen concentrations downstream from Iron Gate Dam are anticipated to generally remain greater than 5 mg/L. Exceptions include predicted concentrations in February of the dam removal year for median (1976) and typical dry year (2001) hydrologic conditions, which exhibit minimum values of 3.5 mg/L and 1.3 mg/L, respectively.

For all water year types (wet, median, dry), the predicted dissolved oxygen minimum values would occur by approximately RM 188-190 (~3-5 miles downstream from Iron Gate Dam) and would return to at least 5 mg/L by approximately RM 175-177 (2-4 miles below the Shasta

River confluence. The North Coast Basin Plan water quality objective for dissolved oxygen is expressed as percent saturation; at 90 percent saturation, the water quality objective for November through April, assuming average February (2009) water temperatures, would be 9.6-10.6 mg/l. Based on the spreadsheet model results, recovery to the North Coast Basin Plan water quality objective of 90 percent saturation would occur generally within the reach from Seiad Valley (RM 131.9) to the mainstem confluence with Clear Creek, or within a distance of 62-93 miles downstream from Iron Gate Dam, for all water years.

Dissolved oxygen monitoring during dam removal projects is complicated by the harsh in-stream conditions influenced by high suspended sediment concentrations. The U.S. Geological Survey monitored dissolved oxygen levels associated with the drawdown of Fall Creek Reservoir in the Willamette Basin. The Fall Creek monitoring included a water quality monitoring station downstream from the dam, and a second station at Jasper approximately 10 miles downstream from Fall Creek Dam. The *Fall Creek Outflow* station at the dam detected a decrease in dissolved oxygen concurrent with the sediment release, although the extent of the depletion was unknown due to equipment fouling (Schenk and Bragg 2014). Collected dissolved oxygen data suggested a decline from approximately 12.5 mg/L to between 6 mg/L and 7 mg/L during the first 5 hours following the drawdown. Dissolved oxygen levels trended upward over the course of the of the following 4 days until returning to background levels 6 days after the onset of drawdown (Schenk and Bragg 2014). Dissolved oxygen levels at the downstream Jasper station did not experience a large, rapid decrease in dissolved oxygen during the drawdown, suggesting the drawdown effects on dissolved oxygen were isolated to less than 10 miles of Fall Creek and the Middle Fork Willamette River.

4.3.3.5 Outmigration and Suspended Sediment Summary

Reservoir drawdown and dam removal sequencing was developed to minimize effects on Klamath River anadromous fish. A review of recent juvenile salmonid outmigration data collected from 2008 to 2015/2016, provides and updated understanding of juvenile salmonid outmigration timing on the Klamath River and select tributaries. Comparing outmigration timing and anticipated reservoir drawdown-influenced suspended sediment concentrations in the Klamath River is informative for predicting potential sediment effects to juvenile salmonids entering the Klamath River during the winter and early spring coincident with reservoir drawdowns. The data review suggests potential sediment effects to early outmigrating juvenile salmonids in the Shasta and Scott rivers. However, juvenile outmigration timing suggests a high degree of plasticity when fish outmigrate from tributaries to the Klamath River. Environmental conditions including stream flow, water temperature, food availability, and other biological and environmental cues influence outmigration timing. Initiating the reservoir drawdowns 2 weeks to a month earlier than planned, may reduce the exposure of early outmigrants to peak suspended sediment concentrations. The adaptive monitoring and salvage plan included in AR-2 is also intended to reduce sediment effects on outmigrating salmonids.

4.3.4 Juvenile Salmonid Suspended Sediment Avoidance Behavior Review

The following section provides a summary of reviewed literature pertaining to juvenile salmonid avoidance behaviors in response to elevated suspended sediment. The high levels of suspended sediment in the Klamath River during reservoir drawdown are anticipated to be problematic for outmigrating juvenile salmonids during peak concentrations. However, as concentrations decline over time and with distance from Iron Gate Dam, juvenile salmonids are expected to employ behavioral adaptations to reduce exposure effects.

4.3.4.1 Avoidance Behavior

The reservoir drawdown period will be marked by poor water quality caused by high suspended sediment concentrations. Juvenile salmonids inhabiting the Klamath River are expected to employ coping strategies to survive poor conditions. Juveniles may use clear water tributary junctions, clear water off-channel ponds and tributaries, spring seeps, or increase their use of the benthic zone (Bash et al. 2001; Kjelland et al. 2015), or the upper portion of the water column (Servizi and Martens 1992). We expect juvenile fish to actively seek these areas as they move downstream from natal tributaries into the Klamath River. Factors affecting the ability of juvenile salmonids to find clear water areas include the frequency and output of clear water sources, the magnitude of suspended sediment in the Klamath River, and the developmental stage of juvenile fish (Sedell et al. 1990). Younger fish are generally more susceptible to high suspended sediment concentrations than older fish.

For juvenile salmonids rearing in the mainstem Klamath River at the time of reservoir drawdown, gradually increasing suspended sediment levels may promote more rapid downstream movement of juvenile fish as they seek cleaner water (Berg and Northcote 1985). Redding and Schreck (1987) found juvenile coho and steelhead exposed to 4,000 mg/L exhibited a physiological stress response, but tested fish were able to compensate for the high suspended sediment concentrations within a few days. Fish exposed to 2,000 - 4,000 mg/L of sediment exhibited physiological changes indicative of sublethal stress, but the tested sediment levels also caused modified feeding behavior and lowered the disease resistance of tested fish (Redding and Schreck 1987). Interestingly, physiological responses were moderate compared to cortisol levels in fish severely stressed by confinement and handling (Redding and Schreck 1983 *cited in* Redding and Schreck 1987), suggesting that minimizing handling in favor of allowing juvenile fish to make choices on their outmigration may result in lower juvenile salmonid mortality.

4.3.4.2 Exposure to Organics-based Suspended Sediment

Salmonid suspended sediment studies generally evaluate the effects of mineralized sediment on salmonids. Sockeye smolts were less susceptible to high levels of Frasier River sediments than they were to lower levels of angular ash particles associated with the Mount St. Helens eruption (Newcomb and Flagg *cited in* Servizi and Martens 1987). Compared to gill abrasion effects caused my mineralized sediment, organic-based suspended sediment may cause problematic effects related to low dissolved oxygen levels (Sorenson et al. 1977 *cited in* Bash et al. 2001), but organic sediments may be less abrasive compared to suspended mineralized sediments.

4.3.5 Suspended Sediment Effect Summary

Juvenile salmonids exhibit outmigration timing plasticity that reflects their response to instream conditions influenced by stream flow, water temperature, food availability, and other biological and environmental cues. We would anticipate that juveniles will delay entry into the Klamath River when they experience adverse conditions, and fish will choose to outmigrate in response to tributary condition decline and mainstem river condition improvement. Based on the reviewed outmigration data, juveniles outmigrate from tributaries over several weeks from late winter through summer, with juvenile Chinook salmon being the earliest outmigrants from upper Klamath River tributaries. If juvenile fish remain in upper Klamath River tributaries through early to mid-March, they will experience substantially lower suspended sediment concentrations upon entry into the Klamath River. The mid-March time period precedes the start of irrigation season (beginning of April) in the Shasta River, when tributary conditions begin to decline due to reduced instream flows and rising water temperatures (Jetter et al. 2016).

Our data review suggests juvenile salmonids are capable of outmigrating from Iron Gate Dam to the Klamath estuary in less than 2 weeks. Clear water sources in the form of tributary confluences, off-channel ponds, and spring seeps will serve as moderate to high water quality stepping stones in an otherwise harsh aquatic environment. As juveniles migrate downstream, not only will they encounter pockets of improved water quality, but suspended sediment concentrations will also decline with tributary inputs. Water quality conditions downstream of the Trinity River confluence are anticipated to be near background levels as the Trinity River and other tributaries dilute suspended sediment concentrations. We would also expect fish exposed to high suspended sediment concentrations to outmigrate more rapidly, further reducing the exposure duration.

If suspended sediment concentrations remain elevated above 1,000 mg/L for any 2-week period during the outmigration, there may be up to 20 percent mortality of exposed fish. However, this conclusion should be considered in light of documented evidence of juvenile coho and steelhead survival at suspended sediment concentrations exceeding 2,000 mg/L (Redding et al. 1997). Likewise, it is unlikely fish will be continuously exposed to high suspended sediment concentrations over 14 days as they will have access to clear water refuges and will experience improving water quality conditions as they move downstream.

Based on juvenile salmonid outmigration data, anticipated suspended sediment concentrations during reservoir drawdown, and expected juvenile salmonid avoidance behaviors, an adaptive strategy that includes monitoring and salvaging juvenile fish as a last resort, is a prudent approach to reducing sediment effects on juvenile salmonids.

Beginning the reservoir drawdowns 2-4 weeks earlier than the Detailed Plan's proposed schedule would reduce the number of early outmigrating Chinook salmon and coho salmon from the Shasta and Scott rivers that would be exposed to high suspended sediment concentrations. However, an earlier start to reservoir drawdown would also potentially affect late migrating coho salmon that spawn in Klamath River tributaries through late December. Additional discussion with fisheries agencies is warranted to determine the appropriateness of beginning drawdown earlier than currently planned.

4.4 AR-2 Summary

The Klamath River dam decommissioning project is anticipated to have significant short-term effects, but long-term benefits, for fall Chinook salmon, coho salmon, winter steelhead, and Pacific lamprey. The 2012 EIS/R AR-2 measure included installing 17 screw traps on 13 tributaries to capture outmigrating juvenile fish in an effort to protect juvenile fish from entering the Klamath River during the dam decommissioning project. Captured fish would be transported and released downstream of the Trinity River confluence where water quality conditions during the dam decommissioning are expected to be improved by tributary dilution. ATWG input highlighted several concerns associated with the 2012 AR-2 plan including trapping feasibility and cost, life safety during winter flow conditions, handling mortality, and potential insufficient juvenile imprinting, followed by elevated stray rates associated with future adult returns. The ATWG concluded that the basis of these concerns could result in the proposed AR-2 mitigation effort being ineffective at reducing the project's impacts and potentially introducing additional risks to outmigrating juvenile salmonids. Therefore, KRRC determined that revised actions in the form of an updated AR-2 are warranted.

The updated AR-2 plan includes three primary actions; salvaging mainstem overwintering juvenile salmonids prior to reservoir drawdown; maintaining tributary-mainstem connectivity to ensure volitional fish passage between tributaries and the Klamath River; and developing a water quality monitoring network, trigger thresholds, and plan for salvaging and relocating juvenile fish from tributary confluence areas to cool water tributaries or nearby off-channel ponds. The three-pronged approach proposed by KRRC is anticipated to mitigate the short-term effects to outmigrating juvenile salmonids

5. AR-3 Fall Pulse Flows

The objective of AR-3 is to address reservoir drawdown and dam removal effects on anadromous fish that migrate and spawn in the mainstem Klamath River and its tributaries. The original 2012 EIS/R AR-3 plan focused on increasing fall flows to encourage outmigration of post-spawned green sturgeon from the lower Klamath River and estuary to the Pacific Ocean, and increase fall Chinook salmon, coho salmon, and steelhead spawning in tributaries downstream from Iron Gate Dam. Fall pulse flows were anticipated to reduce the effects of elevated suspended sediment concentrations on anadromous fish inhabiting the Klamath River.

A review of current information regarding Klamath River fisheries and dam decommissioning effects suggests that the use of fall pulse flows would likely be ineffective in reducing the effects of suspended sediment on migrating and spawning salmon, steelhead, and green sturgeon. The uncertainty of storage water availability on the mainstem Klamath River prior to reservoir drawdown, and the natural (unregulated) hydrology of most Klamath River tributaries make implementation and success of this measure unpredictable. The measure may therefore be either infeasible or unnecessary to implement depending on the meteorological conditions prior to dam decommissioning. Therefore, fall pulse flows will not be implemented to offset the suspended sediment effects related to the dam decommissioning.

5.1 Summary of the 2012 EIS/R AR-3, Dam Removal Benefits and Effects, and Recent Fisheries Literature

The following sections review the components of the 2012 EIS/R AR-3 measure, anticipated dam removal effects and benefits on AR-3 species, and recent fisheries literature relative to juvenile salmonid outmigration.

5.1.1 AR-3 Affected Species

Species identified in AR-3 include:

- Coho salmon (*Oncorhynchus kisutch*) – Southern Oregon/Northern California Coastal (SONCC) evolutionary significant unit (ESU): Federally Threatened; California Threatened; Tribal Trust Species
- Chinook salmon (*O. tshawytscha*) – Upper Klamath-Trinity Rivers ESU - Fall Run: California Species of Special Concern; Tribal Trust Species
- Steelhead (*O. mykiss*) – Klamath Mountains Province distinct population segment (DPS) – Summer Run: California Species of Special Concern; Tribal Trust Species
- Steelhead (*O. mykiss*) – Klamath Mountains Province DPS – Winter Run: Tribal Trust Species
- Green sturgeon (*Acipenser medirostris*) - Northern DPS: Tribal Trust Species

5.1.2 Anticipated Dam Decommissioning Effects on AR-3 Species

Short-term effects of dam removal (from both suspended sediment and bedload movement) were predicted to result in high mortality of fall Chinook salmon and coho salmon embryos and pre-emergent alevin within redds that are constructed in the mainstem Klamath River downstream from Iron Gate Dam in the fall prior to reservoir drawdown (USBR and CDFG

2012). Approximately 2,100 fall Chinook salmon redds and approximately 13 SONCC coho salmon redds were predicted to be affected during reservoir drawdown. Migrating steelhead within the mainstem Klamath River after December 31 prior to reservoir drawdown are also anticipated to be directly affected by suspended sediment related to reservoir drawdown. Additionally, any adult green sturgeon remaining in the lower Klamath River and estuary could be exposed to elevated suspended sediment concentrations which could result in major stress to affected fish, although the effects of the dam decommissioning project are expected to be the same as under existing conditions (USBR and CDFG 2012). Table 5-1 includes the likely and worst-case effects to adult anadromous fish species downstream from Iron Gate Dam.

Table 5-1 2012 EIS/R anticipated effects summary for migratory adult salmonids and green sturgeon

Species	Life Stage	Likely Effects	Worst Effects
Coho Salmon	Adult Spawning	Loss of 13 redds (0.7-26%)[1]	Loss of 13 redds (0.7-26%)[1]
Chinook Salmon - Fall	Adult Spawning	Loss of 2,100 redds (8%)[1]	Loss of 2,100 redds (8%)[1]
Steelhead - Summer	Migrating Adults	No anticipated mortality	Loss of 0-130 adults (0-9%)
Steelhead - Winter	Migrating Adults	Loss of up to 1,008 adults (14%)[1]	Loss of up to 1,988 adults (28%)
Green Sturgeon	Holding Adults	Sublethal effects	Sublethal effects

Source: USBR and CDFG 2012

[1] Range of potential year class loss based on the average number of redds associated with the evaluated population(s).

The following sections include descriptions of species-specific effects adapted from the 2012 EIS/R (USBR and CDFG 2012; Vol. I, pp. 3.3-129 to 3.3-168).

5.1.2.1 Coho Salmon

The wide distribution and use of tributaries by both juvenile and adult coho salmon will likely protect the population from the worst effects of the dam decommissioning. However, direct mortality is anticipated for redds and smolts from the upper Klamath River, mid-Klamath River, Shasta River, and Scott River population units. No mortality is anticipated for the Salmon River, Trinity River, and Lower Klamath River populations under the most likely or worst-case scenarios. Based on substantial reduction in the abundance of a year class in the short-term, the effect of the dam decommissioning was found to be significant for the coho salmon from the Upper Klamath River, Mid-Klamath River, Shasta River, and Scott River population units.

Based on spawning surveys conducted from 2001 to 2005 (Magneson and Gough 2006), 6 to 13 redds could be affected during reservoir drawdown. The anticipated loss of redds from the Upper Klamath River coho salmon population unit was based on the peak count of redds surveyed in all years (13 redds counted in 2001). Mainstem Upper Klamath River coho redd surveys completed between 2001 and 2016 (not completed in 6 years) yielded 6 redds on average and no redds in 2009. A total of only 38 mainstem redds were documented between 2001-2005, with two-thirds of those redds being found within 12 miles of the dam (NOAA 2010). Many of the redds anticipated to be affected by the dam decommissioning are thought to be from returning hatchery fish (NOAA 2010). Based on the range of escapement estimates in Ackerman et al. (2006), 13 redds could represent anywhere from 0.7 to 26 percent of the naturally returning spawners in the upper Klamath River Population Unit, and likely much less than 1 percent of the natural and hatchery returns combined (Magneson and Gough 2006; USFWS, unpublished data 2017).

5.1.2.2 Chinook Salmon – Fall Run

Fall Chinook salmon use the mainstem Klamath River for spawning, rearing, and as a migratory corridor. Direct mortality is predicted for fall Chinook salmon redds and some smolts. The effect of suspended sediment concentrations on juvenile fall Chinook salmon from the dam decommissioning is expected to be relatively minor because of variable life histories, the large majority of age-0 juveniles that remain in tributaries until later in the spring and summer, and because many of the fry that out-migrate to the mainstem come from tributaries in the mid-or lower Klamath River, where suspended sediment concentrations resulting from the dam decommissioning are expected to be lower due to dilution from tributaries.

Suspended sediment is predicted to result in 100 percent mortality of fall Chinook salmon eggs and fry spawned in the mainstem Klamath River during the fall prior to reservoir drawdown. Much of the overall effect on fall run Chinook salmon will depend on the relative proportion of mainstem spawners during the fall prior to reservoir drawdown. Based on redd surveys using a mark and re-sight methodology from 1999 through 2009 (Magneson and Wright 2010), an average of 2,100 redds from hatchery and naturally returning adults are constructed in the mainstem Klamath River and represents approximately 8 percent of total, basin-wide escapement (USBR and CDFG 2012).

5.1.2.3 Steelhead – Summer and Winter

High suspended sediment concentrations resulting from the dam decommissioning are anticipated to affect winter steelhead migrating during the winter and spring of reservoir drawdown, particularly for the portion of the population that spawns in tributaries upstream of the Trinity River. For that portion of the population, effects are anticipated on adults, run-backs, half-pounders, any juveniles rearing in the mainstem, and out-migrating smolts. However, the broad spatial distribution of steelhead in the Klamath Basin and their flexible life history suggests that some steelhead will avoid the most serious effects of the dam decommissioning by remaining in tributaries for extended rearing, rearing farther downstream where suspended sediment concentrations should be lower due to dilution, and/or moving out of the mainstem into tributaries and off-channel habitats during winter to avoid periods of high suspended sediment concentrations.

Additionally, the life history variability observed in steelhead means that, although numerous year classes will be affected, not all individuals in any given year class will be exposed to project effects. Some portion of the progeny of those adults that spawn successfully would also rear in tributaries long enough to not only avoid the highest suspended sediment concentrations, but may also not return to spawn for up to 2 years, when suspended sediment resulting from the dam decommissioning should be greatly reduced. The high incidence of repeat spawning among summer steelhead, ranging from 40 to 64 percent (Hopelain 1998) should also increase that population's resilience to dam decommissioning effects. Dam decommissioning modeling results suggest the loss of up to 1,988 winter steelhead redds and up to 130 summer steelhead redds.

5.1.2.4 Green Sturgeon

Under the 2012 EIS/R most-likely-to-occur scenario and worst-case scenario, the dam decommissioning project was anticipated to have no effect relative to existing conditions on adult green sturgeon (USBR and CDFG 2012; Vol. I, p. 3.3-164). Because green sturgeon are distributed downstream of Ishi Pishi Falls (river mile [RM 66]) in the lower Klamath River (McCovey 2008), and generally do not enter the lower Klamath River until April, green sturgeon are likely to experience lower dam decommissioning-related suspended sediment concentrations. Tributary inputs between Iron Gate Dam and Ishi Pishi Falls will dilute suspended sediment concentrations, and green sturgeon entering the system later in spring will be subjected to near background water quality conditions as dam decommissioning effects diminish into summer. Green sturgeon also emigrate from the Klamath River in the fall (Benson et al. 2007) and are not expected to experience high suspended sediment concentrations associated with the early stages of dam decommissioning.

Green sturgeon in the Klamath River spawn on average of every four years, although males occasionally spawn every two years (McCovey 2010), and therefore up to 75 percent of the mature adult population (as well as 100 percent of sub-adults) are likely to be in the ocean during the spring and summer of reservoir drawdown and avoid effects associated with dam decommissioning. Green sturgeon are long-lived (>40 years) and are able to spawn multiple times (Klimley et al. 2007), so effects on two year classes may have little influence on the population as a whole (USBR and CDFG 2012).

5.1.3 2012 EIS/R AR-3 Actions

The 2012 EIS/R AR-3 plan (Vol. I, pp. 3.3-245 and 3.3-246) described the potential for augmented fall flows in the mainstem Klamath River downstream from Iron Gate Dam to encourage the outmigration of post-spawned green sturgeon from the lower Klamath River and to potentially increase the proportion of fall Chinook salmon, coho salmon, and steelhead spawning in tributaries. Green sturgeon outmigration from the Klamath River and increased tributary spawning by anadromous salmonids would reduce the number of fish exposed to elevated suspended sediment concentrations in the Klamath River as a result of the dam decommissioning project.

The 2012 EIS/R AR-3 plan suggested that water releases from the Klamath River Hydroelectric Reach reservoirs should mimic the natural hydrograph during a wet year prior to the dam deconstruction project, and flows should be consistent with previous recommendations intended to recover endangered and threatened fishes in the Klamath River (National Research Council 2004). During a dry year, water balancing would need to be considered to meet the needs of other basin programs and ecological goals. The 2012 EIS/R plan also stated that increasing fall flows would likely be most successful if elevated mainstem flows coincided with elevated tributary flows. Synchronized mainstem and tributary flows would create a large enough pulse of water to encourage upstream mainstem migration and unhindered access into tributary streams.

The plan also specified that spawning surveys could be conducted prior to reservoir drawdown to monitor AR-3 effectiveness.

5.1.4 KRRC Review of AR-3 for Feasibility and Appropriateness

The KRRC assessed the feasibility and appropriateness of AR-3 through multiple planning meetings held with the ATWG between May and August 2017. During these meetings, new information on Klamath River fisheries was presented and information on other dam removal projects conducted in the western United States was reviewed to understand how the aquatic ecosystem might respond to the dam decommissioning project. Major concerns voiced by the ATWG regarding the 2012 AR-3 included:

- Uncertainty of water availability during fall prior to reservoir drawdown.
- Tributary flows influencing tributary spawning.
- Water needs during reservoir drawdown for sediment evacuation.
- Adult coho salmon locations at the time of the reservoir drawdowns.
- Green sturgeon outmigration timing.

The following sections provide additional information regarding AR-3 feasibility and appropriateness, based on fisheries literature and ATWG input.

5.1.4.1 Uncertainty of Water Availability Prior to Reservoir Drawdown

The ATWG voiced concerns that the extra water needed to create the fall pulse flows prior to reservoir drawdown may not be available depending on the water year, water rights, and other basin program needs. Given these concerns, water availability creates a project uncertainty and executing the measure may not be possible. The ATWG concluded that the current operation plans in place for USBR's Klamath Project have been analyzed under a biological opinion (NOAA and USFWS 2013) and are sufficient to describe water releases throughout the year to meet biological goals in the basin.

5.1.4.2 Tributary Flows Influencing Tributary Spawning

ATWG stated that the proportion of tributary spawning by coho salmon and Chinook salmon is dictated by flows in natal tributaries and not by flow conditions in the mainstem Klamath River. Since many of the primary spawning tributaries are unregulated, fall flows will be determined by the meteorological conditions that occur during the fall prior to reservoir drawdown and thus cannot be predetermined. The ATWG thought that while some water leasing options could be pursued in the Shasta River, water leasing in other tributaries is unlikely based on a lack of existing water leasing agreements and therefore, tributary flows may have minimal influence on the number of spawning fish in the Klamath River. The ATWG also stated that efforts to use pulse flows in the past have been unsuccessful in moving large numbers of fish into the river or into tributary streams.

In summary, KRRC and ATWG concluded that the prescribed fall pulse flows would have little or no effect on tributary streamflow and therefore is not anticipated to result in any additional tributary spawning during a dry year, and therefore could not be relied upon as a measure.

5.1.4.3 Water Needs During Reservoir Drawdown

ATWG expressed concerns that using available water volume for fall pulse flows could increase or extend the deleterious effects of elevated suspended sediment concentrations to other aquatic organisms in the Hydroelectric Reach and downstream from Iron Gate Dam. By using available water prior to reservoir drawdown, the ATWG expressed concern that less reservoir sediments would be evacuated in the first year, causing prolonged sediment effects beyond dam decommissioning.

KRRC and ATWG concluded that using available storage water in the fall prior to reservoir drawdown could potentially worsen or extend the deleterious effects of elevated suspended sediment concentrations on Klamath River focal species and stored water would be better used to evacuate as much sediment as possible during dam decommissioning.

5.1.4.4 Adult Coho Salmon Locations at Time of Reservoir Drawdown

KRRC and ATWG concluded that since coho salmon primarily spawn in Klamath River tributaries, adult coho salmon will largely be unaffected by poor water quality conditions associated with reservoir drawdown in the mainstem Klamath River. Coho salmon peak spawning typically occurs in November and December after fall freshets contribute to tributary flows (USBR and CDFG 2012). Additionally, the low numbers of coho salmon that spawn in the mainstem Klamath River are mostly of hatchery origin (NOAA 2014).

KRRC and ATWG concluded that the dam decommissioning effects to adult coho salmon will be minimal as the majority of coho salmon spawning takes place in tributaries, and that the implementation of fall pulse flows would not likely result in any further tributary spawning by natural origin coho salmon.

5.1.4.5 Green Sturgeon Outmigration Timing

ATWG stated that while green sturgeon outmigration timing from the lower Klamath River and estuary is correlated to increasing streamflow and decreasing water temperatures, these conditions would likely occur naturally prior to reservoir drawdown and additional releases of water are unnecessary to promote outmigration. Benson et al. (2007) stated that outmigration of any holding green sturgeon occurred during the first significant rainfall, usually in November and December. A green sturgeon tagging program in the lower Klamath River, has found no green sturgeon in either the Klamath River or Trinity River after mid-December (Barry McCovey, Yurok Tribe, personal communication, 2017).

KRRC and ATWG concluded that streamflow will naturally increase with fall rains, and no additional flow augmentation will be necessary to ensure that green sturgeon will outmigrate from the lower Klamath River and estuary prior to dam decommissioning.

5.1.4.6 2012 EIS/R Baseline Population Estimates and Project Effects Uncertainty

Effects to adult fish outlined in the 2012 EIS/R (Vol. II, Appendix E) included approximations and assumptions that were based on limited data on Klamath River anadromous salmonids and green sturgeon; incorporated a conservative analysis of fish avoidance behavior to the anticipated water quality conditions; and in part included a worst-case scenario analysis of dam decommissioning effects on adult Chinook and coho salmon, and green sturgeon.

5.1.4.7 Project Effects Uncertainty

Studies suggest that high suspended sediment concentrations (Newcombe and Jensen 1996; Chapman et al. 2014; Kjelland et al. 2015) and low dissolved oxygen concentrations (Bjorn and Reiser 1991; Washington Department of Ecology [WDOE] 2002; Carter 2005) affect adult salmonid behavior. Adult salmonid behavioral changes to high suspended sediment concentrations include avoidance of turbid waters in homing adult anadromous salmonids. Physiological effects of high turbidity include physiological stress and respiratory impairment, damage to gills, reduced tolerance to disease and toxicants, reduced survival, and direct mortality (Newcombe and Jensen 1996). Concentration and duration of elevated suspended sediment, as well as other factors including water temperature, disease, and river flow, influence the effect of suspended sediment on salmonids.

Very little information is available on the effects of suspended sediment on sturgeon, and most life stages of sturgeon are more resilient to poor water quality than salmonids (USBR and CDFG 2012).

Adult steelhead and Pacific lamprey entering the Klamath River during reservoir drawdown and dam removal would encounter poor water conditions and would be expected to avoid poor water quality by either entering tributary streams or using habitats less affected by high suspended sediment concentrations (e.g., tributary confluences or off-channel areas). For instance, in 2012 during dam deconstruction on the Elwha River, a high proportion (44 percent) of Chinook salmon redds were documented in two clear water tributaries (Indian Creek and Little River), while surveys conducted following dam removal activities (2014-2016) resulted in over 95 percent of Chinook redds constructed in the mainstem river. The high proportion of tributary spawning by fall Chinook salmon in 2012 suggests that these streams provided refugia from the effects of dam removal (McHenry et al. 2017). There is increasing evidence that fish will modify their behavior to avoid areas of high suspended sediment concentrations immediately following dam removal, thereby reducing the impact of reduced water quality on their populations. This is consistent with ecological and evolutionary theories that would predict that fish would evolve behaviors to avoid episodic events resulting is poor water quality, such as landslides, fires, and other naturally occurring processes.

The 2012 EIS/R effects determination assumed that fish would not exhibit behavioral responses to poor water quality, and instead would experience high mortality by voluntarily remaining in areas that had lethal concentrations of suspended sediment for extended periods of time.

5.2 AR-3 Summary

The 2012 EIS/R AR-3 included fall pulse flows to promote adult Chinook salmon and coho salmon migration into tributary streams for spawning, and to encourage the outmigration of green sturgeon from the lower Klamath River and estuary in advance of the dam decommissioning project. These migratory behaviors in response to the fall pulse flows were anticipated to reduce the effects of high suspended sediment concentrations on anadromous species in the mainstem Klamath River. KRRC and ATWG concluded that fall pulse flows would be difficult to execute due to unknown water availability and water needs of other water users in the basin. Additionally, higher mainstem flows would not necessarily improve tributary flow conditions unless higher tributary flows occurred concurrently with the mainstem pulse flows, or if water leasing could be undertaken on key tributaries. Chinook salmon, coho salmon, and green sturgeon have also evolved with the variable hydrology of the Klamath River and are likely to migrate into tributaries (Chinook and coho salmon) or to the Pacific Ocean (green sturgeon) with the onset of fall rain and increased flows which will precede the dam decommissioning project. Finally, implementing the fall pulse flows could also diminish available storage that could be used to maximize reservoir sediment flushing during reservoir drawdown.

In summary, KRRC proposes to follow USBR's existing operational plans outlined in the 2013 Biological Opinion (NOAA and USFWS 2013) and will not implement the 2012 EIS/R AR-3 plan.

6. AR-4 Iron Gate Hatchery Management

The objective of AR-4 is to address reservoir drawdown and dam removal effects on hatchery-produced Chinook salmon and coho salmon smolts that would be released from Iron Gate Hatchery during the spring of the reservoir drawdown year during periods of high suspended sediment concentration which are potentially lethal to outmigrating juvenile salmonids. The original 2012 EIS/R AR-4 plan focused on delaying the release timing for hatchery produced smolts, or trucking hatchery smolts to downstream reaches of the Klamath River less affected by suspended sediment concentrations.

The KRRC recommends Iron Gate Hatchery-reared yearling coho salmon scheduled to be released in the spring of the drawdown year could be held at Iron Gate Hatchery or at another facility (depending on Iron Gate Hatchery's operational capacity) until water quality conditions in the mainstem Klamath River improve to sublethal levels. Based on the current Iron Gate Hatchery release schedules and suspended sediment predictions in the Klamath River following dam decommissioning, yearling coho salmon releases could be delayed approximately 2 weeks to avoid lethal water quality conditions. Water quality monitoring stations established prior to reservoir drawdown would be used to determine when conditions in the mainstem Klamath River are suitable for the release of hatchery-reared coho salmon.

6.1 Summary of the 2012 EIS/R AR-4, Dam Removal Benefits and Effects, and Recent Fisheries Literature

The following sections review the components of the 2012 EIS/R AR-4 measure, anticipated dam removal effects and benefits on AR-4 species, and recent fisheries literature relative to juvenile salmonid outmigration. This information is presented in support of the existing AR-4 measure.

6.1.1 AR-4 Affected Species

Species identified in AR-4 include:

- Coho salmon (*Oncorhynchus kisutch*) – Southern Oregon/Northern California Coastal (SONCC) evolutionary significant unit (ESU): Federally Threatened; California Threatened; Tribal Trust Species
- Chinook salmon (*O. tshawytscha*) – Upper Klamath-Trinity Rivers ESU - Fall Run: California Species of Special Concern; Tribal Trust Species

6.1.2 Anticipated Dam Decommissioning Effects on AR-4 Species

Short-term effects of dam removal were expected to result in mostly sublethal, and in some cases lethal, impacts to a portion of the juvenile Chinook salmon, coho salmon, steelhead, and Pacific lamprey that are outmigrating from tributary streams to the Klamath River during late winter and early spring of 2020 (USBR and CDFG 2012). Deleterious short-term effects are expected to be caused by high SSC levels and low dissolved oxygen concentrations in the Klamath River from Iron Gate Dam downstream to Orleans. Hatchery-produced Chinook and coho salmon smolts that are released from the Iron Gate Hatchery into this reach could suffer from high mortality if they are released during periods of high SSC levels as a result of the dam decommissioning. Iron Gate Hatchery current production goals include 75,000 yearling coho salmon, 900,000 yearling Chinook salmon, and 5,100,000 Chinook salmon smolts (CDFW and PacifiCorp 2014). Table 6-1 includes the production goals and typical release schedules for Iron Gate Hatchery. Table 6-2 includes the actual production for 2001 to 2017 (K. Pomeroy, CDFW, personal communication, 2017).

Table 6-1 Current Iron Gate Hatchery production goals and release schedules

Species	Release Type	Production Goal	Release Schedule
Coho Salmon	Yearling	75,000	March-April
Chinook Salmon - Fall	Yearling	900,000	November
Chinook Salmon - Fall	Smolt	5,100,000	May-June

Table 6-2 Iron Gate Hatchery actual annual production totals for 2001 to 2017

Release Year	Chinook	Coho	Steelhead	Total
2001	5,849,147	46,254	31,898	5,929,300
2002	5,880,294	67,933	141,362	6,091,591
2003	5,595,997	74,271	192,771	5,865,042
2004	5,777,904	109,374	148,991	6,038,273
2005	6,212,640	74,716	195,698	6,485,059
2006	7,046,755	89,482	83,034	7,221,277
2007	6,348,474	118,487	21,208	6,490,176
2008	6,394,875	53,950	18,461	6,469,294
2009	4,749,470	118,340	29,683	4,899,502
2010	5,380,185	121,000	22,500	5,525,695
2011	4,882,247	22,236	21,034	4,927,528
2012	6,180,447	155,840	51,948	6,390,247
2013	5,091,396	39,402	-	5,132,811
2014	5,422,994	79,585	-	5,504,593
2015	943,489	89,500	-	1,035,004
2016	4,612,598	27,568	-	4,642,182
2017	410,686	17,102	-	429,805
Total	86,779,598	1,305,040	958,588	89,077,379
Max	7,046,755	155,840	195,698	7,221,277
Ave	5,104,682	76,767	79,882	5,239,846
Min	410,686	17,102	18,461	429,805

6.1.3 2012 EIS/R AR-4 Actions

The 2012 EIS/R AR-4 plan (Vol. I, p. 3.3-246) included two potential actions that could be implemented to reduce the impacts of high SSC levels on hatchery Chinook and coho salmon smolts as a result of dam decommissioning. The first action is to delay the coho salmon yearling release until later in the spring (e.g., early to mid-May) in order to avoid peak SSC levels associated with the dam decommissioning. Avoiding the peak SSC levels is anticipated to reduce smolt mortality.

An alternative action to the delayed smolt release approach included allowing sub-yearling and yearling smolts to imprint at the hatchery and then truck them to Klamath River release locations downstream of the Trinity River where tributary flows are anticipated to reduce SSC levels to near background. The timing of the releases would be consistent with normal hatchery release schedules.

The 2012 EIS/R AR-4 plan suggested that the implementation of this measure is contingent on the hatchery remaining open and having a suitable water supply during dam decommissioning.

6.1.4 KRRC Review of AR-4 for Feasibility and Appropriateness

The KRRC assessed the feasibility and appropriateness of AR-4 through multiple planning meetings held with the ATWG between May and August 2017. During these meetings, new information on Klamath River fisheries and hatchery management was presented and information on other dam removal projects conducted in the western United States was reviewed to understand how the aquatic ecosystem might respond as discussed above. Major concerns voiced thus far by the ATWG regarding the 2012 AR-4 included:

- Iron Gate Hatchery water supply uncertainty during and after dam decommissioning.
- Potential mortality associated with hauling and releasing juvenile salmonids.
- Potential Chinook and coho salmon juvenile imprinting and adult straying issues.

The following sections provide additional information regarding AR-4 feasibility and appropriateness, based on fisheries literature and ATWG input.

6.1.4.1 Iron Gate Hatchery Water Supply Uncertainty

The ATWG voiced concerns that the current water supply for the Iron Gate Hatchery is located at varying depths in Iron Gate Reservoir and will no longer be operational following dam decommissioning. Additionally, high SSC levels in the Klamath River during reservoir drawdown will require an alternative water source(s) or filtration of river water for use in the hatchery, as the water quality will not be sufficient for hatchery operation. The ATWG to currently reviewing potential alternative water sources or water treatment solutions that would allow for continued Iron Gate Hatchery operation during and after the dam decommissioning.

6.1.4.2 Potential Mortality Associated with Hauling and Releasing Juvenile Salmonids

The ATWG expressed concerns that long trucking distances could result in stress and handling mortality of transported fish. The ATWG was concerned that truck or equipment malfunction could also result in smolt losses during transport. Transporting juvenile salmonids causes stress in smolts (Barton et al. 1980; Specker and Schreck 1980; Matthews et al. 1986), which may reduce survival when fish are released (Kenaston et al. 2001).

The ATWG concluded that transporting hatchery Chinook and coho salmon smolts long distances downstream from Iron Gate Hatchery could lead to high mortality rates.

6.1.4.3 Potential Chinook and Coho Salmon Juvenile Imprinting and Adult Straying Issues

ATWG expressed concerns regarding how handling and transport of juvenile salmonids may affect imprinting processes resulting in future straying of returning adults. Juvenile imprinting is influenced by natal stream water chemistry and the juvenile fish's physiological state during rearing and outmigration (Keefer and Caudill 2014). Juvenile fish with extended freshwater residency times, or long-distance migrations, almost certainly experience multiple imprinting events that contribute to homing success of adult spawners. Transporting juvenile fish has been shown to disrupt this 'sequential imprinting' process, and several studies on coho salmon (Solazzi et al. 1991) and Atlantic salmon (Gunnerød et al. 1988; Heggberget et al. 1991) have shown that adult homing success is inversely related to transport distance from rearing sites (Keefer and Caudill 2014).

Therefore, the release of juvenile fish downstream of the Trinity River could compromise the imprinting process for relocated juvenile fish. Insufficient imprinting to natal streams or the loss of spatially distinct imprinting events during outmigration could potentially increase adult straying rates during future returns and result in the loss of genetic integrity in distinct populations. Future, elevated stray rates could result in a more homogenous distribution of fish returning to the lower Klamath River and also hinder the natural recolonization of areas upstream of Iron Gate Dam.

The ATWG concluded that releasing hatchery-reared fish downstream of the Trinity River could jeopardize future hatchery returns to the upper Klamath River and could increase straying rates that could negatively affect wild populations.

6.2 AR-4 Summary

The 2012 EIS/R AR-4 included two strategies for addressing short-term dam decommissioning effects to hatchery-produced Chinook and coho salmon smolts. The two strategies included either delaying the release of Chinook salmon smolts and coho salmon yearlings, or the transport of these fish from Iron Gate Hatchery to the lower Klamath River where the fish would be released into reaches less affected by poor water quality associated with the dam decommissioning. Delaying the release of yearling coho salmon is not expected to require a substantial change in the typical hatchery release schedule and may only require a two-week delay in the release schedule. The ATWG raised concerns about potential juvenile stress and mortality associated with the trucking option, and increased stray rates of returning adults due to insufficient juvenile imprinting. In summary, the KRRC recommends the delayed release of yearling coho salmon from Iron Gate Hatchery.

7. AR-5 Pacific Lamprey Ammocoetes

The objective of AR-5 is to monitor the distribution and abundance of Pacific lamprey ammocoetes downstream of Iron Gate Dam. The original 2012 EIS/R AR-5 measure involved capturing and relocating Pacific lamprey ammocoetes from the Klamath River starting at, and extending 2 miles downstream from Iron Gate Dam (RM 192.9). Relocating lamprey ammocoetes from this reach was expected to offset some of the potential effects of high suspended sediment concentrations and low dissolved oxygen levels during reservoir drawdown.

Based on existing lamprey ammocoete presence information, dam removal effects to Pacific lamprey ammocoetes in the 2-mile reach downstream from Iron Gate Dam (RM 192.9) are expected to be minimal, and the KRRC recommends no protective action is necessary for Pacific lamprey ammocoetes.

7.1 Summary of the 2012 EIS/R AR-5, Dam Removal Benefits and Effects, and Recent Fisheries Literature

The following sections review the components of the 2012 EIS/R AR-5 measure, anticipated dam removal effects and benefits on Pacific lamprey ammocoetes, and recent fisheries literature relative to Pacific lamprey ammocoetes.

7.1.1 AR-5 Affected Species

Species identified in AR-5 include:

- Pacific lamprey (*Entosphenus tridentatus)*: California Species of Special Concern; Oregon Sensitive Species, Tribal Trust Species

7.1.2 Anticipated Dam Decommissioning Effects on AR-5 Species

The short-term effects of dam removal (high suspended sediment concentrations and low dissolved oxygen) are anticipated to result in high rates of ammocoete mortality, although the resilience of ammocoetes to extended periods of high suspended sediment concentrations and low dissolved oxygen are unknown (Goodman and Reid 2012). The 2012 EIS/R (Reclamation and CDFG 2012; Vol. II, Appendix E, pp. E52-E56) analysis applied the effects of suspended sediment on salmonids to predict effects on Pacific lamprey ammocoetes, with the assumption that effects on Pacific lamprey ammocoetes are equivalent to or less severe than on salmonids. This likely overestimates any effects to lamprey ammocoetes since their preferred rearing strategy is to burrow in fine sediments mixed with organic matter. In general, most life stages of Pacific lamprey appear to be more resilient to poor water quality conditions (such as suspended sediment) than salmonids (Zaroban et al. 1999). Table 7-1 includes the anticipated effects to Pacific lamprey ammocoetes presented in the 2012 EIS/R (Reclamation and CDFG 2012).

Table 7-1 2012 EIS/R anticipated effects summary for Pacific lamprey ammocoetes

Species	Life Stage	Likely Effects	Worst Effects
Pacific Lamprey	Ammocoete Rearing	High mortality (52%)[1]	High mortality (71%)[1]

Source: USBR and CDFG 2012

Dam decommissioning would have short-term effects on Pacific lamprey ammocoetes related to suspended sediment concentrations, bedload sediment transport and deposition, and impaired water quality (particularly low dissolved oxygen levels). Overall, because multiple year classes of Pacific lamprey rear in the mainstem Klamath River at any given time, and since adults will migrate upstream over the entire year, including January of the reservoir drawdown year when effects from the dam decommissioning will be most pronounced, effects on Pacific lamprey adults and ammocoetes are anticipated to be substantial. However, because of their wide spatial distribution and varied life history, most of the population (which spans nearly the entire northern Pacific Rim), would not be affected by the dam decommissioning. In addition, Pacific lamprey are considered to have low fidelity to their natal streams (FERC 2006), and may not enter the mainstem Klamath River if environmental conditions are unfavorable during the reservoir drawdown period. Migration into the Trinity River and other lower Klamath River tributaries may also increase during reservoir drawdown because of poor water quality in the upper Klamath River. Low site fidelity and a prevalence of tributary ammocoetes also increases the potential for Pacific lamprey recolonization of mainstem habitats following dam decommissioning.

The 2-mile reach of the Klamath River downstream from Iron Gate Dam (RM 192.9) was the focus of lamprey relocation efforts in the 2012 EIS/R (Reclamation and CDFG 2012). At the time of the 2012 EIS/R, lamprey ammocoete presence downstream from Iron Gate Dam was unknown. Recent surveys have found very low numbers or absence of lamprey ammocoetes in the Klamath River between Iron Gate Dam and the Scott River (approximately 47 river miles; Goodman and Hetrick 2017). Referenced as a "dead zone" containing few ammocoetes this reach is presumably affected by flow management, poor water quality, lack of sandy fines, and high deposition rates of organic material (Goodman and Reid 2015). Kostow (2002) also found Pacific lamprey ammocoete distributions can be patchy, perhaps due to environmental conditions, and Petersen (2006) related tribal eelers' belief that the effects of the dams on anadromous fish returns may affect marine-derived nutrients that sustain ammocoetes.

Tribal elders and eelers with the Yurok and Karuk Tribes were interviewed as part of a traditional ecological knowledge (TEK) project investigating the importance of Pacific lamprey to the lower Klamath River tribes (Petersen 2006). Eelers noted the dramatic reduction in Pacific lamprey since European-American settlement and specifically over the last 50 years. The construction of Iron Gate Dam, mining, forest fire suppression, commercial logging, other forestry practices including herbicide application, road building, rotenone treatments (see Jackson et al. 1996 for similar treatments in the Columbia Basin), periodic high magnitude floods, and changing ocean conditions were frequently identified as reasons for Pacific lamprey declines in the basin (Petersen 2006). Of these impacts, loss of the natural flow regime on the Klamath River was highlighted as having the most detrimental effect on Pacific lamprey spawning and ammocoete rearing habitats. Dewatering of channel margin ammocoete rearing habitats downstream from Iron Gate Dam caused by hydropower ramping were also suspected in the decline of Pacific lamprey (Petersen 2006).

Dam decommissioning will address some of the limiting factors that are believed to currently affect Pacific lamprey across their geographic region and in the Klamath River basin. Increasing connectivity across the river network and restoring connectivity between the Klamath River and tributaries in the Hydroelectric Reach will provide access to more Pacific lamprey spawning and rearing habitats (Schultz et al. 2014). Restoring more natural flow and temperature regimes, and transport of fine sediments downstream of Iron Gate Dam, will improve ammocoete rearing habitat conditions. Ammocoete rearing habitats are believed to be important for maintaining recruitment to the population as these areas provide pheromone-based migratory cues for spawning adults (Stone et al. 2002; Li et al. 2003) and may preserve lamprey population persistence (Jolley et al. 2016).

7.1.3 2012 EIS/R AR-5 Actions

The 2012 EIS/R AR-5 plan directed the capture and relocation of Pacific lamprey ammocoetes from preferred habitats in the reach of the Klamath River starting at, and extending 2 miles downstream from Iron Gate Dam. Relocating lamprey ammocoetes from this reach was expected to offset some of the potential effects of high suspended sediment concentrations and low dissolved oxygen levels during reservoir drawdown.

The 2012 EIS/R AR-5 measure included the following tasks.

- Identify preferred habitat areas where dissolved oxygen levels would be particularly low, including pools, alcoves, backwaters, and channel margins that experience low water velocities and sand and silt deposition from the reach within 2 miles downstream from Iron Gate Dam.
- Conduct reconnaissance level surveys to assess if enough ammocoetes are present in this reach to warrant protection.
- The salvage operation, if implemented, would be conducted utilizing a specialized backpack electrofishing unit to capture ammocoetes. Captured individuals would be transported to suitable locations (with current low occurrences of lamprey) within tributaries upstream or upstream of Keno Dam.

7.1.4 KRRC Review of AR-5 for Feasibility and Appropriateness

The KRRC assessed the feasibility and appropriateness of AR-5 through multiple planning meetings held with the ATWG between May and August 2017. During these meetings, current information on Klamath River fisheries was presented and information on other dam removal projects conducted in the western United States were reviewed to understand how the aquatic ecosystem might respond as discuss above. Major concerns voiced by the ATWG regarding the 2012 AR-5 included:

- Pacific lamprey ammocoete absence in the prescribed 2012 EIS/R salvage reach.
- Potential effects of relocated Pacific lamprey ammocoetes on endemic lamprey species.

- Effects to the Pacific lamprey metapopulation.

The following sections provide additional information regarding AR-5 feasibility and appropriateness based on supplemental information provided in the 2012 EIS/R, current fisheries research literature, and input from the ATWG.

7.1.4.1 Pacific Lamprey Ammocoetes Absence from Salvage Reach

Previous sampling efforts conducted by the Karuk Tribe and USFWS in the proposed salvage reach (2 miles downstream from Iron Gate Dam) found very few or no ammocoetes in sampled habitats (Goodman and Hetrick 2017; T. Soto, Karuk Tribe, personal communication, 2017). At 37 sites sampled in the Klamath River, ammocoetes were detected at an expected catch per unit effort at all locations except those within proximity to Iron Gate Dam (Goodman and Hetrick 2017). Goodman and Reid (2015) documented the 47-mile reach of the Klamath River from Iron Gate Dam to the Scott River as a “dead zone” containing few ammocoetes, presumably due to flow management, poor water quality, lack of sandy fines, and high deposition rates of organic material. Since river conditions and river management have not changed since these ammocoete survey were completed, Pacific lamprey ammocoete habitation in the 2-mile reach downstream of Iron Gate Dam is unlikely. The ATWG concluded further allocation of resources to sample ammocoetes from this reach is not warranted.

7.1.4.2 Effects of Relocated Pacific Lamprey Ammocoetes on Endemic Lamprey Ammocoetes

Currently, five other resident species of lamprey occur in the Klamath Basin. Although Pacific lamprey likely historically occupied the Upper Klamath Basin (Goodman and Reid 2015) and tribal knowledge relates that Pacific lamprey occupied habitats beyond the upstream limit of steelhead occupation (Petersen 2006), there are uncertainties regarding the historical overlap of Pacific lamprey and endemic lamprey species (ODFW 2008). The ATWG suggested that it would be difficult or impossible to differentiate larval lamprey ammocoetes of a variety of species during a field relocation effort. With this consideration, the ATWG expressed concerns regarding the potential effects of relocating non-target ammocoetes to areas upstream of Keno Dam or into Klamath River tributaries as the original 2012 EIS/R AR-5 specified. Potential effects on endemic lamprey species could include competition for habitat and food, and disease transmission from relocated lamprey ammocoetes to existing populations. ODFW’s 2008 draft of *A Plan for the Reintroduction of Anadromous Fish in the Upper Klamath Basin* sought a passive reintroduction strategy for Pacific lamprey. ODFW’s current strategy is likely to follow a similar passive reintroduction process (T. Wise, ODFW, personal communication, 2017). The ATWG concluded that relocating salvaged lamprey ammocoetes from the mainstem Klamath River could pose significant risks to other endemic lamprey species.

7.1.4.3 Pacific Lamprey Metapopulation

Recent genetic analysis of Pacific lamprey suggests no significant population structure exists across populations or regions, indicating a high degree of historical gene flow even across expansive distances of the northern Pacific Rim (Goodman and Reid 2012). Klamath Basin Pacific lamprey are part of a more geographically-widespread interbreeding population that exhibits little basin-specific site fidelity (Goodman and Hetrick 2017). Because the metapopulation is now believed to extend potentially across the species' range, the percentage of the metapopulation's adult and larval Pacific lamprey that will be affected by the dam decommissioning will be insignificant. The ATWG concluded that the potential loss of Pacific lamprey ammocoetes during dam decommissioning would be a temporary impact to the population and ammocoete mortality would constitute a minimal impact to the metapopulation.

7.2 AR-5 Summary

The Klamath River from Iron Gate Dam downstream to the Scott River (47 miles) is referred to as a "dead zone" for Pacific lamprey ammocoetes. Past sampling efforts have detected few or no ammocoetes in this reach. Based on these sampling efforts and concerns regarding Pacific lamprey ammocoete relocation, no protective actions are planned to address project effects to Pacific lamprey ammocoetes. Like other reviewed species, Pacific lamprey are expected to benefit from the dam decommissioning project over the long-term. Benefits to Pacific lamprey include restoring access to historical habitat upstream of Iron Gate Dam, fine sediment transport and local fining of channel bed sediments downstream of Iron Gate Dam, and improved water quality conditions.

8. AR-6 Suckers

The objective of AR-6 is to address reservoir drawdown and dam removal effects on Lost River and shortnose suckers inhabiting the Hydroelectric Reach reservoirs by salvaging suckers from the reservoirs and relocating the salvaged suckers to waterbodies outside of the affected area. The original 2012 EIS/R AR-6 measure focused on trapping and hauling Lost River, shortnose, and Klamath smallscale suckers. Lost River and shortnose suckers would be released into Upper Klamath Lake, and Klamath small smallscale suckers released into Spencer Creek, a tributary to the Klamath River in the Hydroelectric Reach. Based on a review of the information provided herein, the KRRC concluded that an updated AR-6 is necessary to address anticipated short-term effects of the dam decommissioning project. The updated AR-6 measure includes a step-wise adaptive process for sampling, salvaging, and releasing Lost River and shortnose suckers into waterbodies that will not be affected by dam decommissioning effects.

8.1 Proposed Updated AR-6

Based on a review of the original 2012 EIS/R AR-6 measure presented in Section 8.2, input from the ATWG, and recent Lost River and shortnose suckers literature, the KRRC concluded that an updated AR-6 is necessary to offset the anticipated short-term effects of dam decommissioning on Lost River and shortnose suckers. The updated AR-6 includes sampling, and salvaging and releasing suckers into designated waterbodies that are isolated from sucker recovery populations in Upper Klamath Lake. The updated AR-6 has two actions.

- **Action 1**: Lost River and shortnose suckers will be sampled in the Klamath River and in Hydroelectric Reach reservoirs in 2018. River sampling will be completed in spring of 2018 and reservoir sampling will be completed in fall of 2018. The purpose of sampling is to document the abundance and genetics of Lost River and shortnose suckers in the Hydroelectric Reach. Captured fish will be marked with a passive integrated transponder (PIT) tag, fin clipped for genetic material, measured, and released. Recaptured fish will be used to estimate the sucker population abundance. Fin clips will be used to determine the genetics of the sampled fish. USFWS is currently developing genetic markers for Lost River and shortnose suckers.
- **Action 2**: Adult Lost River and shortnose suckers in reservoirs downstream from Keno Dam would be captured and relocated to isolated water bodies in the Klamath Basin. The proposed relocation of rescued suckers to isolated waterbodies is to ensure hybridized suckers do not mix with sucker populations designated as recovery populations in Upper Klamath Lake. An estimated 14 days will be required for sampling, and 14 days will be required for salvage and release efforts. We anticipate salvaging and translocating 100 Lost River and 100 shortnose suckers from each of the three Klamath River reservoirs (600 fish total). The number of translocated fish will not exceed 3,000 fish, which is the capacity of the currently identified recipient waterbody (Tule Lake). The salvage effort will likely translocate less than 10 percent of the sucker populations in the respective reservoirs.

The proposed actions are intended to reduce Project effects on Lost River and shortnose suckers inhabiting the Hydroelectric Reach reservoirs. The following sections provide additional detail on the proposed actions.

8.1.1 Action 1: Reservoir and River Sampling

Lost River and shortnose suckers will be sampled in the Hydroelectric Reach reservoirs and the Klamath River in 2018. Sampling in both the reservoirs and the Klamath River is anticipated to improve the number of fish encounters since suckers may not spawn every year (Buettner 2000) and the current population demographics are unknown.

River sampling will be completed in spring of 2018 and reservoir sampling will be completed in fall of 2018. The intent of the sampling is to document the abundance and genetics of Lost River and shortnose suckers in the Hydroelectric Reach. Sampling will include placing trammel nets in the reservoirs (reservoir sampling) and in Klamath River segments upstream of the reservoirs (river sampling) to determine the abundance and genetics of suckers in the Hydroelectric Reach. Electrofishing or other means of trapping suckers may also be employed if trammel netting is ineffective. Captured fish will be marked with a PIT tag (Burdick 2013), fin clipped for genetic material, measured, and released. Recaptured fish will be used to estimate the size of sucker populations, and fin clips will be used to determine the genetics of the sampled fish. Summary reports will be prepared following each sampling effort and the ATWG will meet to review the sampling data and determine if additional sampling is necessary. Collected data will be stored in a database managed by USFWS or USGS.

Primers will need to be developed from the genetic markers that USFWS's Abernathy Fish Technology Center identifies for Lost River and shortnose suckers. Genetic analysis of the sampled suckers will be used to inform managers on the genetics of Lost River and shortnose sucker populations in the Hydroelectric Reach. Genetic information will in part be used to determine appropriate salvaged suckers' release locations.

8.1.2 Action 2: Sucker Salvage and Relocation

Adult Lost River and shortnose suckers in reservoirs downstream from Keno Dam would be captured and relocated to isolated water bodies in the Klamath Basin using similar methods as outlined for the sampling. The proposed relocation of rescued suckers to isolated waterbodies is to ensure hybridized suckers do not mix with sucker populations designated as recovery populations in Upper Klamath Lake. An estimated 14 days will be required for sampling, and 14 days will be required for salvage and release efforts. We anticipate salvaging and translocating 100 Lost River and 100 shortnose suckers from each of the three Klamath River reservoirs (600 fish total). The number of translocated fish will not exceed 3,000 fish, which is the capacity of the currently identified recipient waterbody (Tule Lake). The salvage effort will likely translocate less than 10 percent of the sucker populations in the respective reservoirs.

In summary, the updated AR-6 includes two actions to sample and then salvage and relocate Lost River and shortnose suckers from the Hydroelectric Reservoirs to Tule Lake.

8.2 Summary of the 2012 EIS/R AR-6, Dam Removal Benefits and Effects, and Recent Fisheries Literature

The following sections review the components of the 2012 EIS/R AR-6 measure, anticipated dam removal effects on Lost River and shortnose suckers, and current sucker literature.

8.2.1 AR-6 Affected Species

Species identified in AR-6 include:

- Lost River sucker (*Deltistes luxatus*): Federally Endangered; California Endangered and Fully Protected; Oregon Endangered; Tribal Trust Species
- Shortnose sucker (*Chasmistes brevirostris*): Federally Endangered; California Endangered and Fully Protected; Oregon Endangered; Tribal Trust Species
- Klamath smallscale sucker (*Catostomus rimiculus*)

8.2.2 Anticipated Dam Decommissioning Effects on AR-6 Species

The dam decommissioning project will result in the loss of Lost River and shortnose sucker reservoir populations as the lake-type habitat these sucker species inhabit will be restored to free-flowing riverine conditions. Although sucker populations in the Hydroelectric Reach reservoirs are generally unknown (Buettner et al. 2006), past sampling efforts have documented larval and adult suckers in Topsy Reservoir (J.C. Boyle Dam; Desjardins and Markle 2000), Copco Reservoir (Copco 1 Dam; Beak Consultants 1987; Desjardins and Markle 2000), and Iron Gate Reservoir (Desjardins and Markle 2000). More recent anecdotal evidence suggests a sucker spawning run occurred upstream of Topsy Reservoir in April 2017 (B. Tinniswood, ODFW, personal communication, 2017). Table 8-1 includes the likely and worst-case effects to Lost River and shortnose suckers in the Hydroelectric Reach reservoirs.

Table 8-1 2012 EIS/R anticipated effects summary for Lost River and shortnose suckers

Species	Life Stage	Likely Effects	Worst Effects
Lost River & Shortnose Suckers	All	Loss of reservoir populations	Loss of reservoir populations

Source: USBR and CDFG 2012

The following section includes a description of species-specific effects adapted from the 2012 EIS/R (Reclamation and CDFG 2012; Vol. I, pp. 3.3-166 to 3.3-168) and other literature.

8.2.2.1 Lost River Suckers and Shortnose Suckers

Lost River and shortnose suckers are endemic to the Upper Klamath Basin (Moyle 2002). The Lost River sucker historically occurred in Upper Klamath Lake (Williams et al. 1985) and its tributaries, and the Lost River watershed, Tule Lake, Lower Klamath Lake, and Sheepy Lake (Moyle 1976). Shortnose suckers historically occurred throughout Upper Klamath Lake and its tributaries (Williams et al. 1985; Miller and Smith 1981). The present distribution of both species includes Upper Klamath Lake and its tributaries (Buettner and Scoppettone 1990), Clear Lake Reservoir and its tributaries (USFWS 1993), Tule Lake, Lost River up to Anderson-Rose Dam (USFWS 1993), and the Klamath River downstream to Copco Reservoir and probably to Iron Gate Reservoir (USFWS 1993). Shortnose sucker occur in Gerber Reservoir and its tributaries, but Lost River sucker do not.

The dam decommissioning project will eliminate existing reservoir habitat used by Lost River and shortnose suckers. The Lost River and shortnose suckers that have been observed in the Hydroelectric Reach reservoirs are believed to be fish that originated in Upper Klamath Lake and moved down through Lake Euwana and the Hydroelectric Reach (Buettner and Scoppettone 1991; Markle et al. 1999; Desjardins and Markle 2000). The populations are not thought to represent a viable, self-supporting populations (Buettner et al. 2006; USFWS 2012), and no longer interact with Upper Klamath Lake populations. The Hydroelectric Reach habitat is not designated critical habitat for either species, and Hydroelectric Reach populations are not part of the species' recovery units (USFWS 2012).

8.2.3 2012 EIS/R AR-6 Actions

The 2012 EIS/R AR-6 plan (Vol. I, pp. 3.3-247 to 3.3-248) directed a multi-step process that included a telemetry study to determine sucker locations in the Hydroelectric Reach reservoirs, followed by salvaging Lost River and shortnose suckers during the reservoir drawdowns, and releasing the salvaged suckers into Upper Klamath Lake. If deemed feasible prior to dam decommissioning, Klamath smallscale suckers were to be collected in a 2-mile reach downstream from J.C. Boyle Dam and transported for release into Spencer Creek immediately downstream of the Spencer Creek hook-up road (upper limits for sucker in Spencer Creek; Reclamation and CDFG 2012).

8.2.4 KRRC Review of AR-6 for Feasibility and Appropriateness

The KRRC assessed the feasibility and appropriateness of AR-6 through multiple planning meetings held with the ATWG between May and August 2017. During these meetings, current information on Klamath River fisheries was presented and information on other dam removal projects conducted in the western United States were reviewed to understand how the aquatic ecosystem might respond as discussed above. Major concerns voiced by the ATWG regarding the 2012 AR-6 included:

- Genetic integrity of salvaged suckers and effects on recipient populations.
- Relocation site availability.
- Klamath smallscale sucker salvage.
- Designated critical habitat and sink populations.
- Telemetry study feasibility and benefit.
- 2012 EIS/R baseline population estimates and effects uncertainty.

The following sections provide additional information regarding AR-6 feasibility and appropriateness based on fisheries literature and ATWG input.

8.2.4.1 Genetic Integrity of Salvaged Suckers and Effects on Recipient Populations

Klamath reservoir sucker populations have not been formally studied since the late 1990s (see Beak Consultants 1987; 1988; Desjardins and Markle 2000). Current population sizes, age class distribution, and genetic composition of Lost River and shortnose suckers are unknown, although genetic introgression between Lost River and shortnose suckers and Klamath smallscale suckers is suspected (Beak Consultants 1987; Markle et al. 1999). USFWS is concerned that relocating hybridized Lost River and shortnose suckers into Upper Klamath Lake could compromise the genetic integrity of recovery unit populations in Upper Klamath Lake. As Klamath smallscale suckers are very rare in Upper Klamath Lake (one has been found in Upper Klamath Lake; Markle et al. 1999), hybridized Lost River-Klamath smallscale suckers or shortnose-Klamath smallscale suckers in Upper Klamath Lake would create a novel sucker hybrid not known to exist in designated critical habitat (i.e., Klamath Basin upstream from Keno Dam). However, Markle et al. (1999) found more genetic similarity between Lost River suckers and Klamath smallscale suckers, and shortnose suckers and Klamath largescale suckers, although there also geographic-related differences among individuals within the respective species (e.g., Lost River suckers from Lost River and the Upper Klamath subbasins had meristic differences). Markle et al. (1999) concluded that Klamath Basin suckers are part of a species complex, or syngameon, defined as groups of interbreeding species that maintain their ecological, morphological, genetic, and evolutionary integrity in spite of hybridization (Templeton 1989 *cited in* Markle et al. 1999). In these hybrid species complexes, species integrity may be maintained by selection.

Based on the unknown genetic composition of suckers in the Hydroelectric Reach, it was concluded that relocating salvaged suckers to Upper Klamath Lake could threaten recovery populations and alternative release locations are necessary.

8.2.4.2 Relocation Site Availability

Salvaged sucker relocation sites must be isolated from Lost River and shortnose sucker populations inhabiting critical habitat or recovery areas in order to maintain the genetic integrity and health of recovery populations. Although it is unlikely that Lost River and shortnose suckers would have disease and parasite loads different from suckers in Upper Klamath Lake, such concerns further require the separation of salvage fish from recovery populations in the Upper Klamath Basin.

Tule Lake is the most likely relocation site for salvaged suckers. Tule Lake is an agricultural sump that is maintained by agricultural return flow. USFWS currently uses Tule Lake as a relocation site for Lost River and shortnose suckers salvaged from other areas in the basin, and the lake currently has the capacity for an additional 2,000 to 3,000 relocated suckers (J. Rasmussen, USFWS, personal communication, 2017). Management of Tule Lake is complicated by multiple user groups and the periodic need to draw down the reservoir for sediment maintenance. USFWS is currently investigating other potential sucker relocation sites in the Upper Klamath Basin.

We recommend that salvaged suckers be relocated to Tule Lake or another isolated waterbody until Hydroelectric Reach sucker genetics are better understood.

8.2.4.3 Klamath Smallscale Sucker Salvage

Klamath smallscale sucker is a riverine sucker species that historically inhabited the Klamath River below the Keno reef, and the adjacent Rogue River basin (Markle et al. 1999). The species is not known to inhabit Upper Klamath Lake or Upper Klamath Basin tributaries. Klamath smallscale sucker salvage would require sorting and releasing Klamath smallscale suckers at different locations than Lost River and shortnose suckers since the listed suckers are lake-type suckers (Buettner and Scoppettone 1991). ODFW also expressed concern with releasing salvaged Klamath smallscale suckers into Spencer Creek due to competition with the existing Spencer Creek sucker population (T. Wise, ODFW, personal communication, 2017). Although included in the original AR-6, Klamath smallscale sucker is not a federal or state listed species, and is not recognized as a tribal trust species. Therefore, we recommend Klamath smallscale sucker be removed from consideration in the updated AR-6 plan.

8.2.4.4 Designated Critical Habitat and Sink Populations

Hydroelectric Reach reservoirs and Klamath River downstream from Keno Dam were not designated as critical habitat by USFWS (2012). The sucker populations inhabiting the Klamath reservoirs are part of the Upper Klamath Lake Recovery Unit, however, they are sink populations that will likely never be viable and therefore are not actively managed for recovery (USFWS 2012). From a federal regulatory perspective, recovery of Lost River and shortnose suckers does not require preservation of the Hydroelectric Reach reservoirs or the sucker populations within.

8.2.4.5 Telemetry Study

Based on research in Upper Klamath Lake and past studies in the Klamath River reservoirs, USFWS and the U.S. Geological Survey (USGS) are in support of a multi-stage sampling and salvage effort that would use passive integrated transponder (PIT) tag technology to mark suckers. Lost River and shortnose suckers would be netted during a two-year sampling effort (2017 and 2018) and marked to estimate population sizes and demographics for suckers in the Hydroelectric Reach reservoirs. Sampling would occur in the reservoirs in the fall and in reaches of the Klamath River upstream of the reservoirs in the spring. Fall sampling would focus on shallow areas in the reservoirs and spring sampling would target sucker spawning migrations as fish leave the reservoirs and enter river reaches for spawning (Janney et al. 2009; Hewitt et al. 2014). Genetic material collected during the sampling phase would be used to develop genetic profiles of reservoir suckers and inform the sucker relocation effort. Suckers would be relocated during salvage efforts in the spring and fall of 2019. Based on this information, we have concluded the proposed PIT tag study will be more informative and less costly to implement relative to the originally proposed telemetry study.

8.2.4.6 2012 EIS/R Baseline Population Estimates

Desjardins and Markle (2000) provided the most comprehensive population estimates for suckers in the Hydroelectric Reach reservoirs. The number of adult shortnose suckers was estimated to be highest in Copco Reservoir (n=165), followed by J.C. Boyle (n=50), and then Iron Gate (n=22). Larger and older individuals dominated Copco and Iron Gate reservoirs and little size structure was detected. J. C. Boyle tended to have smaller adult shortnose suckers and many size classes were present. It appeared that recruitment of young-of-the-year suckers only occurred in J.C. Boyle with downstream reservoirs recruiting older individuals, perhaps those that had earlier recruited to J.C. Boyle Reservoir.

No new baseline population data have been produced for suckers inhabiting the Hydroelectric Reach reservoirs. However, anecdotal evidence (B. Tinniswood, ODFW, personal communication, 2017) suggests more suckers may inhabit the reservoirs than previously anticipated (e.g., Buettner and Scoppettone 1991; Beak Consultants 1987). USFWS's Abernathy Fish Technology Center, Longview, Washington, is also currently undertaking a genetic analysis of Lost River, shortnose, and other basin sucker species to identify genetic markers that may be used to differentiate suckers in the future. The Abernathy lab is anticipated to produce a report on sucker genetics by summer of 2018.

8.3 AR-6 Summary

The Klamath River dam decommissioning project is anticipated to have significant short-term effects on Lost River and shortnose suckers in the Hydroelectric Reach. Because the reservoirs will be restored to free-flowing historical conditions and the special-status suckers are lake-type suckers, individuals of these species that remain in the Hydroelectric Reach following dam removal are not expected to survive. The 2012 EIS/R AR-6 measure included a telemetry study to assess potential sucker locations in the Hydroelectric Reach, followed by a sucker salvage effort to remove fish from the reservoirs and transport them to Upper Klamath Lake for release. Several concerns were identified with the 2012 AR-6 plan, including the genetic integrity of Hydroelectric Reach suckers, relocation site availability, the need to salvage Klamath smallscale suckers, and the feasibility and benefit of the proposed telemetry study. We concluded that the basis of these concerns could result in the originally proposed AR-6 measure negatively affecting the recovery of Lost River and shortnose sucker populations in Upper Klamath Lake. Therefore, it was determined that additional actions in the form of an updated AR-6 are warranted.

The updated AR-6 plan, prepared by the KRRC and supported by the ATWG, includes two primary actions including reservoir and river sampling, and sucker salvage and release into appropriate waterbodies selected by fisheries managers. The proposed actions are anticipated to maximize the survival of Lost River and shortnose suckers currently inhabiting the Hydroelectric Reach. The number of translocated fish will not exceed 3,000 fish, which is the capacity of the currently identified recipient waterbody (Tule Lake). The salvage effort will likely translocate less than 10 percent of the sucker populations in the respective reservoirs.

9. AR-7 Freshwater Mussels

The objective of AR-7 is to address reservoir drawdown and dam removal effects on freshwater mussels located in the Klamath River in the Hydroelectric Reach and downstream from Iron Gate Dam (RM 192.9). The 2012 EIS/R AR-7 measure focused conducting a freshwater mussel relocation pilot study followed by the salvage and relocation of freshwater mussels prior to reservoir drawdown. Salvaged mussels were to be held in a temporary location for later placement following reservoir drawdown, and placed in locations that would not be affected by the reservoir drawdown. Based on a review of the provided information herein, the KRRC and the ATWG concluded that a moderate scale freshwater mussel relocation effort is warranted. The updated AR-7 includes a freshwater mussel reconnaissance in 2018 followed by a limited freshwater mussel salvage in 2019 prior to reservoir drawdown. Freshwater mussels will be salvaged from the 8-mile long Iron Gate Dam (RM 192.9) to Cottonwood Creek (RM 184.9) reach, and translocated to the Klamath River between the upstream extent of J.C. Boyle Reservoir (RM 233.0) and Keno Dam (RM 238.2).

9.1 Proposed Updated AR-7

Based on a review of the original 2012 EIS/R AR-7 measure presented in Section 9.2, input from the ATWG, and current freshwater mussels literature, the KRRC concluded that an updated AR-7 is necessary to offset the anticipated short-term effects of dam decommissioning on freshwater mussels. The updated AR-7 includes a reconnaissance, salvage, and relocation of freshwater mussels from the 8-mile reach between Iron Gate Dam and the Cottonwood Creek confluence with the Klamath River. The monitoring and adaptive management plan has two specific actions.

- **Action 1**: A reconnaissance will be completed in 2018 to assess the distribution and density of freshwater mussels in the 8-mile long bedload deposition reach from Iron Gate Dam (RM 192.9) downstream to the Cottonwood Creek confluence (RM 184.9). The reconnaissance will confirm mussel beds identified in the 2007-2010 surveys and estimate abundance at a subset of the mussel beds in the reach.
- **Action 2**: Based on the reconnaissance, a portion of the freshwater mussels located between Iron Gate Dam and Cottonwood Creek will be salvaged and relocated to reduce dam decommissioning effects to the mussel community. Approximately 15,000 to 20,000 mussels are planned for translocation to appropriate habitats in the Klamath River between the upstream extent of J.C. Boyle Reservoir (RM 233.0) and Keno Dam (RM 238.2). The proposed number of translocated mussels is likely less than 10 percent of freshwater mussels in the mainstem Klamath River in the Hydroelectric Reach and downstream from Iron Gate Dam.

The proposed actions are intended to reduce Project effects on freshwater mussels located downstream from Iron Gate Dam. The following sections provide additional detail on the proposed actions.

9.1.1 Action 1: Freshwater Mussel Reconnaissance

The KRRC will prepare a reconnaissance plan to assess freshwater mussels in the Iron Gate Dam to Cottonwood Creek reach in 2018. Habitat conditions will also be evaluated from the upstream extent of J.C. Boyle Reservoir (RM 233.0) upstream to Keno Dam (RM 238.2) to determine the habitat capacity for translocated mussels. An existing freshwater mussel data set (base data for Davis et al. 2013), compiled by the Karuk Tribe, USFWS, and other collaborators from 2007 to 2010 for the Klamath River downstream from Iron Gate Dam, will be reviewed and used to plan the reconnaissance. The reconnaissance will confirm mussel beds identified in the 2007-2010 surveys and estimate abundance at a subset of the mussel beds locations. Habitat metrics in the potential translocation reach will be evaluated to maximize translocation success. The freshwater mussel reconnaissance and translocation reach habitat assessment are anticipated to take 5 days

9.1.2 Action 2: Freshwater Mussel Salvage and Relocation

The KRRC will coordinate and implement a freshwater mussel salvage plan with freshwater mussel specialists. Based on the reconnaissance, a portion of the freshwater mussels located between Iron Gate Dam and Cottonwood Creek will be salvaged and relocated to reduce dam decommissioning effects to the freshwater mussel community. The freshwater mussel salvage and translocation effort is anticipated to require 10 days. The percentage of the existing mussel beds that will be salvaged and translocated is predicated on the available habitat in the Klamath River from the upstream extent of J.C. Boyle Reservoir to Keno Dam, and the abundance of mussels between Iron Gate Dam and Cottonwood Creek. Approximately 15,000 to 20,000 mussels are planned for translocation. The proposed number of translocated mussels is likely less than 10 percent of freshwater mussels in the mainstem Klamath River in the Hydroelectric Reach and downstream from Iron Gate Dam.

9.2 Summary of the 2012 EIS/R AR-7, Dam Removal Benefits and Effects, and Recent Fisheries Literature

The following sections review the components of the 2012 EIS/R AR-7 measure, anticipated dam removal effects and benefits on freshwater mussels, and current freshwater mussel literature.

9.2.1 AR-7 Affected Species

Species identified in AR-7 include:

- Oregon floater (Anodonta oregonensis)
- California floater (A. californiensis)
- Western ridged mussel (Gonidea angulata)
- Western pearlshell mussel (Margaritifera falcata)

9.2.2 Anticipated Dam Decommissioning Effects on AR-7 Species

Short-term effects of dam removal (prolonged exposure to high suspended sediment levels and bedload movement) are predicted to be deleterious to freshwater mussels in the

Hydroelectric Reach and in the lower Klamath River downstream from Iron Gate Dam (Reclamation and CDFG 2012). Substantial freshwater mussel population reductions are expected due to sediment effects and possibly low dissolved oxygen levels. The change in hydrological properties following dam removal may also disrupt the current distribution of freshwater mussels downstream from Iron Gate Dam (Davis et al. 2013). Table 9-1 includes the likely and worst-case effects on freshwater mussel species in the Klamath River.

Table 9-1 2012 EIS/R anticipated effects summary for freshwater mussels

Species	Life Stage	Likely Effects	Worst Effects
California Floater Oregon Floater Western Ridged Western Pearlshell	All	Substantial reduction in populations	Substantial reduction in populations

Source: USBR and CDFG 2012

The following sections include descriptions of anticipated effects to freshwater mussels adapted from the 2012 EIS/R (Reclamation and CDFG 2012; Vol. 1, pp. 3.3-173 to 3.3-175) and augmented with information from other freshwater mussel studies.

9.2.2.1 Freshwater Mussels

Past studies evaluated Klamath River Basin freshwater mussel age structure, growth rates, and size distribution (*G. angulata*; Tennant 2010); population distribution and habitat use (Krall 2010; Davis et al. 2013; May and Pryor 2015); and habitat associations (Westover 2010; Davis et al. 2013). Klamath River mussels are long lived (from 10 to more than 100 years, depending on species) and may not reach sexual maturity until 4 years of age or more. *Anodonta* species are found primarily downstream from Iron Gate Dam, and likely benefit from the stable hydrology and fine sediment deposits attributed to hydroregulation below the dam (Davis et al. 2013). *G. angulata* is the most abundant freshwater mussel in the Klamath River and the species is widely distributed between Iron Gate Dam and the Trinity River (Westover 2010; Davis et al. 2013). *M. falcata* is the least abundant freshwater mussel found in the Klamath River and seems to be mostly found downstream from the confluence of the Salmon River (Westover 2010; Davis et al. 2013).

Freshwater mussel tolerance of high suspended sediment, low dissolved oxygen, and bedload deposition are not well understood. Vannote and Minshall (1982) evaluated freshwater mussels in an aggrading river system in Idaho and concluded that *G. angulata* appear to be better adapted for aggrading rivers based on siphon positions, shell morphology, and foot placement in the underlying substrate. *M. falcata* seemed to be less adapted for aggrading rivers due to a less developed siphon for filtering water. *M. falcata* also rarely burrow into substrate more than 25-40 percent of the valve length which may increase the mussel's susceptibility to scour (Vannote and Minshall 1982). *G. angulata* migrate vertically in the channel bed and are capable of maintaining position near the channel bed surface (Vannote and Minshall 1982). *M. falcata* are not known to migrate and are therefore more susceptible to sediment burial. *Anodonta* species are likewise susceptible to sediment scour and burial due to their thinner shells. Mussels that are dislodged from their normal vertical position and fall onto their sides may not regain the normal position and may perish (Vannote and Minshall 1982).

Mussels play important roles in aquatic ecosystems. Mussels influence water quality, nutrient cycling, and habitat and are also known as “ecosystem engineers” that actively modify their environment (Xerces Society 2009; Lopes-Lima et al. 2016; Lummer et al. 2016). They filter fine sediment and organic particles, create byproducts that are food items for macroinvertebrates, and comprise the greatest proportion of animal biomass in some waterbodies (Xerces Society 2009). In the Klamath River Basin, freshwater mussels filter and sequester toxins including toxigenic algae microsystins (Kann et al. 2010) and mercury (Bettaso and Goodman 2010). Filtration of waterborne toxins may result in bioaccumulation in freshwater mussels leading to human consumption risks (Bettaso and Goodman 2010; Kann et al. 2010).

The dam decommissioning project is anticipated to result in high suspended sediment levels and bedload deposition in the 8 miles of the Klamath River between Iron Gate Dam and Cottonwood Creek. Extremely poor water quality due to high suspended sediment concentrations is expected in the first 2 miles of the Klamath River downstream from Iron Gate Dam (Reclamation and CDFG 2012). Fine sediment effects on freshwater mussels include gill clogging, possible growth reduction, and impairment to mussel larval stages (Lummer et al. 2016). Due to both the anticipated deleterious high suspended sediment concentrations and low dissolved oxygen levels, freshwater mussels downstream from Iron Gate Dam may experience substantial mortality with the most significant impacts anticipated to mussels located immediately downstream from Iron Gate Dam.

Over the long-term, freshwater mussels are expected to benefit from the dam decommissioning through the conversion of Hydroelectric Reach reservoirs to gravel bed rivers which will restore freshwater mussel habitat, reduce water quality and water temperature impairments related to the reservoirs, and restore access for anadromous and resident host fish species that will distribute freshwater mussel larvae throughout the Klamath River upstream from Iron Gate Dam. However, due to the long time freshwater mussels take to reach sexual maturity, the recolonization and/or growth of existing freshwater mussel populations upstream of Iron Gate Dam may be slow and may not be readily noticeable for some time.

9.2.3 2012 EIS/R AR-7 Actions

The 2012 EIS/R AR-1 plan (Vol. I, pp. 3.3-248 to 3.3-249) directed the salvage of freshwater mussels from the Hydroelectric Reach and downstream from Iron Gate Dam. Salvaged mussels were to be relocated to suitable instream habitat unaffected by high suspended sediment concentrations, or could be placed in temporary facilities and returned to the Klamath River following the dam decommissioning project. A salvage and relocation pilot study was also suggested to assess salvage feasibility and relocated mussel survival. Based on the pilot study results, a detailed salvage and relocation plan was to be developed.

9.2.4 KRRC Review of AR-7 for Feasibility and Appropriateness

The KRRC assessed the feasibility and appropriateness of AR-7 through multiple planning meetings held with the ATWG between May and August 2017. During these meetings, current information on Klamath River fisheries was presented and information on other dam removal projects conducted in the western United States was reviewed to understand how the aquatic ecosystem might respond, as discussed above. Concerns voiced by the ATWG regarding the 2012 AR-7 included:

- Unfamiliarity with successful freshwater mussel relocation efforts.
- Disease transmission concerns.

The following sections provide additional information regarding AR-7 feasibility and appropriateness, based on fisheries literature and ATWG input.

9.2.4.1 Unfamiliarity with Successful Freshwater Mussel Relocation Efforts

The ATWG was unfamiliar with successful freshwater mussel translocation efforts. Anecdotal information discussed during the ATWG planning meeting (Yreka, CA, May 23, 2017) alluded to low translocation success for the Elwha Dam Removal Project and highway construction projects. Additional information was acquired by the KRRC on the Elwha Dam Removal Project freshwater mussel (*M. falcata*) translocation. Freshwater mussels were translocated to two sites and remained in one site prior to the dam removal project (P. Crain, U.S. Park Service, personal communication, 2017). The relocated freshwater mussels had high survival following the translocation and prior to the dam removals. Subsequent events that impacted the translocated mussels resulted in high mussel mortality. The events included raccoon predation due to shallow habitat at the first translocation site, and excessive sediment deposition at a side channel translocation site. The third monitored site was an artificial outfall channel from the water treatment facility that went dry due to inadvertent project operations. Mussels that remained in the Elwha River downstream from Elwha Dam are suspected to have experienced high mortality due to excessive sediment deposition following dam removal, followed by channel scour during the post-dam sediment sorting process.

Freshwater mussel translocation project monitoring results are not well represented in the fisheries literature. Unpublished freshwater mussel translocation monitoring manuscripts were reviewed to better understand the range of potential translocation success. Fernandez (2013) described the translocation success of 265 individual *M. falcata* in coastal southwest Washington. Between 55 percent and 95 percent of the transplanted *M. falcata* were accounted for in the translocation sites between one and three years following the translocation.

Seventeen percent of *G. angulata* translocated to a site downstream of a channel reconstruction project on the Upper Truckee River, were relocated three years after the translocation effort.

A review of translocation projects found mean mortality of relocated mussels was 49 percent based on an average recovery rate of 43 percent (Cope and Waller 1995). Cope and Waller (1995) found that survival of relocated mussels was generally poor and the factors influencing the survival of relocated mussels were poorly understood. For mussel relocation to be successful, more consideration must be given to habitat characterization at both the source and translocation sites. Olden et al. (2010) and Germano et al. (2015) offer considerations for successful freshwater organism and wildlife translocation efforts, respectively Luzier and Miller (2009) offer suggestions and considerations for freshwater mussel translocations.

9.2.4.2 Disease Transmission Concerns

The role of freshwater mussels in freshwater disease transmission is not well understood. Freshwater mussels are known to provide habitat for polychaete works, one of the hosts in the life *C. shasta*. Polychaetes have been infrequently collected from freshwater mussel shells in the Hydroelectric Reach of the Klamath River (PacifiCorp 2004). Mussels may serve as a vector for other fish pathogens like *Flavobacterium columnare* and *Ichthyophthirius multifiliis* that are endemic to the Klamath River Basin (K. Kwak, CDFW, personal communication 2017).

Freshwater mussels inhabit the Klamath River upstream from Iron Gate Dam (Byron and Tupen 2017) and in tributaries upstream (Byron and Tupen 2017) and downstream from Iron Gate Dam (Davis et al. 2013; Howard et al. 2015; May and Pryor 2015), disease transmission may be less of a concern.

9.3 AR-7 Summary

The Klamath River dam decommissioning project is anticipated to have significant short-term effects, but long-term benefits for freshwater mussels. The 2012 EIS/R AR-7 mitigation plan included a freshwater mussel salvage and relocation pilot study followed by an informed salvage and relocation plan prior to the dam decommissioning. The updated AR-7 measure includes completing a reconnaissance of existing freshwater mussels from Iron Gate Dam to Cottonwood Creek and potential relocation habitat between the upstream extent of J.C. Boyle Reservoir and Keno Dam. Freshwater mussels will be salvaged and relocated in 2019 prior to the reservoir drawdown. Approximately 15,000 to 20,000 mussels are planned for translocation. The proposed number of translocated mussels is likely less than 10 percent of freshwater mussels in the mainstem Klamath River in the Hydroelectric Reach and downstream from Iron Gate Dam.

10. References

10.1 10.1 Introduction

U.S. Bureau of Reclamation [USBR], and California Department of Fish and Game [CDFG]. 2012. Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report. Volume I and Volume II. 3063 pp. https://klamathrestoration.gov/Draft-EIS-EIR/download-draft-eis-eir.

10.2 Dam Removal Benefits and Effects

Allen, M.B, R.O. Engle, J.S. Zendt, F.C. Shrier, J.T. Wilson, and P.J. Connolly. 2016. Salmon and steelhead in the White Salmon River after the removal of Condit Dam – planning efforts and recolonization results. Fisheries 41:190-203.

Anderson J.H., P.L. Faulds, K.D. Burton, M.E. Koehler, W.I. Atlas, and T.P. Quinn. 2015. Dispersal and productivity of Chinook (Oncorhynchus tshawytscha) and coho (Oncorhynchus kisutch) salmon colonizing newly. Can. J. Fish. Aquat. Sci. 72(3):454-465.

Anderson, J. H., G.R. Pess, P.M. Kiffney, T.R. Bennett, P.L. Faulds, W.I. Atlas, T.P. Quinn. 2013. Dispersal and tributary immigration by juvenile coho salmon contribute to spatial expansion during colonization. Ecology of Freshwater Fish 22:30-42.

Anderson, J. H., and T. P. Quinn. 2007. Movements of adult coho salmon (Oncorhynchus kisutch) during colonization of newly accessible habitat. Canadian Journal of Fisheries and Aquatic Sciences 64:1143–1154

Bartholow, J.M., S.G. Campbell, and M. Flug. 2004. Predicting the thermal effects of dam removal on the Klamath River. Environmental Management 34:856-874.

Bartholow, J.M., S.G. Campbell, and M. Flug. 2005. Predicting the thermal effects of dam removal on the Klamath River. Environmental Management 34:856-874.

Bartholomew, J.L., and J.S. Foott. 2010. Compilation of information relating to myxozoan disease effects to inform the Klamath Basin Restoration Agreement. Department of Microbiology, Oregon State University, Corvallis, and U.S. Fish and Wildlife Service, California-Nevada Fish Health Center.

Beeman, J.W., Stutzer, G.M., Juhnke, S.D., Hetrick, N.J. 2008. Survival and migration behavior of juvenile coho salmon in the Klamath River relative to discharge at Iron Gate Dam, 2006. Open-File Report 2008-1332. U.S. Geological Survey.

Burton, KD., L.G. Lowe, H.B. Berge, H.K. Barnett, and P.L. Faulds. 2013. Comparative dispersal patterns for recolonizing Cedar River Chinook salmon above Landsburg Dam, Washington, and the source population below the dam. Trans. Am. Fish. Soc. 142:703–716.

California Department of Fish and Game [CDFG]. 1965. California Fish and Wildlife Plan, Volume III, Supporting Data, Part B. Inventory (Salmon-Steelhead and Marine Resources): 429 pp.

Cech, J.J., Jr. and Myrick, C.A. (1999) Steelhead and chinook salmon bioenergetics: temperature, ration, and genetic effects. Technical Completion Report. UCAL-WRC-W-885, University of California Water Resources Center, Davis, CA, 72 pp.

Chapman, D.W. 1981. Pristine production of anadromous salmonids – Klamath River. Final consultant report to the Bureau of Indian Affairs. Bureau of Indian Affairs, U.S. Department of the Interior, Portland, Oregon. July 1981.

Coots, M. 1977. Klamath River Anadromous Fisheries. Draft comments prepared in reference to the People vs. Ederhardt case in Del Norte County Superior Court., California Department of Fish and Game: 63 p.

Cunanan, M. 2009. Historic anadromous fish habitat estimates for Klamath River mainstem and tributaries under Klamath Hydropower reservoirs. U.S. Fish and Wildlife Service, Arcata, California.

Department of the Interior [DOI]. 2007. Modified terms and conditions, and prescriptions for fishways filed pursuant to sections 4(e) and 18 of the Federal Power Act with the Federal Energy Regulatory Commission for the Klamath River Hydroelectric Project No. 2082. Bureau of Land Management, Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service. Sacramento, California.

Department of the Interior, U. S. Department of Commerce, and National Marine Fisheries Service [NOAA Fisheries]. 2013. Klamath Dam Removal Overview Report for the Secretary of the Interior an Assessment of Science and Technical Information, Version 1.1, March 2013.

Dunsmoor L.K., and C.W. Huntington. 2006. Suitability of environmental conditions within Upper Klamath Lake and the migratory corridor downstream for use by anadromous salmonids. Technical Memorandum. Klamath Tribes, Chiloquin, Oregon.

Engle, R. O., J. Skalicky, and J. Poirier. 2013. Translocation of lower Columbia River fall Chinook Salmon (Oncorhynchus tshawytscha) in the year of Condit Dam removal and year one postremoval assessments. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, 2011 and 2012 Report, Vancouver, Washington.

Federal Energy Regulatory Commission [FERC]. 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027. FERC/EIS-0201F. FERC, Office of Energy Projects, Division of Hydropower Licensing, Washington, DC.

Federal Energy Regulatory Commission [FERC]. 1963. Opinion and order for petition to require licensee to construct, operate, and maintain a fish hatchery, amending license, and directing revised filings, Opinion No. 381, Issued March 14, 1963. Washington D.C., Formerly Federal Power Commission: 1-13.

Fortune, J.D., A.R. Gerlach, and C.J. Hanel. 1966. A study to determine the feasibility of establishing salmon and steelhead in the Upper Klamath Basin. Oregon State Game Commission and Pacific Power and Light Company, Portland, Oregon.

Greig, S.M., D.A. Sear, and P.A. Carling. 2005. The impact of fine sediment accumulation on the survival of incubating salmon progeny: Implications for sediment management. Science of the Total Environment 344: 241-258.

Hamilton, J. et al. 2011. Synthesis of the Effects to Fish Species of Two Management Scenarios for the Secretarial Determination on Removal of the Lower Four Dams on the Klamath River – Final Draft. Prepared by the Biological Subgroup (BSG) for the Secretarial Determination (SD) Regarding Potential Removal of the Lower Four Dams on the Klamath River.

Hatten, J. R., T.R. Batt, J.J. Skalicky, R. Engle, G J. Barton, R.L. Fosness, and J. Warren. 2015. Effects of dam removal on Tule fall Chinook salmon spawning habitat in the White Salmon River, Washington. River Research and Applications 32(7): 1481-1492.

Huntington, C.W. 2004. Klamath River flows within the J.C. Boyle Bypass and below the J.C. Boyle Powerhouse. Clearwater BioStudies, Canby, Oregon.

Huntington, C.W. 2006. Estimates of anadromous fish runs above the site of Iron Gate Dam. Clearwater BioStudies, Inc., Canby, Oregon.

Kiffney, P.M., G.R. Pess, J.H. Anderson, P. Faulds, K. Burton, and S.C. Riley. 2009. Changes in fish communities following recolonization of the Cedar River, WA USA by Pacific salmon after 103 years of local extirpation. River Res. Appl. 25 (4):438–452.

Levasseur, M., N.E. Bergeron, M.F. Lapointe, and F. Berube. 2006. Effects of silt and very fine sand dynamics in Atlantic salmon (Salmo salar) redds on embryo hatching success. Canadian Journal of Fisheries and Aquatic Sciences 63:1450-1459.

Liermann, M., G. Pess, M. McHenry, J. McMillan, M. Elofson, T. Bennett, and R. Moses. 2017. Relocation and Recolonization of Coho Salmon in Two Tributaries to the Elwha River: Implications for Management and Monitoring, Transactions of the American Fisheries Society 146:(5)955-966.

McHenry, M., G. Pess, J. Anderson, and H. Hugunin. 2017. Spatial distribution of Chinook Salmon (Oncorhynchus tshawytscha) spawning in the Elwha River, Washington State during dam removal and early stages of recolonization (2012-2016).

Department of the Interior, U. S. Department of Commerce, National Marine Fisheries Service [NOAA Fisheries]. 2007. Magnuson-Stevens Reauthorization Act Klamath River Coho Salmon Recovery Plan. Prepared by Rogers, F.R., I.V. Lagomarsino and J.A. Simondet for the National Marine Fisheries Service, Long Beach, California. 48 p.

Department of the Interior, U. S. Department of Commerce, and National Marine Fisheries Service [NOAA Fisheries]. 2013. Klamath Dam Removal Overview Report for the Secretary of the Interior an Assessment of Science and Technical Information, Version 1.1, March 2013.

North Coast Regional Water Quality Control Board (NCRWQCB). 2010. Action plan for the Klamath River Total Maximum Daily Loads addressing temperature, dissolved oxygen, nutrient, and microcystin impairments in the Klamath River, California, and Site-specific objectives for dissolved oxygen in the Klamath River in California, and implementation plans for the Klamath and Lost River basins. NCRWQCB, Santa Rosa, California. Sykes, G.E., C.J. Johnson, and J.M. Shrimpton. 2009. Temperature and flow effects on migration timing of Chinook salmon smolts. Transactions of the American Fisheries Society 138:1252-1265.

Oregon Department of Fish and Wildlife [ODFW]. 2011. Rogue River Chinook salmon spawning redd survey data. Unpublished data.

PacifiCorp. 2004. Klamath Hydroelectric Project (FERC project no. 2082): fish resources. Final technical report Prepared by PacifiCorp, Portland, Oregon.

Spina, A. P. 2007. Thermal ecology of juvenile steelhead in a warm-water environment. Environmental Biology of Fishes 80:23–34.

Tonra, C.M., K. Sager-Fradkin, S.A. Morley, J.J. Duda, and P.P. Marra. 2015. The rapid return of marine-derived nutrients to a freshwater food web following dam removal. Biological Conservation 192:130-134.

True, K., Voss, A., and J.S. Foott. 2016. Myxosporean parasite Prevalence of infection in Klamath River Basin juvenile Chinook salmon, April–July 2015. California–Nevada Fish Health Center, US Fish and Wildlife Service, Anderson, California.

U.S. Bureau of Reclamation [USBR]. 2011. Appendix E – an analysis of potential suspended sediment effects on anadromous fish in the Klamath Basin. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado. 70 pp.

U.S. Bureau of Reclamation [USBR], and California Department of Fish and Game [CDFG]. 2012. Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report. Volume I and Volume II. 3063 pp. https://klamathrestoration.gov/Draft-EIS-EIR/download-draft-eis-eir.

U.S. Fish and Wildlife Service [USFWS]. 2016. Response to Request for Technical Assistance – Prevalence of C. shasta Infections in Juvenile and Adult Salmonids. Unpublished memo to D. Hillemeier, Yurok Tribal Fisheries, and Craig Tucker, Karuk Department of Natural Resources. 17 pp.

Personal Communication

T. Williams, NOAA Fisheries. September 6, 2017. Personal communication with T. Brandt regarding dam removal benefits for adult and juvenile salmonids, and additional input regarding Aquatic Mitigation Measures.

10.3 AR-1 Mainstem Spawning

Ackerman, N.K., B. Pyper, S. Cramer, and I. Courter. 2006. Estimation of returns of naturally produced coho to the Klamath River – review draft Technical Memorandum #1 of 8 Klamath Coho Integrated Modeling Framework Technical Memorandum Series.

Bigelow, M. D. Portz, and Z. Jackson. 2013. Trap and Haul of Adult Fall Run Chinook. Final 2014 Monitoring and Analysis Plan. San Joaquin River Restoration Program. 31 pp.

Bjornn, T., and D. Reiser. 1991. Habitat requirements of salmonids in streams. In Meehan, W. ed., Influences of Forest and Rangeland Management on Salmonids Fishes and Their Habitat. American Fisheries Society Special Publication 19. pp. 83-138.

Busby, P.J., T.C. Wainwright, and R.S. Waples. 1994. Status review for Klamath Mountains Province steelhead. NOAA Technical Memorandum NMFS-NWFSC-19. National Marine Fisheries Service, Seattle, Washington.

California Department of Fish and Wildlife [CDFW]. 2016 Annual Report – Iron Gate Hatchery, 2015 – 2016. 38 pp.

California Department of Fish and Wildlife [CDFW]. 2017. Unpublished data – steelhead adult monitoring data for Bogus Creek, Shasta River, and Scott River.

Carter, K. 2005. The effects of dissolved oxygen on steelhead trout, coho salmon, and Chinook salmon-Biology and function by life stage: California Regional Water Quality Control Board North Coast Region report, 9 p.

Chapman J.M., C.L. Proulx, M.A. Veilleux, C. Levert, S. Bliss, M.E. Andre, N.W.R. Lapointe, and S.J. Cooke. 2014. Clear as mud: a meta-analysis on the effects of sedimentation on freshwater fish and the effectiveness of sediment-control measures. Water Res 56:190–202.

Fortune, J.D., A.R. Gerlach, and C.J. Hanel. 1966. A study to determine the feasibility of establishing salmon and steelhead in the Upper Klamath Basin. Oregon State Game Commission and Pacific Power and Light Company, Portland, Oregon.

Geist, D.R., A.H. Colotelo, T.J. Linley, K.A. Wagner, and A.L. Miracle. 2016. Physical, physiological, and reproductive effects on adult fall Chinook Salmon due to passage through a novel fish transport system. Journal of Fish and Wildlife Management 7(2):1-12.

Goodman, D.H., and S.B. Reid. 2012. Pacific Lamprey (Entosphenus tridentatus) Assessment and Template for Conservation Measures in California. U.S. Fish and Wildlife Service, Arcata, California. 117 pp.

Hopelain, J.S. 1998. Age, growth, and life history of Klamath Basin steelhead trout (Oncorhynchus mykiss irideus) as determined from scale analysis. Inland Fisheries Administration Report 98-3. California Department of Fish and Game, Sacramento.

Huntington, C.W. 2004. Klamath River flows within the J.C. Boyle Bypass and below the J.C. Boyle Powerhouse. Clearwater BioStudies, Canby, Oregon.

Huntington, C.W. 2006. Estimates of anadromous fish runs above the site of Iron Gate Dam. Clearwater BioStudies, Inc., Canby, Oregon.

Keefer M.L., G.A. Taylor, D.F. Garletts, G.A. Gauthier, T.M. Pierce, and C.C. Caudill. 2010. Prespawn mortality in adult spring Chinook salmon outplanted above barrier dams. Ecol. Freshw. Fish 19(3):361-372.

Kinziger, A.P., M. Hellmair, D.G. Hankin, and J. Carlos Garza. 2013. Contemporary Population Structure in Klamath River Basin Chinook Salmon Revealed by Analysis of Microsatellite Genetic Data, Transactions of the American Fisheries Society, 142(5):1347-1357.

Kjelland, M.E., C.M. Woodley, T.M. Swannack, and D.L. Smith. 2015. A review of the potential effects of suspended sediment on fishes: potential dredging-related physiological, behavioral, and transgenerational implications. Environ Syst Decis 35:334-350.

Magneson, M.D., and S. Gough. 2006. Mainstem Klamath River coho salmon redd surveys 2001 to 2005. Arcata Fisheries Data Series Report DS 2006-7. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.

Magneson, M.D., and K. Wright. 2010. Mainstem Klamath River fall Chinook salmon redd survey 2009. Arcata Fisheries Data Series Report DS 2010-19. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.

Mann, R.D., C.C. Caudill, M.L. Keefer, A.G. Roumasset, C.B. Schreck, and M.L. Kent. 2011. Migration behavior and spawning success of spring Chinook salmon in Fall Creek and the North Fork Middle Fork Willamette River: Relationships among fate, fish condition, and environmental factors, 2010. Technical Report 2011-8-DRAFT. 85 pp.

McHenry, M., G. Pess, J. Anderson, and H. Hugunin. 2017. Spatial distribution of Chinook Salmon (Oncorhynchus tshawytscha) spawning in the Elwha River, Washington State during dam removal and early stages of recolonization (2012-2016).

Mesa, M.G., L.P. Gee LP, L.K. Weiland, and H.E. Christiansen. 2013. Physiological responses of adult rainbow trout experimentally released through a unique fish conveyance device. North American Journal of Fisheries Management 33:1179-1183.

National Oceanic and Atmospheric Administration - National Marine Fisheries Service [NOAA]. 2010. Biological opinion on the operation of the Klamath Project between 2010 and 2018. Prepared for Bureau of Reclamation by NOAA Fisheries Service, Southwest Region.

National Oceanic and Atmospheric Administration - National Marine Fisheries Service [NOAA]. 2014. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (Oncorhynchus kisutch). National Marine Fisheries Service. Arcata, CA.

Newcombe, C.P., and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16:693–727.

U.S. Bureau of Reclamation [USBR], and California Department of Fish and Game [CDFG]. 2012. Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report. Volume I and Volume II. 3063 pp. https://klamathrestoration.gov/Draft-EIS-EIR/download-draft-eis-eir.

U.S. Fish and Wildlife Service [USFWS]. 2016. Response to Request for Technical Assistance – Prevalence of C. shasta Infections in Juvenile and Adult Salmonids. Unpublished memo. 17 pp.

U.S. Fish and Wildlife Service [USFWS]. 2017. Unpublished coho salmon redd count data.

Washington State Department of Ecology (WDOE). 2002. Evaluating Criteria for the Protection of Freshwater Aquatic Life in Washington's Surface Water Quality Standards: Dissolved Oxygen. Draft Discussion Paper and Literature Summary. Publication Number 00-10-071. 90 pp.

Personal Communication

N. Hetrick. USFWS. Unpublished table regarding likely suspended sediment effects on post dam removal adult returns provided by email August 18, 2017.

T. Wise. ODFW. May 23, 2017. ODFW anadromous salmonid reintroduction plan discussion.

T. Williams. NOAA Fisheries. September 6, 2017. Personal communication with T. Brandt regarding dam removal benefits for adult and juvenile salmonids, and additional input regarding Aquatic Mitigation Measures.

K. Pomeroy. CDFW. September 27, 2017. Iron Gate Hatchery annual production 2001-2017.

10.4 AR-2 Outmigrating Juveniles

Allen, M.B., and P.J. Connolly. 2011. Current use and productivity of fish in the lower White Salmon River, Washington, prior to the removal of Condit Dam: U.S. Geological Survey Open-File Report 2011-1087, 32 p.

Antonetti. A., and E. Partee. 2012. Blue Creek Chinook outmigration monitoring – 2012 Technical Memorandum. 15 pp.

Barton, B.A., R.E. Peter, and C.R. Paulencu. 1980. Plasma cortisol levels of fingerling rainbow trout (Salmo gairdneri) at rest and subjected to handling, confinement, transport, and stocking. Canadian Journal of Fisheries and Aquatic Sciences 37:805– 811.

Bash, J. C. Berman, and S. Bolton. 2001. Effects of Turbidity and Suspended Solids on Salmonids. 80 pp.

Beeman, J., S. Juhnke, G. Stutzer, and K. Wright. 2012, Effects of Iron Gate Dam discharge and other factors on the survival and migration of juvenile coho salmon in the lower Klamath River, northern California, 2006–09: U.S. Geological Survey Open-File Report 2012-1067, 96 pp.

Berg, L., and T.G. Northcote. 1985. Changes in territorial, gill-flaring, and feeding behaviour in juvenile coho salmon (Oncorhynchus kisutch) following short-term pulses of suspended sediment. Canadian Journal of Fisheries and Aquatic Sciences 42: 1410–1417.

Bisson, P.A., and R.E. Bilby. 1982. Avoidance of suspended sediment by juvenile coho salmon. North American Journal of Fisheries Management 2: 371–374.

Bjornn, T. and D. Reiser. 1991. Habitat requirements of salmonids in streams. In Meehan, W. ed., Influences of Forest and Rangeland Management on Salmonids Fishes and Their Habitat. American Fisheries Society Special Publication 19. pp. 83-138.

Carter, K. 2005. The effects of dissolved oxygen on steelhead trout, coho salmon, and Chinook salmon-Biology and function by life stage: California Regional Water Quality Control Board North Coast Region report, 9 p.

Chesney, W.R., C.C. Adams, W.B. Crombie, H.D. Langendork, S.A. Stenhouse, K.M. Kirkby. 2009. Shasta river juvenile coho habitat and migration study. Prepared for U.S. Bureau of Reclamation, Klamath Area Office by California Department of Fish and Game.

Courter, I., S.P. Cramer, R. Ericksen, C. Justice, and B. Pyper. 2008. Klamath coho life-cycle model version 1.3. Prepared by Cramer Fish Sciences for USDI Bureau of Reclamation, Klamath Basin Area Office. http://www.fishsciences.net/projects/klamathcoho/model.php.

Goodman, D.H., and S.B. Reid. 2012. Pacific Lamprey (Entosphenus tridentatus) Assessment and Template for Conservation Measures in California. U.S. Fish and Wildlife Service, Arcata, California. 117 pp.

Gough, S.A., A.T. David, and W.D. Pinnix. 2015. Summary of abundance and biological data collected during juvenile salmonid monitoring in the mainstem Klamath River below Iron Gate Dam, California 2000-1023. 211 pp.

Harris, N.J., P. Petros, and W.D. Pinnix. 2016. Juvenile salmonid monitoring on the mainstem Trinity River, California, 2015. 45 pp.

Hillemeier D., T. Soto, S. Silloway, A. Corum, M. Kleeman, and L. Lestelle. 2009. The role of the Klamath River mainstem corridor in the life history and performance of juvenile coho salmon (Oncorhynchus kisutch) May 2007 - May 2008. Submitted to U.S. Bureau of Reclamation, Mid - Pacific Region, Klamath Area Office, Klamath Falls, Oregon.

Huntington, C.W. 2006. Estimates of anadromous fish runs above the site of Iron Gate Dam. Clearwater BioStudies, Inc, Canby, Oregon.

Gunnerød, T.B., N.A. Hvidsten, and T.G. Heggberget. 1988. Open sea releases of Atlantic salmon smolts, Salmo salar, in Central Norway, 1973-¬-83. Canadian Journal of Fisheries and Aquatic Sciences 45:1340-1345.

Heggberget, T.G., N.A. Hvidsten, T.B. Gunnerød, P.I. Møkkelgjerd. 1991. Distribution of adult recaptures from hatchery-reared Atlantic salmon (Salmo salar) smolts released in and off-shore of the River Surna, western Norway. Aquaculture 98:89–96.

Jetter, C.N. and W.R Chesney. 2016. Shasta and Scott River Outmigration Study, 2016 Report. California Department of Fish and Wildlife Anadromous Fisheries Resource Assessment and Monitoring Program. August 2016

Keefer, M.L., and C.C. Caudill. 2014. Homing and straying by anadromous salmonids: a review of mechanisms and rates. Fish Biol. Fisheries 24:333–368

Kenaston, K. R., R.B. Lindsay, and R.K. Schroeder. 2001. Effect of acclimation on the homing and survival of hatchery winter steelhead. North American Journal of Fisheries Management 21(4):765-773.

Kjelland, M.E., C.M. Woodley, T.M. Swannack, and D.L. Smith. 2015. A review of the potential effects of suspended sediment on fishes: potential dredging-related physiological, behavioral, and transgenerational implications. Environ Syst Decis 35:334-350.

Newcombe, C.P., and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16:693–727.

Noggle, C.C. 1978. Behavioral, physiological, and lethal effects of suspended sediment on juvenile salmonids. Master's thesis, University of Washington, Seattle, Washington, USA.

Redding, J.M., C.B. Schreck, F.H. Everest. 1987. Physiological effects on coho salmon and steelhead of exposure to suspended solids. Trans Am Fish Soc 116:737–744

Schenk, L.N., and H.M Bragg. 2014. Assessment of suspended-sediment transport, bedload, and dissolved oxygen during a short-term drawdown of Fall Creek Lake, Oregon, winter 2012–13: U.S. Geological Survey Open-File Report 2014–1114, 80 p., http://dx.doi.org/10.3133/ofr20141114.

Sedell, J.R., G.H. Reeves, F.R. Hauer, J.A. Stanford, and C.P. Hawkins. 1990. Role of refugia in recovery from disturbance: modern fragmented and disconnected river systems. Environmental Management. 14:711-724.

Serl, J., and C. Morrill. 2010. Summary report for the 1996 to 2009 seasonal operation of the Cowlitz Falls fish facility and related Cowlitz Falls anadromous reintroduction program activities. Washington Department of Fish and Wildlife.

Servizi, J.A., and D.W. Martens. 1987. Effect of temperature, season, and fish size on acute lethality of suspended sediments to coho salmon (Oncorhynchus kisutch). Can. J. Fish. Aquat. Sci. 48: 493-497.

Servizi, J.A., and D.W. Martens. 1991. Some effects of suspended Fraser River sediments on sockeye salmon (*Oncorhynchus nerka*). *In* Sockeye salmon (*Oncorhynchus nerka*) population biology and future management. *Edited by* H.D. Smith, L. Margolis, and C.C. Wood. Can. Spec. Publ. Fish. Aquat. Sci. No. 96. pp 254-264.

Servizi J.A., and D.W. Martens. 1992. Sublethal responses of coho salmon (Oncorhynchus kisutch) to suspended sediments. Can J Fish Manag Aquat Sci 49:1389–1395.

Sigler, J.W., T.C. Bjornn, and F.H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Transactions of the American Fisheries Society 113:142-150.

Solazzi, M.F., S.L. Johnson, B. Miller, T. Dalton, and K.A. Leader. 2003. Salmonid life-cycle monitoring project 2002. Oregon Department of Fish and Wildlife, Monitoring Program Report OPSW-ODFW-2003–2, Portland

Specker, J.L., and C.B. Schreck. 1980. Stress responses to transportation and fitness for marine survival in coho salmon (Oncorhynchus kisutch) smolts. Canadian Journal of Fisheries and Aquatic Sciences 37:765–769.

Sorenson, D.L., M.M. McCarthy, E.J. Middlebrooks, and D.B. Porcella. 1977. Suspended and dissolved solids effects on freshwater biota: a review. United States Environmental Protection Agency, Report 600/3-77-042, Environmental Research Laboratory, Corvallis, Oregon, USA.

Som, N.A., and N.J. Hetrick. 2016. Response to Request for Technical Assistance – Prevalence of C. shasta Infections in juvenile and adult salmonids. Unpublished memo to D. Hillemeier, Yurok Tribal Fisheries, and Craig Tucker, Karuk Department of Natural Resources. 17 pp.

Sorenson, D.L., M.M. McCarthy, E.J. Middlebrooks, and D.B. Porcella. 1977. Suspended and dissolved solids effects on freshwater biota: a review. United States Environmental Protection Agency, Report 600/3-77-042, Environmental Research Laboratory, Corvallis, Oregon, USA.

Soto T. A., A. Corum, H. Voight, D. Hillemeier, and L. Lestelle. 2009. The role of the Klamath River mainstem corridor in the life history and performance of juvenile coho salmon (Oncorhynchus kisutch). Draft report to U.S. Bureau of Reclamation.

Stenhouse S.A., C.E. Bean, W.R. Chesney, and M.S. Pisano. 2012. Water temperature thresholds for coho salmon in a spring-fed river, Siskiyou County, California. California Fish and Game 98(1): 17–37.

Stillwater Sciences. 2010. Potential Responses of Coho Salmon and Steelhead Downstream of Iron Gate Dam to No-Action and Dam-Removal Alternatives for the Klamath Basin Prepared for U.S. Bureau of Reclamation in support of the Biological Subgroup for the Klamath Basin Secretarial Determination. August 2010.

Stillwater Sciences. 2011. Model Development and Estimation of Short-term Impacts of Dam Removal on Dissolved Oxygen in the Klamath River. pp. 70.

Stutzer, G.M., J. Ogawa, N.J. Hetrick, T. Shaw. 2006. An initial assessment of radio telemetry for estimating juvenile coho survival, migration behavior, and habitat use in response to Iron Klamath Coho Life Cycle Model – Technical Memorandum #2 Draft for Review Cramer 22 Fish Sciences Gate Dam discharge on the Klamath River, Oregon. U.S. Fish and Wildlife Service, Arcata Fisheries Technical Report, TR2006-05.

U.S. Bureau of Reclamation [USBR]. 2011. Appendix E – an analysis of potential suspended sediment effects on anadromous fish in the Klamath Basin. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado. 70 pp.

U.S. Bureau of Reclamation [USBR], and California Department of Fish and Game [CDFG]. 2012. Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report. Volume I and Volume II. 3063 pp. https://klamathrestoration.gov/Draft-EIS-EIR/download-draft-eis-eir.

U.S. Fish and Wildlife Service [USFWS]. 2016. Response to Request for Technical Assistance – Prevalence of C. shasta Infections in Juvenile and Adult Salmonids. Unpublished memo. 17 pp.

Wallace M. 2004. Natural vs. hatchery proportions of juvenile salmonids migrating through the Klamath River estuary and monitor natural and hatchery juvenile salmonid emigration from the Klamath Basin. July 1, 1998 through June 30, 2003. Final performance report. Federal Aid in Sport Fish Restoration Act. Project no. F-51-R-6. Arcata, California.

Washington State Department of Ecology (WDOE). 2002. Evaluating Criteria for the Protection of Freshwater Aquatic Life in Washington's Surface Water Quality Standards: Dissolved Oxygen. Draft Discussion Paper and Literature Summary. Publication Number 00-10-071. 90 pp.

Personal Communication

Karuk Tribe. 2017. Salmon River outmigrant data. Unpublished Excel workbook provided by E. Tripp, November 30, 2017.

T. Soto. May 23, 2017. AR-2 Juvenile outmigration and relocation discussion.

Yurok Tribe. 2017. Blue Creek outmigrant data. Unpublished Excel workbook provided by A. Antonetti, November 17, 2017.

10.5 AR-3 Fall Pulse Flows

Ackerman, N.K., B. Pyper, S. Cramer, and I. Courter. 2006. Estimation of returns of naturally produced coho to the Klamath River – review draft Technical Memorandum #1 of 8 Klamath Coho Integrated Modeling Framework Technical Memorandum Series.

Allen, M.B, R.O. Engle, J.S. Zendt, F.C. Shrier, J.T. Wilson, and P.J. Connolly. 2016. Salmon and steelhead in the White Salmon River after the removal of Condit Dam – planning efforts and recolonization results. Fisheries 41:190-203.

Anderson J.H., P.L. Faulds, K.D. Burton, M.E. Koehler, W.I. Atlas, and T.P. Quinn. 2015. Dispersal and productivity of Chinook (Oncorhynchus tshawytscha) and coho (Oncorhynchus kisutch) salmon colonizing newly. Can. J. Fish. Aquat. Sci. 72(3):454-465.

Bartholow, J.M., S.G. Campbell, and M. Flug. 2004. Predicting the thermal effects of dam removal on the Klamath River. Environmental Management 34:856-874.

Benson, R.L., S. Turo, and B.W. McCovey Jr. 2007. Migration and Movement Patterns of Green Sturgeon (Acipenser medirostris) in the Klamath and Trinity rivers, California, USA. Environmental Biology of Fishes 79: 269 - 279.

Bjornn, T. and D. Reiser. 1991. Habitat requirements of salmonids in streams. In Meehan, W. ed., Influences of Forest and Rangeland Management on Salmonids Fishes and Their Habitat. American Fisheries Society Special Publication 19. pp. 83-138.

Burton, KD., L.G. Lowe, H.B. Berge, H.K. Barnett, and P.L. Faulds. 2013. Comparative dispersal patterns for recolonizing Cedar River Chinook salmon above Landsburg Dam, Washington, and the source population below the dam. Trans. Am. Fish. Soc. 142:703–716.

Carter, K. 2005. The effects of dissolved oxygen on steelhead trout, coho salmon, and Chinook salmon-Biology and function by life stage: California Regional Water Quality Control Board North Coast Region report, 9 p.

Chapman J.M., C.L. Proulx, M.A. Veilleux, C. Levert, S. Bliss, M.E. Andre, N.W.R. Lapointe, and S.J. Cooke. 2014. Clear as mud: a meta-analysis on the effects of sedimentation on freshwater fish and the effectiveness of sediment-control measures. Water Res 56:190–202.

Dunsmoor L.K., and C.W. Huntington. 2006. Suitability of environmental conditions within Upper Klamath Lake and the migratory corridor downstream for use by anadromous salmonids. Technical Memorandum. Klamath Tribes, Chiloquin, Oregon.

Engle, R. O., J. Skalicky, and J. Poirier. 2013. Translocation of lower Columbia River fall Chinook Salmon (Oncorhynchus tshawytscha) in the year of Condit Dam removal and year one postremoval assessments. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, 2011 and 2012 Report, Vancouver, Washington.

Federal Energy Regulatory Commission [FERC]. 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027. FERC/EIS-0201F. FERC, Office of Energy Projects, Division of Hydropower Licensing, Washington, DC.

Greig, S.M., D.A. Sear, and P.A. Carling. 2005. The impact of fine sediment accumulation on the survival of incubating salmon progeny: Implications for sediment management. Science of the Total Environment 344: 241-258.

Hatten, J.R., T.R. Batt, J.J. Skalicky, R. Engle, G J. Barton, R.L. Fosness, and J. Warren. 2015. Effects of dam removal on Tule fall Chinook salmon spawning habitat in the White Salmon River, Washington. River Research and Applications 32(7): 1481-1492.

Hopelain, J.S. 1998. Age, growth, and life history of Klamath Basin steelhead trout (Oncorhynchus mykiss irideus) as determined from scale analysis. Inland Fisheries Administration Report 98-3. California Department of Fish and Game, Sacramento.

Huntington, C.W. 2004. Klamath River flows within the J.C. Boyle Bypass and below the J.C. Boyle Powerhouse. Clearwater BioStudies, Canby, Oregon.

Huntington, C.W. 2006. Estimates of anadromous fish runs above the site of Iron Gate Dam. Clearwater BioStudies, Inc., Canby, Oregon.

Huntington, C., E. Claire, F. Espinosa Jr, and R. House. 2006. Reintroduction of Anadromous Fish to the Upper Klamath Basin; an Evaluation and Conceptual Plan. Prepared for Klamath Tribes and Yurok Tribes. 63 pp.

Kiffney, P.M., G.R. Pess, J.H. Anderson, P. Faulds, K. Burton, and S.C. Riley. 2009. Changes in fish communities following recolonization of the Cedar River, WA USA by Pacific salmon after 103 years of local extirpation. River Res. Appl. 25 (4):438–452.

Kjelland, M.E., C.M. Woodley, T.M. Swannack, and D.L. Smith. 2015. A review of the potential effects of suspended sediment on fishes: potential dredging-related physiological, behavioral, and transgenerational implications. Environ Syst Decis 35:334-350.

Klimley, P., P.J. Allen, J.A. Israel and J.T. Kelly. 2007. The Green Sturgeon and its Environment: Past, Present, and Future. Environmental Biology of Fishes 79:3-4, 415-421.

Levasseur, M., N.E. Bergeron, M.F. Lapointe, and F. Berube. 2006. Effects of silt and very fine sand dynamics in Atlantic salmon (Salmo salar) redds on embryo hatching success. Canadian Journal of Fisheries and Aquatic Sciences 63:1450-1459.

Liermann, M., G. Pess, M. McHenry, J. McMillan, M. Elofson, T. Bennett, and R. Moses. 2017. Relocation and Recolonization of Coho Salmon in Two Tributaries to the Elwha River: Implications for Management and Monitoring, Transactions of the American Fisheries Society 146:(5)955-966.

Magneson, M.D., and S. Gough. 2006. Mainstem Klamath River coho salmon redd surveys 2001 to 2005. Arcata Fisheries Data Series Report DS 2006-7. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.

Magneson, M.D., and K. Wright. 2010. Mainstem Klamath River fall Chinook salmon redd survey 2009. Arcata Fisheries Data Series Report DS 2010-19. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.

Mann, R.D., C.C. Caudill, M.L. Keefer, A.G. Roumasset, C.B. Schreck, and M.L. Kent. 2011. Migration behavior and spawning success of spring Chinook salmon in Fall Creek and the North Fork Middle Fork Willamette River: Relationships among fate, fish condition, and environmental factors, 2010. Technical Report 2011-8-DRAFT. 85 pp.

McCovey, B.W. Jr. 2008. Klamath River Green Sturgeon Acoustic Biotelemetry Monitoring, FY 2007 Final Report. Yurok Tribal Fisheries Program. Yurok Tribal Fisheries Program. pp. 16.

McCovey, B.W. Jr. 2010. Klamath River Green Sturgeon Acoustic Tagging and Biotelemetry Monitoring, 2009 Final Technical Report. March 2010. Yurok Tribal Fisheries Program.

McHenry, M., G. Pess, J. Anderson, and H. Hugunin. 2017. Spatial distribution of Chinook Salmon (Oncorhynchus tshawytscha) spawning in the Elwha River, Washington State during dam removal and early stages of recolonization (2012-2016).

National Oceanic and Atmospheric Administration - National Marine Fisheries Service [NOAA] and U.S. Fish and Wildlife Service [USFWS]. 2013. Biological Opinions on the effects of proposed Klamath Project operations from May 31, 2013 through March 31, 2023, on five federally listed threatened and endangered species: National Marine Fisheries Service, Southwest Region.

National Oceanic and Atmospheric Administration - National Marine Fisheries Service [NOAA]. 2010. Biological opinion on the operation of the Klamath Project between 2010 and 2018. Prepared for Bureau of Reclamation by NOAA Fisheries Service, Southwest Region.

National Oceanic and Atmospheric Administration - National Marine Fisheries Service [NOAA]. 2014. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (Oncorhynchus kisutch). National Marine Fisheries Service. Arcata, CA.

National Oceanic and Atmospheric Administration - National Marine Fisheries Service [NOAA]. 2017. Unpublished data – potential fish passage and habitat restoration opportunities.

National Research Council. 2004. Endangered and Threatened Fishes in the Klamath River Basin: Causes of Decline and Strategies for Recovery. Washington, DC: The National Academies Press.

Newcombe, C.P., and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16:693–727.

Oregon Department of Fish and Wildlife [ODFW]. 2011. Rogue River Chinook salmon spawning redd survey data. Unpublished data.

PacifiCorp. 2004. Klamath Hydroelectric Project (FERC project no. 2082): fish resources. Final technical report Prepared by PacifiCorp, Portland, Oregon.

U.S. Bureau of Reclamation [USBR]. 2011. Appendix E – an analysis of potential suspended sediment effects on anadromous fish in the Klamath Basin. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado. 70 pp.

U.S. Bureau of Reclamation [USBR]. 2012. Hydrology, hydraulics and sediment transport studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration, Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado.

U.S. Bureau of Reclamation [USBR], and California Department of Fish and Game [CDFG]. 2012. Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report. Volume I and Volume II. 3063 pp. https://klamathrestoration.gov/Draft-EIS-EIR/download-draft-eis-eir.

Tonra, C.M., K. Sager-Fradkin, S.A. Morley, J.J. Duda, and P.P. Marra. 2015. The rapid return of marine-derived nutrients to a freshwater food web following dam removal. Biological Conservation 192:130-134.

U.S. Fish and Wildlife Service [USFWS]. 2016. Response to Request for Technical Assistance – Prevalence of C. shasta Infections in Juvenile and Adult Salmonids. Unpublished memo. 17 pp.

U.S. Fish and Wildlife Service [USFWS]. 2017. Unpublished coho salmon redd count data.

Washington State Department of Ecology (WDOE). 2002. Evaluating Criteria for the Protection of Freshwater Aquatic Life in Washington's Surface Water Quality Standards: Dissolved Oxygen. Draft Discussion Paper and Literature Summary. Publication Number 00-10-071. 90 pp.

Personal Communication

B. McCovey. Yurok Tribe. May 23, 2017, Yreka, CA. Green sturgeon outmigration.

10.6 AR-4 Iron Gate Hatchery Management

Allen, M.B, R.O. Engle, J.S. Zendt, F.C. Shrier, J.T. Wilson, and P.J. Connolly. 2016. Salmon and steelhead in the White Salmon River after the removal of Condit Dam – planning efforts and recolonization results. Fisheries 41:190-203.

Anderson J.H., P.L. Faulds, K.D. Burton, M.E. Koehler, W.I. Atlas, and T.P. Quinn. 2015. Dispersal and productivity of Chinook (Oncorhynchus tshawytscha) and coho (Oncorhynchus kisutch) salmon colonizing newly. Can. J. Fish. Aquat. Sci. 72(3):454-465.

Bartholow, J.M., S.G. Campbell, and M. Flug. 2004. Predicting the thermal effects of dam removal on the Klamath River. Environmental Management 34:856-874.

Barton, B.A., R.E. Peter, and C.R. Paulencu. 1980. Plasma cortisol levels of fingerling rainbow trout (Salmo gairdneri) at rest and subjected to handling, confinement, transport, and stocking. Canadian Journal of Fisheries and Aquatic Sciences 37:805– 811.Beeman, J., Juhnke, S., Stutzer, G., and Wright, K., 2012, Effects of Iron Gate Dam discharge and other factors on the survival and migration of juvenile coho salmon in the lower Klamath River, northern California, 2006–09: U.S. Geological Survey Open-File Report 2012-1067, 96 p.

Burton, KD., L.G. Lowe, H.B. Berge, H.K. Barnett, and P.L. Faulds. 2013. Comparative dispersal patterns for recolonizing Cedar River Chinook salmon above Landsburg Dam, Washington, and the source population below the dam. Trans. Am. Fish. Soc. 142:703–716.

California Department of Fish and Wildlife [CDFW] and PacifiCorp. 2014. Hatchery and genetic management plan for Iron Gate Hatchery coho salmon. Prepared for National Oceanic and Atmospheric Administration – National Marine Fisheries Service. 163 pp.

Dunsmoor L.K., and C.W. Huntington. 2006. Suitability of environmental conditions within Upper Klamath Lake and the migratory corridor downstream for use by anadromous salmonids. Technical Memorandum. Klamath Tribes, Chiloquin, Oregon.

Engle, R. O., J. Skalicky, and J. Poirier. 2013. Translocation of lower Columbia River fall Chinook Salmon (Oncorhynchus tshawytscha) in the year of Condit Dam removal and year one postremoval assessments. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, 2011 and 2012 Report, Vancouver, Washington.

Federal Energy Regulatory Commission [FERC]. 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No.

2082-027. FERC/EIS-0201F. FERC, Office of Energy Projects, Division of Hydropower Licensing, Washington, DC.

Gunnerød, T.B., N.A. Hvidsten, and T.G. Heggberget. 1988. Open sea releases of Atlantic salmon smolts, Salmo salar, in central Norway, 1973-83. Canadian Journal of Fisheries and Aquatic Sciences 45(8):1340-1345.

Hatten, J.R., T.R. Batt, J.J. Skalicky, R. Engle, G J. Barton, R.L. Fosness, and J. Warren. 2015. Effects of dam removal on Tule fall Chinook salmon spawning habitat in the White Salmon River, Washington. River Research and Applications 32(7): 1481-1492.

Heggberget, T.G., N.A. Hvidsten, T.B. Gunnerød, and P.I. Møkkelgjerd. 1991. Distribution of adult recaptures from hatchery-reared Atlantic salmon (Salmo salar) smolts released in and off-shore of the River Surna, western Norway. Aquaculture, 98: 89-96.

Huntington, C.W. 2004. Klamath River flows within the J.C. Boyle Bypass and below the J.C. Boyle Powerhouse. Clearwater BioStudies, Canby, Oregon.

Huntington, C.W. 2006. Estimates of anadromous fish runs above the site of Iron Gate Dam. Clearwater BioStudies, Inc., Canby, Oregon.

Keefer, M.L. and C.C. Caudill. 2014. Homing and straying by anadromous salmonids: a review of mechanisms and rates. Fish Biol. Fisheries 24:333–368

Kenaston, K.R., R.B. Lindsay, and R.K. Schroeder. 2001. Effect of acclimation on the homing and survival of hatchery winter steelhead. North American Journal of Fisheries Management 21(4):765-773.

Kiffney, P.M., G.R. Pess, J.H. Anderson, P. Faulds, K. Burton, and S.C. Riley. 2009. Changes in fish communities following recolonization of the Cedar River, WA USA by Pacific salmon after 103 years of local extirpation. River Res. Appl. 25 (4):438–452.

Levasseur, M., N.E. Bergeron, M.F. Lapointe, and F. Berube. 2006. Effects of silt and very fine sand dynamics in Atlantic salmon (Salmo salar) redds on embryo hatching success. Canadian Journal of Fisheries and Aquatic Sciences 63:1450-1459.

Liermann, M., G. Pess, M. McHenry, J. McMillan, M. Elofson, T. Bennett, and R. Moses. 2017. Relocation and Recolonization of Coho Salmon in Two Tributaries to the Elwha River: Implications for Management and Monitoring, Transactions of the American Fisheries Society 146:(5)955-966.

Matthews, G.M., D.L. Park, S. Achord, and T.E. Ruehle. 1986. Static seawater challenge test to measure relative stress levels in spring chinook salmon smolts. Trans. Am. Fish. Soc. 115(2):236-244.

McHenry, M., G. Pess, J. Anderson, and H. Hugunin. 2017. Spatial distribution of Chinook Salmon (Oncorhynchus tshawytscha) spawning in the Elwha River, Washington State during dam removal and early stages of recolonization (2012-2016).

Oregon Department of Fish and Wildlife [ODFW]. 2011. Rogue River Chinook salmon spawning redd survey data. Unpublished data.

PacifiCorp. 2004. Klamath Hydroelectric Project (FERC project no. 2082): fish resources. Final technical report Prepared by PacifiCorp, Portland, Oregon.

Solazzi, M.F., S L. Johnson, B. Miller, T. Dalton, and K.A. Leader. 2003. Salmonid life-cycle monitoring project 2002. Oregon Department of Fish and Wildlife, Monitoring Program Report OPSW-ODFW-2003–2, Portland

Specker, J.L., and C.B. Schreck. 1980. Stress responses to transportation and fitness for marine survival in coho salmon (Oncorhynchus kisutch) smolts. Canadian Journal of Fisheries and Aquatic Sciences 37:765–769.

Tonra, C.M., K. Sager-Fradkin, S.A. Morley, J.J. Duda, and P.P. Marra. 2015. The rapid return of marine-derived nutrients to a freshwater food web following dam removal. Biological Conservation 192:130-134.

U.S. Bureau of Reclamation [USBR]. 2011. Appendix E – an analysis of potential suspended sediment effects on anadromous fish in the Klamath Basin. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado. 70 pp.

U.S. Bureau of Reclamation [USBR], and California Department of Fish and Game [CDFG]. 2012. Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report. Volume I and Volume II. 3063 pp. https://klamathrestoration.gov/Draft-EIS-EIR/download-draft-eis-eir.

U.S. Fish and Wildlife Service [USFWS]. 2016. Response to Request for Technical Assistance – Prevalence of C. shasta Infections in Juvenile and Adult Salmonids. Unpublished memo. 17 pp.

10.7 AR-5 Pacific Lamprey Ammocoetes

Anderson J.H., P.L. Faulds, K.D. Burton, M.E. Koehler, W.I. Atlas, and T.P. Quinn. 2015. Dispersal and productivity of Chinook (Oncorhynchus tshawytscha) and coho (Oncorhynchus kisutch) salmon colonizing newly. Can. J. Fish. Aquat. Sci. 72(3):454-465.

Bartholow, J.M., S.G. Campbell, and M. Flug. 2005. Predicting the thermal effects of dam removal on the Klamath River. Environmental Management 34:856-874.

Burton, K.D., L.G. Lowe, H.B. Berge, H.K. Barnett, and P.L. Faulds. 2013. Comparative dispersal patterns for recolonizing Cedar River Chinook salmon above Landsburg Dam, Washington, and the source population below the dam. Trans. Am. Fish. Soc. 142:703–716.

Dunsmoor L.K., and C.W. Huntington. 2006. Suitability of environmental conditions within Upper Klamath Lake and the migratory corridor downstream for use by anadromous salmonids. Technical Memorandum. Klamath Tribes, Chiloquin, Oregon.

Engle, R. O., J. Skalicky, and J. Poirier. 2013. Translocation of lower Columbia River fall Chinook Salmon (Oncorhynchus tshawytscha) in the year of Condit Dam removal and year one postremoval assessments. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, 2011 and 2012 Report, Vancouver, Washington.

Federal Energy Regulatory Commission [FERC]. 2006. Licensing for the continued operation of PacifiCorp's Klamath Hydroelectric Project, located principally on the Klamath River, in Klamath County, Oregon and Siskiyou County, California, FERC Project No. 2082. Draft environmental impact statement. Prepared by FERC, Office of Energy Projects, Washington, DC.

Federal Energy Regulatory Commission [FERC]. 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027. FERC/EIS-0201F. FERC, Office of Energy Projects, Division of Hydropower Licensing, Washington, DC.

Goodman, D.H., and N.J. Hetrick. 2017. Technical Memorandum. Response to Request for Technical Assistance – Distribution of Pacific Lamprey in the reach immediately downstream of Iron Gate Dam, Klamath River. September 5, 2017.

Goodman, D.H., and S.B. Reid. 2012. Pacific Lamprey (Entosphenus tridentatus) Assessment and Template for Conservation Measures in California. U.S. Fish and Wildlife Service, Arcata, California. 117 pp.

Goodman, D.H., and S.B. Reid. 2015. Regional Implementation Plan for Measures to Conserve Pacific Lamprey (Entosphenus tridentatus), California - North Coast Regional Management Unit. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR 2015-21, Arcata, California. 35 pp.

Greig, S.M., D.A. Sear, and P.A. Carling. 2005. The impact of fine sediment accumulation on the survival of incubating salmon progeny: Implications for sediment management. Science of the Total Environment 344: 241-258.

Hatten, J. R., T.R. Batt, J.J. Skalicky, R. Engle, G J. Barton, R.L. Fosness, and J. Warren. 2015. Effects of dam removal on Tule fall Chinook salmon spawning habitat in the

White Salmon River, Washington. River Research and Applications 32(7): 1481-1492.

Huntington, C.W. 2004. Klamath River flows within the J.C. Boyle Bypass and below the J.C. Boyle Powerhouse. Clearwater BioStudies, Canby, Oregon.

Huntington, C.W. 2006. Estimates of anadromous fish runs above the site of Iron Gate Dam. Clearwater BioStudies, Inc, Canby, Oregon.

Huntington, C., E. Claire, F. Espinosa Jr, and R. House. 2006. Reintroduction of Anadromous Fish to the Upper Klamath Basin; an Evaluation and Conceptual Plan. Prepared for Klamath Tribes and Yurok Tribes. 63 pp.

Jolley, J.C., G.S. Silver, and T.A. Whitesel. 2013. Occurrence, detection, and habitat use of larval lamprey in the Lower White Salmon River and mouth: post-Condit Dam removal, 2012 Annual Report. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA. 22 pp

Jolley, J.C., G.S. Silver, J.E. Harris, E.C. Butts, and C. Cook-Tabor. 2016. Occupancy and Distribution of Larval Pacific Lamprey and Lampetra spp. in Wadeable Streams of the Pacific Northwest. U.S. Fish and Wildlife Service, Columbia River Fish and Wildlife Conservation Office, Vancouver, WA. 35 pp

Jolley, J.C., G.S. Silver, J. J. Skalicky, J.E. Harris, and T.A. Whitesel. 2016. Evaluation of Larval Pacific Lamprey Rearing in Mainstem Areas of the Columbia and Snake Rivers Impacted by Dams. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA. 33 pp.

Kiffney, P.M., G.R. Pess, J.H. Anderson, P. Faulds, K. Burton, and S.C. Riley. 2009. Changes in fish communities following recolonization of the Cedar River, WA USA by Pacific salmon after 103 years of local extirpation. River Res. Appl. 25 (4):438–452.

Kjelland, M.E., C.M. Woodley, T.M. Swannack, and D.L. Smith. 2015. A review of the potential effects of suspended sediment on fishes: potential dredging-related physiological, behavioral, and transgenerational implications. Environ Syst Decis 35:334-350.

Kostow, K. 2002. Oregon Lampreys: Natural history status and analysis management issues. Oregon Department of Fish and Wildlife.

Levasseur, M., N.E. Bergeron, M.F. Lapointe, and F. Berube. 2006. Effects of silt and very fine sand dynamics in Atlantic salmon (Salmo salar) redds on embryo hatching success. Canadian Journal of Fisheries and Aquatic Sciences 63:1450-1459.

Liermann, M., G. Pess, M. McHenry, J. McMillan, M. Elofson, T. Bennett, and R. Moses. 2017. Relocation and Recolonization of Coho Salmon in Two Tributaries to the Elwha

River: Implications for Management and Monitoring, Transactions of the American Fisheries Society 146:(5)955-966.

Li, W., M.J. Siefkes, A.P. Scott, and J.H. Teeler. 2003. Sex pheromone communication in the sea lamprey: implications for integrated management. Journal of Great Lakes Research 29, Supplement 1:85-94.

McHenry, M., G. Pess, J. Anderson, and H. Hugunin. 2017. Spatial distribution of Chinook Salmon (Oncorhynchus tshawytscha) spawning in the Elwha River, Washington State during dam removal and early stages of recolonization (2012-2016).

Morley, S. A., H. J. Coe, J. J. Duda, L. S. Dunphy, M. L. McHenry, B. R. Beckman, M. Elofson, E. M. Sampson, and L. Ward. 2016. Seasonal variation exceeds effects of salmon carcass additions on benthic food webs in the Elwha River. Ecosphere 7(8):e01422. 10.1002/ecs2.1422

Oregon Department of Fish and Wildlife [ODFW]. 2008. A Plan for the Reintroduction of Anadromous Fish in the Upper Klamath Basin. 56 pp.

Oregon Department of Fish and Wildlife [ODFW]. 2011. Rogue River Chinook salmon spawning redd survey data. Unpublished data.

PacifiCorp. 2004. Klamath Hydroelectric Project (FERC project no. 2082): fish resources. Final technical report Prepared by PacifiCorp, Portland, Oregon.

Petersen, R.S. 2006. The role of traditional ecological knowledge in understanding a species and river system at risk: Pacific Lamprey in the lower Klamath Basin. Master of Arts in applied Anthropology Thesis. 182 pp.

Bureau of Reclamation [USBR]. 2012. Hydrology, hydraulics and sediment transport studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration, Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado.

Schultz, L., M.P. Mayfield, G.T. Sheoships, L.A. Wyss, B.J. Clemens, B. Chasco, and C.B. Schreck. 2014. The distribution and relative abundance of spawning and larval Pacific lamprey in the Willamette River Basin. Final Report to the Columbia Inter-Tribal Fish Commission for project years 2011-2014. 113 pp.

Stone, J., J. Pirtle, and S. Barndt. 2002. Evaluate habitat use and population dynamics of lampreys in Cedar Creek, Annual Report 2001, Bonneville Power Administration, Contract No. 00004672, Project No. 200001400, 44 pp.

Tonra, C.M., K. Sager-Fradkin, S.A. Morley, J.J. Duda, and P.P. Marra. 2015. The rapid return of marine-derived nutrients to a freshwater food web following dam removal. Biological Conservation 192:130-134.

U.S. Department of the Interior (USDI). USBR and CDFG. 2012. Klamath Facilities Removal Final Environmental Impact Statement/ Environmental Impact Report (Vol. I). Report prepared by the US Department of Interior through the Bureau of Reclamation (USBR), and California Department of Fish and Game (CDFG), Sacramento, California. State Clearinghouse # 2010062060. 2092 pp.

U.S. Fish and Wildlife Service [USFWS]. 2010. Unpublished data – Klamath River lamprey ammocoete surveys. D. Goodman, personal communication, July 2017.

Zaroban, D. W., Mulvey, M. P., Maret, T. R., Hughes, R. M. and Merrit, G. D. 1999. Classification of species attributes for Pacific Northwest freshwater fishes. Northwest Science, 73(2): 81–93.

Personal Communication

T. Soto. Karuk Tribe. May 23, 2017. AR-5 Pacific lamprey ammocoete relocation discussion.

T. Wise. ODFW. May 23, 2017. ODFW anadromous salmonid reintroduction plan discussion.

10.8 AR-6 Sucker Salvage and Relocation

Beak Consultants Incorporated. 1987. Shortnose and Lost River sucker studies: Copco Reservoir and the Klamath River. Unpublished manuscript. Project No. D3060.01. Portland, Oregon, 37 pp. and appendix.

Beak Consultants Incorporated. 1988. Shortnose and Lost River sucker studies: Larval sucker study between Copco Reservoir and the proposed Salt Caves diversion pool. Unpublished manuscript. Project No. 73060.03. Portland, Oregon, 36 pp. and appendix.

Buettner, M.E., and G.G. Scoppettone. 1990. Life history and status of Catostomids in Upper Klamath Lake, Oregon: Completion report. Reno Field Station, National Fisheries

Buettner, M.E. and G.G. Scoppettone. 1991. Distribution and information on the taxonomic status of the shortnose sucker (Chasmistes brevirostris) and Lost River sucker (Deltistes luxatus) in the Klamath River Basin, California. Completion Report. National Fisheries Research Center, reno field Station, Nevada, 100 pp.

Buettner, M.E. 2000. Analysis of Tule Lake water quality and sucker telemetry, 1992-1995. U.S. Bureau of Reclamation, Mid-Pacific Region, Klamath Basin Area Office. 47 pp.

Buettner, M., R. Larson, J. Hamilton, and G. Curtis. 2006. Contribution of Klamath reservoirs to federally listed sucker populations and habitat. U.S. Fish and Wildlife Service, Yreka, California.

Burdick, S.M. 2013. Assessing movement and sources of mortality of juvenile catostomids using passive integrated transponder tags, Upper Klamath Lake, Oregon—Summary of 2012 effort: U.S. Geological Survey Open-File Report 2013-1062, 12 pp.

Desjardins, M., and D.F. Markle. 2000. Distribution and biology of suckers in lower Klamath reservoirs. 1999 Final Report submitted to PacifiCorp. 78 pp.

Hewitt, D.A., E.C. Janney, B.S. Hayes, and A.C. Harris. 2014. Demographics and run timing of adult Lost River (Deltistes luxatus) and shortnose (Chasmistes brevirostris) suckers in Upper Klamath Lake, Oregon, 2012: U.S. Geological Survey Open-File Report 2014-1186, 44 pp.

Janney, E.C., B.C. Hayes, D.A. Hewitt, P.M. Barry, A.C. Scott, J.P. Koller, M.A. Johnson, and G. Blackwood. 2009. Demographics and 2008 run timing of adult Lost River (Deltistes luxatus) and shortnose (Chasmistes brevirostris) suckers in Upper Klamath Lake, Oregon, 2008: U.S. Geological Survey Open-File Report 2009-1183, 32 pp.

Levasseur, M., N.E. Bergeron, M.F. Lapointe, and F. Berube. 2006. Effects of silt and very fine sand dynamics in Atlantic salmon (Salmo salar) redds on embryo hatching success. Canadian Journal of Fisheries and Aquatic Sciences 63:1450-1459.

Markle, D.F., M.R. Cavalluzzi, T.E. Dowling, and D. Simon. 1999. Ecology of Upper Klamath Lake shortnose and Lost river suckers – The Klamath Basin sucker species complex. Submitted to U.S. Biological Resources Division – U.S. Geological survey and Klamath Project – U.S. Bureau of Reclamation. 35 pp.

Miller, R.R., and G.R. Smith. 1981. Distribution and evolution of Chasmistes (Pisces:Catostomidae) in western North America. Occasional Papers of the Museum of Zoology, University of Michigan 696:1-48.

Moyle, P.B. 1976. Inland fishes of California. University of California Press, Berkeley and Los Angeles.

Moyle, P.B. 2002. Inland fishes of California. University of California Press, Berkeley, California.

Templeton, A.R. 1989. The meaning of species and speciation; a genetic perspective. Pp. 3-27 in D. Otte and J.A. Endler. Speciation and its consequences. Sinauer Assoc. Inc., Sunderland, Massachusetts, 679 pp.

U.S. Bureau of Reclamation [USBR]. 2012. Hydrology, hydraulics and sediment transport studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration, Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado.

U.S. Bureau of Reclamation [USBR], and California Department of Fish and Game [CDFG]. 2012. Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report. Volume I and Volume II. 3063 pp. https://klamathrestoration.gov/Draft-EIS-EIR/download-draft-eis-eir.

U.S. Fish and Wildlife Service [USFWS]. 1993. Shortnose sucker (Chasmistes brevirostris) and Lost River (Deltistes luxatus) Sucker Recovery Plan. Portland, Oregon.

U.S. Fish and Wildlife Service [USFWS]. 2012. Revised recovery plan for the Lost River sucker (Deltistes luxatus) and shortnose sucker (Chasmistes brevirostris). U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, California. xviii + 122 pp.

Williams, J.E., D.B. Bowman, J.E. Brooks, A.A. Echelle, R.J. Edwards, D.A. Hendrickson, and J.J. Landye. 1985. Endangered aquatic ecosystems in North American deserts with a list of vanishing fishes of the region. Journal of the Arizona-Nevada Academy of Science 20:1-62.

Personal Communication

B. Tinniswood. ODFW. June 19, 2017. Observed sucker spawning migration April 2017 upstream from Topsy Reservoir. Comments provided during ATWG planning meeting.

J. Rasmussen. USFWS. May 24, 2017 and June 19, 2017. Recipient waterbody capacity. Comments provided during ATWG planning meeting.

T. Wise. ODFW. May 23, 2017. Klamath smallscale sucker salvage concerns. Comments provided during ATWG planning meeting.

10.9 AR-7 Freshwater Mussels

Bartholow, J.M., S.G. Campbell, and M. Flug. 2004. Predicting the thermal effects of dam removal on the Klamath River. Environmental Management 34:856-874.

Bettaso, J.B., and D.H. Goodman. 2010. A Comparison of Mercury Contamination in Mussel and Ammocoete Filter Feeders. Journal of Fish and Wildlife Management: November 2010, Vol. 1, No. 2, pp. 142-145.

Byron, E., and J. Tupen. 2017. Mussels of the Upper Klamath River, Oregon and California. California Fish and Game 103(1):21-26.

Cope, W.G., and D.L. Waller. 1995. Evaluation of freshwater mussel relocation as a conservation and management strategy. Regulated Rivers: Research & Management 11:147-155.

Davis, E.A., A.T. David, K.M. Norgaard, T.H. Parker, K. McKay, C. Tennant, T. Soto, K. Rowe, and R. Reed. 2013. Distribution and abundance of freshwater mussels in the mid Klamath Subbasin, California. Northwest Science, 87(3):189-206. 2013.

Dunsmoor L.K., and C.W. Huntington. 2006. Suitability of environmental conditions within Upper Klamath Lake and the migratory corridor downstream for use by anadromous salmonids. Technical Memorandum. Klamath Tribes, Chiloquin, Oregon.

Federal Energy Regulatory Commission [FERC]. 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027. FERC/EIS-0201F. FERC, Office of Energy Projects, Division of Hydropower Licensing, Washington, DC.

Fernandez, M.K. 2013. Transplants of western pearlshell mussels to unoccupied streams on Willapa National Wildlife Refuge, southwestern Washington. Journal of Fish and Wildlife Management 4(2):316-325.

Germano, J.M., K.J. Field, R.A. Griffiths, S. Clulow, J. Foster, G. Harding, and R.R. Swaisgood. 2015. Mitigation-driven translocations: are we moving wildlife in the right direction? Front Ecol Environ 2015; 13(2):100–105.

Greig, S.M., D.A. Sear, and P.A. Carling. 2005. The impact of fine sediment accumulation on the survival of incubating salmon progeny: Implications for sediment management. Science of the Total Environment 344: 241-258.

Howard, J. 2013. Upper Truckee Airport Reach freshwater mussel (Margaritifera falcata) relocation: two years later. Unpublished manuscript. 36 pp.

Howard, J.K., J. L. Furnish, J. BrimBox, and S. Jepsen. 2015. The decline of the native freshwater mussels (Bivalvia: Unionoida) in California as determined from his¬torical and current surveys. California Fish and Game 101(1):8-23.

Huntington, C.W. 2004. Klamath River flows within the J.C. Boyle Bypass and below the J.C. Boyle Powerhouse. Clearwater BioStudies, Canby, Oregon.

Huntington, C.W. 2006. Estimates of anadromous fish runs above the site of Iron Gate Dam. Clearwater BioStudies, Inc., Canby, Oregon.

Kann, J., S. Corum, and K. Fetcho. 2010. Microsystin bioaccumulation in Klamath River freshwater mussel tissue: 2009 results. Aquatic Ecosystem Sciences LLC, Ashland, OR. Unpublished manuscript. 37 pp.

Krall, M. 2010. Freshwater mussel abundance and habitat in the Klamath River of Northern California. Bachelor of Arts thesis submitted to Biology Department, Whitman College. 36 p.

Levasseur, M., N.E. Bergeron, M.F. Lapointe, and F. Berube. 2006. Effects of silt and very fine sand dynamics in Atlantic salmon (Salmo salar) redds on embryo hatching success. Canadian Journal of Fisheries and Aquatic Sciences 63:1450-1459.

Lopes-Lima, M., Sousa, R., Geist, J., Aldridge, D.C., Araujo, R., Bergengren, J., et al. 2016. Conservation status of freshwater mussels in Europe: state of the art and future challenges. Biological Reviews http://dx.doi.org/10.1111/brv.12244.

Lummer, E., K. Auerswald, and J. Geist. 2016. Fine sediment as environmental stressor affecting freshwater mussel behavior and ecosystem services. Science of the Total Environment 571:1340-1348.

Luzier, C., and S. Miller. 2009. Freshwater mussel relocation guidelines. A product of the Pacific Northwest Native Freshwater Mussel Workgroup. 7 pp.

May, C. L., and B.S. Pryor. 2016. Explaining Spatial Patterns of Mussel Beds in a Northern California River: The Role of Flood Disturbance and Spawning Salmon. River research and applications.

Olden, J.D., M.J. Kennard, J.J. Lawler, and N.L Poff. 2010. Challenges and opportunities in implementing managed relocation for conservation of freshwater species. Conservation Biology 25(1):40-47.

PacifiCorp. 2004. Klamath Hydroelectric Project (FERC project no. 2082): fish resources. Final technical report Prepared by PacifiCorp, Portland, Oregon.

Tennant, C. 2010. Freshwater mussels of the Klamath River: a personal and scientific account. Bachelor of Arts thesis submitted to Biology Department, Whitman College. 45 p.

U.S. Bureau of Reclamation [USBR]. 2012. Hydrology, hydraulics and sediment transport studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration, Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado.

U.S. Bureau of Reclamation [USBR], and California Department of Fish and Game [CDFG]. 2012. Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report. Volume I and Volume II. 3063 pp. https://klamathrestoration.gov/Draft-EIS-EIR/download-draft-eis-eir.

U.S. Fish and Wildlife Service [USFWS]. 2016. Response to Request for Technical Assistance – Prevalence of C. shasta Infections in Juvenile and Adult Salmonids. Unpublished memo. 17 pp.

Vannote, R.L., and G.W. Minshall. 1982. Fluvial processes and local lithology controlling abundance, structure, and composition of mussel beds. Proc. Natl. Acad. Sci. USA 79:4103-4107.

Westover, M. 2010. Freshwater mussel distribution, abundance and habitat use in the middle Klamath River. Bachelor of Science thesis submitted to Biology Department, Whitman College. 45 p.

Xerces Society. 2009. Freshwater mussels of the Pacific Northwest. Second Edition. 60 pp.

Xerces Society. 2012. Margaritifera falcata (Gould, 1850) Western pearlshell, Bivalvia: Margaritiferidae. Profile prepared by Sarina Jepsen, Caitlin LaBar, and Jennifer Zarnoch. 24 pp.

Personal Communication

P. Crain. U.S. National Park Service. September 15, 2017. Phone call with T. Brandt regarding Elwha Dam Removal Project freshwater mussel relocation effort.

K. Kwak. CDFW. September 15, 2017. Email communication with C. Bean (CDFW) provided to T. Brandt regarding freshwater mussel pathogen concerns.

Appendix A Juvenile Salmonid Outmigration Variability Plots

Appendix A – Juvenile Salmonid Outmigration Variability Plots

1. Introduction

Appendix A includes outmigration variability plots for trap data from the Klamath River and select tributaries. The plots provide an indication of the variability of outmigration timing by species and trap location. Outmigration variability is related to flow, water temperature, food resources, and other biological and environmental cues.

2. Upper Klamath River – Bogus Net Frame and Kinsman Trap Results

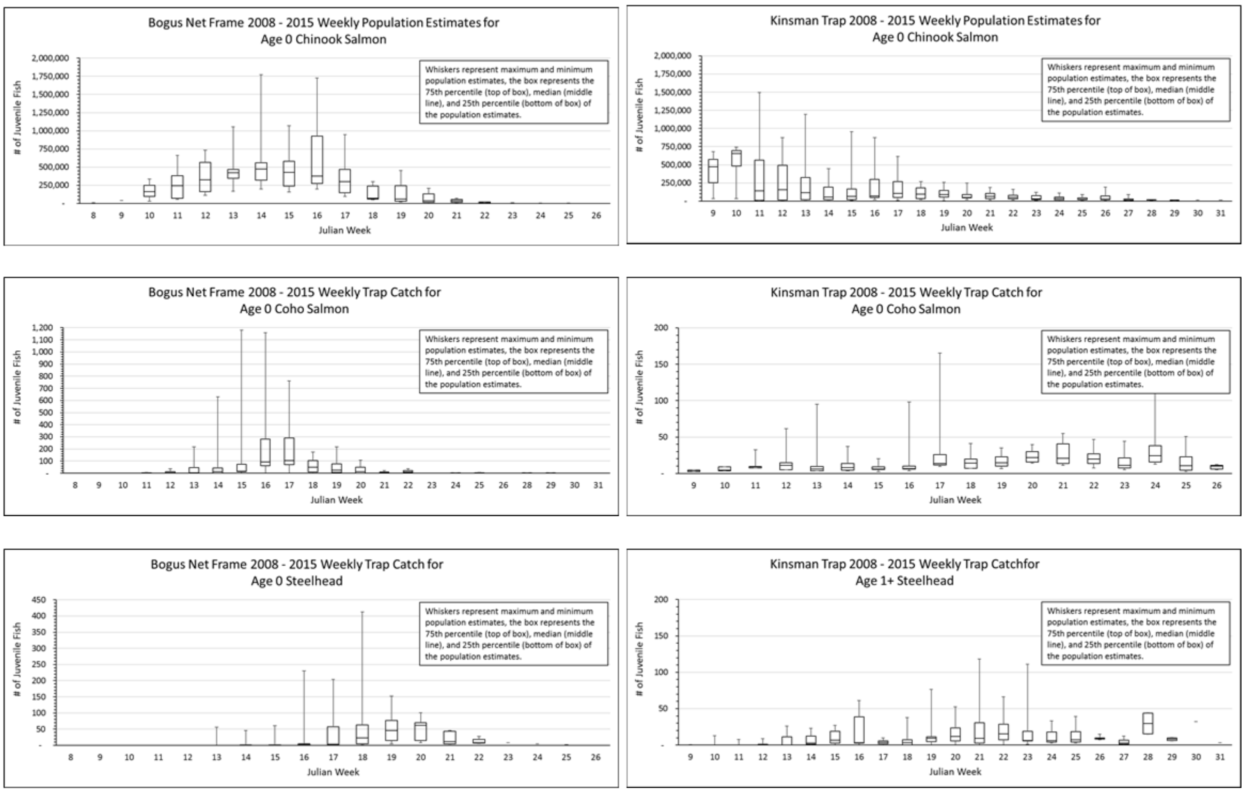


Figure A-1. Chinook salmon, coho salmon, and steelhead weekly population estimates and trap catch results for the Bogus net frame and Kinsman rotary screw trap on the Klamath River.

3. Upper Klamath River – Shasta River and Scott River Trap Results

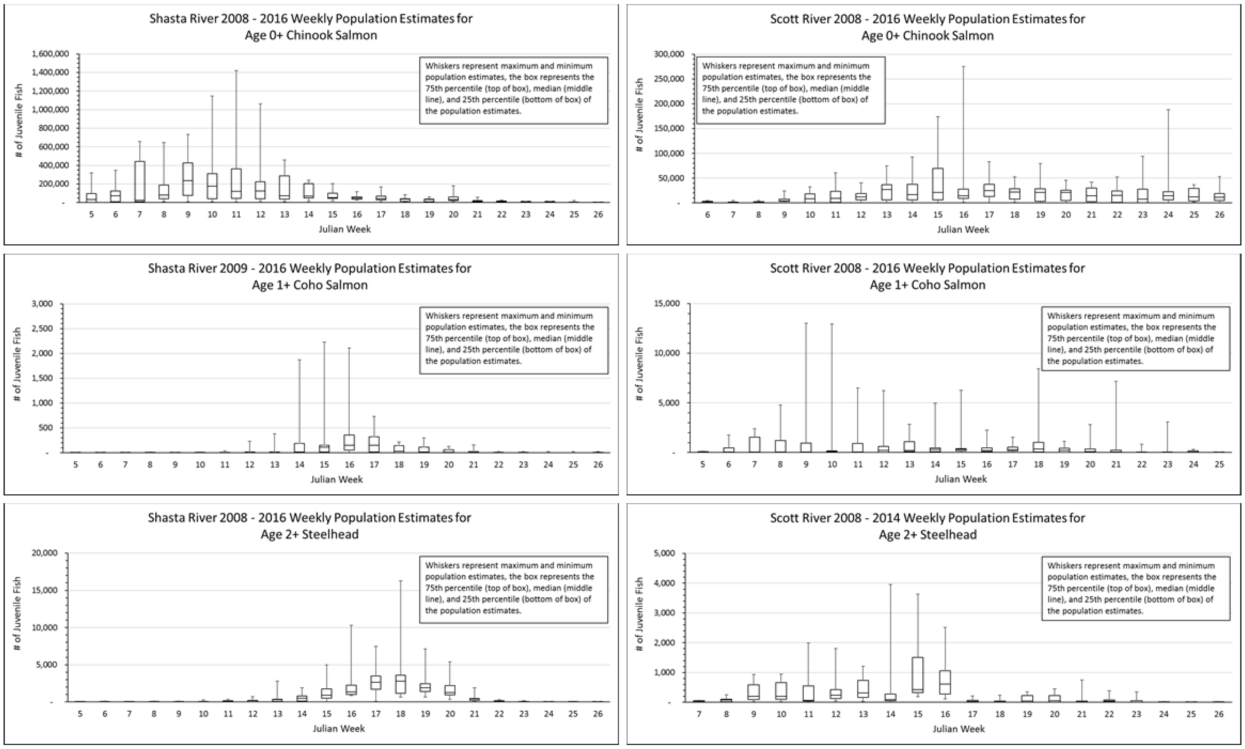


Figure A-2. Chinook salmon, coho salmon and steelhead weekly population estimates for the Shasta River and Scott River traps.

4. Middle Klamath River – Salmon River and Trinity River Trap Results

Trap variability calculations were not completed for the Salmon River trap catch.

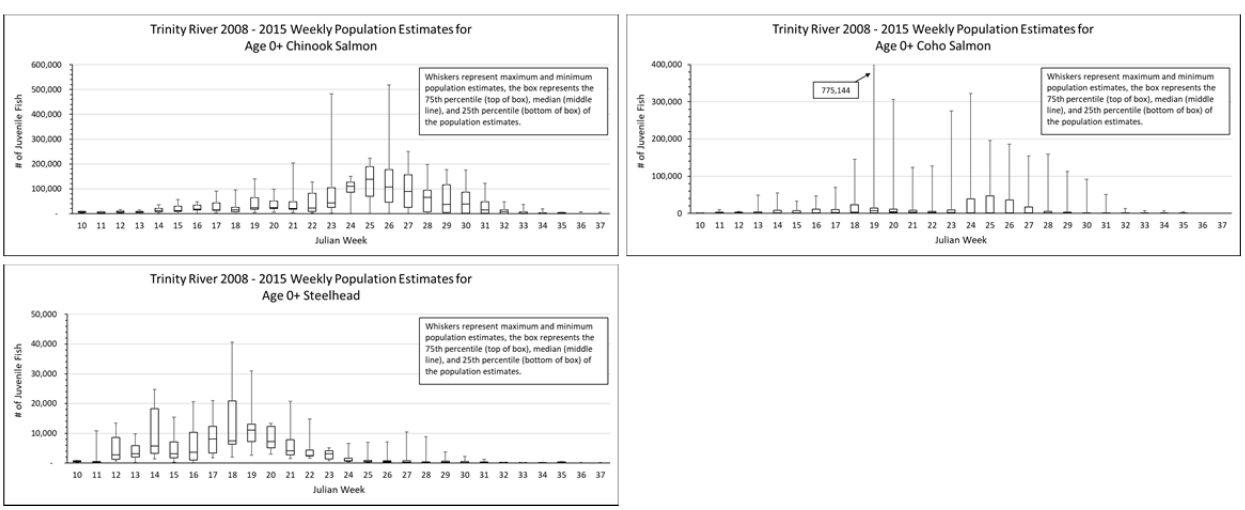


Figure A-3. Chinook salmon, coho salmon and steelhead weekly population estimates for the Trinity River trap.

5. Lower Klamath River – Blue Creek Trap Results

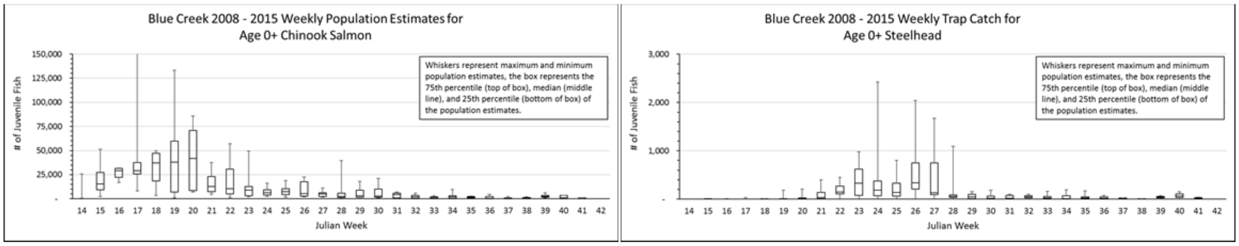


Figure A-4. Chinook salmon and steelhead weekly population estimates for the Blue Creek trap.

aecom.com

Appendix L Cultural Resources Plan

AECOM

Klamath River Renewal Project

Definite Plan for Decommissioning
Appendix L – Cultural Resources Plan

Administrative Draft

Submitted to: California State Water Resource Control Board

Submitted by: Klamath River Renewal Corporation

Date: January 2018

Prepared for:

Klamath River Renewal Corporation
Federal Energy Regulatory Commission

Prepared by:

KRRC Technical Representative:

AECOM Technical Services, Inc.
300 Lakeside Drive, Suite 400
Oakland, California 94612

Table of Contents

Figures

Tables

1. Introduction

The Klamath River Renewal Corporation (KRRC) is preparing the necessary documentation of compliance with all local, state, and federal laws, including those for cultural and tribal resources. The tasks described in this plan provide FERC with a framework for the cultural resources studies that the KRRC has completed, those that are currently ongoing, and others that are anticipated, to achieve regulatory requirements under Section 106 of the National Historic Preservation Act of 1966 (NHPA). As requested in the FERC Additional Information Request for cultural resources (AIR #28 and #29) , the plan also provides a summary of the status of informal consultation completed by KRRC and PacifiCorp, as FERC's non-federal representative, for carrying out informal consultation pursuant to Section 106 (AIR #28) and to consultation with affected Indian Tribes and other tribal organizations (AIR #29).

2. Plan Overview

The Cultural Resources Plan that follows has been developed to guide the multifaceted phases of cultural resources compliance planned for the Klamath River Renewal Project (Project). Foremost among these tasks is identification of historic properties in the Project's Area of Potential Effects (APE). Historic properties are cultural resources listed or eligible for listing in the National Register of Historic Places (NRHP). The Advisory Council on Historic Preservation (ACHP) regulations define the APE as the geographic area or areas within which an undertaking may directly or indirectly cause changes in the character or use of historic properties, if any such properties exist. The scale and nature of an undertaking influences an APE, which may be different for different kinds of effects caused by the undertaking (36 CFR 800.16(d). Once defined, the APE will become the primary focus of the project's cultural and tribal resources studies.

Additional resource identification efforts, effects determinations, and potential mitigation measures also are needed to meet Section 106 requirements, including an assessment of the completeness of previous inventory conducted within the APE and areas of direct impacts from dam removal. Anticipated effects to cultural and tribal resources include, but are not limited to, removal of historic project facilities, including the four dams; disturbances associated with road construction, disposal sites and staging activities; erosion and exposure associated with reservoir drawdown and enhanced river flows; and potential vandalism and theft to re-exposed sites. Cultural resources identification efforts for the Project, including pre- drawdown surveys for direct impact areas not previously inventoried such as haul routes and waste disposal sites, are underway. Also important is during and post-drawdown inventory and monitoring to ensure identification and treatment of both anticipated (based on the historic record) and unanticipated cultural and tribal resources.

Previous cultural resources surveys conducted by PacifiCorp in the early 2000s for the Klamath Hydroelectric Project relicensing encompassed existing developments on the main stem Klamath River, including the four Project dams. The PacifiCorp cultural resources study (PacifiCorp 2004) documented hundreds of cultural resources sites within a defined Field Inventory Corridor (FIC), with varying status of NRHP evaluation. The eligibility of many cultural resources sites within the direct impact area for the Project require reevaluation because their eligibility under the Klamath Hydroelectric Project relicensing was never formalized through consultation with the California and Oregon State Historic Preservation Officers (SHPO), or because other components of the sites were not considered in the original evaluations. New cultural and tribal resources sites identified through future survey efforts also require NRHP evaluation determinations, particularly for those resources within direct impact areas. Following evaluation and effects assessment, mitigation measures will be needed for any historic property that cannot be avoided.

PacifiCorp completed the NRHP evaluation of the Klamath Hydroelectric Project (FERC License No. 2082), comprised of seven generation facilities and their related resources located along the Klamath River and its tributaries in Klamath County, Oregon and Siskiyou County, California, including the four complexes planned for decommissioning (J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate). An eighth complex was also evaluated, comprised of the Fall Creek powerhouse, located on a tributary of the Klamath River, just north of Copco No. 2. A historic context statement (Kramer 2003a) and Determination of Eligibility (Kramer 2003b) were developed for the Klamath River Hydroelectric Project District (P-47-004015), noting its eligibility to the National Register under Criterion A for its association with the industrial and economic development of southern Oregon and northern California (Kramer 2003b). The California and Oregon SHPOs have not concurred with this eligibility recommendation, which remains an important element to be completed as part of this Cultural Resource Plan.

PacifiCorp sponsored tribal ethnographic studies, prepared by the Klamath, Shasta, Karuk, and Yurok Tribes, which combined ethnography with extensive oral interviews to identify traditional cultural properties/sensitive cultural resources (TCPs/SCRs). PacifiCorp also provided for an investigation of the feasibility of nominating Klamath River corridor as a traditional cultural riverscape/traditional cultural property (TCR/TCP). The NRHP evaluation of the TCPs, SCRs, and the TCR was not formalized through consultation with the California and Oregon SHPOs and remains a task for implementation under the Project.

PacifiCorp prepared a Draft Historic Properties Management Plan (HPMP) to address its relicensing efforts, but the plan was not finalized. The Draft HPMP will be amended and revised for the Project to reflect dam removal activities, and will include management, treatment, protection, and mitigation measures for National Register eligible resources.

Other planned cultural resources tasks will include preparation of a Programmatic Agreement (PA) governing cultural resources, to be completed by AECOM at the direction of the FERC. Accompanying the PA will be an Inadvertent Discovery Plan, outlining protocols regarding unanticipated finds, as well as a Monitoring Plan to provide general protocols for monitoring historic properties and other select areas that would benefit from monitoring during and post dam decommissioning,

Finally, both Native American and European American human burial sites have been previously identified in the Project area, individually, in prehistoric village sites, and in prehistoric and historic-period cemeteries along the Klamath River corridor. Adverse effects to human burial sites have been identified as a key concern of Indian Tribes, and downstream erosion and enhanced river flows may cause degradation of soil and exposure of human burials. Before dam removal, a NAGPRA Plan of Action and protocols for treating human burials will be developed.

3. Informal Consultation

The KRRC intends to initiate informal consultation with affected Indian Tribes and other tribal organizations in January 2018. Among the topics requiring consultation are the identification and evaluation of Traditional Cultural Properties (TCPs), the Klamath Tribe's proposed Klamath Riverscape, and the management and disposition of cultural and human remains. KRRC is preparing a cultural resources work plan to guide Section 106 actions through the course of the Project. This plan includes a draft Area of Potential Effects (APE), a discussion of the integration of the proposed Klamath Riverscape into the APE, draft protocols for inadvertent discoveries and appropriate treatment of human remains, funerary objects, sacred objects, and objects of cultural patrimony, and a draft NAGPRA Plan of Action.

Although not part of the Section 106 process, the KRRC is participating in related tribal resources consultation efforts being conducted by the California State Water Resources Control Board (SWRCB) for the Lower Klamath Project. SWRCB's consultation is being conducted as part of California Environmental Quality Act (CEQA) 401 water certification process for the Project. KRRC's tribal resources lead has participated in meetings and teleconferences held between the SWRCB and tribes . The California Natural Resources Agency (CNRA) and the California Department of Fish and Wildlife (CDFW) have recently provided notice to 17 northern California and southern Oregon tribes requesting input on developing a process for identifying potential recipients of certain lands (Parcel B) in California to be transferred to the KRRC, and then, after dam decommissioning, to the State of California under the Amended KHSA. As state and federal tribal consultation for the Lower Klamath Project will run concurrently, efforts will be made to coordinate and integrate the two processes to the extent feasible.

4. Cultural Resources Working Group

As FERC's designated non-federal representative, the KRRC has initiated informal consultation pursuant to Section 106 of the National Historic Preservation Act. KRRC initiated a Cultural Resources Working Group (CRWG) to provide a collaborative and interactive process for data sharing, participation, and decision-making among the applicants, tribes, and resource agencies. The goals of the CRWG include: (1) definition of the Project APE; (2) preparation of a Programmatic Agreement and other guidance documents; (3) overall guidance on the scope and level of effort required for inventory and evaluation of historic, archaeological, and tribal resources; (4) assessment of effects to Historic Properties; (5) identification and implementation of mitigation measures, and (6) development of a Historic Properties Management Plan.

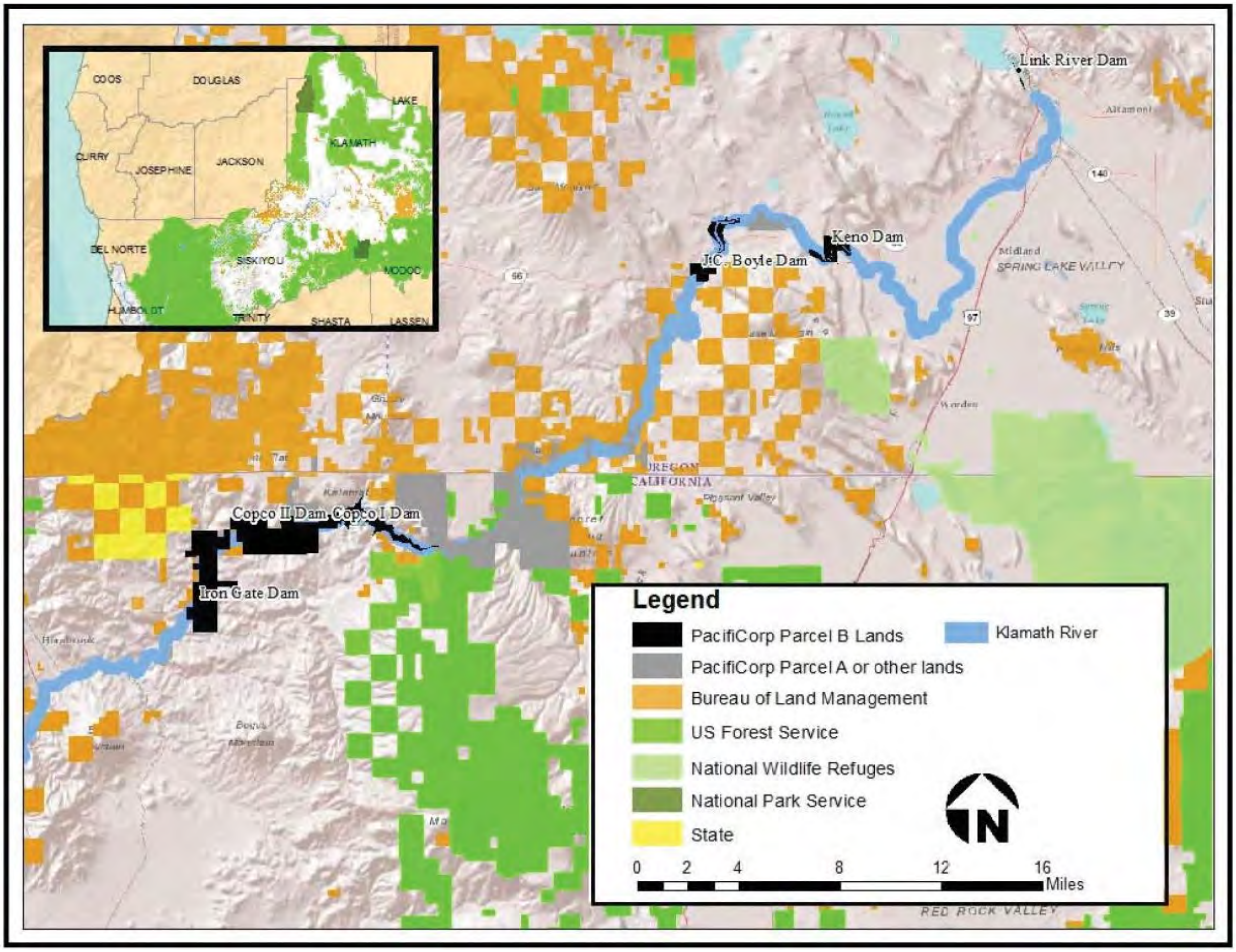
To begin this process, the CRWG is comprised of representatives federal agencies with administered lands in the Project area (U.S. Forest Service and Bureau of Land Management; Figure 4-1), as well as California and Oregon Offices of Historic Preservation (Table 4-1). Other invited parties include the USDI Bureau of Reclamation and US Army Corps of Engineers who have currently elected not to participate. Membership of the CRWG is expected to expand as consultation proceeds, and will include representatives from affected tribes and their Tribal Historic Preservation Officers (THPOs). KRRC anticipates initiating tribal outreach in January 2018.

The CRWG held an initial meeting on September 5, 2017, the purpose of which was to provide working group members with background information on the project, status of cultural resources inventory and evaluation efforts, and allow for the identification and discussion of the CRWG's goals and objectives. Subsequent to that meeting, a draft APE for the Lower Klamath Project has been developed.

A second meeting was held on December 14, 2017 to review the preliminary APE being developed by the applicant. It is anticipated that subsequent CRWG meetings will be held on an approximately monthly basis.

Table 4-1 Current Participants - Cultural Resources Working Group

Agency	Federal/State/Local
KRRC	Applicant
PacifiCorp	Applicant
AECOM	Technical Representative
CDM Smith	Technical Representative
USDA Forest Service, Klamath National Forest	Federal
Bureau of Land Management, Klamath Falls, Oregon and Redding, California Field Offices	Federal
California Office of Historic Preservation	State of California
Oregon State Historic Preservation Office	State of Oregon



Source: 2012 EIS/R (USBR and CDFW 2012)

Figure 4-1 Land ownership in the project vicinity

5. Definition of the Area of Potential Effects

Implementing regulations of the National Historic Preservation Act (NHPA) require federal undertakings to determine the scope of identification efforts (36 CFR 800.4(a)). This is accomplished in part by determining and documenting the Area of Potential Effects (APE) (36 CFR 800.4(a)(1)). The APE means the "geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist." Furthermore, the APE "is influenced by the scale and nature of an undertaking and may be different for different kinds of effects caused by the undertaking" (36 CFR 800.16(d)). Inclusion of land within an APE does not mean that an undertaking would affect any or all cultural resources in that area. Defining an APE provides both the lead federal agency and consulting parties with a basis for understanding the geographic extent of anticipated impacts of the proposed project, which is necessary to determine whether the project may adversely affect historic properties.

As the lead federal agency for the Lower Klamath Project (a.k.a. the Klamath River Renewal Project), FERC defines the APE, in consultation with other federal agencies, Indian Tribes, State Historic Preservation Offices (SHPOs), KRRC, PacifiCorp, and other consulting parties. The KRRC and PacifiCorp, in collaboration with the CRWG, are actively working on defining a Project APE for FERC's review..

6. Resource Identification

6.1 Records Search Update

As part of the Klamath Hydroelectric Relicensing (FERC 2007) and Klamath River Dam Removal (BOR 2012) studies, PacifiCorp (2004) and Cardno ENTRIX (2012) completed cultural resources records searches to collect information of previous archaeological research and historical information. These earlier record searches provided baseline resource data for the respective project areas through 2012. The KRRC has recently completed an updated records search and literature review for the Klamath River Renewal Project to add information for the intervening 5-year period, or through 2017. The cumulative results of the KRRC records searches are summarized first, followed by State-specific summaries.

The KRRC records search area extended from the outlet of the Klamath River at the southern end of Upper Klamath Lake in Klamath County, Oregon (RM 255) downstream to the confluence of Klamath River and Humbug Creek in Siskiyou County (RM 174), for a total of 81 river miles. The section of river below Iron Gate Dam (the most downstream Project dam) was included in the records search since this area lies within the altered 100-year floodplain following dam removal, where cultural resources have the potential to be affected. The records search area encompassed a 0.5-mile wide zone, extending on either side of the shorelines of Lake Ewauna, Link River, J.C. Boyle Reservoir, Copco Lake, and Iron Gate Reservoir, or from the center point of the Klamath River in areas where a flowing river exists. The records search identified 502 previously recorded cultural resources, comprised of a broad range of archaeological sites, built environment resources, isolated finds, and a few locations of an undetermined resource type (Table 6-1).

Table 6-1 Summary of Previously Recorded Cultural Resources for Oregon and California.

Resource Type	Component Type					
	Prehistoric	**Historic**	**Multiple**	**Ethnographic Only**	**Unknown**	**Total**
Archaeological Site	162	83	44	--	1	290
Ethnographic	--	--	--	1	--	1
Built Environment	--	24	3	--	--	27
Isolated Find	158	17	--	--	1	176
Undetermined	--	--	--	--	8	8
Total	320	124	47	1	10	502

*PRE = Prehistoric; PRE/ETH = Prehistoric/Ethnographic; HIS = Historic; MUL = Multiple; MUL/ETH = Multiple/Ethnographic; ETH = Ethnographic; UNK = Unknown

Among the 290 previously recorded archaeological sites are 170 sites in Oregon and 120 sites in California. Collectively, these sites include 162 prehistoric resources, 19 of which have documented ethnographic associations or uses. Also recorded are 83 historic-period archaeological sites and 44 sites with both prehistoric and historic-period components. These latter sites, termed multiple component sites, include at least eight locations that have documented ethnographic use. The final archaeological site consists of a resource of unknown temporal association.

One resource has been recorded as an ethnographic location that figures prominently in an important legend in Shasta Indian oral history.

A group of 27 built environment resources, comprised of manufactured structures, features, and facilities, have been previously recorded, including 15 in Oregon and 12 in California. The built environment resources include intact structures, such as log cabins and sheds; power facilities, including powerhouses; bridges; boardwalks; cemeteries; a lumberyard; a commercial sawmill; and other constructed features.

Eight resources of undetermined resource type or age have been reported in California. While the physical locations for these sites has been recorded, other information such as the types of artifacts and/or features present, is unavailable.

The final resource type consists of a group of 176 isolated finds, which typically represent locations with five or fewer artifacts or single features. These finds include 108 isolates in Oregon and 68 isolates in California. The isolated finds encompass 158 prehistoric resources, 17 historic-period isolates, and 1 feature of unknown age.

6.1.1 Oregon Records Search

Within the State of Oregon, the KRRC records search area included the length of the Klamath River from its outlet at Upper Klamath Lake at Link River Nature Trailhead (RM 255) south to the Oregon/California Stateline (RM 214), for a total length of roughly 41 river miles. This river stretch also included the Link River and Lake Ewauna. The records search area encompassed a 0.5-mile wide zone, extending on either side of the shorelines of Lake Ewauna, Link River, and J.C. Boyle Reservoir, or from the center point of the Klamath River in areas where the river remains free flowing.

In April 2017, AECOM reviewed records on file at the Oregon SHPO to determine the extent of previously recorded cultural resources and past investigations within Oregon records search area. This records search was conducted using the Oregon Archaeological Records Remote Access (OARRA) GIS database maintained by the Oregon SHPO. This database contains all cultural resources reports and resource forms approved by SHPO and provides information on the location of previously recorded archaeological sites, cultural resource surveys, National Register properties, and cemeteries. In addition, the separate Oregon SHPO online Oregon Historic Sites Database was also reviewed to collect information regarding built environment resources located within the records search area.

In July 2017, a records search was conducted at the BLM Klamath Falls Resource Area office in Klamath Fall, Oregon. With the assistance of BLM Archaeologist Laird Naylor, cultural resources files for government lands in Klamath County, Oregon, were examined for recent project reports and copies were made of relevant reports and resource records. In October 2017, the Southern Oregon Historical Society (SOHS) Library in Medford, Oregon was visited to examine the John C. Boyle papers, maps, and photograph collection pertaining to the Klamath River area.

In addition to these office visits, online newspaper archives were researched, including the National Digital Newspaper Program archives provided by the Library of Congress and National Endowment for the Humanities (chroniclingamerica.loc.gov); GeneaologyBank newspaper archives provided by NewsBank, Inc. (geneaologybank.com); the California Digital Newspaper Collection repository provided by University of California, Riverside (cdnc.ucr.edu); and newspaper archives provided by Ancestry.com. Copies of the Klamath County Historical Society *Klamath Echoes* were also reviewed for relevant site and historic context information.

In May 2017, the KRRC requested and received cultural sources data from PacifiCorp, including GIS shapefiles with previous survey and resource locations, as well as a copy of the final cultural resources technical report for Klamath Hydroelectric Relicensing Project (PacifiCorp 2004). In addition, Dr. Joanne Mack, professor emeritus at Notre Dame University, a primary researcher in the upper Klamath River area, was contacted to discuss the Project and to learn of her on-going research in the area that might not be reflected in published or unpublished literature.

6.1.1.1 Previous Cultural Resources Studies

The KRRC records search and literature review conducted for Oregon identified 119 previous cultural resources investigations as having been conducted within the records search area, with five of these studies (Kramer 2003a, 2003b; Cardno ENTRIX 2012; PacifiCorp 2004; Daniels 2006) completed specifically for the Project (Table 6-2). Collectively, these reports provide a broad range of reference materials derived from pedestrian surveys, archaeological testing and evaluation, prehistoric and historic-period context documents, and professional studies. Most reports (n=79) detail the results of cultural resources surveys or survey/excavation work conducted across the records search area. Twenty three reports consist of archaeological, ethnographic, or historical overviews that include the Klamath River area. An additional 10 reports describe archaeological excavations and one report focuses on an archaeological survey and provides a cultural overview. Also included are two archaeological research designs, one scope of work, one Ph.D. dissertation, and two professional papers.

Table 6-2 Oregon - Summary of Previous Cultural Resource Studies Identified in the Records Search

SHPO Report No.	Report Title	Report Reference	Study Conducted Specifically for Klamath Dams Projects	Project Type	Acres Surveyed
160	A Cultural Resources Overview of the Proposed Conger Heights Subdivision on the East Site of the Link River, Klamath Falls, Oregon.	Hopkins 1978	No	Survey	80
161	A Cultural Resources Overview of the Proposed Conger Heights Subdivision on the East Side of the Link River Klamath Falls, Oregon (Addendum).	Hopkins 1978	No	Survey	80
165	A Cultural Resources Survey of Proposed Drainage Improvements in Lower Klamath Lake, Klamath County, Oregon. Department of Sociology/Anthropology, Southern Oregon State College, Ashland, Oregon.	Hopkins 1978	No	Survey	--
796	Preliminary Report, Malin-Medford Powerline Survey	Cole 1979	No	Survey	--
1044	Report of a Cultural Resources Survey of the Pacific Power and Light Company's Proposed Malin to Medford 500KV Powerline Project Through the Klamath Basin, Klamath County, California	Cole 1979	No	Survey	18.37 miles (44.1 acre)
1347	Report on a Cultural Resources Survey of the Pacific Power and Light Company's 500KV Powerline Project between Medford and Klamath Falls in Jackson and Klamath Counties, Oregon	Cole, Minor, and Toepel 1979	No	Survey	--
1351	Prehistory and History of the Jackson-Klamath Planning Unit: A Cultural Resources Overview	Follansbee, Pollack, Duenwald, and Robert 1978	No	Overview	--
2216	An Overview of Native American Cultural Areas in the City of Klamath Falls, Klamath County, Oregon	Hopkins 1978	No	Overview	--
4150	Miller Island Canal Project: Klamath Game Management Area. Prepared for Oregon State Fish and Wildlife.	Philipek and Ray 1982	No	Survey	10
4714	Report on the Archaeological Survey of the Proposed Klamath Falls South Side Bypass, Klamath County, OR. Oregon State Museum of Anthropology, University of Oregon, Eugene. Submitted to Oregon Department of Transportation (ODOT), Salem, Oregon.	Pettigrew 1982	No	Survey	--

SHPO Report No.	Report Title	Report Reference	Study Conducted Specifically for Klamath Dams Projects	Project Type	Acres Surveyed
5180	Cultural Resources Survey on Miller Island, Klamath Wildlife Area, Oregon	Toepel 1983	No	Survey	1000
5768	Archaeological and Historical Survey: Salt Caves Hydroelectric Project (no report in SHPO database)	Gehr and Erwin 1984	No	Survey	--
6331	Archaeological Investigations at the Salt Caves Locality: Subsistence, Uniformity, and Cultural Diversity on the Klamath River, Oregon. Ph.D. dissertation. University of Oregon Anthropological Papers. No. 29. Eugene, Oregon.	Mack 1983	No	Ph.D. Dissertation	--
6332	Historical and Archaeological Site Report Section 1.0	Gehr 1985	No	Overview	--
6333	Section 4.0: Report on Historic and Archaeological Resources. In Application for License Salt Caves Hydroelectric Project, Vol. III, Exhibit E. Beak Consultants, submitted to the Federal Energy Regulatory Commission by the City of Klamath Falls. Klamath Falls, Oregon.	Gehr 1985	No	Overview	--
7097	Application for License: Salt Caves Hydroelectric Project Initial Stage Consultation Section 4.0 (Report on Historic and Archaeological Resources)	City of Klamath Falls 1986	No	Overview	--
7492	Draft Application for License: Salt Caves Hydroelectric Project Second Stage Consultation, Volume 1	Jensen 1986	No	Overview	--
7493	Draft Application for License: Salt Caves Hydroelectric Project Second Stage Consultation, Volume 3	Jensen 1986	No	Overview	--
7495	Research Design for Cultural Resources Survey and Testing CONUS OTH-B Buffalo Flat, Oregon Transmitter Site	Toepel , Oetting, Minor, and Baxter 1986	No	Research Design	--
7688	Congruence of Ethnohistoric and Archaeological Settlement Models in the Klamath River Canyon: the Eastern Shasta and the Lost Klamath Village of Laik' elmi (Paper Presented at 2nd Annual California Indian Conference 1986)	Gehr 1986	No	Paper	--
8196	Archaeological Survey of the Green Springs Highway – Midland Junction Section, the Dalles-California Highway (US 97), Klamath County, Oregon	Connolly 1987	No	Survey	5 miles
8367	Application for License: Salt Caves Hydroelectric	City of Klamath Falls	No	Overview	

SHPO Report No.	Report Title	Report Reference	Study Conducted Specifically for Klamath Dams Projects	Project Type	Acres Surveyed
	Project Section 4.0	1986			
8733	Report on Investigations of Archaeological Sites in the Reservoir Areas of Sucker Creek, Applegate, Elk Creek, Lost Creek and Collier State Park	Cole 1965	No	Excavation	
8914	Additional Information Supporting, Report on Historic and Archaeological Resource for the Salt Caves Hydroelectric Project, Klamath County, Oregon (Excavation of 35KL16) (FERC No. 10199-000). Prepared for the City of Klamath Falls, Oregon. Sacramento, California.	Jensen 1987	No	Overview	
10212	Inventory Report for the Klamath District Modular Ranger Office (no report in SHPO database)	McAlister 1987	No	Survey	0.5
10957	Cultural Resource Inventory of Segments 1 and 4 of PP&L's Proposed 500 kV Eugene-Medford Transmission Line; Lane, Douglas and Jackson Counties, Oregon	O'Neill 1989	No	Survey	143
12727	Klamath River Canyon Prehistory. Klamath Canyon Prehistory and Ethnology, Cultural Resource Series, No. 8 (Richard Hanes, editor) (OR-010-PH9-233). Submitted to the United States Bureau of Land Management, Lakeview District, Klamath Falls Resource Area. Klamath Falls, Oregon.	Mack 1991	No	Overview	--
12947	Letter Report: Archaeological Survey of the Wetland Mitigation Site of the Green Spring Highway to Midland Junction Section of The Dalles-California Highway (U.S. 97), Klamath County	Cheatham 1992	No	Survey	19.5
13885	Klamath River Put-in 7m	Cannon 1993	No	Survey	2.5
13891	Klamath River Campground	Cannon 1993	No	Survey	40
14795	Cultural Resources Inventory and Site Testing Plans for the Proposed Pacific Gas Transmission Company's Medford Extension, Volume 1. Prepared for Pacific Gas Transmission Company. Archaeological Investigations Northwest, Inc., Portland, OR.	Fagan, Wilson, Hills, Hess, Wollin, and Forgeng 1994	No	Research Design	--
15083	Archaeological Inventory Survey: The Proposed Klamath Cogeneration Project Area, Approximately 400 Acres, Including Blocks and Linear Corridors,	Jensen and Associates 1995	No	Survey	400

SHPO Report No.	Report Title	Report Reference	Study Conducted Specifically for Klamath Dams Projects	Project Type	Acres Surveyed
	Klamath Falls, Klamath County, Oregon. Prepared by Jensen and Associates. Prepared for Resource Management International, Inc. Report #15083 on file at the Oregon State Historic Preservation Office, Salem.				
15448	Human Remains from Columbia Plywood Property, Klamath Falls, Oregon	Tasa 1996	No	Paper	--
15720	Volume 2: Weyerhauser Camp 2 (OR-KL-46): The Archaeology And Socioeconomic History Of A Depression-era Railroad Logging Camp In Southern Oregon. PGT Project Report # 19 Results of Treatment Of Cultural Resources In Pacific Gas Transmission Company's Medford Extension Pipeline Project. Prepared for Pacific Gas Transmission Company. Archaeological Investigations Northwest, Inc. Report # 114, Portland, OR.	Hills, Chapman, and Wilson 1996	No	Excavation	--
15847	Results of an Archaeological Survey of 890 Acres in the Klamath Resource Area	Draper 1996	No	Survey	34
15889	Volume I: Expanding the Archaeology of the Klamath Basin and Cascade Range of Southern Oregon PGT Project Report #19. Results of Treatment of Cultural Resources in Pacific Gas Transmission Company's Medford Extension Pipeline Project. Archaeological Investigations Northwest, Inc. Report # 114, Portland, OR.	Wilson, Ozbun, Forgeng, Wilt, and Chapman 1996	No	Overview	--
15889b	Part 2 of Volume 1: Expanding the Archaeology of the Klamath Basin and Cascade Range of Southern Oregon Appendices A-S. PGT Project Report #19	Wilson, Ozbun, Forgeng, Wilt, and Chapman 1996	No	Overview	-
16216	A Cultural Resource Inventory of the Undeveloped Eastern Portion of the Klamath Falls Memorial Park, Klamath County, California	Fleming 1997	No	Survey	40
16292	Archaeological Recovery and Reburial at the Klamath River Bridge Cemetery Site (35KL1121)	Tasa and Connolly 1997	No	Excavation	--
16293	Archaeological Survey of BLM Properties in the Klamath Falls Resource Area (OR014-CRR-FY97-008). Rainshadow Research. Report submitted to Klamath Falls Resource Area, Lakeview District,	Ferguson and Reid 1997	No	Survey	--

SHPO Report No.	Report Title	Report Reference	Study Conducted Specifically for Klamath Dams Projects	Project Type	Acres Surveyed
	Bureau of Land Management, Klamath Falls, Oregon.				
16294	Klamath Falls Area Cultural Resource Inventory (OR014-CRR-FY97-009). Stepp Consulting. Report submitted to Klamath Falls Resource Area, Lakeview District, Bureau of Land Management, Klamath Falls, Oregon.	Stepp 1998	No	Survey	2080
16386	East Ward Cultural Resources Survey	Kritzer 1997	No	Survey	560
16491	Archaeological Survey of the Proposed Klamath Falls Southside Bypass Modifications, Klamath Falls-Lakeview Highway (OR 140), Klamath County (ODOT Key #09741)	Connolly 1998	No	Survey	Uncertain
16494	Oak Woodlands Report #16494	Ross 1998	No	Survey	20
16582	Cultural Resources Inventory of the Slim Chicken Project Area, Klamath County, Oregon	Stepp 1998	No	Survey	1910
17761	A Cultural Resources Survey Of Natural Gas Pipeline Facilities Related To The PPM Klamath Power Plant, Klamath County, Oregon	Root 2001	No	Survey	--
17762	Cultural Resources Inventory for the Cal-Ore Telephone Company Fiber Optic Project in Klamath County, Oregon	Nelson, Mikkelsen, and Leach-Palm 2001	No	Survey	20 miles (48 acres)
18149	A Cultural Resources Report for Extra Workspace Associated with the West Klamath Meter Station M-3 Expansion, Klamath County, Oregon	Root 2002	No	Survey	--
18471	Cultural Resource Survey of the Klamath River Bridge-Green Springs Interchange Section (MP 49.96-59.29), Green Springs Highway (Oregon 66), Klamath County (Key No.)	Connolly 2003	No	Survey	9.3 miles (22.3 acres)
18485	Kerwin Ranch Meadow Restoration Cultural Resource Survey (OR014-CRR-FY03-004). Klamath Falls Resource Area, Lakeview District, Bureau of Land Management, Klamath Falls, Oregon	Canaday 2002	No	Survey	10
18501	Draft Final Archaeological Survey Technical Report Prospect Nos. 1, 2, and 4 Hydroelectric Relicensing FERC No. 2630	PacifiCorp 2003	No	Survey	--
18677	Section 106 Compliance for Miller Island Habitat Improvement Project; Cultural Resources Survey on Miller Island, Klamath Wildlife Area, Oregon	Michny 1983	No	Survey	5

SHPO Report No.	Report Title	Report Reference	Study Conducted Specifically for Klamath Dams Projects	Project Type	Acres Surveyed
18740	Cultural Resources Inventory for a Proposed Public Access Trail from the Link River Nature Trail to Moore Park, Klamath Falls, Klamath County	Welch 2002	No	Survey	--
18810	Klamath River Canyon Survey (OR014-CRR-FY03-012).	Jones 2004	No	Survey	843
18815	2001 Grenada West Miscellaneous Historic Sites Cultural Resource Inventory	Mutch 2004	No	Survey	--
18831	U.S. Timber Riparian Enclosure Cultural Resource Survey	Durant 2004	No	Survey	27.93
18835	Klamath River Oak Thinning Cultural Resource Survey (OR014-CRR-FY06-005).	Durant 2004	No	Survey	113
19108	Grenada West Riparian Treatment Cultural Resource Survey	Durant 2004	No	Survey	63
19237	Letter Report: Bridge 09692 (Highway 4 over Greensprings Drive), Klamath County, Oregon	Henrikson 2003	No	Survey	60
19535	Preliminary Results of Archaeological Testing at Sites 35KL1941 and 35KL1943, in Klamath River (Spencer) Bridge Vicinity along OR 66 (Key #10712)	O'Neill 2004	No	Excavation	13
19589	A Cultural Resources Inventory of the Quail Point Residential Development Project, Klamath County, California	Fleming 2005	No	Survey	14.7
19742	Bridge 08346 (Highway 4 over California Avenue), Klamath County, California	Henrikson 2004	No	Survey	40
19755	A Cultural Resources Inventory of the Linkville Estates Residential Development Project, Klamath County, Oregon	Fleming 2005	No	Survey	25
20059	A Cultural Resources Inventory of the Klamath Wildlife Area, Miller Island Administrative Site and Underground Pump Powerline Route, Klamath County, Oregon	Fleming 2005	No	Survey	3
20243	Big Bend Slashbusting Cultural Resource Survey	Durant 2005	No	Survey	22
20560	Moore Park Fuels Treatment Project for the City of Klamath Falls Park and Recreation Department, Klamath County, Oregon	Fleming 2006	No	Survey	79
21039	Shasta Nation TCP Study	Daniels 2006	Yes	Overview	--
21180	Archaeological Survey of Bridge 08510 (USBR Canal,	Henrikson 2005	No	Survey	92

SHPO Report No.	Report Title	Report Reference	Study Conducted Specifically for Klamath Dams Projects	Project Type	Acres Surveyed
	Nevada Avenue conn to Hwy 4, U.S. Highway 97, Mile Point 273.68), Klamath County, Oregon. UO Museum of Natural & Cultural History, Research Report No 2005-15.				
21222	Cultural Resources Inventory for the Modoc Lumber Company Wetland Mitigation Site, Klamath County, Oregon.	Butler 2006	No	Survey	60
21494	Final Technical Report: Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp. Portland, Oregon.	PacifiCorp 2004	Yes	Survey and Overview	2260
21584	Pacific Connector Gas Pipeline Project Cultural Resource Survey, Coos, Douglas, Jackson, and Klamath Counties, Oregon	Bowden, Byram, Derr, Ragsdale, Solimano, and Tveskov 2009	No	Survey	--
22124	Determination of Eligibility of 19 Archaeological Sites in the Klamath River Canyon, Oregon.	McCutcheon 2008	No	Excavation	--
22179	First Salmon: The Klamath Cultural Riverscape and PacifiCorp's Klamath Hydroelectric Project. Klamath River Intertribal Fish and Water Commission.	King 2004	Yes	Overview	--
22180	White Paper on Behalf of the Karuk Tribe of California: A Context Statement Concerning the Effect of Iron Gate Dam on Traditional Resource Uses and Cultural Patterns of the Karuk People Within the Klamath River Corridor	Salter 2003	No	Overview	--
22181	Ethnographic Riverscape: Regulatory Analysis	Gates 2003	No	Overview	--
22339	Cultural Resources Inventory of the Oregon Department of Forestry Eastern (Klamath Falls) Region: The 2004-2005 Seasons	O'Neill 2008	No	Survey	4245
22458	Archaeological Survey for the Texum Substation Project, Klamath Falls, Oregon	Falkner and Boden 2009	No	Survey	8.8
22547	Klamath FY 2009-01 WRP Cultural Resources Inventory	Gebauer 2009	No	Survey	17
22766	NRCS Cultural Resources Report, Klamath Field Office, T-931 GRF	Gaston 2006	No	Survey	90
23146	Expanded Keno Water Improvement Project Cultural Resources Inventory	Gebauer 2010	No	Survey	6
23171	Archaeological Investigations at the Klamath River	O'Neill and Connolly	No	Excavation	21

SHPO Report No.	Report Title	Report Reference	Study Conducted Specifically for Klamath Dams Projects	Project Type	Acres Surveyed
	(Spencer) Bridge, Klamath County, Oregon	2009			
23548	Tule Smoke Wetland Restoration	Tickner 2010	No	Survey	25
23842	Archaeological Survey for the Link River Bike Trail Project, Klamath County, Oregon	Tveskov et al. 2010	No	Survey	2.3
23852	Archaeological Investigation for a Water Pipeline Installation Project in Klamath Falls, Klamath County, Oregon	Barnes 2010	No	Survey	6.5
23973	Results of a Cultural Resource Investigation of the Proposed Klamath Bioenergy Facility, Klamath Falls, Oregon	Wilt 2011	No	Survey	107
24179	Pacific Connector Gas Pipeline Project Cultural Resources Survey, Coos, Douglas, Jackson, and Klamath Counties, Oregon: Survey Report Addendum for December 2009 FERC Data Request	Knuston et al. 2010	No	Survey	--
24535	A Cultural Resources Inventory of the Viveiros' Home Site Development Project, Klamath County, Oregon	Fleming 2006	No	Survey	0.5
24568	Cultural Resource Concerns Within PacifiCorp's J.C. Boyle Gravel Placement Project, Klamath River, Klamath and Siskiyou Counties, Oregon and California	Bowden 2011	No	Overview	--
24658	Archaeological Studies for the Proposed Klamath Generation Facility, Klamath County, Oregon	Davis and Osbun 2011	No	Survey	111
24693	Archaeological and Historical Resource Studies for the Proposed Klamath Solar Energy Project, Klamath County, Oregon	Davis and Osbun 2011	No	Survey	57
24709	Blue Heron Cultural Resource Survey (OR014-CRR-FY11-010). Report submitted to Klamath Falls Resource Area, Lakeview District, Bureau of Land Management, Klamath Falls, Oregon.	Hescock 2011	No	Survey	74.5
24714	Test Excavations at Site 35KL3594 Keno, Klamath County, Oregon	Jones 2011	No	Excavation	1
24717	Moore Park Forest Restoration Project	Ray 2011	No	Survey	183
24867	Phase 1 Cultural Resources Survey for the California Pump Station Force Main Replacement Project, City of Klamath Falls, Klamath County, Oregon	Ramires 2011	No	Survey	5
24913	Cultural Resource Survey of the OR 39: Link River	Connolly 2012	No	Survey	8

SHPO Report No.	Report Title	Report Reference	Study Conducted Specifically for Klamath Dams Projects	Project Type	Acres Surveyed
	Bridge Project, Klamath County (ODOT Key No. 16104; Museum Report No. 2012-005-rev).				
25592	Klamath River Canyon Prehistory and Ethnology	Jones 2015	No	Overview	2394
26108	Klamath River Canyon Underburn Cultural Resource Survey (OR014-CRR-FY12-004).	Hescock 2013	No	Survey	340
26202	Pokegama Plateau Cultural Resource Survey (OR014-CRR-FY07-003).	Hescock 2007	No	Survey	310
26908	Cultural Resource Survey of the Moore Park Trail Development Project, Klamath County, Oregon	Volkenand 2014	No	Survey	0.6
27011	A Class III Cultural Resource Inventory of 6722 Acres in the Klamath Falls Resource Area, Lakeview District, Klamath County, Oregon	Boughton 2003	No	Survey	6722
27465	Cultural Resource Survey for the Spencer Creek Restoration Project, PacifiCorp Energy Parcel, Klamath County, Oregon. [35KL2428] [Klamath Basin Rangeland Trust], SHPO Case No. 14-1285.	Volkenand 2015	No	Survey	0.3
27625	Initial Cultural Resource Study Report for the Prospect No. 3 Hydroelectric Project	Davis and Perrin 2015	No	Overview	344
27668	Addendum to: Cultural Resource Survey for the Spencer Creek Restoration Project, PacifiCorp Energy Parcel, Klamath County, Oregon [35KL2428]	Volkenand 2015	No	Survey	1
27993	Oregon Gulch Salvage and Replanting Project Cultural Resource Survey	Jones 2015	No	Survey	2367
28452	Archaeological Survey of the Greensprings Interchange-Klamath Falls/Malin Highway, Klamath County (ODOT Key No. 18677; Museum Report No. 2016-039).	Connolly 2016	No	Survey	15
28574	Addendum I Cultural Resource Survey of the Moore Park Trail Development Project Klamath County, Oregon	Volkenand 2015	No	Survey	0.75
N/A	Table and Maps of Previously Inventoried Lands along the Klamath River – Draft, Special Report	Mack 2002	No	Overview	--
N/A	Final Report on Archaeological Salvage Program in the Big Bend Project of Copco on the Klamath River, Oregon. Submitted to California Oregon Power	Newman and Cressman 1959	No	Survey and Excavation	--

SHPO Report No.	Report Title	Report Reference	Study Conducted Specifically for Klamath Dams Projects	Project Type	Acres Surveyed
	Company.				
N/A	Salt Caves Dam Reservoir Interim Report on Archaeological Project 1961 Field Season to Pacific Power and Light (COPCO Division). University of Oregon.	Cressman and Wells 1962	No	Excavation	--
N/A	Salt Caves Dam Reservoir Interim Report on Archaeological Project to Pacific Power and Light (COPCO Division). University of Oregon.	Cressman and Olien 1963	No	Excavation	--
N/A	Excavations at Site SC-1. Salt Caves Dam Reservoir Archaeological Project - 1963 to Pacific Power and Light (COPCO Division). University of Oregon, Museum of Natural History, Eugene.	Anderson and Cole 1964	No	Excavation	--
N/A	Section 4.0 – Report on Historical and Archaeological Resources. Salt Caves Hydroelectric Project. City of Klamath Falls, Oregon.	Beak Consultants, Inc. 1984	No	Survey and Excavation	--
N/A	Detailed Scope of Work Describing Archival, Archaeological, Historic, Ethnographic and Management Research Proposed for Salt Caves Project Area Archaeological Sites.	Gehr and Jensen 1986	No	Scope of Work	--
N/A	Klamath Hydroelectric Project, Federal Energy Regulatory Commission Project No. 2082, Historic Context Statement.	Kramer 2003b	Yes	Overview	--
N/A	Klamath Hydroelectric Project, Federal Energy Regulatory Commission Project No. 2082, Determination of Eligibility. CH2M Hill, Corvallis.	Kramer 2003a	Yes	Overview	--
N/A	FY06 Klamath River Oak Thinning Cultural Resource Survey OR014-CRR-FY06-005. BLM, Klamath Falls.	Durant 2006	No	Survey	97
N/A	Klamath River Canyon Oak Thin Cultural Resource Survey OR014-CRR-FY08-001. BLM, Klamath Falls.	Hescock 2007	No	Survey	200
N/A	Final Klamath Secretarial Determination Cultural Resources Report. Prepared for U.S. Bureau of Reclamation.	Cardno ENTRIX 2012	Yes	Overview	--
N/A	PacifiCorp Botanical Exclosure Fence Cultural Resource Survey (OR014-CRR-FY14-008). BLM, Klamath Falls.	Hescock 2014	No	Survey	1.19

SHPO – State Historic Preservation Office

6.1.1.2 Previously Recorded Cultural Resources

The Oregon records search identified 296 previously recorded cultural resources, consisting of 170 archaeological sites, 18 built environment resources, and 108 isolated finds (Tables 6-3 and 6-4). By component type, these resources include 206 prehistoric, 65 historic-period, 22 multiple (prehistoric and historic-period), and 1 resource of unknown temporal association.

Table 6-3 Oregon - Previously Recorded Resources by Resource Type and Component

Resource Type	Component Type				
	Prehistoric	Historic	Multiple	Unknown	Total
Archaeological Site	113	35	21	1	170
Built Environment	--	15	3	--	18
Isolated Find	93	15	--	--	108
Total	206	65	22	1	296

Archaeological Sites

Archaeological sites represent roughly 57 percent of the previously recorded resources. The sites consist of 113 prehistoric, 35 historic-period, 21 multiple component, and 1 unknown component property. The prehistoric component sites include housepit villages; lithic scatters; bedrock milling features (BRMs); lithic scatters with associated cultural features; one toolstone quarry; peeled trees; village sites and lithic scatters with human burials; a rockshelter with human burials; a cremation site; and rock art sites.

The historic-period archaeological sites include late-nineteenth or early-twentieth century properties associated with the development of agriculture including abandoned ditches or other features such as homesteads; logging; public works (hydroelectric); transportation (railroad berms); and recreation. Agricultural-related sites include settlements (homesteads) with or without features, irrigation ditches, rock walls, cairns, and artifact scatters. Logging-related sites include a portable sawmill location and artifact scatters. Homesteads include the remains of Hoover's 41 Ranch and artifact scatters. The former locations of a dam and powerhouse near Keno represent public works sites. Transportation-related sites consist of an abandoned segment of the Weyerhaeuser Railroad grade and other railroad berms. Also related to transportation is Robber's Rock, a large boulder, historically used as a hiding spot for stagecoach thieves.

The multiple component sites comprise both prehistoric and historic-period archaeological components. Prehistoric components associated with these sites include housepit villages, a housepit village with a documented historic-period boat landing, lithic scatters, and a rock art panels with both prehistoric and historic elements. Historic-period components comprise historic homesteads or ranches and artifact scatters, and water conveyance ditches.

One peeled tree represents an unknown component of either prehistoric or historic-period use.

Information provided in Table 6-3 regarding the NRHP eligibility of the archaeological sites is based on recommendations provided by Cardno ENTRIX (2012), or by eligibility information noted on site records that were updated since preparation of the Cardno ENTRIX study. Overall, 38 archaeological sites are considered NRHP-eligible, 53 sites are potentially eligible for listing, 8 sites are not eligible, and 71 sites are either unevaluated or have undetermined NRHP eligibility status.

Built Environment Resources

The Oregon records search identified 18 properties with built environment resources, including 15 historic-period and 3 multiple component locations. Collectively, the built environment resources are associated with the historic themes of commerce, settlement, transportation, public works, and recreation or tourism.

The commerce-themed resources include the Weyerhaeuser Company Mill Complex, a water tower, and a lumberyard. Settlement-related sites include a log cabin, a shed, a split rail fence, the Frain Ditch, the Way Ranch Complex, the Topsy/Frain School, Way Cemetery, Spencer Cemetery, and grave and structural remains at Hoover's 41 Ranch. Transportation-related resources include a bridge and an associated boat dock. Public works resources include two hydroelectric powerhouses, comprised of the westside and eastside plants at Klamath Falls. Recreation or tourism is represented by a group of boardwalks for wildlife viewing. The final built environment resource consists of a New Age rock medicine wheel.

NRHP eligibility information for these resources indicates that eight are NRHP-eligible properties, including the Way Station/Ranch Complex, Topsy/Frain School, Frain Ranch, the westside and eastside powerhouses, a lumberyard with nine features near Lake Ewauna, Hoover's 41 Ranch with a grave, and the Weyerhaeuser Company Mill Site. Three built environment resources have been assessed as not eligible, including a bridge and dock, a water tower, and boardwalks associated with wildlife viewing. Four built environment resources are unevaluated and three other resources are classified as undetermined concerning NRHP eligibility.

Table 6-4 Oregon – Previously Recorded Archaeological Sites and Built Environment Resources

State Trinomial	Other Site Numbers	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
--	FY94-014-067	Prehistoric	Site	Lithic Scatter and Features	1994, 2012	Unevaluated
--	FY95-014-001	Prehistoric	Site	Lithic Scatter	1995	Unevaluated
--	FY96-014-008	Prehistoric	Site	Lithic Scatter	1996	Undetermined
--	FY96-014-009	Prehistoric	Site	Features	1996	Undetermined
--	FY96-014-010	Prehistoric	Site	Features and Artifact	1996	Undetermined

State Trinomial	Other Site Numbers	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
--	FY97-014-012	Historic	Site	Artifact Scatter	1997	Unevaluated
--	FY97-014-013	Historic	Site	Artifact Scatter	1997	Unevaluated
--	FY97-014-021	Historic	Built Env.	Log Cabin	1997	Undetermined
--	FY01-014-007	Historic	Built Env.	Way Cemetery	2001	Undetermined
--	FY05-014-017	Historic	Site	Artifact Scatter	2005, 2014	Unevaluated
--	FY06-014-023	Historic	Site	Features	2006, 2012	Unevaluated
--	FY06-014-027	Prehistoric	Site	Features and Artifact	2006, 2012	Unevaluated
--	FY09-014-048	Historic	Built Env.	Shed	2009, 2012	Unevaluated
--	FY13-014-001	Historic	Site	Rock Wall	2012	Unevaluated
--	FY13-014-016	Historic	Site	Artifact Scatter	2013	Unevaluated
--	CB-04	Prehistoric	Site	Lithic Scatter and Features	2002	Potentially eligible
--	FH-15	Multiple	Site	Prehistoric Village; Teeter's Landing	2003	Eligible
--	JC03-29	Historic	Site	Developed Spring		Eligible
--	JS-05H	Historic	Site	Homestead	2004	Not eligible
--	JS-12	Historic	Site	Homestead	2004	Not eligible
--	RM-03	Historic	Site	Artifact Scatter		Not eligible
35KL13	FY58-014-001; HRA-32	Prehistoric	Site	Rockshelter	1958, 2002	Eligible
35KL14	FY58-014-002; HRA-33	Prehistoric	Site	Rockshelter and Burial Site	1958, 2002	Eligible
35KL15	FY58-014-003; HRA-34	Prehistoric	Site	Lithic Scatter and Features	1958, 2002	Potentially eligible
35KL16	FY61-014-001; SC #1; SC #2; CW1; CW2; CKF1; HRA-35	Prehistoric	Site	Village	1961, 2002	Eligible
35KL17/554	FY61-014-002; SC #3; CW3; CKF2	Prehistoric	Site	Village	1961, 1984	Eligible
35KL18	FY61-014-003; SC #4; CW4; CKF3; KRC-6	Prehistoric	Site	Village	1961	Eligible
35KL19	FY61-014-004; SC #5; CKF4	Prehistoric	Site	Village	1961, 1992	Eligible
35KL20	FY61-014-005; SC #6; CW6; CKF5; KRC-7	Prehistoric	Site	Village	1961, 1994	Eligible

State Trinomial	Other Site Numbers	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
35KL21/ 786	FY61-014-006; SC #7; CW7; CKF6; KRC-8	Prehistoric	Site	Village	1961	Eligible
35KL22	FY61-014-007; SC #8; CKF7	Prehistoric	Site	Village	1961, 1993, 2004	Eligible
35KL23/566	FY61-014-008; SC #9; CKF8; 39/7-36-4	Prehistoric	Site	Village	1961, 1993, 2004	Eligible
35KL24	CW10; CKF9; KRC-13	Prehistoric	Site	Rockshelter	1961	Potentially eligible
35KL25	SC #11; CW11; CKF10	Prehistoric	Site	Village	1961, 1992, 1993	Eligible
35KL26	SC #12; CW12; CKF11	Prehistoric	Site	Village	1961, 1992	Eligible
35KL487/ 1901	PC 1-94	Multiple	Site	Prehistoric Rock Art; Historic Graffiti	1966, 1969, 1978, 1984, 1994	Eligible
35KL550	FY84-014-001; CKF12	Prehistoric	Site	Village	1984, 2004	Potentially eligible
35KL551/ 787	CKF42; RS-7	Prehistoric	Site	Lithic Scatter	1984, 1989	Undetermined
35KL552	--	Prehistoric	Site	Lithic Scatter with Features	1984	Undetermined
35KL553	CKF15	Prehistoric	Site	Feature	1984	Undetermined
35KL556	FY84-014-007; FY03-014-005	Prehistoric	Site	Lithic Scatter	1984, 2002	Unevaluated
35KL558	FY84-014-009; CKF20; KRC-2	Prehistoric	Site	Lithic Scatter	1984	Eligible
35KL567	FY84-014-012; CKF23	Multiple	Site	Prehistoric Lithic Scatter and Features; Historic Features	1984	Eligible
35KL576	FY84-014-013; CKF24; KRC-3	Prehistoric	Site	Village	1984	Eligible
35KL577	FY84-014-015; CKF26; KRC-16	Prehistoric	Site	Features and Origin Site	1984	Potentially eligible
35KL578	FY84-014-010; FY84-014-016; CKF21	Multiple	Site/ Built Env.	Prehistoric Village; Frain Homestead	1984, 2002, 2004	Eligible
35KL628/	FY79-014-004;	Prehistoric	Site	Village	1986,	Unevaluated

State Trinomial	Other Site Numbers	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
789/ 2354	FY89-014-008; FY03-014-091; CKF29; RS-9				1992, 1989, 1994, 1993, 2003, 2015	
35KL629	FY85-014-001; CKF30	Prehistoric	Site	Village and Burial Site	1986, 1993, 2004	Eligible
35KL630	FY85-014-002; CKF31	Prehistoric	Site	Possible Quarry	1986, 2003	Potentially eligible
35KL631	OR-KL-83; CKF35; OSI-429	Multiple	Site	Prehistoric Village; Way Homestead	1986	Unevaluated
35KL632	FY85-014-004; CKF33	Prehistoric	Site	Lithic Scatter with Possible Features	1986, 1994, 2004	Potentially eligible
35KL633	FY85-014-005; CKF34	Prehistoric	Site	Village	1986, 1994, 2004	Eligible
35KL634	FY85-014-011; CKF40	Prehistoric	Site	Lithic Scatter	1986, 1993, 2004	Not eligible
35KL635	FY85-014-012; CKF41	Multiple	Site	Prehistoric Lithic Scatter and Possible Features; Historic Features and Artifact Scatter	1986, 1993	Eligible
35KL783	RS-1	Prehistoric	Site	Lithic Scatter	1989	Unevaluated
35KL784	FY89-014-003; RS-3	Prehistoric	Site	Lithic Scatter	1989	Not eligible
35KL785	FY89-014-004; RS-5	Prehistoric	Site	Feature	1989, 1993	Undetermined
35KL788	RS-8	Prehistoric	Site	Lithic Scatter and Possible Feature	1989, 1994	Unevaluated
35KL790	RS-10	Prehistoric	Site	Lithic Scatter	1989, 1993, 1997	Unevaluated
35KL791/ 797	FY89-014-010; FY92-014-008; RS-4	Prehistoric	Site	Village with Features	1993, 2003	Eligible
35KL798	38/9-29-1P	Prehistoric	Site	Lithic Scatter	1987, 2010	Undetermined
35KL1058	--	Prehistoric	Site	Human	1992	Undetermined

State Trinomial	Other Site Numbers	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
				Cremation		
35KL1059	--	Prehistoric	Site	Village and Burial Site	1992, 2003	Potentially eligible
35KL1083	FY97-014-010	Multiple	Site	Prehistoric Village; Historic Ditch	1997, 2003, 2004	Potentially eligible
35KL1084	FY97-014-011	Multiple	Site	Prehistoric Lithic Scatter; Historic Isolate	1997	Undetermined
35KL1121	KRB-1	Prehistoric	Site	Village and Burial Site	1993	Eligible
35KL1348	EW-1	Prehistoric	Site	Lithic Scatter	1993	Potentially eligible
35KL1408	93/126-21	Prehistoric	Site	Lithic Scatter	1994	Unevaluated
35KL1419	FY94-014-014; 40/6-35-014	Historic	Built Env.	New Age Rock Medicine Wheel	1993, 1994, 2004	Undetermined
35KL1458	93/126-107; OR-KL-39	Multiple	Site	Prehistoric Lithic Scatter; Historic Ditch	1993	Potentially eligible
35KL1459	93/126-106; OR-KL-41	Multiple	Site	Prehistoric Lithic Scatter; Historic Artifact Scatter	1993, 1994	Undetermined
35KL1460	93/126-04	Prehistoric	Site	Features	1993	Undetermined
35KL1461	93/126-203; JS-02	Historic	Site	Weyerhaeuser Camp #2	1993	Undetermined
35KL1468	93/126-206	Multiple	Site	Prehistoric Lithic Scatter; Historic Artifact Scatter	1993	Undetermined
35KL1469	93/126-101	Multiple	Site	Prehistoric Lithic Scatter; Historic Artifact Scatter	1993	Undetermined
35KL1472	94/174-308	Multiple	Site	Prehistoric Lithic Scatter; Historic Isolate	1994	Unevaluated
35KL1473	93/126-20	Prehistoric	Site	Lithic Scatter	1993	Unevaluated
35KL1474	93/126-22	Prehistoric	Site	Lithic Scatter	1992	Unevaluated
35KL1475	OR-KL-75; 93/126-23	Multiple	Site	Prehistoric Lithic Scatter; Historic Artifact Scatter	1993	Unevaluated
35KL1861	Columbia #1	Prehistoric	Site	Burial Site	1996	Undetermined
35KL1921	FY96-014-011	Prehistoric	Site	Features	1996	Unevaluated
35KL1941	39/7-32-2	Prehistoric	Site	Lithic Scatter and Historic Artifact Scatter;	1996, 2005	Potentially eligible

State Trinomial	Other Site Numbers	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
				Former Lumber Mill		
35KL1942	39/7-29-2	Prehistoric	Site	Village	1996	Eligible
35KL1943	39/7-31-1	Prehistoric	Site	Village	1997	Potentially eligible
35KL1944	39/7-32-1	Prehistoric	Site	Lithic Scatter	1996	Eligible
35KL1964	FY98-014-002	Prehistoric	Site	Lithic Scatter	1997	Unevaluated
35KL2227	FY85-014-009; FY94-014-067; CKF38; BK #38	Historic	Built Env.	Hoover's 41 Ranch and Historic Burial Site	1984, 1986, 1994, 2000, 2012	Eligible
35KL2228	39/7-36-3	Historic	Site	Former Dam	2000	Eligible
35KL2229	39/7-36-4	Historic	Site	Former Powerhouse	2000	Eligible
35KL2350	Soula 10.15	Multiple	Site	Prehistoric Lithic Scatter; Historic Artifact Scatter	2010	Undetermined
35KL2355	FY03-014-092	Historic	Site	Peeled and Blazed Trees	2003	Unevaluated
35KL2356	FY03-014-093	Prehistoric	Site	Lithic Scatter	2003	Unevaluated
35KL2357	FY03-014-094	Prehistoric	Site	Lithic Scatter	2003	Unevaluated
35KL2358	FY03-014-095	Historic	Site	Peeled Tree	2003	Unevaluated
35KL2359	FY03-014-096	Historic	Site	Peeled Tree	2003	Unevaluated
35KL2360	FY03-014-097	Historic	Site	Peeled Trees	2003	Unevaluated
35KL2367	FY01-014-015	Historic	Site	Artifact Scatter	2001, 2010, 2012	Unevaluated
35KL2368	FY01-014-016	Historic	Site	Artifact Scatter	2001, 2012	Unevaluated
35KL2371	FY01-014-019	Historic	Site	Artifact Scatter	2001, 2004, 2010	Unevaluated
35KL2372	FY01-014-020	Historic	Site	Artifact Scatter	2001, 2004, 2010	Unevaluated
35KL2373	FY01-014-021	Historic	Site	Artifact Scatter	2001	Unevaluated
35KL2374	FY01-014-022	Historic	Site	Artifact Scatter	2001	Unevaluated
35KL2387	FY01-014-002	Prehistoric	Site	Village	2001	Unevaluated
35KL2388	FY01-014-003	Prehistoric	Site	Features	2001	Unevaluated
35KL2389	FY01-014-004	Prehistoric	Site	Feature	2002	Unevaluated
35KL2390	JS-11	Prehistoric	Site	Village and Burial Site	2004	Eligible
35KL2391	FH-16	Prehistoric	Site	Village and Burial	2003	Eligible

State Trinomial	Other Site Numbers	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
				Site		
35KL2392	FH-11	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2393	CB-26	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2394	CB-25	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2395	CB-24	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2396	CB-21	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2397	CB-20	Prehistoric	Site	Village	2003	Eligible
35KL2398	CB-06	Prehistoric	Site	Lithic Scatter	2002	Potentially eligible
35KL2399	CB-03	Prehistoric	Site	Lithic Scatter	2002	Potentially eligible
35KL2400	CB-01	Prehistoric	Site	Lithic Scatter	2002	Potentially eligible
35KL2401	CB-02	Prehistoric	Site	Village	2002	Eligible
35KL2402	FH-14	Prehistoric	Site	Village	2003	Potentially eligible
35KL2403	FH-13	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2404	FH-12	Multiple	Site	Prehistoric Lithic Scatter; Historic Artifact Scatter	2003	Potentially eligible
35KL2405	FH-10	Prehistoric	Site	Village	2003	Potentially eligible
35KL2406	AS-01	Prehistoric	Site	Lithic Scatter and Cemetery	2003	Potentially eligible
35KL2407	FH-17	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2408	FH-18	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2409	FH-19	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2410	JC-01	Prehistoric	Site	Lithic Scatter	2002	Potentially eligible
35KL2411	JC03-09	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2412	JC03-10	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2413	JC03-11	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2414	JC03-12	Prehistoric	Site	Lithic Scatter	2003	Potentially

State Trinomial	Other Site Numbers	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
						eligible
35KL2415	JC03-13	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2416	JC03-14	Prehistoric	Site	Village	2003	Potentially eligible
35KL2417	JC03-15	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2418	JC03-16	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2419	JC03-17	Prehistoric	Site	Village	2003	Potentially eligible
35KL2420	JC03-18	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2421	JC03-20	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35kl2422	JC03-21	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2423	JC03-22	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2424	JC03-24	Prehistoric	Site	Village	2003	Potentially eligible
35KL2425	JS-01	Prehistoric	Site	Village with Features	2002	Potentially eligible
35KL2426	JS-03	Prehistoric	Site	Lithic Scatter	2002	Potentially eligible
35KL2427	JS-04	Prehistoric	Site	Village	2002	Eligible
35KL2428	JS-05	Prehistoric	Site	Village	2002	Unevaluated
35KL2429	FY01-014-005; JS-06	Historic	Built Env.	Spencer Cemetery	2001, 2002	Unevaluated
35KL2430	JS-07	Prehistoric	Site	Village	2002	Potentially eligible
35KL2431	JS-08	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2432	JS-09	Prehistoric	Site	Village	2003	Potentially eligible
35KL2433	JS-10	Prehistoric	Site	Lithic Scatter	2003	Potentially eligible
35KL2434	LA-01	Historic	Site	Logging Camp and Portable Sawmill Location	2004	Unevaluated
35KL2435	RM-01	Prehistoric	Site	Lithic Scatter	2004	Potentially eligible
35KL2436	CB-05	Prehistoric	Site	Village	2002	Potentially eligible
35KL2486	03-09692-01	Historic	Site	Foundation and	2003	Unevaluated

State Trinomial	Other Site Numbers	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
				Artifact Scatter		
35KL2487	03-09692-02	Historic	Site	Rock Wall	2003	Unevaluated
35KL2488	FY01-014-003	Prehistoric	Site	Features	2002	Unevaluated
35KL2561	--	Prehistoric	Site	Lithic Scatter	2005	Unevaluated
35KL2589	--	Prehistoric	Site	Lithic Scatter	2005	Undetermined
35KL2702	--	Prehistoric	Site	Lithic Scatter	2006	Undetermined
35KL2831	OR-KL-40	Historic	Built Env.	Weyerhaeuser Co. Mill Site	1993, 2006, 2010, 2011	Eligible
35KL2832	OR-KL-42	Multiple	Site	Prehistoric Lithic Scatter; Historic Artifact Scatter	1994	Unevaluated
35KL2833	OR-KL-43	Historic	Site	Artifact Scatter	1993	Unevaluated
35KL2834	OR-KL-44	Historic	Site	Artifact Scatter	1993	Unevaluated
35KL2835	OR-KL-45	Historic	Site	Artifact Scatter	1994	Unevaluated
35KL2836	OR-KL-47	Historic	Site	Artifact Scatter	1994	Unevaluated
35KL2865	OR-KL-83	Historic	Built Env.	Way Station/Ranch Complex	1994	Eligible
35KL2866	FY85-014-007	Historic	Built Env.	Topsy/Frain School	1994	Eligible
35KL2981	I-33	Prehistoric	Site	Features	2004	Unevaluated
35KL2994	39/9-32-1	Historic	Built Env.	Westside Powerhouse	2000	Eligible
35KL2995	38/9-32-2	Historic	Built Env.	Eastside Powerhouse	2000	Eligible
35KL3044	HRA-18	Historic	Site	Artifact Scatter	2006	Eligible
35KL3045	HRA-25	Multiple	Site	Prehistoric Flake; Historic Artifact Scatter	2009	Unevaluated
35KL3055	HRA-201	Multiple	Isolate/ Built Env.	Prehistoric Projectile Point; Historic Water Tower	2009	Not eligible
35KL3103	JS-02	Historic	Site	Weyerhauser 100 Railroad Grade	2003	Unevaluated
35KL3056	HRA-202	Multiple	Site/ Built Env.	Prehistoric Lithic Scatter; Historic Bridge/Dock	2009	Not eligible
35KL3114	FY90-014-007; 41/6-11-3; JC03-30; CKF43	Multiple	Site	Prehistoric Lithic Scatter; Topsy Road/Grade	1977, 1986, 1990, 2007	Eligible

State Trinomial	Other Site Numbers	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
35KL3264	RPOR-119	Historic	Built Env.	Lumberyard with Features	2008	Eligible
35KL3281	RPOR-120	Historic	Site	Railroad Berms	2008, 2016	Not eligible
35KL3309	T-931-GRF	Prehistoric	Site	Lithic Scatter	2006	Eligible
35KL3349	FH-08	Prehistoric	Site	Village	2003	Potentially eligible
35KL3350	FH-09	Prehistoric	Site	Village	2003	Potentially eligible
35KL3441	TS1	Historic	Built Env.	Wildlife Viewing Boardwalks	2002	Not eligible
35KL3587	FY10-014-050	Historic	Site	Robber's Rock Hideout	2010	Not eligible
35KL3594	Keno-01	Multiple	Site	Prehistoric Lithic Scatter; Historic Artifact Scatter	2011	Unevaluated
35KL3610	11/1919-1	Prehistoric	Site	Lithic Scatter	2011	Unevaluated
35KL3620	0501040917SI	Historic	Built Env.	Frain Ditch	2011	Unevaluated
35KL3622	Moore Park #4	Unknown	Site	Peeled Tree	2011	Eligible
35KL3741	FY09-014-065	Historic	Built Env.	Fence	2011	Unevaluated
35KL4342	FY15-014-013	Prehistoric	Site	Lithic Scatter	2015	Not eligible

*NRHP Eligibility from Cardno ENTRIX (2012) and/or Oregon site records

Isolated Finds

The Oregon records search identified 108 isolated finds, consisting of 93 prehistoric and 15 historic-period resources (Table 6-5). Prehistoric isolates include 5 ground stone tools, 1 ground stone tool with debitage, 1 exposure of multiple ground stone tools, 27 single flakes, 36 locations with multiple flakes, 18 flaked stone tools, 4 flaked stone tools with debitage, and 1 flaked stone tool with a battered stone tool. The ground stone tools include pestles, a mano, a metate fragment, bowl mortar fragments, and unspecified objects. The flaked stone tools include chert cores, flake tool, and scrapers; obsidian projectile points and fragments, bifaces and fragments, and a flake tool; and one uniface of unspecified material. Debitage comprises obsidian, chert, and basalt flakes.

The historic-period isolates consist of one metal watering can, two bottle glass fragments, one automobile body, one blazed tree, one dump of oyster shell, seven debris scatters or dumps, and two areas containing multiple dumps possibly associated with logging.

Table 6-5 Oregon - Previously Recorded Isolated Finds

Isolate Description	Component			Total
	Prehistoric	Historic	Unknown	
Single ground stone tool	5	--	--	5

Isolate Description	Component			Total
	Prehistoric	Historic	Unknown	
Multiple ground stone tools	1	--	--	1
Single piece of debitage or shatter	27	--	--	27
Multiple pieces of debitage and/or shatter	36	--	--	36
Single flaked stone tool	18	--	--	18
Flaked stone tool(s) and debitage	4	--	--	4
Flaked stone tool and battered stone tool	1	--	--	1
Ground stone tool and debitage	1	--	--	1
Metal watering can with spout	--	1	--	1
Bottle glass fragment	--	2	--	2
Blazed tree	--	1	--	1
Single debris scatter/dump	--	7	--	7
Multiple debris scatters/dumps	--	2	--	2
Automobile body	--	1	--	1
Oyster shell dump	--	1	--	1
TOTAL	93	15	--	108

6.1.2 California Records Search Results

Within the State of California, the KRRC records search area included the length of the Klamath River from the Oregon/California Stateline (RM 214), downstream to Humbug Creek (RM 174), for a total length of roughly 40 river miles. The section of river below Iron Gate Dam (the most downstream Project dam) was included in the records search since this 18-mile-long area lies within the altered 100-year floodplain following dam removal, where cultural resources have the potential to be affected. The records search area included a 0.5-mile wide zone, extending on either side of the shorelines of Copco Lake and Iron Gate Reservoir, or from the center point of the Klamath River in areas where the river remains free flowing.

The KRRC has completed two records searches for the Project area in California. In April 2017, the KRRC conducted a review of the records housed at the Northeast Information Center at California State University, Chico. Research included gathering archaeological site forms, survey and excavation reports, maps, and other records. Survey and site locations were hand-plotted onto United States Geologic Survey (USGS) topographic maps at the Northeast Information Center. Archival research of historic registers included the California Historic Landmarks, National Register of Historic Places (NRHP), California Register of Historical Resources (CRHR), California Points of Historical Interest, California Inventory of Historic Resources, and the California State Historic Resources Inventory. Also in April 2017, a visit was made to the Klamath National Forest office and the Siskiyou County Museum, both in Yreka, California. Klamath National Forest Heritage Program Manager Jeanne Goetz conducted a search of records for Forest Service lands within or near the records search area and provided appropriate archaeological site record forms.

In addition to these office visits, online newspaper archives were searched, including the National Digital Newspaper Program archives provided by the Library of Congress and National Endowment for the Humanities (chroniclingamerica.loc.gov); GeneaologyBank newspaper archives provided by NewsBank, Inc. (geneaologybank.com); the California Digital Newspaper Collection repository provided by University of California, Riverside (cdnc.ucr.edu); and newspaper archives provided by Ancestry.com.

Dr. Brian Daniels, director of research and programs for the Penn Cultural Heritage Center at the University of Pennsylvania Museum, was consulted regarding ethnographic information, archival documents, and oral histories pertaining to tribal cultural resources within the California records search area.

The KRRC contacted the Native American Heritage Commission (NAHC) in June 2017, to secure a review of the Sacred Lands file for a 0.5-mile wide area on either side of the Klamath River corridor, extending from the California-Oregon state line downstream to the Pacific Ocean. In a June 14, 2017 letter, the NAHC stated that there was a positive result, with the recommendation to contact the Karuk Tribe, the Yurok Tribe, and Shasta Nation. THE NAHC also provided a consultation list of 29 tribes with traditional lands or cultural places located within the boundaries of Del Norte, Humboldt, and Siskiyou counties.

6.1.2.1 Previous Cultural Resources Studies

The California records search and literature review identified that 58 previous cultural resources investigations have been conducted within the records search area, with 5 of these studies (Kramer 2003a, 2003b; Cardno ENTRIX 2012; Durio 2003; PacifiCorp 2004) completed specifically for the Lower Klamath Project (Table 6-6). Fourteen of these studies are archaeological, ethnographic, or historical overviews, while eight reports describe archaeological excavations. Two studies involved cultural resources monitoring, while the remaining 34 projects involved archaeological survey or inventory. Overall, an estimated 8,189 acres of federal, state, and/or private land have been surveyed within the records search area, although survey acreage information was not available for all projects.

Table 6-6 Summary of Previous Cultural Resource Studies Identified in the California Records Search

NEIC Report No.	Report Title and Firm	Report Reference	Study Conducted Specifically for Klamath Dams Projects	Project Type	Acres Surveyed
--	*The Cultural Position of the Iron Gate Site*. Unpublished Master's thesis, Department of Anthropology, University of Oregon, Eugene.	Leonhardy 1961	No	Excavation	--
--	Part Two of the Klamath Lake Railroad. *Western Railroader* 27(12).	Stephens 1964	No	Overview	--
--	The Archaeology of a Late Prehistoric Village in Northwestern California. *University of Oregon Museum of Natural History Bulletin* 4.	Leonhardy 1967	No	Excavation	--
--	Shasta Villages and Territory. Part 1: Shasta Villages. *University of California Archaeological Research Facility Contributions* 9(5):119-131. Berkeley.	Heizer and Hester 1970	No	Overview	--
--	*Looking Back: The California-Oregon Stage Road from Ager, California to Topsy, Oregon*. Printers Inc., Carson City.	Hessig 1978	No	Overview	--
13073	*Archaeological Reconnaissance of the Proposed Meadowview Estates, Siskiyou County, California.* ARK II Anthropological Resource Management, Redding.	Dotta 1980	No	Survey	15
13075	*Archaeological Reconnaissance of the Proposed Copco Shores Estates, Siskiyou County, California.* ARK II Anthropological Resource Management, Redding.	Dotta 1980	No	Survey	510
SI-L-146	Letter Report for Archaeological Clearance of the Copco Lake Mutual Water Company Snackenburg Spring Development, Siskiyou County.	Ritter 1983	No	Survey	10
--	Letter Report for Archaeological Survey of the Annie Clawson #2 / Model Ed Mining Claim near Hornbrook, California. USDI, Bureau of Land Management, Redding.	Ritter 1985	No	Survey	20
SI-L-211	*Cultural Resources Survey of the Klamath River Bridge (2C-39) Replacement Located Near Copco Lake, California*. Mountain Anthropological Research, Redding.	Nilsson and Greenway 1985	No	Survey	10
883	*Cultural Resources Survey of the Phase III (KRCE) Realignment of the Hornbrook-Ager Road, Siskiyou County, California*. Mountain Anthropological Research, Redding.	Nilsson 1987	No	Survey	95

NEIC Report No.	Report Title and Firm	Report Reference	Study Conducted Specifically for Klamath Dams Projects	Project Type	Acres Surveyed
1421	*Cultural Resources Assessment of AT&T's Medford, Oregon to Redding, California, Fiber Optic Cable*. Peak & Associates, Sacramento.	Peak & Associates 1988	No	Survey	64
SI-L-384	Negative Archaeological Survey Report for the US Route 96 Project, Siskiyou County, California.	Wiant and Bennett 1990	No	Survey	2.5 miles
--	Cottonwood Henley 1851-, Hornbrook 1887-, Klamathon 1888-1909.	French 1990	No	Overview	--
--	*Klamath River Canyon Ethnology Study*. Theodoratus Cultural Research, Inc., Fair Oaks.	Theodoratus et al. 1990	No	Overview	--
--	Northwest Hunters and Traders Report for the Summer of 1992 Field Season.	Mack 1992	No	Survey and Excavation	--
--	THP #2-92-263 Sis(6) Laubacher. ARP Letter Report #92-181. Archaeological Research Program, California State University, Chico.	Hamusek 1992	No		
--	An Archaeological Survey along Line 19,a Pacific Power & Light Company 115kV Transmission Line between the Klamath River, California and the Rogue River, Oregon.	Oetting 1993	No	Survey	--
--	Northwest Hunters and Traders Report for the Summer of 1993 Field Season.	Mack 1994	No	Survey and Excavation	--
--	*Archaeological Survey Report for the Proposed Jenny Creek Bridge Replacement Project (Bridge 2C-06), Siskiyou County, California.* Coyote and Fox Enterprises, Redding.	Vaughan and McGann 1995	No	Survey	<1
4575	Archaeological and Historical Resources Survey and Impact Assessment: A Supplemental Report for a Timber Harvesting Plan, Oregon Border THP.	Levy and Calvert 1995	No	Survey	194
1428	*Archaeological Inventory and Evaluation of the Orwick BLM Copco Lake Land Exchange Parcels, Siskiyou County, California.* Heritage Research Associates Report No. 198. Heritage Research Associates, Inc., Eugene.	Oetting 1996	No	Survey	2,560
4578	Confidential Archaeological Addendum for Timber Operations on Non-Federal Lands in California, Edge Flat THP, Siskiyou County.	Osterhoudt 1997	No	Survey	141
3310	Confidential Archaeological Addendum for Timber	Caster 1999	No	Survey	120

NEIC Report No.	Report Title and Firm	Report Reference	Study Conducted Specifically for Klamath Dams Projects	Project Type	Acres Surveyed
	Operations on Non-Federal Lands in California.				
2657	Tree of Heaven Archaeological Survey Report with Test Excavations.	Cook-Slette 1999	No	Excavation	<5
2960	Archaeological Resource Management Report for NEWCOM Wireless Communication Hilt, Collier, South Yreka, and Gazelle Antenna Structures, Siskiyou County.	Rock 2000a	No	Survey	<1
2971	Archaeological Resource Management Report for NEWCOM Wireless Communication Klamath/Shasta, Vista, Hornbrook, and Black Butte Antenna Structures, Siskiyou County.	Rock 2000b	No	Survey	<1
3266	Archaeological Inventory Survey, Proposed Osburger Cell Tower, West of I-5 at Hornbrook Off-Ramp, Siskiyou County, California. Jensen & Associates, Chico.	Jensen 2001	No	Survey	<1
3923	*Survey Report for Dunsmuir to Hilt California on Behalf of Qwest Communications*. QWEST, Durham, California.	Brown 2001	No	Survey	1,080
4150	*Toilet Project (CIP 2001), Salmon, Scott, Oak Knoll, and Happy Camp Ranger Districts, ARR05-05-1529.* USDA, Klamath National Forest, Yreka.	Cook-Slette 2001	No	Survey	<1
4608	*Archaeological Investigations for A-'chit'-ter-rah'kah – a Portion of CA-SIS-329 along the Klamath River in Siskiyou County, California.* CALTRANS District 2, Redding.	Hamusek and Haney 2001	No	Excavation	20
5056	Memorandum: Martin Right-of-Way and Adjoining Land Archaeological Inventory, Henley, Siskiyou County, California. USDI, Bureau of Land Management, Redding.	Ritter 2001	No	Survey	41
5061	Memorandum: Edge Wireless Right-of-Way CA 41795. USDI, Bureau of Land Management, Redding.	Molter 2001	No	Survey	4
4604	Confidential Archaeological Addendum for Timber Operations on Non-Federal Lands in California, Badger Mt. THP, Siskiyou County.	Wuerfel 2002	No	Survey	58
4737	Monitoring Report, Randolph E. Collier Safety Roadside Rest Area, Siskiyou County, California.	Ross 2002	No	Monitoring	20
4765	Archaeological Resource Management Report for the Zastoupil Proposed Parcel Split, Siskiyou County.	Rock 2002	No	Survey	33.1

NEIC Report No.	Report Title and Firm	Report Reference	Study Conducted Specifically for Klamath Dams Projects	Project Type	Acres Surveyed
6447	*Test Excavation at Paradise Craggy Village (CA-SIS-1066H), Upper Klamath River, Northern California.* Department of Anthropology, University of Notre Dame, Northern California Resource Center.	Mack 2003a	No	Excavation	--
--	The Relationship Between Basketry and Ceramics from Northern California. *Society for California Archaeology Newsletter* 37(2):24-29.	Mack 2003b	No	Overview	--
--	*Klamath Hydroelectric Project, Federal Energy Regulatory Commission Project No. 2082, Historic Context Statement*. CH2M Hill, Corvallis.	Kramer 2003b	Yes	Overview	--
--	*Klamath Hydroelectric Project, Federal Energy Regulatory Commission Project No. 2082, Determination of Eligibility*. CH2M Hill, Corvallis.	Kramer 2003a	Yes	Overview	--
8626	Klamath River Hydroelectric Project Historic District FERC Project No. 2082.	Durio 2003	Yes	Overview	--
10483	*Final Technical Report, Klamath Hydroelectric Project (FERC Project No. 2082), Cultural Resources.* PacifiCorp, Portland.	PacifiCorp 2004	Yes	Survey	2,260
6366	Archaeological Resource Management Report for the Proposed Klamath Ranch Resort Parcel Development, Siskiyou County.	Rock 2005	No	Survey	562
8675	Archaeological Reconnaissance Report for Three PacifiCorp Projects, Siskiyou County, California. USDA, Klamath National Forest, Macdoel.	Hitchcock 2005	No	Survey	40
--	*Historical Landscape Overview of the Upper Klamath River Canyon of Oregon and California.* Cultural Resource Series No. 13. USDI, Bureau of Land Management, Portland.	Beckham 2006	No	Overview	--
7362	*Cultural Resources Final Report of Monitoring and Findings for the Qwest Network Construction Project, State of California.* SWCA Environmental Consultants, Cultural Resources Report No. 06-507, Sacramento.	SWCA 2006	No	Monitoring	52
9506	*Jenny Creek Bridge (No. 02C-0061) Replacement Project Addendum to Vaughan 1995 Archaeological Survey Near*	Brunmeier 2007	No	Survey	4.26

NEIC Report No.	Report Title and Firm	Report Reference	Study Conducted Specifically for Klamath Dams Projects	Project Type	Acres Surveyed
	Copco, Siskiyou County, California, 02-SIS-9KO2, P.M. Bridge #02C-0061, E.A.02-452384. North State Resources, Inc., Redding.				
10768	*A Cultural Resource Investigation of the Greco Fish Screen Project Located in Siskiyou County, California. California Department of Fish and Game Project #K-09.* Cultural Resources Facility, Center for Indian Community Development, Humboldt State University Foundation, Arcata.	Whiteman and Ainis 2007	No	Survey	1
--	*Klamath N.F. Humbug-Area TMP-Project Route Survey: Results of an Archaeological Survey of Roads and Trails on the West-Side of the Klamath National Forest Identified for Possible Motorized-Recreation Designation (KNF A.R.R. #2008-05-05-1709A).*USDA, Klamath National Forest, Yreka.	LaLande 2008	No	Survey	--
--	The Destruction of Dams on the Klamath River and Some Implications for Cultural Resource Management. *Proceedings of the Society for California Archaeology* 25.	Chartkoff 2011	No	Overview	--
12809	*Archaeological Survey Report, Bridge Preventive Maintenance, Siskiyou County; Federal Project Number BRLO-5902(058).* U.S. Department of Transportation, Siskiyou County Public Works Department, and Caltrans District 2. Condor Country Consulting, Inc., Martinez.	Dexter 2012	No	Survey	20
--	*Klamath Secretarial Determination Cultural Resources Report.* Cardno ENTRIX, Sacramento.	Cardno ENTRIX 2012	Yes	Overview	--
--	Notice of Emergency Timber Operations for the Last Tango 2014 Harvest Units. JWTR, LLC, Klamath Falls.	Howard 2014	No	Survey	284
--	Comparison of Two Shasta Villages' Obsidian Source Use. *Proceedings of the Society for California Archaeology* 29:33-38.	Mack 2015	No	Overview	--
--	*Archaeological Survey Report for the Proposed Randolph C. Collier Safety Roadside Rest Area Facilities Upgrade Project, Siskiyou County, California*. Caltrans District 2, Redding.	Hamusek 2015	No	Survey	20

NEIC Report No.	Report Title and Firm	Report Reference	Study Conducted Specifically for Klamath Dams Projects	Project Type	Acres Surveyed
--	*Archaeological Evaluation Report for Site CA-SIS-329 for the Randolph C. Collier SRRA Water/Wastewater Project (Water/Sewer) (EA 02-4E670; EFIS 0212000031-0) and OSHA Break Room (EA-02-4G300; EFIS 0213000099-0).* Far Western Anthropological Research Group, Inc., Davis.	Waechter and Young 2015	No	Excavation	<20
--	Remnant Home Garden Ornamentals Along the Upper Klamath River. *Eden 19(3):12-16.*	Todt and Hannon 2016	No	Overview	--
--	*Historical Resources Evaluation Report, Klamath River Bridge Replacement Project, Yreka, Siskiyou County, California.* CALTRANS District 3, Marysville.	Miller 2016	No	Survey	<1

NEIC – Northeast Information Center

6.1.2.2 Previously Recorded Cultural Resources

The California record searches identified 206 previously recorded cultural resources, consisting of 120 archaeological sites, 1 ethnographic property, 9 built environment resources, 68 isolated finds, and 8 resources of an undetermined resource type (Tables 6-7 and 6-8). By component type, these resources include 114 prehistoric, 59 historic-period, 23 multiple (prehistoric and historic-period), 1 ethnographic property, and 9 resources whose temporal association is unknown.

Table 6-7 California - Previously Recorded Resources by Resource Type and Component

Resource Type	Component Type					Total
	Prehistoric	**Historic**	**Multiple**	**Ethnographic**	**Unknown**	
Archaeological Site	49	48	23	0	--	120
Ethnographic	--	--	--	1	--	1
Built Environment	--	9	--	--	--	9
Isolate	65	2	--	--	1	68
Undetermined	--	--	--	--	8	8
Total	114	59	23	1	9	206

Archaeological Sites

Archaeological sites represent roughly 60 percent of the previously recorded resources. The sites consist of 49 prehistoric, 48 historic-period, and 23 multiple component. Identified prehistoric period sites include housepit villages; campsites; lithic scatters; lithic scatters with associated cultural features; toolstone quarries; a possible vision quest site with multiple features; and a human burial site.

The historic-period archaeological sites consist of late-nineteenth or early-twentieth century properties associated with the development of agriculture, including settlements or features such as homesteads; logging; mining; commercial; public works (hydroelectric); and transportation. Agricultural-related sites include settlements (homesteads) with or without features, irrigation ditches, rock walls, piled rock in agricultural fields, and artifact scatters.

Logging-related sites focus on elements of the former Klamathon townsite, including the town and lumber mill and the associated Pokegama log chute and ditch flume. Mining related sites, located in the Klamath River area below Hornbrook, include two quartz mines and four placer mines with ditches and/or tailings. The Beswick Hotel, ranch, and Klamath Hot Springs area represents the single commercial property. An extensive refuse scatter associated with the Copco No. 1 Village is the sole public works site. Finally, transportation-related sites consist of an abandoned segment of the Klamath Lake Railroad, a collapsed trestle and segment of railroad grade, a segment of Topsy Road, a road leading to Horseshoe Ranch, and a segment of the California-Oregon Stage Road.

The multiple component sites include both prehistoric and historic-period components. Prehistoric components associated with these sites include housepit villages, a housepit village with a documented historic-period cemetery, lithic scatters, a toolstone quarry, and a rockshelter. Historic-period components comprise mining camps and/or tailing, agricultural-related resources such as historic ranches and artifact scatters, and a possible commercial property associated with a former saloon.

A group of eight sites, termed the Pollock Sites, represent unknown site components. Currently, the only information available for these sites relates to their location, which is noted along the Klamath River between Klamathon and Humbug Creek.

Information provided in Table 6-8 regarding the National Register eligibility of the archaeological sites are based on recommendations provided by Cardno ENTRIX (2012), or by eligibility information noted on new or updated site records that were not part of the Cardno ENTRIX study. Of the 120 archaeological sites, one property is listed in the National Register as a contributor to a district (Code 1B), one site is determined individually eligible (Code 2), three sites are contributors to a district determined eligible (Code 2D1), 29 sites appear eligible for listing (Code 3, 3B, or 3S), two sites might become eligible for listing when more historical research is performed (Code 4S2); four sites have been found ineligible (Code 6Z), and the remaining 80 sites have not been evaluated for NRHP eligibility (Code 7).

Ethnographic Resource

The records search identified one resource that figures prominently in an important legend in Shasta Indian oral history. This resource appears eligible for listing in the National Register.

Built Environment Resources

The California records search identified nine historic-period built environment resources associated with the historic themes of commerce, settlement, transportation, and public works. The single commerce-themed resource includes a former service station converted to residence (Klamath Kamp). Two settlement-related sites have been recorded, consisting of a post-1930s duplex residence with associated structures and the Frank Wood cabin, a late 1890s to 1950s era homesite. Transportation-related sites consist of a one-lane, wooden and steel beam truss bridge over the Klamath River (Ash Creek Bridge), and a two-lane, concrete, T-beam bridge over the Klamath River (Bridge 02-0015). Public works sites include four recorded elements of the Klamath Hydroelectric Project, including Copco No. 1 hydroelectric powerhouse and dam; Copco No. 2 hydroelectric powerhouse; Fall Creek hydroelectric powerhouse; and the Copco No. 2 wooden stave penstock. The Fall Creek Powerhouse coincides with the reported location of an ethnographic Shasta Indian village; however, this component of the site has not been archaeologically recorded.

Besides these nine built environment resources, standing historic-period structures have been identified at several archaeological sites, including a ranch house and bunkhouse at the Beswick Hotel site (CA-SIS-513-H) and a shed at Copco II Ranch (CA-SIS-2239-H). The historic Spannaus Barn was noted at prehistoric/ethnographic site CA-SIS-2574, but was not recorded as an element of the site.

National Register eligibility information for these nine sites indicates that the two Klamath River bridges have been determined eligible for listing in the NRHP. The four hydroelectric-related sites were noted by Cardno ENTRIX (2012) as appearing eligible for separate listing, but these sites have also been documented as contributing elements to the Klamath Hydroelectric historic district (Kramer 2003b) which has yet to be concurred upon by the California and Oregon State Historic Preservation Officers (SHPOs). Also recommended as National Register eligible is the Frank Wood cabin. The final two resources, composed of a residence and a former service station, have been noted as not eligible for the National Register.

Table 6-8 California - Previously Recorded Archaeological Sites and Built Environment Resources

Primary No.	State Trinomial	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
P-47-000016	CA-SIS-16/H	Multiple	Site	Prehistoric Village/Rockshelter with Historic Artifact Scatter	1953, 1995, 2002	3B
P-47-000017	CA-SIS-17/H	Multiple	Site	Prehistoric Village and Cemetery and Historic Ranch	1953, 1988	7
P-47-000155	CA-SIS-155	Prehistoric	Site	Village	1952	7
P-47-000156	CA-SIS-156	Prehistoric	Site	Campsite	1952	7
P-47-000157	CA-SIS-157	Prehistoric	Site	Lithic Scatter and Features	1952	7
P-47-000158	CA-SIS-158	Prehistoric	Site	Lithic Scatter	1952, 2007	7
P-47-000159	CA-SIS-159	Prehistoric	Site	Lithic Scatter	1952	7
P-47-000161	CA-SIS-161	Prehistoric	Site	Village	1952	7
P-47-000264	CA-SIS-264	Prehistoric	Site	Burial Site	1957	7
P-47-000326	CA-SIS-326	Prehistoric	Site	Village	1960, 1961, 1969, 1973	7
P-47-000328	CA-SIS-328	Prehistoric	Site	Lithic Scatter	1965, 2007	7
P-47-000329	CA-SIS-329/H	Multiple	Site	Prehistoric Lithic Scatter and Burial Site; Historic	1965, 2000	7

Primary No.	State Trinomial	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
				Artifact Scatter		
P-47-000498	CA-SIS-498-H	Historic	Site	Pokegama Log Chute	1970s, 1997, 2002, 2003	1B
P-47-000513	CA-SIS-513-H	Historic	Site	Klamath Hot Springs/Beswick	1970s, 2004	7
P-47-000522	CA-SIS-522-H	Historic	Site	Empire Quartz Mine	1976	7
P-47-000536	CA-SIS-536-H/ CA-SIS-1315-H	Historic	Site	Klamathon Town Site and Lumber Mill	1970s, 1986, 1987, 2011	7
P-47-000630	CA-SIS-630	Prehistoric	Site	Village	1977	7
P-47-000632	CA-SIS-632/H	Multiple	Site	Prehistoric Village; Mine and Historic Artifact Scatter	1977, 2004	7
P-47-000873	CA-SIS-873	Prehistoric	Site	Lithic Scatter	1982	7
P-47-001066	CA-SIS-1066/H	Multiple	Site	Midden with Lithic Scatter and Features; Mine with Features	1981, 1983, 1999	2
P-47-001198	CA-SIS-1198/H	Multiple	Site	Prehistoric Village; Historic Feature with Artifact Scatter	1984, 1992, 1993, 1995	2D1
P-47-001314	CA-SIS-1314-H	Historic	Site	Dump	1987	7
P-47-001670	CA-SIS-1670	Prehistoric	Site	Lithic Scatter and Features	1993, 1996, 2000	3S
P-47-001671	CA-SIS-1671-H	Historic	Site	Klamath Lake Railroad Grade	1993, 2004	7
P-47-001672	CA-SIS-1672-H	Historic	Site	Structures, Ditch, and Artifact Scatter	1992	7
P-47-001721	CA-SIS-1721	Prehistoric	Site	Village	1996	2D1
P-47-001776	N/A	Prehistoric	Site	Lithic Scatter	1995	7

Primary No.	State Trinomial	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
P-47-001838	CA-SIS-1838/H	Multiple	Site	Prehistoric Village; Historic Ranch with Structures	1994, 1999	3S
P-47-001839	CA-SIS-1839/H	Multiple	Site	Prehistoric Lithic Scatter; James Whalen Saloon	1994, 2002	7
P-47-001840	CA-SIS-1840	Prehistoric	Site	Village	1994, 2002	3S
P-47-002117	CA-SIS-2117-H	Historic	Site	Features	1996	6Z
P-47-002126	CA-SIS-2126-H	Historic	Site	Large Refuse Dump	1996	7
P-47-002127	CA-SIS-2127-H	Historic	Site	Habitation with Artifact Scatter	1996	7
P-47-002128	N/A	Ethnographic	Site	Traditional Area	1996	3
P-47-002129	CA-SIS-2129-H	Historic	Site	Grieve-Miller-DeSoza Ditch	1996	3
P-47-002130	N/A	Historic	Site	Rock Wall	1996	6Z
P-47-002131	CA-SIS-2131	Prehistoric	Site	Features	1996	7
P-47-002132	CA-SIS-2132	Prehistoric	Site	Lithic Scatter	1996	7
P-47-002237	CA-SIS-2237-H	Historic	Site	Copco Mutual Flume	1995	3S
P-47-002238	CA-SIS-2238-H	Historic	Site	Greek Ovens	1995	3S
P-47-002239	CA-SIS-2239-H	Historic	Site	COPCO II Ranch Features	1996	4S2
P-47-002241	CA-SIS-2241/H	Multiple	Site	Prehistoric Village and Features; Historic Irrigation Ditch	1980, 1995, 2002	3S
P-47-002263	CA-SIS-2263	Prehistoric	Site	Lithic Scatter and Features	1997, 2000, 2002	7
P-47-002264	CA-SIS-2264	Prehistoric	Site	Village	1997	3S
P-47-002266	N/A	Historic	Built Env.	COPCO II Powerhouse	1997	3S

Primary No.	State Trinomial	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
P-47-002267	N/A	Historic	Built Env.	COPCO I Powerhouse	1997, 2003	3S
P-47-002268	N/A	Historic	Built Env.	Fall Creek Powerhouse	1997	3S
P-47-002400	CA-SIS-2400/H	Multiple	Site	Prehistoric Village; Historic Cabin and Artifact Scatter	1997, 2002	3S
P-47-002401	CA-SIS-2401	Prehistoric	Site	Lithic Scatter	1997, 2002	3S
P-47-002402	CA-SIS-2402/H	Multiple	Site	Lithic Scatter and Features; Historic Foundation	1997, 2002	7
P-47-002403	CA-SIS-2403/H	Multiple	Site	Prehistoric Village; Historic Rock Wall and Artifact Scatter	1997, 2003	3S
P-47-002566	CA-SIS-2566	Prehistoric	Site	Lithic Scatter and Features	1999, 2004	3S
P-47-002567	CA-SIS-2567/H	Multiple	Site	Prehistoric Village; Historic Refuse	1999, 2001, 2004	3S
P-47-002568	CA-SIS-2568	Prehistoric	Site	Lithic Scatter, Features, and Burial Site	1999	3S
P-47-002569	CA-SIS-2569	Prehistoric	Site	Village and Features	1999, 2002	3S
P-47-002570	CA-SIS-2570	Prehistoric	Site	Village	1999, 2002	3S
P-47-002571	CA-SIS-2571-H	Historic	Site	Burial Site	1999	4S2
P-47-002572	CA-SIS-2572	Prehistoric	Site	Lithic Scatter and Features	1998, 2002	3S
P-47-002573	CA-SIS-2573	Prehistoric	Site	Lithic Scatter and Features	1998, 2003	7
P-47-002574	CA-SIS-2574	Prehistoric	Site	Lithic Scatter	1998, 2002	3S
P-47-002575	CA-SIS-2575/H	Multiple	Site	Prehistoric Lithic Scatter; Historic Feature	1998, 2002	3S
P-47-002276	CA-SIS-2576	Prehistoric	Site	Village	1998, 2002	3S

Primary No.	State Trinomial	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
P-47-002577	CA-SIS-2577/H	Multiple	Site	Village; Ranch Complex	1998, 2002, 2004	3S
P-47-002578	CA-SIS-2578/H Locus 1	Multiple	Site	Prehistoric Village; Historic Barn	1998, 1999, 2002, 2004	3S
P-47-002646	CA-SIS-2646	Prehistoric	Site	Habitation and Features	1999, 2001	2D1
P-47-002823	CA-SIS-2823-H	Historic	Built Env.	COPCO II Wooden Stave Penstock	2000	3S
P-47-002824	CA-SIS-2824-H	Historic	Site	COPCO Guest House	2000	3S
P-47-002825	CA-SIS-2825/H	Multiple	Site	Lithic Scatter; Historic Dam Vista Homestead	2003	7
P-47-002826	N/A	Historic	Built Env.	Frank Wood Cabin	2000	3S
P-47-002827	CA-SIS-2827	Prehistoric	Site	Village	2000, 2002	3S
P-47-002937	CA-SIS-2937	Prehistoric	Site	Lithic Scatter and Features	2001	7
P-47-002940	N/A	Historic	Site	Irrigation Ditch	2001	7
P-47-002990	CA-SIS-2990-H	Historic	Site	Irrigation Ditch	1996	6Z
P-47-003192	N/A	Historic	Site	Artifact Scatter	2002	7
P-47-003913	CA-SIS-3913	Prehistoric	Site	Lithic Scatter and Features	2003	7
P-47-003914	CA-SIS-3914	Prehistoric	Site	Lithic Scatter	2003	7
P-47-003915	CA-SIS-3915	Prehistoric	Site	Lithic Scatter	2003	7
P-47-003916	CA-SIS-3916-H	Historic	Site	Wooden Trestle	2003	7
P-47-003917	CA-SIS-3917-H	Historic	Site	Refuse Scatter	2003	7
P-47-003918	CA-SIS-3918-H	Historic	Site	Refuse Scatter	2003	7
P-47-	CA-SIS-	Prehistoric	Site	Lithic Scatter	2003	7

Primary No.	State Trinomial	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
003919	3919					
P-47-003920	CA-SIS-3920	Prehistoric	Site	Lithic Scatter	2003	7
P-47-003921	CA-SIS-3921	Prehistoric	Site	Village	2003	7
P-47-003922	CA-SIS-3922-H	Historic	Site	Copco Village Dump	2003	7
P-47-003923	CA-SIS-3923	Prehistoric	Site	Village and Rockshelter	2003	3S
P-47-003924	CA-SIS-3924	Prehistoric	Site	Lithic Scatter	2003	7
P-47-003925	CA-SIS-3925	Prehistoric	Site	Lithic Scatter	2003	7
P-47-003926	CA-SIS-3926	Prehistoric	Site	Village	2003	7
P-47-003927	CA-SIS-3927-H	Historic	Site	Refuse Scatter and Feature	2003	7
P-47-003928	CA-SIS-3928-H	Historic	Site	Rock Wall	2003	7
P-47-003929	CA-SIS-3929/H	Multiple	Site	Prehistoric Village; Historic Artifact Scatter	2003	7
P-47-003930	CA-SIS-3930	Prehistoric	Site	Lithic Scatter	2003	7
P-47-003931	CA-SIS-3931	Prehistoric	Site	Lithic Scatter and Midden	2002	7
P-47-003932	CA-SIS-3932-H	Historic	Site	Habitation with Artifact Scatter and Features	2002	7
P-47-003933	CA-SIS-3933	Prehistoric	Site	Lithic Scatter and Features	2003	3S
P-47-003934	CA-SIS-3934-H	Historic	Site	Rock Piles	2003	7
P-47-003935	CA-SIS-3935	Prehistoric	Site	Lithic Scatter	2003	7
P-47-003936	CA-SIS-3936-H	Historic	Site	Rock Piles and Rock Alignments	2003	7
P-47-003937	CA-SIS-3937-H	Historic	Site	Rock Wall	2003	7
P-47-003938	CA-SIS-3938	Prehistoric	Site	Lithic Scatter	2003	7

Primary No.	State Trinomial	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
P-47-003939	CA-SIS-3939/H	Multiple	Site	Prehistoric Rockshelter; Historic Artifact Scatter	2003	7
P-47-003940	CA-SIS-3940-H	Historic	Site	Habitation with Artifact Scatter and Features	2003	7
P-47-003941	CA-SIS-3941-H	Historic	Site	Ditch	2002	7
P-47-003942	CA-SIS-3942-H	Historic	Site	Rock Wall	2003	7
P-47-003943	CA-SIS-3943-H	Historic	Site	Rock Wall	2003	7
P-47-003944	CA-SIS-3944-H	Historic	Site	Rock Wall	2003	7
P-47-003945	CA-SIS-3945-H	Historic	Site	Rock Piles	2003	7
P-47-004089	CA-SIS-4089-H	Historic	Site	Road	2002	7
P-47-004134	CA-SIS-4134/H	Multiple	Site	Prehistoric Lithic Scatter; American Bar Mine	2003, 2004, 2008, 2009	7
P-47-004212	N/A	Historic	Built Env.	Bridge	2001	7
P-47-004303	N/A	Historic	Site	Hilt Mine with Artifact Scatter	2007	7
P-47-004304	CA-SIS-4304/H	Multiple	Site	Prehistoric Quarry; Historic Artifact Scatter and Features	2007	7
P-47-004305	N/A	Historic	Site	Rock Wall	2007	7
P-47-004315	CA-SIS-4315-H	Historic	Site	Mine and Ditch	2007	7
P-47-004321	CA-SIS-4321	Prehistoric	Site	Quarry and Feature	2007	7
P-47-004322	CA-SIS-4322	Prehistoric	Site	Quarry	2007	7
P-47-004323	CA-SIS-4323	Prehistoric	Site	Quarry	2007	7

Primary No.	State Trinomial	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*
P-47-004326	CA-SIS-4326-H	Historic	Site	Mine	2007	7
P-47-004414	N/A	Historic	Built Env.	Ash Creek Bridge	2000	2
P-47-004427	N/A	Historic	Site	Habitation with Artifact Scatter and Features	2000	7
P-47-004945	CA-SIS-4945-H	Historic	Site	Garvey Gulch Arrastra and Mine	2008	7
P-47-004999	N/A	Historic	Site	Mine	2000	7
P-47-005000	N/A	Historic	Site	Rock Wall	2000	7
P-47-005255	CA-SIS-5255-H	Historic	Site	California Oregon Stage Road	2015	3S
P-47-005256	CA-SIS-5256-H	Historic	Site	Anderson Ditch	2015	6Z
P-47-005346	CA-SIS-5346-H	Historic	Site	Topsy Road	2015	7
N/A	N/A	Unknown	Undetermined	Pollock Site 3	Unknown	7
N/A	N/A	Unknown	Undetermined	Pollock Site 4	Unknown	7
N/A	N/A	Unknown	Undetermined	Pollock Site 5	Unknown	7
N/A	N/A	Unknown	Undetermined	Pollock Site 6	Unknown	7
N/A	N/A	Unknown	Undetermined	Pollock Site 7	Unknown	7
N/A	N/A	Unknown	Undetermined	Pollock Site 10	Unknown	7
N/A	N/A	Unknown	Undetermined	Pollock Site 12	Unknown	7
N/A	N/A	Unknown	Undetermined	Pollock Site 13	Unknown	7
N/A	N/A	Historic	Site	Habitation with Artifact Scatter and Features	2013, 2016	7
N/A	N/A	Historic	Built Env.	MR#1 - Klamath Kamp Service Station and Habitation	2015	6Z
N/A	N/A	Historic	Built Env.	MR#2 - Habitation	2015	6Z

*NRHP Eligibility from Cardno ENTRIX (2012) and/or NEIC site records:

1B Listed in the National Register as a contributor to a district and separately;

2 Determined eligible for listing in the National Register;

Primary No.	State Trinomial	Component Age	Resource Type	Site Type	Year(s) Recorded or Updated	NRHP Eligibility*

2D1 Contributor to a district determined eligible by the Keeper;
3 Appears eligible for listing in the National Register;
3S Appears eligible for separate listing;
3B Appears eligible for separate listing and contributor to a district that has been fully documented according to OHP instructions and appears eligible for listing;
4S2 May become eligible for separate listing in the National Register when more historical or architectural research is performed on the property;
6Z Found ineligible for listing in the National Register;
7 Not evaluated.

Isolated Finds

The California records search identified 68 isolated finds, including 65 prehistoric resources, 2 historic-period isolates, and 1 isolated feature of unknown age (Table 6-9). Prehistoric isolates include one small rock cairn, one bedrock milling feature, one location with two possible cupule boulders, one incised cobble, one piece of possible ground stone, one unifacial mano, one cobble mortar, one basalt maul, three obsidian biface fragments, one chert biface fragment, one basalt core, nine chert cores, one jasper core, two chert flake tools, one chert barbed projectile point, one chert projectile point midsection, one chert scraper, and four obsidian unifaces. Forty-one isolate locations were found to contain debitage, ranging from 1 flake to as many as 13 flakes in a single location. Debitage includes obsidian, chert, and basalt. Eleven isolates contain both tools and debitage.

The historic-period isolates consist of one rusted horseshoe and the remains of a wagon. The isolate of unknown age is described as a rocky depression measuring 2.5 m in diameter.

Table 6-9 California - Previously Recorded Isolated Finds

Isolate Description	Component			Total
	Prehistoric	Historic	Unknown	
Small rock cairn	1	--	--	1
Rocky depression	--	--	1	1
Bedrock milling feature	1	--	--	1
Two possible cupule boulders	1	--	--	1
Incised cobble	1	--	--	1
Single ground stone tool	4	--	--	4
Single piece of debitage or shatter	21	--	--	21
Multiple pieces of debitage and/or shatter	11	--	--	11
Single flaked stone tool	11	--	--	11
Multiple flaked stone tools	1	--	--	1

Flaked stone tool(s) and debitage	11	--	--	11
Flaked stone tool, battered stone tool, and debitage	1	--	--	1
Ground stone tool and debitage	1	--	--	1
Horseshoe	--	1	--	1
Wagon	--	1	--	1
TOTAL	65	2	1	68

6.1.3 Archaeological Districts

6.1.3.1 FERC Relicensing Study Proposed Archaeological Districts, California and Oregon

As part of the Klamath Hydroelectric Project relicensing study (FERC 2007), five areas of multiple prehistoric sites were identified along the same section of the Klamath River that was considered as a potential National Register District (PacifiCorp 2004:3-198-199; FERC 2007:3-544). This district included four groups of multiple sites in Oregon located at the head of Link River and the mouth of Upper Klamath Lake, Teeter's Landing, Spencer Creek/mouth of upper Klamath River Canyon, and near Frain Ranch. In California, a cluster of three villages near Fall Creek, in the Copco Lake area, comprised the fifth potential district group (Table 6-10). The National Register eligibility of this district has not been finalized.

A historic-period archaeological district was also considered for the Frain Ranch, in Oregon (PacifiCorp 2004:3-200). Due to their association with early homesteading and the beginning of ranching and agriculture within the upper Klamath River, four Frain ranch area sites were envisioned for this district. The National Register eligibility of this district has not been finalized.

Table 6-10 FERC Relicensing Study Proposed Archaeological Districts

District Type	Area
Prehistoric	Link River area and mouth of Upper Klamath Lake, OR
	Teeter's Landing, OR
	Spencer Creek/mouth of upper Klamath River Canyon, OR
	Near Frain Ranch, OR
	Fall Creek Villages, near Copco Lake, CA
Historic	Frain Ranch, OR

6.1.3.2 Upper Klamath River Stateline Archaeological District, California

The newly designated Upper Klamath River Stateline Archaeological District (Bureau of Land Management 2016) is located along the upper Klamath River, in California, less than 0.5-mile from the California-Oregon border. The district encompasses three pre-contact village sites (contributing) and one lithic scatter (non-contributing). Archaeological research indicates site use in the district extended from circa 1000 years before the Common Era (BCE) or earlier to possibly as late as 1840 BCE (Bureau of Land Management 2016). The district was determined eligible for the National Register at the local level of significance under Criterion D in the areas of Prehistoric Archaeology, Native American Ethnic Heritage, Commerce, Economics, Religion, and Politics/Government. The California SHPO and the Keeper of the National Register have concurred with the district's eligibility.

6.1.3.3 Klamath River Canyon Archaeological District, Oregon

An archaeological study conducted in the upper reaches of the Klamath River Canyon in 2008 by Central Washington University (McCutcheon and Dabling 2008) examined the NRHP eligibility of 19 prehistoric and historic-period sites located along the river corridor between the California/Oregon Stateline and J.C. Boyle Dam. NRHP eligibility recommendations were provided using information gathered during field visits, preparation of updated site records, and the assessment of a site's research potential and integrity ; no new subsurface testing was conducted, although previous excavations had been conducted at some of the sites. Thirteen of the 19 sites were recommended NRHP eligible under Criterion D, while the remaining six sites were assessed as unevaluated resources, requiring additional data to make a determination. Recommendations included consideration of an Archaeological District nomination for the NRHP-eligible resources as a way to provide a broader context to evaluate the archaeological record of the Klamath River Canyon (McCutcheon and Dabling 2008). Documentation and nomination of such a district has not been completed.

6.1.4 Klamath River Hydroelectric Project District

The Klamath Hydroelectric Project comprises seven hydroelectric generation facilities and their related resources located along the Klamath River and its tributaries in Klamath County, Oregon and Siskiyou County, California. Beginning at the Link River Dam, in Klamath Falls, Oregon, the Project boundary continues southwest along the Klamath River to include the Keno Dam Complex and the J.C. Boyle Complex in Oregon. Within California, the Klamath Hydroelectric Project boundary includes the Fall Creek, Copco No. 1 and Copco No. 2 complexes, and terminating at Iron Gate Dam. The Klamath Hydroelectric Project facilities were constructed between 1903 and 1958 by the California Oregon Power Company (COPCO) and its predecessors and are now owned and operated by PacifiCorp under FERC License Nos. 2082 (Kramer 2003a, b) and 14803.

The proposed Klamath River Hydroelectric Project District (P-47-004015) includes the hydroelectric facilities and various diversion dams; support structures; linear elements such as flumes, canals, and tunnels; and other related buildings and structures. A historic context statement (Kramer 2003a) and Determination of Eligibility (Kramer 2003b) developed for the Klamath Hydroelectric Project notes its eligibility to the National Register as a District under Criterion A for its association with the industrial and economic development of southern Oregon and northern California (Kramer 2003b). The California and Oregon SHPOs have not concurred with this eligibility recommendation. Table 6-11 identifies key features of the hydroelectric complexes located in Oregon and California that are part of the Klamath River Renewal Project and their National Register eligibility recommendation.

Table 6-11 Summary of National Register Eligibility Recommendations for the Klamath Hydroelectric District Facilities/Components

Facility/Description	Date	National Register Eligibility Recommendation and Reference	
		Kramer 2003b	EIS/R 2012
J.C. Boyle			
Dam	1956-1958	Historic Contributing	Historic Contributing
Communications Building	Ca. 1995	Non-Contributing	Non-Contributing
Fire Protection Building	Ca. 1995	Non-Contributing	Non-Contributing
Red Barn	Ca. 1958, altered 1978	Non-Contributing	Non-Contributing
Maintenance Shop	1991	Non-Contributing	Non-Contributing
Residence 1	Ca. 1985	Non-Contributing	-
Residence 2	Ca. 1985	Non-Contributing	-
Water Conveyance Features	1958		Potentially Contributing
Steel Pipe	1958	Historic Contributing	Historic Contributing
Flume Headgate	2002	Non-Contributing	Non-Contributing
Open flume/Concrete	1958	Historic Contributing	Historic Contributing
Headgate Structure	1958	Historic Contributing	Historic Contributing
Forebay/spillgates	1958	Historic Contributing	Historic Contributing
Spillway House	Ca. 1958	Historic Contributing	Historic Contributing
Tunnel	1958	Historic Contributing	Historic Contributing
Surge Tank	1958	Historic Contributing	-
Penstocks	1958	Historic Contributing	Historic Contributing
Powerhouse	1958	Historic Contributing	Historic Contributing
Substation	1958	Historic Contributing	Historic Contributing
Residential Site	Ca. 1950/1995	Non-Contributing	-
Armco Warehouse	1957	Historic Contributing	Historic Contributing
Copco No. 1 Complex			
Dam	1912-1918, 1921-1922	Historic Contributing	Historic Contributing
Gatehouse 1	1918	Historic Contributing	Historic Contributing
Gatehouse 2	1922	Historic Contributing	Historic Contributing
Gate Hoist System/Rails	1918	Historic Contributing	Historic Contributing
Single and Double Penstocks	1912-1918	Historic Contributing	Historic Contributing
Powerhouse	1918	Historic Contributing	Historic Contributing
Copco Guesthouse (remains)	1917, 1980s	Historic Contributing	-
House/Garage 1	ca.1922	Historic Contributing	-

Facility/Description	Date	National Register Eligibility Recommendation and Reference	
		Kramer 2003b	EIS/R 2012
House/Garage 2 (21600 Copco Rd)	ca.1922	Historic Contributing	-
Garage/Warehouse	ca.1922	Historic Contributing	-
Copco No. 2 Complex			
Dam	1925	Historic Contributing	Historic Contributing
Water Conveyance Features	1925	Historic Contributing	Historic Contributing
Headgate	1925 (rebuilt)	Historic Contributing--	Historic Contributing
Tunnel Intake	1925	Historic Contributing	Historic Contributing
Concrete-lined Tunnel	1925	Historic Contributing	Historic Contributing
Wood Stave Pipeline	1925	Historic Contributing	Historic Contributing
Concrete Tunnel	1925	Historic Contributing	Historic Contributing
Steel Penstocks	1925	Historic Contributing	Historic Contributing
Timber Cribbing	1925	Historic Contributing	Historic Contributing
Coffer Dam	1925	Historic Contributing	Historic Contributing
Powerhouse	1925, 1996	Historic Contributing	Historic Contributing
Control Center/Office	ca. 1980	Non-Contributing	-
Maintenance Building	1991	Non-Contributing	-
Oil and Gas Shed		Historic Contributing	-
Cookhouse/Bunkhouse	ca. 1925	Historic Contributing	-
Modern Bunkhouse	ca. 1960	Non-Contributing	-
Garage/Accessory Building	ca. 1960	Non-Contributing	-
Ranch Housing	ca. 1965		
Ranch House 1	ca. 1965	Non-Contributing	-
Ranch House 2	ca. 1965	Non-Contributing	-
Ranch House 3	ca. 1965	Non-Contributing	-
Bungalow Housing	ca. 1925		
Bungalow/Garage 1	ca. 1925	Historic Contributing	-
Bungalow/Garage 2	ca. 1925	Historic Contributing	-
Bungalow/Garage 3	ca. 1925	Historic Contributing	-
Modular Residences	1985		
Modular 1	1985	Non-Contributing	-
Modular 2	1985	Non-Contributing	-
Modular 3	1985	Non-Contributing	-
School House/Comm.Center	1965	Non-Contributing	-

Facility/Description	Date	National Register Eligibility Recommendation and Reference	
		Kramer 2003b	EIS/R 2012
Iron Gate Dam Complex			
Dam	1960-1962	Non-Contributing	Historic Contributing
Spillway	ca. 1980	Non-Contributing	Historic Contributing
Diversion Tunnel	1960-1962	Non-Contributing	Historic Contributing
Water Conveyance System	1960-1962		Historic Contributing
Water Way/Trash Racks	1960-1962	Non-Contributing	Historic Contributing
Pipeline	1960-1962	Non-Contributing	Historic Contributing
Penstock	1960-1962	Non-Contributing	Historic Contributing
Powerhouse	1960-1962	Non-Contributing	Historic Contributing
Communication Building	ca. 1980	Non-Contributing	Historic Contributing
Restroom Building	ca. 1980	Non-Contributing	Historic Contributing
Dam Fisheries Facilities			Historic Contributing
Holding Tanks	1962	Non-Contributing	Historic Contributing
Spawning Building	1962	Non-Contributing	
Fish Ladder	1962	Non-Contributing	
Aerator	1962	Non-Contributing	
Fish Hatchery	1965, ca.1994		
Hatchery Building	1962	Non-Contributing	
Warehouse	1962	Non-Contributing	
Office	1962	Non-Contributing	
Workers Housing 1	1962	Non-Contributing	
Workers Housing 2	1962	Non-Contributing	
Workers Housing 3	1962	Non-Contributing	
Workers Housing 4	1962	Non-Contributing	
Fish Rearing Ponds	1962	Non-Contributing	
Fish Ladder	1962	Non-Contributing	
Visitors Center	1962	Non-Contributing	

6.1.5 Ethnographic Information and Traditional Cultural Properties (TCPs)

The KRRC's review of ethnographic information for the Project identified TCPs and other culturally sensitive areas along and near the Klamath River based on ethnographic inventory reports prepared by the Klamath Tribe (Deur 2003), Shasta Nation (Daniels 2003, 2006), Karuk Tribe (Salter 2003), and Yurok Tribe (Sloan 2003) for the FERC 2007 Relicensing FEIS.

The Klamath Tribe identified 11 TCPs in the Klamath Basin area, and noted adverse effects to tribal fisheries resulting from impediment of anadromous fish passage due to Klamath River dams (Deur 2003). The Klamath Tribe also identified three sites along the Klamath River between J.C. Boyle Dam (Oregon) and the Scott River (California) that have cultural value (Theodoratus et al. 1990).

The Shasta Nation report (Daniels 2003, 2006) presents a list of village sites recorded in the ethnographic literature, a list of locations that the Shasta consider TCPs, and another inventory of 11 locations, drawn from the first two listings, that are eligible for the National Register.

The Karuk (Salter 2003) and Yurok (Sloan 2003) ethnographic reports draw upon oral interviews, other writings, ethnographical literature, and a review of natural and cultural resources within the Klamath River to discuss each tribe's traditional and historical relationships with the river and its resources to subsistence, material and spiritual culture, and identity.

In response to AIR #29, consultation with Indian Tribes and other tribal organizations is planned to occur beginning in January 2018, after FERC's tribal outreach effort. The KRRC's informal tribal consultation efforts will focus on tribal input regarding identification and NRHP evaluation of TCPs, the Klamath Tribe's proposed Klamath Riverscape (discussed in Section 6.1.5.1 below), and the management , disposition, and treatment of human remains (discussed in Section 8.5 below).

6.1.5.1 Klamath Cultural Riverscape

The Klamath River Inter-Tribal Fish and Water Commission incorporated information from the tribal ethnographic studies, in addition to information provided by the Hoopa Valley Tribe, into an integration report (King 2004) that focused on the Klamath River. The entire length of the river was identified as a type of cultural or ethnographic landscape, termed the Klamath Riverscape, due to the relationship between the Klamath Tribes, Shasta, Karuk, Hoopa, and Yurok Tribes and the river and its resources (Gates 2003; King 2004). The characteristics that contribute to the riverscape's cultural character include natural and cultural elements such as the river itself; its anadromous and resident fish; its other wildlife and plants; and its cultural sites, uses, and perceptions of value by the tribes (King 2004). Gates (2003) and King (2004) recommended the Klamath Riverscape as eligible for the National Register based on its association with broad patterns of tribal environmental stewardship, spiritual life, and relationships between humans and the non-human world. The riverscape and/or ethnographic reports and eligibility determination have not been submitted by a Federal agency to the Oregon and California SHPOs for National Register eligibility concurrence (USBR and California Department of Fish and Game (CDFG)[1] 2012: Vol. 1, 3.13-29).

Further research and consultations to define and update the riverscape cultural landscape as a historic property is identified as a Cultural Resources mitigation measure for the Project. In response to AIR#29, the Klamath Riverscape is an ongoing topic of discussion for the CRWG and informal tribal consultation efforts.

[1] California Department of Fish and Game is now known as the California Department of Fish and Wildlife.

6.1.6 Historical Landscape Analysis

As part of the records search, the KRRC conducted a historical landscape analysis to identify locations where post 1850s era settlement and resource developments occurred within the records search area. The materials for this study included the review of the General Land Office (GLO) records, including California plat maps (1856, 1876, 1880, and 1881) and surveyor's notes; Oregon plat maps (1858, 1874, 1881, 1900, and 1917) and surveyor's notes; a variety of published and manuscript resources (Beckham 2006; Boyle 1976; Kramer 2003a, b; PacifiCorp 2004; USDI 1989); and USGS maps available at http://historicalmaps.arcgis.com/usgs. Other map searches included the David Rumsey collection, Northwestern California map collection at Humboldt State University, Library of Congress digital collections, and Online Archive of California. Historical landscape information was digitized into a GIS format and a table prepared with site-specific information annotated by Township/Range/Section (Table 6-12).

KRRC is currently completing the review of the J.C. Boyle Collection (MI 165306) housed at the Southern Oregon Historical Society in Medford, Oregon. This archive contains photo albums, newspaper clippings, maps, manuscripts, financial records, and Copco annual reports belonging to Copco Engineer J. C. Boyle, and pertaining predominately to construction of Copco No. 1 dam and reservoir. This archive is a valuable source of information concerning the pre-inundation historical landscape of the Copco No. 1 area and will provide important information regarding cultural and historical resources that may be anticipated during reservoir drawdown. In addition, archival and historical landscape research is currently underway at local County repositories and historical societies to provide information regarding cultural and historical resources that may be anticipated during reservoir drawdown at J.C. Boyle and Iron Gate reservoirs.

Table 6-12 Historic Landscape Analysis Results by State

Township	Range	Section	Notes
Oregon			
39S	6E	General	"Several claims have been taken in the Southern portion [likely outside the APE along the Oregon Road to the west]. The township should be subdivided" (GLO 1899, in Beckham 2006:25). Road depicted on Klamath, OR 1894 topographic quadrangle in Sections 25, 27, 28, 32, 33, 34, and 35.
39S	7E	28	2,000 acres had been logged by 1899 (USGS, in Beckham 2006:30)
39S	7E	29	The Emigrant Trail is depicted in the southwest quarter on the 1858 GLO. The northwest quarter of the section was the probable location of several features at the confluence of Spencer Creek and the Klamath River: a U.S. Army temporary camp, Camp Day in 1860 (Beckham 2006:53); Brown's station, a log stage house was present from late 1860s until 1872, with a sawmill in 1868 (Beckham 2006:210); the property was owned by the Spencer's from late 1860s [sic] until 1890 (Beckham 2006:217).
39S	7E	30	The Emigrant Trail is depicted on the 1858 GLO crossing the section from northwest to southeast, and crossing the Klamath

			River in the southeast quarter. Approximate location of Spencer Cemetery (dates unknown) (Beckham 2006:216).
39S	7E	31	Road depicted on the Ashland, OR 1897 topographic quadrangle in the rough alignment of modern day Topsy Grade Road. Bridge and two dams over Klamath River present on 1953 aerial.
39S	7E	32	The Emigrant Trail is depicted in the east half of the section on the 1858 GLO. Stage station (Chase) located at the junction of Topsy Wagon Road from Ager and Applegate Trail 1887-1909 in south half of section (Beckham 2006:211). Road depicted on the Ashland, OR 1897 topographic quadrangle in the rough alignment of modern day Topsy Grade Road.
39S	7E	33	The Emigrant Trail is depicted in the south half of the section on the 1858 GLO. Road depicted on the Ashland, OR 1897 topographic quadrangle in the rough alignment of modern day Topsy Grade Road.
40S	6E	1	Trail depicted in the west half of the section on the 1881 GLO. 1800 acres had been logged by 1899 (USGS, in Beckham 2006:34).
40S	6E	2	Cabin and spring on 1881 GLO. Road depicted on Klamath, OR 1894 topographic quadrangle.
40S	6E	11	Trail depicted in the east half of the section on the 1881 GLO.
40S	6E	12	Trail depicted in the far northwestern corner of the section on the 1881 GLO.
40S	6E	13	Road depicted on the Ashland, OR 1897 topographic quadrangle in the rough alignment of modern day Topsy Grade Road. J.C. Boyle Powerhouse (built 1958), built as Big Bend, has a substation and small metal maintenance building in the northwest quarter (still present) (Kramer 2003a:38-39).
40S	6E	14	Trail depicted in the west half of the section on the 1881 GLO. J.C. Boyle Powerhouse (constructed in 1958), built as Big Bend, has a substation and small metal maintenance building in the northeast quarter (still present) (Kramer 2003a:38-39).
40S	6E	24	Linkville and Yreka Wagon Road depicted in south half on the 1881 GLO. Road depicted on the Ashland, OR 1897 topographic quadrangle.
40S	6E	25	Linkville and Yreka Wagon Road (depicted in the northwestern corner on the 1881 GLO. Road depicted on the Ashland, OR 1897 topographic quadrangle.
40S	6E	26	Linkville and Yreka Wagon Road depicted in east half on the 1881 GLO. Road depicted on the Ashland, OR 1897 topographic quadrangle.
40S	6E	27	Trail depicted in center of the section on the 1881 GLO.
40S	6E	34	Trail depicted in northwest quarter of the section on the 1881 GLO. Homestead patented in 1918 (PacifiCorp 2004:Appendix 2D)
40S	6E	35	Linkville and Yreka Wagon Road depicted in the center of the section on the 1881 GLO. Road to Klamath Falls (84) platted in approximate same location as Linkville and Yreka Wagon Road on

			the 1884 GLO. Road depicted on the Ashland, OR 1897 topographic quadrangle.
40S	7E	5	1,500 acres had been logged by 1899 (USGS, in Beckham 2006:33).
40S	7E	6	Road depicted on the Ashland, OR 1897 topographic quadrangle in the rough alignment of modern day Topsy Grade Road. Homestead patented in 1918 (PacifiCorp 2004:Appendix 2D).
40S	7E	7	Road depicted on the Ashland, OR 1897 topographic quadrangle in the rough alignment of modern day Topsy Grade Road.
40S	7E	18	Road depicted on the Ashland, OR 1897 topographic quadrangle in the rough alignment of modern day Topsy Grade Road.
40S	7E	19	Linkville and Yreka Wagon Road depicted on the 1881 GLO.
41S	5E	General	“The Pokegama Lumber Company has here extensive logging camps” (USGS, in Beckham 2006:38) [town of Pokegama in Section 3, outside project area]
41S	5E	12	2,000 acres had been logged by 1899. William G. Hoover owned NE and NW 1/4 of the NW 1/4 and NW and SW 1/4 of the NE 1/4 in 1936; Mary Hoover (mother) owned SW, NE, and SE 1/4 of the SW 1/4 and the SW 1/4 of the SE 1/4 of Section 12 (Beckham 2006:102-103). Entire section the location of the 41 Ranch (Beckham 2006:102-103). "Remains of an Indian Village" depicted on 1874 GLO.
41S	5E	13	Irrigation ditch, road to Klamath Falls, unnamed road, fence line, and telephone line depicted on 1917 GLO.
41S	5E	14	Unnamed road depicted on 1917 GLO.
41S	6E	General	Along and near the Klamath River there is some good land. There are 6 settlers in the Township on each in secs. 2, 3, 5, 8, 9, and 14 (GLO 1883, in Beckham 2006:27)
41S	6E	2	1,200 acres had been logged by 1899 (USGS, in Beckham 2006:37). Elgin House (stage stop) in 1900 at location of split in Topsy Road in northeast quarter (Beckham 2006:123). This location was also known as Topsy and settled as early as 1883; two different schools stood near Topsy (Beckham 2006:217). The Overton Station/Stage house was mapped in two locations in two reports: Overton Station mapped in northwest quarter (1989 WASR report) and Overton House described in northwest quarter of southeast quarter ((PacifiCorp 2004:Appendix 2D). Overton House is depicted on the 1884 GLO, suggesting the PacifiCorp report is more accurate. Field depicted in southeast quarter on 1884 GLO. Unnamed Road (and Road to Klamath Falls depicted on 1884 GLO. Road depicted on the Ashland, OR 1897 topographic quadrangle.
41S	6E	3	Vessman Homestead including barn was located in the southeast quarter of the southwest quarter in 1886 (PacifiCorp 2004:Appendix 2D). Rambos house; road (depicted leading to Rambos house; and two trails on each side of the river depicted on the 1884 GLO. Road depicted on the Ashland, OR 1897 topographic quadrangle.

41S	6E	5	Butlers House and trail depicted on north side of river on 1884 GLO.
41S	6E	7	Mary Hoover owned land in this section (Beckham 2006:103). Way cemetery nearby. Ways owned land in sections 7 and 8 (Beckham 2006:105). Old stage barn in Waugh Meadow (location unknown) (Beckham 2006:218). Trail on north side of river and Road to Klamath Falls (on the south side of the river on 1884 GLO. Telephone lines and Road to Klamath Falls on 1917 GLO.
41S	6E	8	Trail on north side of river, Road to Klamath Falls) and salt caves (on south side of river, and Tom Way and Stough houses on 1884 GLO. Way Station/Way Ranch served travelers on Topsy Road in 1900, Way cemetery nearby, Ways owned land in sections 7 and 8 (Beckham 2006:105). Road depicted on the Ashland, OR 1897 topographic quadrangle.
41S	6E	9	Trail, Road to Klamath Falls, unnamed road, and irrigation ditch depicted on 1884 GLO. Location of Robber's Rock within Section 9 a short distance from Topsy School No. 3 (Beckham 2006:216). Road depicted on the Ashland, OR 1897 topographic quadrangle.
41S	6E	10	Road to Klamath Falls and road to Rambos homestead depicted on 1884 GLO. Frain Ranch/Topsy Grade Ranch in this section, owned by Martin Frain, sold to CopCo (Beckham 2006:103). Location of ruins of Topsy Grade School #3, at foot of Topsy Grade where road turns into Frain Ranch. A homestead was described in this section in 1915, not mapped… unknown if homestead developed (PacifiCorp 2004:Appendix 2D). Road depicted on the Ashland, OR 1897 topographic quadrangle.
41S	6E	11	Two unnamed roads and field depicted on 1884 GLO.
41S	6E	14	Unnamed road and spring depicted on 1884 GLO.
41S	6E	16	Irrigation ditch and unnamed road depicted on 1884 GLO.
41S	6E	17	Unnamed road depicted on 1884 GLO. Fence depicted on 1917 GLO. Road depicted on the Ashland, OR 1897 topographic quadrangle. Location of Way's Station stagehouse as mapped in WASR 1989.
California			
48N	4W	26	Nothing depicted.
48N	4W	27	Linkville & Yreka Road and irrigation ditch on 1881 GLO. Lennox's barn on west Section line on 1881 GLO. Unpaved road or trail on *Macdoel, Calif*. 1941 topographic quadrangle.
48N	4W	28	Klamath Lake Railroad switchback (Beckham 2006:126). Boyle (1976) depicts layout of dam construction project showing ditches, dams, buildings, etc., including Klamath Lake Railroad switchback. Linkville & Yreka Road and irrigation ditch on 1881 GLO. Lennox's barn on east Section line on 1881 GLO. Likely Ward barn on west Section line on 1881 GLO. Unpaved road or trail on *Macdoel, Calif*. 1941 topographic quadrangle.
48N	4W	29	Klamath Lake Railroad switchback (Beckham 2006:126). Extinct bison remains found (in 1914?), in pothole while excavating the

			west abutment of Copco dam (Boyle 1976:12). "Ward's camp or camp No. 3...only a few men were there living in tents with an old barn for a cookhouse....It was also a place where Indian Jake (of the Shasta Indians) used to sit and fish" (Boyle 1976:9). Copco announced (in 1917) that it would put a force of 300 men to work on its dam and powerplant at Copco No. 1 Kramer (2003a:39). Map showing Camp Ward and other buildings at Copco No. 1 in Boyle (1976). Post office at "Ward's Canyon" (Boyle 1976:18). Hahn Ranch located south of Klamath River at the Copco No. 1 Diversion Dam (Kramer 2003a: Figure 10). Copco built a beautiful, rustic and (large) spacious guest house, built on the bluff (a few feet back about 50-75 yards above the dam) at Copco No. 1, overlooking dam, powerhouse and lake; to get to the guest house one walked along the cinder path from the cableway winch house over a bridge-like walkway with a railing, onto a wide veranda (Kramer 2003a:40). Other buildings in the Copco No. 1 workers village: a concrete plant, railroad switch yard, turntable, winch house, blacksmith shop (located north of adit (Kramer 2003a: Figure28, page 47), carpentry shop and various others (Kramer 2003a:40-41). A series of buildings are depicted on the 1941 *Macdoel, Calif*. topographic quadrangle (see below). Construction of the dam required a "branch feeder railroad," the old Klamath Lake logging railroad, that connected to the main line of the Southern Pacific Railroad south of Hornbrook (Kramer 2003a:40). Likely road on 1881 GLO. Ward's House, spring, and barn along section line between 28 and 29 on 1881 GLO. Unpaved road or trail, Copco Dam, and Iron Gate Powerhouse, Southern Pacific Railroad, and four unidentified buildings on *Macdoel, Calif.* 1941 topographic quadrangle.
48N	4W	30	Community of Copco (construction site for dam), included a post office that operated between 1914 and 1954 (Beckham 2006:224); possible location of Fall Creek School (Beckham 2006:226). Klamath Hot Springs Station (RR) located in the northern 1/2 of section (Boyle 1976 [page 43 of PDF]. Two bungalows were building for the engineers at Fall Creek during the 1921-22 expansion work at Copco No. 1; many workers brought their families so another school house was built at Fall Creek, a few feet north of the first - 1922 school in place until Copco No. 2 was completed in 1965 (Kramer 2003a:41). Copco No. 2 Village is a series of dwellings built for workers and other company employees, storage buildings, a former cookhouse and 1965 school building that was in use as a community center in 2003 (Kramer 2003a:44, 48). Most of the workers' cottages were removed or replaced by more modern "ranch" housing; several ca. 1930s cottages as well as the cookhouse remain (Kramer 2003a:45). Likely road on 1881 GLO. Unpaved road or trail, two unidentified buildings, State Fish Hatchery, and Southern Pacific Railroad on *Macdoel, Calif*. 1941 topographic quadrangle.
48N	4W	31	"During Fall Creek Power Plant construction there was quite a camp of tents, tent houses, etc., however, a boardinghouse built

			just a bit easterly above the plant was run by Mrs. Beck and her daughter - this burned in the 1930s and replaced with a modern cottage" (Kramer 2003a:49). Location of Mrs. Beck's boarding house unknown. Unpaved road or trail on *Macdoel, Calif*. 1941 topographic quadrangle. Cluster of buildings, power house, water tank, and radio station on *Copco, Calif*. 1954 topographic quadrangle.
48N	4W	32	Unpaved road or trail on *Macdoel, Calif*. 1941 topographic quadrangle. Road depicted on Boyle (1976) map from south to the Copco No. 1 then crossing Klamath River and meeting up with Copco Road, may be 1941 road.
48N	4W	33	Road depicted on Boyle (1976) map from south to the Copco No. 1 then crossing Klamath River and meeting up with Copco Road. Road on *Macdoel, Calif*. 1941 topographic quadrangle. Road in approximate same alignment on 1881 GLO. G.S. Raymond's Home on 1881 GLO [appears outside project area].
48N	4W	34	Lennox Rock and Lennox Ranch within Section. Lennox's secured homestead in 1882; Siskiyou Electric Power… crews maintained survey headquarters at ranch (Beckham 2006:229; Boyle 1976:8-9). Headquarters at ranch where the Ager - Klamath Falls road approached the Klamath River (Boyle 1976:8). Boyle (1976) layout of project showing ditches, dams, buildings, etc., including Lenox Ranch buildings. The Ager - Klamath Falls Road is depicted on Boyle's (1976) map. G. Pecard's field, irrigation ditch, J. Lennox Homestead in NW ¼, and Linkville & Yreka Road on 1881 GLO. Roadon *Macdoel, Calif*. 1941 topographic quadrangle. Road in approximate same alignment on 1881 GLO.
48N	4W	35	Spannaus Gulch within Section. Spannaus family secured homestead patents between 1908 and 1919 in sections 25, 26, 35 (Beckham 2006:236). G. Pecard's field, irrigation ditch, Ang. Kempler's Meadow, and Linkville and Yreka Road depicted on 1881 GLO. Unpaved road or trail and road on *Macdoel, Calif*. 1941 topographic quadrangle. 1941 Road in approximate same alignment as on 1881 GLO.
48N	4W	36	Circa 1902 Siskiyou Electric Power Co worked on Fall Creek Power Plant...a camp has been set up on the flat near the flume and penstock…and the Plant will be located on the North Bank wagon road upon the Klamath River (Kramer 2003a:16). No specific location identified within the Section for work camp. Linkville and Yreka Road, Ang. Kempler's Meadow, and irrigation ditch depicted on 1881 GLO. Unpaved road or trail and road on *Macdoel, Calif*. 1941 topographic quadrangle. 1941 Road in approximate same alignment as on 1881 GLO.
48N	5W	25	Road and Southern Pacific Railroad on *Macdoel, Calif*. 1941 topographic quadrangle.
48N	5W	26	Dutch Creek, a cobbler built cabin on this creek (Beckham 2006:225). Location of cabin unknown.
48N	5W	30	Spaulding's Camp, homestead and cabin (Beckham 2006:236).

			Location of camp unknown.
48N	5W	31	Possible road in SE 1/4 on 1881 GLO appears outside project area. Unpaved road or trail on *Macdoel, Calif*. 1941 topographic quadrangle.
48N	5W	32	Small road segment in SE 1/4 of 1881 GLO. Unpaved road or trail on *Macdoel, Calif*. 1941 topographic quadrangle.
48N	5W	33	Possible location of Madero Ranch (Beckham 2006:230-231). Small road segment and irrigation ditch on 1881 GLO. Two unpaved roads or trails, road, Southern Pacific Railroad on *Macdoel, Calif*. 1941 topographic quadrangle. Ranch with two buildings visible in 1953 aerial.
48N	5W	34	Location of steel bridge for Klamath Railroad crossing (Beckham 2006:236) [appears incorrect - bridge shown on 1941 topo in Section 35, though there is a bridge over Jenny Creek in this section]. Road and Southern Pacific Railroad on *Macdoel, Calif*. 1941 topographic quadrangle. Bridge over Jenny Creek on 1953 aerial.
48N	5W	35	Location of truss steel bridge for Klamath Railroad crossing river (under reservoir) (Beckham 2006:126); location of Grieve Lower Ranch, founded just after Civil War, under Iron Gate Reservoir (Beckham 2006:226). Road, unidentified building, and Southern Pacific Railroad on *Macdoel, Calif*. 1941 topographic quadrangle.
48N	5W	36	Location of Fall Creek School, dated from 1911, site on the south side of headwaters of Iron Gate (Beckham 2006:203). Spearin Ranches on lower Fall Creek, flooded by Iron Gate (Beckham 2006:104). Road, unpaved road or trail, and Southern Pacific Railroad on *Macdoel, Calif*. 1941 topographic quadrangle. Two gage stations on the river on *Copco, Calif*. 1954 topographic quadrangle.

6.1.7 Data Gap Analysis

Subsequent to the completion of the record search, compiled data is being examined to identify any missing information, including gaps in survey coverage or site recordation, incomplete evaluation efforts and other data that are necessary to identify potential impacts from project activities. In particular, this analysis will be used to determine the completion of inventory coverage of the APE and the status of eligibility determinations of identified cultural resources potentially subject to effects during implementation of project activities. The data gap analysis will be used to determine the need for additional cultural resources studies.

6.2 Resource Identification

6.2.1 Pre-Decommissioning Resource Inventory

In response to AIR #28, beginning in July 2017, KRRC initiated cultural resources identification efforts focused on areas within the *Project Limits of Work* that were not subject to previous pedestrian inventory for cultural and historical resources. To date, this new inventory has included three local waste disposal sites currently planned to accommodate concrete rubble and loose earth materials associated with dam removal. The disposal sites include one area for J.C. Boyle Dam (see Figure 5.2-1(C), Sheet 1 in Appendix C), a combined site for Copco No. 1 and Copco No. 2 Dams (see Figure 5.3-1 (C), Sheet 1 in Appendix C), and one area for Iron Gate Dam (see Figure 5.5-1(C), Sheet 2 in Appendix C).

6.2.1.1 Disposal Site Inventories

J.C. Boyle Disposal Site

The J.C. Boyle Dam disposal site encompasses a 6-acre area located near the current right dam abutment (see Figure 5.2-1(C), Sheet 1 in Appendix C). This area was included within the cultural resources inventory conducted by PacifiCorp for the Klamath Hydroelectric Project Relicensing study (PacifiCorp 2004). Therefore, the KRRC did not undertake a new cultural resources inventory. The PacifiCorp survey did not identify any archaeological sites, isolated finds, or built environment resources within the disposal area.

Copco No. 1 and Copco No. 2 Disposal Site

The Copco No.1 and Copco No. 2 disposal site is located between the two dams, on the northern hillslope above the Klamath River (Figure 5.3-1(C), Sheet 1 in Appendix C). This area also was included within the cultural resources inventory conducted by PacifiCorp for the Klamath Hydroelectric Project Relicensing study (PacifiCorp 2004). Therefore, the KRRC did not undertake a new cultural resources inventory. The PacifiCorp survey did not identify any archaeological sites or isolated finds within the disposal area.

Two extant buildings are located within the Copco No.1 and Copco No. 2 disposal site, consisting of a ca. 1922 residential building and a small garage. These buildings are associated with the Copco No. 1 complex of Klamath Hydroelectric Project. PacifiCorp prepared a Determination of Eligibility for the Klamath Hydroelectric Project (Kramer 2003b) that documents its regional significance and eligibility for listing in the National Register of Historic Places under Criterion A for its association with the industrial and economic development of southern Oregon and northern California.

Copco No. 1 was the first project developed on the river by the California-Oregon Power Company and was placed into service in 1918 and further expanded in 1922 (Kramer 2003b:8). The Copco No. 1 complex includes seven features consisting of the Copco No. 1 dam, water conveyance system (two penstocks), powerhouse, the remains of a guesthouse, two residential buildings and associated garages surviving from the original worker's housing village, and a separate garage/warehouse (Kramer 2003b:8). PacifiCorp evaluated the seven features, constructed between the period of 1912 and 1922, as contributing elements to the NRHP-eligible Klamath Hydroelectric Project (Kramer 2003b).

Iron Gate Disposal Site

The Iron Gate disposal site encompasses an approximately 36-acre area located approximately 750-feet east of Iron Gate Dam, within a small basin that overlooks Iron Gate Reservoir to the northwest (Figure 5.5-1 (C), Sheet 2 in Appendix C). An area within the western portion of the disposal site, totaling approximately 9 acres, was included within the cultural resources inventory conducted by PacifiCorp for the Klamath Hydroelectric Project

Relicensing study (PacifiCorp 2004). The PacifiCorp survey did not identify any archaeological sites, isolated finds, or built environment resources within the disposal area.

To provide 100 percent coverage of the disposal area, in July 2017, the KRRC conducted a cultural resources inventory of the remaining acres. The inventory was conducted using a standard systematic pedestrian survey that employed transects spacing of 15 m (65 ft.). The survey convention included a buffer of 46 m (150 ft.) around the footprint of the proposed disposal site. The inventory identified one historic-period archaeological site (LKP-RB-1) and one historic-period isolated find (LKP-EN1-IF).

Site LKP-RB-1 consists of a ca. 1960s refuse disposal site comprised of a concentration of discarded heavy equipment tires and several push piles or earthen berms, one of which contains a dispersed artifact scatter. The tire concentration includes 14 well-worn rubber tires with manufacturer's marks that include "FIRESTONE ROCK GRIP EXCAVATOR, FIRESTONE SUPER ROCK GRIP DEEP TREAD, FIRESTONE RIB EXCAVATOR, SILVERTOWN UNIVERSAL, and GENERAL ROCK RIB. The tire concentration is visible on a 1973 aerial photograph of the disposal site area, but it does not appear on earlier 1944, 1951, or 1954 aerial images. An artifact concentration associated with the western-most earthen berm contains a mix of domestic and structural-related items. These artifacts and features (berms) are likely associated with the Iron Gate Dam and Reservoir construction period in the early 1960s.

Site LKP-RB-1 is a near-surface cultural deposit. The site lacks association with nearby eligible properties (such as Klamath Hydroelectric Project complexes) for which historic contexts are or can be established. The deposit represents variable and idiosyncratic behavior by unknown persons or groups, and without a historic context, it cannot contribute to property significance. As an isolated refuse deposit that lacks integrity and association, the KRRC recommends Site LKP-RB-1 as not eligible to the National Register of Historic Places (NHRP) or the CRHR. The site does not meet eligibility criteria by being associated with specific events important in history (Criterion A/Criterion 1), association with persons important in history (Criterion B/Criterion 2), design/construction (Criterion C/Criterion 3), or ability to yield information important in history (Criterion D/Criterion 4).

Isolate LKP-EN-1-IF consists of a single, weathered, partially upright juniper fencepost. The isolate is part of a former fence line, portions of which are still visible outside the southeastern edge of the disposal area.

A review of the 1944, 1951, and 1954 aerial photographs of the Iron Gate waste disposal site area shows a linear feature that crosses northeast/southwest through the disposal site for a distance of several hundred feet. Interpretation of this linear feature suggests that it was a former fence line, and one that was distinct from the fence line possibly associated with Isolate LKP-EN-1-IF. The linear feature is not depicted in a 1973 aerial photograph, and no evidence of it was found during the current survey effort.

6.2.1.2 Other Areas

In addition to the Disposal Site inventories conducted in July 2017, KRRC is currently undertaking a data gap analysis to identify other land-based areas within the *Project Limits of*

Work (e.g. haul routes) that were not previously inventoried for cultural resources, including archaeological, historical, and built environment resources. Such areas will be subject to pedestrian survey to provide 100 percent coverage of direct impact areas associated with the *Project Limits of Work.*

Additional survey areas located outside the *Project Limits of Work* may be identified for pedestrian survey as part of ongoing efforts by the CRWG to define the Project APE, as well as based on recommendations from informal consultation with tribes and consulting parties.

6.2.2 During and Post-Decommissioning Resource Inventory

Mitigation measures to resolve adverse effects to cultural and historical resources developed for the 2012 Klamath Facilities Removal EIS/EIR remain as the principal measures for the current Project. Mitigation Measure CHR-2 provides for cultural resources surveys in the reservoir drawdown zones to identify historic and significant properties. KRRC is in the process of developing a plan for implementing during and post-decommissioning cultural resources surveys based on archival research, historical landscape analyses, and tribal consultation. In addition, KRRC will conduct post-demolition surveys of areas outside of the reservoir footprints (i.e., hydropower infrastructure areas, former recreation areas) where revegetation will occur.

6.2.3 General Inventory and Resource Recordation Methods

6.2.3.1 Archaeological Inventory

Archaeological inventory to be conducted for the Project will include 100 percent, intensive-level survey of designated areas. The inventory will employ a standard systematic pedestrian survey following the appropriate Oregon and California survey and reporting standards, tailored if appropriate to meet any specific federal land management agency guidelines. Inventory of parcels will employ standard transect spacing of 15 m (65 ft.) or less. The survey convention for elements such as staging areas, borrow areas, substations, and other facilities will include a buffer of 46 m (150 ft.) around the footprint of the proposed activity.

Survey will be conducted in accordance with the *Guidelines for Conducting Field Archaeology in Oregon*, published by the Oregon State Historic Preservation Office (SHPO 2007), and, in California, by the guidelines provided by the California Department of Historic Preservation. All inventory efforts on federal lands will be completed under the supervision of field supervisors authorized under agency-specific cultural resources permits. All inventory methods will follow those prescribed by USFS and BLM protocols, dependent upon the lands being surveyed, and will be conducted by field supervisors and archaeological technicians that fully meet qualifications and standards dependent upon appropriate land management agency permitting requirements

It is expected that two categories of cultural resources will be identified: archaeological sites and isolated finds. An archaeological site in Oregon is defined as 10 or more artifacts (including lithic debitage) or a feature likely to have been generated by patterned cultural activity within a surface area reasonable to that activity (a form of density measure). An isolated find in Oregon is defined as one (1) to nine (9) artifacts discovered in a location that appears to reflect a single event, loci, or activity. The presence of any feature advances the find into a site status. Similar guidelines will be followed in California, where a strict written policy is not provided. Alternatively, on lands managed by federal agencies, the policies of those agencies will be followed.

Previously recorded sites present within the areas to be inventoried will be relocated, if possible, and rerecorded, as necessary. Newly identified sites will be given a temporary field number and plotted onto a USGS field map; UTM coordinates will be recorded using a GPS instrument. Identified resources will not be permanently flagged or otherwise marked in the field, unless requested by land management agencies.

All above-ground resources, such as buildings, within or adjacent to (within 100 feet of) the survey areas that are 50 years of age or older, or of indeterminate age, will be noted, and their location and information provided to the Built Environment study team for documentation on an appropriate site record. Visual effects to above-ground resources beyond the pedestrian survey area will be considered in a separate study.

6.2.3.2 Built Environment Inventory

Fieldwork methodology for the built environment inventory will consist of two phases of identification and evaluation. A Phase I effort will make a preliminary evaluation of resources and determine whether they meet the National Register Criteria of Evaluation, retain integrity, whether they were constructed over 45 years ago (prior to 1967), and whether they meet any Criteria Considerations. The 45-year criterion was chosen to take into account that effects that could be present during the full course of project activities.

Fieldwork will be conducted by teams of two architectural historians, who will drive publicly accessible rights-of-way and record resources in a systematic manner. For those resources that would clearly not have views of the Project due to vegetation, landform, or surrounding development, only location information will be collected, as the resource will be considered outside the APE. For those resources inventoried in the APE, specific information will be collected, at least two or more photographs taken, and each resource noted on a field map with recorded by GPS. For those properties that clearly lack historic integrity, or that is a type of resource that is not indicative of broad patterns of history or related to historical events (Criterion A), not associated with significant person or people (Criterion B), and/or is of a common type, style, or method of construction that does not exhibit high artistic values or represent a significant and distinguishable entity whose components may lack individual distinction (Criterion C), no additional information will be collected and a "not eligible" recommendation will be made. In order to apply the criteria, information collected during fieldwork will be used to revise the historic context for the APE and provide an initial basis from which to evaluate the relative importance of identified resources. Additional secondary and archival research will also be conducted on common resource types so that a more comprehensive historic context of these resources within the APE can be developed and used for a comparative analysis and an assessment of significance. This assessment will consider whether the resource retains significance at the local, state, or national levels. Further, the analysis will take into account the relative rarity of a resource type and likewise adjust considerations related to that resource's historical integrity. For those resources that retain integrity, are 45 years old or older, and may be eligible under any of the NRHP criteria for evaluation, the resource will be listed as "unevaluated" and subject to Phase II analysis. This analysis will include detailed recordation and full evaluation.

In addition to field recordation, research will be undertaken to better understand the resource's history. This will include SHPO/USFS/BLM files, historic maps (such as GLO, Metsker's, and Sanborn, newspapers, and other applicable resources such as census records, genealogical records, biographical encyclopedias, city directories, and family histories. After taking into account the overall integrity and historical significance of the resource, a final recommendation concerning a resource's eligibility for the NRHP will be made.

6.2.3.3 Built Environment HABS/HAER/HALS Recordation

A significant effort that will be initiated during the 2018 plan year will consist of Historic American Building Survey (HABS), Historic American Engineering Record (HAER), and Historic American Landscape Survey (HALS) documentation of built environment features. HABS/HAER/HALS recordation has been determined to be an important mitigation measure in compliance with NHPA Section 106 provisions. HABS/HAER/HALS recordation must be initiated in a timely manner, given that full recordation must be completed prior to the removal of any dam-related or other historic built environment structures.

7. Resource Evaluation

7.1 Archaeological Evaluation

Mitigation Measure CHR-2 calls for the continued identification and evaluation of historic properties and historical resources for unevaluated cultural resources. To date, the evaluation of cultural resources identified within the Project Limits of Work (and subject to potential direct effects) has occurred based on survey-level data or from subsurface testing work (Phase II investigations) conducted by other parties (not KRRC). The 2004 PacifiCorp report identified three levels of NRHP eligibility for identified sites: eligible, potentially eligible, and not eligible. Eligible sites include those resources that were designated as historic properties on the basis of sufficient existing information about them to draw that conclusion. Potentially eligible sites include those that would require more intensive, subsurface investigations to obtain information necessary to determine if they are or are not eligible for the NRHP under Criterion D. Those sites identified as not eligible lack attributes necessary for their inclusion in the NRHP. Neither the California nor Oregon SHPOs has concurred with the NRHP evaluations offered in the previous Klamath River cultural resources reports (Cardno ENTRIX 2012; PacifiCorp 2004). The KRRC, working through the CRWG, is facilitating SHPO review of the previous eligibility recommendations to reach a NRHP eligibility determination. Once eligibility concurrence is reached, the list of potentially eligible and any yet unevaluated properties will be screened against areas of direct impacts to develop an inventory of affected sites that would require evaluation through Phase II testing. Because most individual sites have not yet been identified for evaluation, site-specific methods will be developed later.

The TCPs identified in the tribal ethnographic reports (Section 6.1.5 above) may or may not have archaeological components with information potential and have been evaluated as NHRP-eligible based on other cultural values including associations under Criterion A.

7.2 Evaluation of Historic Built Environment Resources

The evaluation of historic built environment resources will focus on Mitigation Measure CHR-1 and include an update to the Klamath Hydroelectric Project Request for Determination of Eligibility to include Iron Gate Dam as a historic property and to identify contributing elements to the Klamath Hydroelectric Historic District (KHHD). In addition, an estimated 50 historic structures (including buildings, bridges, and other built environment facilities) identified during inventory efforts will require evaluation for eligibility to the NRHP. Built environment evaluation studies will be performed to Oregon and California standards. Two historical resources reports, one each for California and Oregon State Historic Preservation Offices, will be prepared that include information on the resources located in the respective states. The reports will identify the APE, apply the NRHP Criteria for Evaluation, assess project effects, and make recommendations to avoid and minimize effects and mitigate adverse effects. This task will also include a reassessment of those built environment resources that were not 50 years old at time of previous evaluation; and a complete analysis of cultural resources within potential downstream Inundation zones (flood proofing or levee construction).

8. Management Plans and Agreement Documents

The KRRC will produce a number of management plans and agreements to support the project's Section 106 compliance efforts. The documents currently being planned include a Historic Properties Management Plan, Programmatic Agreement, Inadvertent Discovery Plan, Monitoring Plan, and NAGPRA Plan of Action. Other plans may be added based on recommendations made by the CRWG and Tribes.

8.1 Historic Properties Management Plan

In response to AIR #28, working through the CRWG, and following pre-decommissioning inventory and evaluation efforts for cultural and historic resources, a Historic Properties Management Plan (HPMP) will be prepared to identify mitigation measures for implementation before and during drawdown and dam removal activities. KRRC initially plans to revise the Draft HPMP prepared by PacifiCorp in 2006 for the Klamath Hydroelectric Relicensing Project to reflect dam decommissioning.

As currently envisioned, the revised HPMP will address historic properties identified to date within the APE and will be used as a guide to address treatment measures to avoid, minimize and mitigate adverse effects to historic properties through the course of the Project. The revised HPMP will also broadly identify classes of historic properties, relevant research, and potential data gaps in research for classes of properties present in the APE and propose a range of resource-specific strategies, including but not limited to mitigation and monitoring, to address reasonably foreseeable direct, indirect and/or cumulative adverse effects that may result from drawdown and dam removal. Wherever feasible, avoidance and preservation in place will be the preferred treatment for historic properties located within the APE. Avoidance may include design changes and/or use of fencing or barricades to limit access to identified historic properties.

The revised HPMP will include a discussion of measures to protect identified historic properties from effects that may result from the Undertaking. These measures will include but not be limited to placement of barricades and fencing, notices to law enforcement, seasonal restrictions, and post-drawdown monitoring.

All historic properties adversely affected by the Project will be subject to property-specific mitigation plans drafted to resolve adverse effects. The mitigation plans will be included in a final HPMP that will be consistent with the Secretary of the Interior's Standards for Archaeological Documentation, Historical Documentation, and Architectural and Engineering Documentation; the ACHP Section 106 Archaeology Guidance; and other guidance from the appropriate SHPOs. For effects to archaeological sites that will be mitigated through data recovery, mitigation plans will include but not be limited to a research design that articulates research questions; data needed to address research questions; methods to be employed to collect data; laboratory methods employed to examine collected materials; and proposed disposition and curation of collected materials and records.

Mitigation plans for direct effects to historic properties eligible for listing in the NRHP under criteria other than or in addition to criterion D will articulate the context for assessing the properties significance, an assessment of the character-defining features that make the property eligible for listing in the NRHP, and an assessment of how the proposed mitigation measures will resolve the effects to the property.

Mitigation plans for indirect effects to historic properties eligible under any NRHP criteria will include an assessment of the character-defining features that make the property eligible for listing in the NRHP; the nature of the indirect effect; an evaluation of the need for long-term monitoring; and an assessment of how the proposed mitigation measure(s) will resolve the effects to the property.

While the revised HPMP is not yet under preparation, the mitigation measures designed to resolve adverse effects/significant impacts to cultural and historic resources included in Section 8.7 of the main document, will likely serve as the basis for the HPMP. Additional mitigation measures may be identified through the project's ongoing Section 106 consultation process, which may supplement or replace one or more of the currently identified measures.

8.2 Programmatic Agreement

As the non-federal agency representative, AECOM will lead the CRWG's efforts to prepare a Programmatic Agreement (PA) designed to assist with compliance of Section 106 of the National Historic Preservation Act. The PA will consist of a signed, formal agreement between KRRC, lead and cooperating agencies, and consulting parties, and will outline all measures necessary for full compliance with NHPA. These will include but will not be limited to protocols for the identification and evaluation of historic properties, permitting requirements, treatment of historic properties, monitoring requirements, inadvertent discovery protocols, curation, and treatment of human remains. AECOM will provide a draft PA suitable for review by FERC and KRRC, followed by a revised draft to be submitted to lead and cooperating agencies, the California and Oregon State Historic Preservation Officers, and other agencies as appropriate. AECOM will assist with revising the PA following review by these agencies. Obtaining necessary signatures for acceptance of the agreement will be the responsibility of FERC.

8.3 Inadvertent Discovery Plan

Drawdown of the Project reservoirs has potential risk to expose previously recorded and unidentified cultural resources, including archaeological resources and human remains. Detailed plans addressing the discovery of such resources will be developed during the course of agency and tribal consultation. These plans will include measures that will be implemented in and downstream of reservoirs if tribal cultural, burials, or human remains are discovered during drawdown activities. The outline below provides a basis and framework for the development of those plans.

8.3.1 Inadvertent Discovery of Cultural Resources

A. KRRC will develop and implement procedures for their personnel and contractors in the event that historic properties (i.e., National Register-eligible) are discovered or unanticipated effects on historic properties occur during and after the reservoir drawdown period. These procedures will be developed prior to the initiation of dam removal in accordance with 36 CFR § 800.13 (a)(2)(b) Post-review Discoveries.

B. KRRC's procedures will address situations where unanticipated non-human cultural materials, historic properties, or human remains are encountered on private, non-federal public, or federal lands. The procedures will also include the appropriate agency and tribal contacts for all such situations.

C. KRRC's procedures will address such situations occurring once reservoir drawdown has commenced and throughout the dam removal and restoration process. Applicable federal, tribal, and state laws may govern the procedures.

D. Environmental inspectors will receive instruction regarding the cultural resources that could be discovered during the course of project activities. All personnel involved in project field activities will be instructed on site discovery, avoidance, and protection measures, including information on the statutes protecting cultural resources.

E. In the event that previously unidentified cultural resources are discovered during drawdown or other project activities, KRRC will immediately notify BLM, USFS, or other appropriate land management agencies. Where a discovery is made by KRRC or its contractors, project activities will be redirected away from the discovery or halted by the Environmental Monitor at the discovery location and the discovery will be protected. Drawdown will be allowed to continue if the discovery can be protected and is not in danger of destruction from slurry flow or other drawdown activities. KRRC's Environmental Monitor will notify KRRC's qualified archaeologist of the find. Work will be redirected or halted for a period adequate to assess the nature of the discovery and to determine, and implement, the necessary course of action, as determined by the qualified archaeologist in consultation with FERC and the land management agency. KRRC's qualified archaeologist will complete a letter report to assess and document a discovery each time project activities are redirected for such a discovery. Work will not resume in the area of discovery until authorized by the lead federal agency and the land management agency. Specific procedures for dealing with discoveries will be developed in conjunction with the development of site-specific Treatment Plans.

8.3.2 Treatment of Human Remains

A. The federal lead and land management agencies shall ensure that any human remains encountered during Project construction are treated in a respectful manner. While drawdown is expected to continue, no additional project activities will be allowed within 200 feet of the discovery until written authorization is provided by the appropriate agency. As appropriate, the activity that resulted in the inadvertent discovery can resume five (5) days after certification by the notified Federal agency of receipt of the written notification of inadvertent discovery if the resumption of the activity is otherwise lawful. The activity may resume, if otherwise lawful, at any time that a written binding agreement is executed between the Federal agency and the affiliated Indian tribes with rights of disposition (43 CFR 10.4(b)(2)). For human remains inadvertently discovered on Federal land, the lead agency will make a reasonable and good-faith effort to identify the appropriate Native American tribe(s), or other ethnic group(s) related to the human remains. The lead agency will consult with the appropriate group regarding the appropriate treatment of the human remains and associated grave goods. The lead and land management agencies will ensure that any human remains and associated funerary objects encountered during the project are treated in accordance with the wishes of the descendants or the authorized group. The lead and land management agencies will make determinations for associated burial objects.

B. If human remains are encountered on Federal lands the lead and land management agencies will consult with the Native American tribe or other ethnic groups related to the human remains identified to determine the treatment and disposition measures consistent with the applicable Federal laws (ergo Native American Graves Protection and Repatriation Act [NAGPRA]) (Public Law 101-601; 25 U.S.C. 3001 et seq.), regulations, and policies.

C. If human remains are encountered on State or private lands, the appropriate County Coroner will be contacted. All human remains will be treated according to the provisions of the applicable State laws, regulations or policies, as determined through consultation with the appropriate State Historic Preservation Office (SHPO) and the Native American tribe or other ethnic groups related to the human remains.

D. Human remains and associated artifacts may be discovered during drawdown, other project activities, or during controlled archaeological excavations. If human remains are discovered under any circumstances, they will be secured and protected until appropriate disposition has been determined, in accordance with applicable local, state, and Federal statutes. The provisions of the NAGPRA govern inadvertent discoveries of Native American human remains on Federal or tribal lands. Archaeological excavation and/or construction activities in the immediate vicinity of the discovery will cease immediately. Upon discovery, KRRC's Environmental Monitor, in accordance with the procedures outlined below, will secure the location with appropriate security and avoidance measures. It may be necessary for KRRC to provide 24-hour on-site security for NAGPRA associated discoveries and for other discoveries as determined by the lead federal agency.

E. Specific procedures to be followed will depend on the ownership status of the lands where the human remains and associated artifacts are discovered. In all cases, the lead federal agency, along with the relevant county coroner or sheriff (as appropriate) will be immediately notified by phone by KRRC's representative or their consultant. This will be followed by written notification to the lead agency, of any discoveries of human remains, associated and unassociated funerary objects, sacred objects, or objects of cultural patrimony. The lead agency would be responsible for compliance with the

NAGPRA and its implementing regulations (43CFR10) for all NAGPRA-related inadvertent discoveries and discovery situations on Federal or tribal lands.

In California, treatment of human burials found on State or private lands are covered under the Public Resources Code, Division 5, Parks and Monuments [5001 - 5873] (Division 5 added by Stats. 1939, Ch. 94.) Chapter 1.75. Native American Historical, Cultural, and Sacred Sites [5097.9 - 5097.991] and the California Native American Graves Protection and Repatriation Act of 2001 (Chapter 5 (commencing with Section 8010) of Part 2 of Division 7 of the Health and Safety Code).

In Oregon, treatment of human burials found on State or private lands are covered under Oregon Revised Statute (ORS) 97.745. If human remains are encountered, the state police, Oregon SHPO, the Commission on Indian Services, and the appropriate Tribe(s) (which are determined by the Commission on Indian Services) need to be immediately contacted.

8.4 Monitoring Plan

A Monitoring Plan will be developed in conjunction with the HPMP for implementation during drawdown and dam removal efforts. This plan will establish general protocols for monitoring NRHP-eligible historic properties and other areas the CRWG agree would benefit from monitoring, including known archaeological sites and those areas determined to show a high probability for buried cultural deposits. Monitoring will, as appropriate, include archaeological inspection by personnel under the direct supervision of a person meeting the Secretary of the Interior's Professional Qualifications standards and will make provisions for tribal monitors per the discretion of consulting tribes. The Monitoring Plan will address long-term management and protection of historic properties in the APE to avoid effects from drawdown, dam removal, and restoration efforts. Any cultural resource, human remains or funerary objects discovered Project activities will be treated in accordance with the protocols described in the Inadvertent Discovery Plan, which will be appended to the HPMP.

8.5 NAGPRA Plan of Action

In response to AIR #29, working through the CRWG, AECOM will assist with preparation of a NAGPRA Plan of Action once consultation has been initiated with affected Indian Tribes and other tribal organizations. This written plan of action is an integral part of the consultation process mandated by 43 CFR 10.5 whenever there is activity affecting or likely to affect Native American cultural items on Federal or tribal lands. The plan of action must document compliance with the Archaeological Resources Protection Act (ARPA). The plan will include (1) information on the kinds of objects that are considered to be funerary objects, sacred objects, and objects of cultural patrimony; (2) specific information used to determine custody/ownership under 43 CFR 10.6; (3) planned treatment, care, and handling of human remains, funerary objects, sacred objects, and objects of cultural patrimony; (4) the methods to be used for archeological recording, analysis, and reporting of human remains, funerary objects, sacred objects, and objects of cultural patrimony; (5) the steps to be followed to contact Indian tribe officials at the time of excavation or inadvertent discovery of human remains, funerary objects, sacred objects, and objects of cultural patrimony; (6) the kind of traditional treatment, if any, to be used for human remains, funerary objects, sacred objects, objects of cultural patrimony; and (7) the planned disposition of human remains, funerary objects, sacred objects, and objects of cultural patrimony following 43 CFR 10.6. The plan of action will require signature by FERC as the Federal agency official, and a copy of the plan of action will be provided to the consulting tribes.

9. References

AECOM 2017. Klamath River Renewal Project California Environmental Quality Act (CEQA) and California and Oregon 401 Water Quality Certifications Technical Support Document.

Beckham 2006. Beckham, S.D. Historical Landscape Overview of the Upper Klamath River Canyon of Oregon and California. Oregon Bureau of Land Management Cultural Resources Series No. 13.

BLM 2016. Bureau of Land Management. National Register of Historic Places Registration Form for the Upper Klamath River Stateline Archaeological District, Beswick Vicinity, Siskiyou County.

BOR 2012. U.S.D.I., Bureau of Reclamation and California Department of Fish & Game. Klamath Facilities Removal Final EIS/EIR.

Boyle 1976. Boyle, J.C. 50 Years on the Klamath. Medford, OR.

Cardno ENTRIX 2012. Klamath Secretarial Determination Cultural Resources Report. Prepared for Bureau of Reclamation.

Daniels 2003. Daniels, B. Draft Shasta Nation TCP Study. Report prepared for PacifiCorp.

Daniels 2006. Daniels, B. Shasta Nation TCP Study. Report prepared for PacifiCorp.

Deur 2003. Deur, D. Traditional Cultural Properties and Sensitive Resource Study, Klamath Tribes, Klamath Hydroelectric Project FERC Relicensing Documentation. Report prepared for the Klamath Tribes.

FERC 2007. Federal Energy Regulatory Commission. Final Environmental Impact Statement for Hydroelectric License, Klamath Hydroelectric Project FERC Project No. 2087-027, Oregon and California.

Gates 2003. Gates, T. Ethnographic Riverscape: Regulatory Analysis. Draft report prepared for PacifiCorp Hydroelectric Inc., by Yurok Tribe Heritage Preservation Office under contract #P13342 in conjunction with FERC Project No. 2082.

King, 2004. King, T. F. First Salmon: The Klamath Cultural Riverscape and the Klamath River Hydroelectric Project. Prepared for the Klamath River Intertribal Fish and Water Commission.

Kramer 2003a. Kramer, G. Klamath Hydroelectric Project FERC No. 2082 Historic Context Statement. Prepared for PacifiCorp, Portland, OR.

Kramer 2003b. Kramer G. Klamath Hydroelectric Project FERC No. 2082 Request for Determination of Eligibility. Prepared for PacifiCorp, Portland, OR.

PacifiCorp 2004. Cultural Resources Final Technical Report and Associated Confidential Appendices. Klamath Hydroelectric Project FERC No. 2082. PacifiCorp, Portland, OR.

Salter 2003. Salter, J. A Context Statement Concerning the Effect of the Klamath Hydroelectric Project on Traditional Resources Uses and Cultural Patterns of the Karuk People within the Klamath River Corridor. Report prepared for PacifiCorp.

SHPO 2007. Oregon State Historic Preservation Office. Guidelines for Conducting Field Archaeology in Oregon.

Sloan 2003. Sloan, K. Ethnographic Riverscape: Klamath River Yurok Tribe Ethnographic Inventory. Report prepared for the Yurok Tribe Culture Department and PacifiCorp.

USDI 1989. U.S. Department of Interior, Bureau of Land Management, Klamath Falls Resource Area Office Draft Eligibility, and Sustainability Report for the Upper Klamath Wild and Scenic River Study.

aecom.com

Appendix P Risk Management Plan

AECOM

Klamath River Renewal Project

Definite Plan for Decommissioning
Appendix P – Risk Management Plan

Administrative Draft

Submitted to: California State Water Resource Control Board

Submitted by: Klamath River Renewal Corporation

Date: January 2018

Prepared for:

Klamath River Renewal Corporation

Prepared by:

KRRC Technical Representative:

AECOM Technical Services, Inc.
300 Lakeside Drive, Suite 400
Oakland, California 94612

Table of Contents

Figures

Tables

Attachments

List of Abbreviations and Acronyms

CA	California
CEQA	California Environmental Quality Act
CMAR	Construction Manager at Risk
cfs	cubic feet per second
DB	Design-Builder
DSOD	Division of Safety of Dams
DWR	Department of Water Resources
FERC	Federal Energy Regulatory Committee
ID	Identification
KRRC	Klamath River Renewal Corporation
NEPA	National Environmental Policy Act
PFMA	Potential Failure Modes Analysis
QA	Quality Assurance
QC	Quality Control

1. Plan Objectives & Background

1.1 Plan Objectives

The implementation of any project comes with uncertainty and risk that can affect schedule, budget, and project performance. This is even more applicable to large, multi-disciplinary and high profile projects. Successful implementation includes planning to identify and manage those uncertainties and risks.

The objective of this Risk Management Plan is to provide a tool to identify and quantify the risks that are particular to the Klamath River Renewal Project (Project), assign those risks to the appropriate party, and develop risk mitigation strategies to reduce or eliminate the risk and associated Project impact. This draft plan provides a first effort at identifying risks (in the form of a risk register), estimating their likelihood and consequences of occurrence, ranking those risks to determine which pose the greatest risk to the Project, and developing mitigation strategies for the highest ranking risks. The risk register will be a living document prepared with the participation of the full project team (Klamath River Renewal Corporation (KRRC), consultants, stakeholders, etc.) eventually including the Design-Builder (DB) or Contractor. This draft plan is based on the Project as it has been described and developed in the California Environmental Quality Act (CEQA) Support Document (AECOM 2017a) and the Federal Energy Regulatory Commission (FERC) Definite Plan submittal (AECOM 2017b).

The plan will be updated periodically by the full project team to add newly identified risks, and adjust risks that have been previously identified either upward or downward.

1.2 Project Background & Overview

The proposed Project includes the decommissioning and removal of four dam developments (Iron Gate, Copco No. 1 and No. 2, and J.C. Boyle) on the Klamath River approximately 200 miles from the Pacific Ocean in the states of Oregon and California by the KRRC (see Figure 1.3-1). The four dam developments (facilities) are currently owned by PacifiCorp, and a formal Transfer Application was submitted to the FERC jointly by PacifiCorp and the KRRC that would result in KRRC ownership of the license and facilities if approved by FERC. Up until the time of the Transfer Application, the facilities were part of FERC Project 2082. As part of the Transfer Application, PacifiCorp and the KRRC requested and FERC approved designation of the facilities as the "Lower Klamath Project" under new Project 14803. The KRRC has submitted a separate Surrender Application to FERC for Project 14803 that, if approved, would allow the KRRC to decommission the facilities. Figure 1.2-1 provides an overview of the Klamath River watershed and the locations of the four dams.

Prior to removal of the dams and hydropower facilities, the water surface elevation in each reservoir will be drawn down as low as possible to facilitate accumulated sediment evacuation and to create a dry work area for facility removal activities. In order to meet the agreed upon drawdown timing and duration, specific infrastructure modifications are required at Iron Gate and Copco No. 1 dams. In general, drawdown will begin on January 1 of the drawdown year, and will extend through March 15 of the same year.

After drawdown is accomplished, dam and hydropower facility removal will begin, and remaining reservoir sediments will be stabilized to the extent feasible. Full reservoir area restoration will begin after drawdown, and extend throughout the year, and possibly into the subsequent year. Vegetation establishment could extend several years.

Other key project components include measures to reduce Project related effects to aquatic and terrestrial resources, road and bridge improvements, relocation of the City of Yreka's pipeline across Iron Gate Reservoir and associated diversion facility improvements, flood improvements downstream, as well as demolition of various recreation facilities adjacent to the reservoirs.

1.3 Document Organization

The sections in the document are organized as follows:

- **Section 1 –Plan Objectives and Background:** describes the objectives of the plan, project background and overview, and document organization
- **Section 2 – Risk Register**: describes the process and method(s) that were utilized to develop the initial risk register, and will be utilized moving forward make additions and revisions to the plan
- **Section 3 – Top Risks**: describes the top risks identified in the initial plan, with preliminary discussion on possible mitigation strategies
- **Section 4 – References**: provides citations for references used in the document.

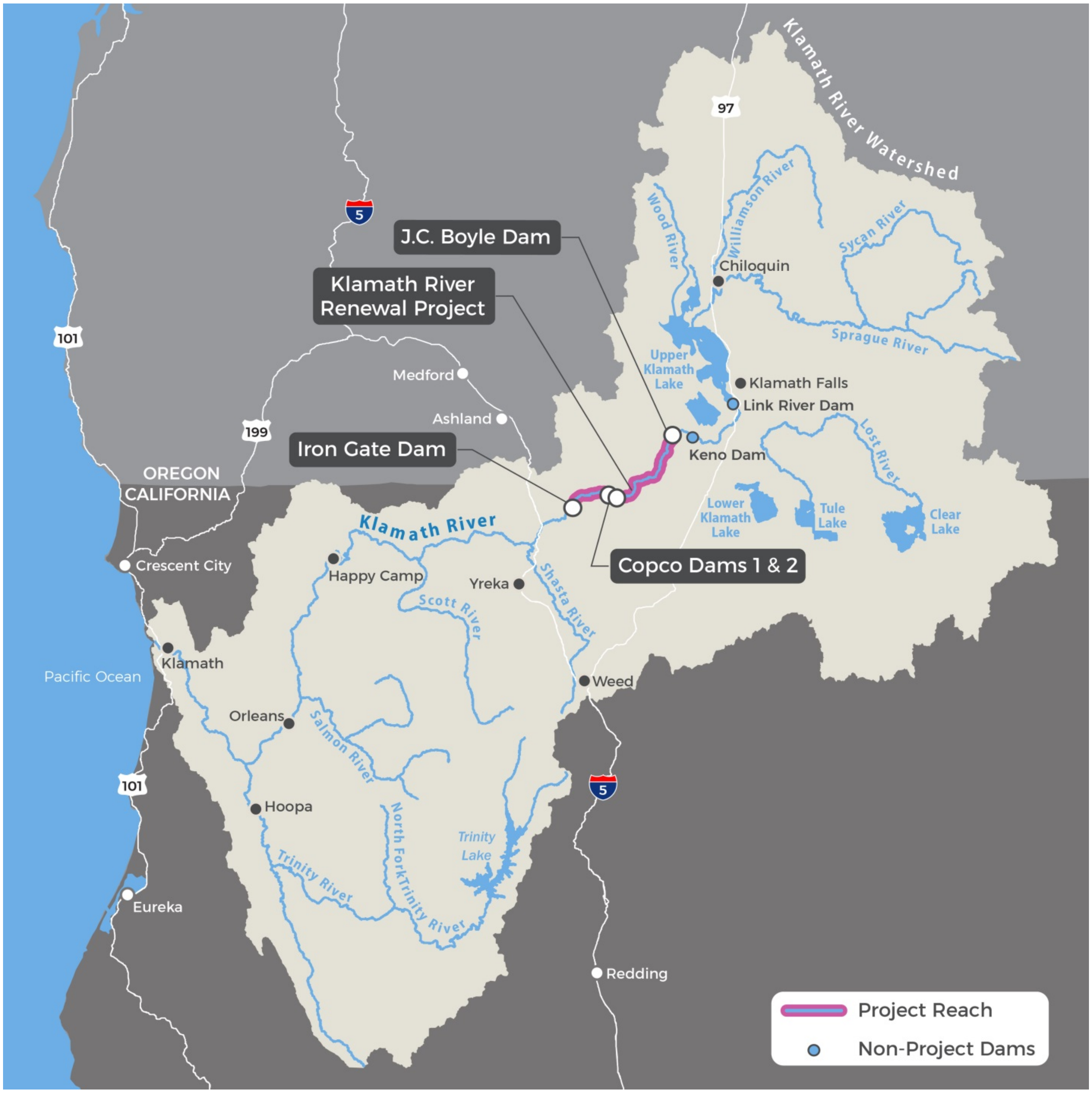


Figure 1.3-1 Klamath River Watershed and Facilities Locations

2. Risk Register

The risk register is a tool that is used to capture risks as they are identified throughout the duration of the Project. Each identified risk is assigned its own unique Risk identification (ID) number and categorized into one of seven risk categories, which are described further below. The register also includes:

- A description of the risk
- The root causes of the risk
- The risks relationship to the four phases of the Project
- The primary aspect of the risk
- The probability the risk will occur
- A rating of the impact or consequence should the risk occur
- A risk score and rating, the strategy to deal with the risk
- A summary mitigation measures for significant risks
- The owner of the risk

As the risk register is further developed and implemented, responsible parties from the Owner and Contractor will be assigned to further develop and implement mitigation measures identified for each risk. As risks are mitigated or avoided, or as new relevant information is obtained, risk categories, score and rating will be updated to reflect the latest information.

Since the risk register will evolve and be updated throughout the life of the Project, ongoing assessment and reporting will be necessary. At a minimum, quarterly updates throughout the planning phase will be completed, with more frequent updates likely required during the detailed design and construction phases. The KRRC risk register will extend through all phases of the Project to ensure that identified risks are being managed and tracked.

Once a DB or Construction Manager at Risk (CMAR) is selected, they will likely develop their own risk register, which will focus solely on the design and construction phases of the Project. It will be important to compare and resolve differences between the KRRC and Contractor risk registers, but it is also critical that they remain as separate processes so that the KRRC is managing and tracking all Project risks, some of which may involve strategic Contractor management, or may extend beyond the Contractor’s scope.

2.1 Risk Category

Each risk is categorized into one of the following general categories:

1. **Environmental -** Risks that are primarily related to environmental aspects of the Project. Environmental aspects and associated risks could involve existing or future biological, cultural or other environmental conditions/species, potential construction related effects such as air quality or noise, or potential downstream environmental effects such as water quality or flooding.

2. **Permitting** – Risks that are primarily related to environmental compliance and permitting. This includes process-related considerations, requirements associated

with CEQA and National Environmental Policy Act (NEPA) compliance, acquisition of necessary regulatory permits (local, state, or federal), and associated permit compliance.

3. **Design -** Risks that are primarily related to development of the Project design and subsequent performance of associated Project features. Risks could involve performance failures as a result of incorrect assumptions or calculations, incomplete or inaccurate drawings and specifications, etc.

4. **Procurement and Construction -** Risks primarily related to the procurement of a DB or Contractor, and with actual construction of the Project including labor, equipment, material, existing conditions, subsurface conditions, site safety, etc. Procurement related risks could involve the procurement process and/or contract negotiation. Construction related risks could involve Contractor quality of work or production, as well as health and safety.

5. **Operations and Maintenance -** Risks primarily related to post-construction Project performance and maintenance. While the Project is anticipated to have minimal long-term operations and maintenance requirements, risks in this category could involve ongoing irrigation or maintenance during vegetation establishment, unforeseen need for repairs associated with tributary connectivity, etc.

6. **External -** Risks that are primarily related to events or conditions outside of the control of the Project, such as unforeseen site conditions, forces of nature, local resident protests, legal challenges to the Project, etc.

7. **Organizational -** Risks that are primarily related to the Project organization, governance and associated constraints such a financing/funding, access agreements, funding agreements, transfer agreements, etc.

2.2 Phases

Each identified risk will exist during particular phases of the Project. The Project phases include the following:

1. **Planning:** The period until a DB or CMAR is selected for implementation. Activities during the Planning phase include data collection, preliminary field investigations, preliminary design, permitting and regulatory consultation and application development, and preparation of the Request for Proposals for a DB or CMAR, evaluation of proposals, and negotiation of the associated contract.

2. **Design:** Design is considered to be the period during which the detailed and final design of the Project is performed. Activities during this phase include field investigations for final design, final design, permitting activities, and regulatory review and approval of the final design documents.

3. **Construction**: The period during which construction activities to implement the final design actually take place. Activities during the Construction Phase include mobilization, preparation of the site, pre-reservoir drawdown construction activities, other early construction activities, dam and appurtenances demolition activities, followed by site restoration.

4. **Post-Construction:** The period following dam removal and site restoration.

Within the risk register, each risk is shown in relation to the four phases (see Figure 2.2-1 for example). Phases during which the risk could be realized are indicated by green, and earlier phases during which mitigation can be developed and implemented are indicated by yellow.

					Project Phases (Yellow - Mitigation can be developed Green - Phases in which risk can occur)			
Risk ID	**Phase**	**Risk Category**	**Risk Description**	**Root Cause(s)**	**Planning**	**Design**	**Construction**	**Post-Construction**
37	Construction	ENV	Special-status species presence delays construction	Unanticipated species found onsite cause stop work				
38	Construction	ENV	Bald and Golden Eagle present within restriction buffer and halt construction.	Did not identify birds prior to construction				

Figure 2.2-1 Risk Register Phases Designation Example

2.3 Primary Aspect of Risk

For additional classification and subsequent data processing, each identified risk is also categorized as one of five primary risk aspects as follows:

1. **Time:** The consequence of the risk is greatest with respect to the Project Schedule.

2. **Cost:** The consequence of the risk is greatest with respect to the Project Budget.

3. **Public Safety:** The consequence of the risk is greatest with respect to the safety of the public.

4. **Environmental Impact:** The consequence of the risk is greatest with respect to impacts the environment.

5. **Legal:** The consequence of the risk is greatest with respect to legal challenges or outcomes of the Project.

It is understood that any risk will include more than one of the five aspects. The categorization by aspect is meant to help be able to assess the project risk in these five different areas.

2.4 Risk Score and Rating

The risk score and rating is a function of the probability of the risk occurring and the severity of impact if the risk were to occur. Probability of occurrence is broken into five different categories to provide sufficient ranges of likelihood, as listed below:

- Probability Score of 5: Risk has a 60 to 100% probability of occurrence, meaning it is highly likely to occur
- Probability Score of 4: Risk has a 40 to 59% probability of occurrence, meaning it is likely to occur
- Probability Score of 3: Risk has a 20 to 39% probability of occurrence, meaning it is less likely to occur
- Probability Score of 2: Risk has a 10 to 19% probability of occurrence, meaning it is unlikely to occur
- Probability Score of 1: Risk has a 1 to 9% probability of occurrence, meaning it will most likely not occur

Severity of impact is also broken into five different categories to provide sufficient ranges for the severity of impact. Since impacts for various risks can apply to one or more aspects or categories, it can be difficult to quantify all risks using the same metric (e.g. cost increase in $, etc.). For that reason, significant engineering and management judgement is involved when assigning severity of impact scores. A high level of coordination and collaboration among key Project decision makers is necessary for assigning severity of impact scores. Table 2.4-1 provides some general guidance on severity of impact scores under aspect categories identified in Section 2.3.

The risk score is calculated by multiplying the probability of risk by the severity of impact, and then categorizing or rating the risk as low, moderate, or high as shown on the risk score matrix in Table 2.4-2. As shown in the risk score matrix, any risk that has a severity of impact score of 5 is categorized as a high risk.

Table 2.4-1 Severity of Impact Definition for Various Aspects

PRIMARY ASPECT	*THREAT IMPACT LEVEL* Very Low (1)	Low (2)	Moderate (4)	High (8)	Very High (16)
Schedule	No or little impact to schedule	Schedule delay of less than 3 months	Schedule delay of 3 to <6 months	Schedule delay of 6 to 12 months	Schedule delay of more than 12 months
Cost	No or little impact to project cost	Cost increase of less than 10%	Cost increase of 10% to <30%	Cost increase of 30% to 50%	Cost increase of greater than 50%
Public Safety	No or little impact to public safety	Number of individuals exposed to minor safety risk less than 5	Number of individuals exposed to minor safety risk greater than 5	Number of individuals exposed to serious safety risk less than 5	Number of individuals exposed to life threatening safety risk more than 5
Environmental Issues	No significant impact to any environmental resource	Short-term impact that is insignificant	Short-term impact that is significant. Long-term impact that is insignificant.	Long-term significant impact to non-listed species	Long-term significant impact to fisheries or listed species
Legal Issues	No legal challenges expected	1 or 2 isolated minor (resolved before trial) legal challenges expected	No serious (results in trial) legal challenge expected, but 3 or more minor legal challenges likely to occur	1 or 2 serious legal challenges expected	Multiple, serious legal challenges expected

Table 2.4-2 Risk Score Matrix

Probability of Occurrence	**5 (60-100%)**	**5**	**10**	**15**	**20**	**25**
	4 (40-59%)	4	8	12	16	20
	3 (20-39%)	3	6	9	12	15
	2 (10-19%)	2	4	6	8	10
	1 (1-9%)	1	2	3	4	5
		1	**2**	**3**	**4**	**5**
		Severity of Impact				

2.5 Risk Status

As the project develops and is implemented, the status of identified risks will be assigned using the following codes:

1. **Open** for risks that continue to pose a threat for the Project. These are risks that may or may not have occurred that will not expire until some future date.

2. **Mitigated** for risks which have had mitigations implemented such that the likelihood of occurrence or consequences of occurrence have been reduced to a level that the Project could accept in the event the risk occurs.

3. **Expired** for risks that may, or may not, have occurred but no longer pose a threat to the Project. When a risk expires, the probability becomes zero thereby making the risk score zero.

2.6 Risk Strategy

Risk strategies refer to the ways in which the identified risk was dealt with, as follows:

1. **Mitigate:** Mitigation seeks to reduce the likelihood of the risk occurring and/or the consequence of the risk, should it occur. An example could include reducing the likelihood of the risk of CEQA litigation through mitigation strategies such as public outreach and education to the local community.

2. **Avoid:** Avoidance of the risk eliminates the likelihood of the risk occurring and/or the consequence of the risk, should it occur. An example could include reducing the likelihood of the risk of impacts to certain cultural resources through modification of the project boundary to avoid the resource.

3. **Transfer:** Transference of the risk makes the risk either completely another party's. An example would be transferring the risk of design errors or omissions from the KRRC's Engineer to a DB team. Presumably this could limit the risk of disagreements between the Contractor and Engineer, since they would both be under the DB umbrella.

4. **Accept**: Acceptance absorbs the risk and all associated consequences. Acceptance of a risk typically occurs when the risk cannot be fully mitigated, avoided, or transferred. An example could involve acceptance of the risk that released reservoir sediment during drawdown could have a greater than anticipated impact on downstream biological resources. Should this occur, it may result in subsequent mitigation requirements from regulatory agencies and associated cost.

5. **Shared**: Shared risk means that the liability associated with the risk can be partially transferred (as described above), but certain aspects of the risk remain with the KRRC and will need to be mitigation, avoided or accepted.

3. Top Risks

This section of the report discusses the risks that, based on our initial assessment of probability of occurrence and consequence, categorize as High risks. The High risks are discussed in two groups; those that had a risk score of 15 or greater, and those that have a Consequence score of 5 (Very High) if they were to occur.

As discussed in Section 2, ongoing assessment, scoring and reporting will continue throughout the life of the Project, and the update for each reporting period will include the latest understanding of prioritized risks and associated mitigation measures. As conditions or Project details change over time, risks descriptions, status, scoring and mitigation/avoidance strategy will be updated, as appropriate. Because of this, the top risks will evolve over time, and focused effort on mitigation strategies will be prioritized to have the biggest effect on reducing key Project risks.

Once the team determines that a risk has been sufficiently mitigated, the score will be modified and/or the risk status may change to "Expired."

3.1 Risks with Highest Risk Score

Risk ID 2 - Litigation of CEQA Document. There is a risk of litigation on the CEQA document due to the fact that the local communities and politicians in Siskiyou County have a long track record of strong opposition to the Project. Litigation of the CEQA document could have a significant impact on schedule and cost. Cost increases can result both from required legal fees, as well as from extended Project management effort and delayed construction (escalation). The KRRC has implemented mitigation strategies including local outreach and education, public meetings, development of a local jobs plan, attempts at negotiated benefits for the local communities, close coordination with the CEQA lead, and development of sound technical information and arguments that will hold up to scrutiny.

For the reasons stated above, the probability of occurrence is judged to be 3 (Medium) and the severity of impact to be a 5 (Very High), resulting in a Risk Score of 15 (High). It is recommended to continue with outreach and technical mitigation strategies described above to attempt to reduce the likelihood of occurrence.

Risk ID 3 - Litigation of FERC dam decommissioning process. There is a risk of litigation associated with the FERC process due to the fact that the local communities and politicians in Siskiyou County have a long track record of strong opposition to the Project. Litigation of the FERC process could have a significant impact on schedule and cost. Cost increases can result both from required legal fees, as well as from extended Project management effort and delayed construction (escalation). The KRRC has implemented mitigation strategies including local outreach and education, public meetings, development of a local jobs plan, attempts at negotiated benefits for the local communities, and development of sound technical information and arguments that will hold up to scrutiny.

For the reasons stated above, the probability of occurrence is judged to be 3 (Medium) and the severity of impact to be a 5 (Very High), resulting in a Risk Score of 15 (High). It is recommended to continue with outreach and technical mitigation strategies described above to attempt to reduce the likelihood of occurrence.

Risk ID 64 - Iron Gate Dam excavation production less than required to complete excavation by required date. There is a risk during the construction phase that reduced Contractor production rates or weather delays could result in failure to completely remove the Iron Gate embankment dam during the dry season after reservoir drawdown. Root causes of this risk could include inadequate planning by the Contractor or DB, inadequate construction staff or equipment, unforeseen environmental issues, or wetter-than-anticipated weather. Extending dam removal beyond September increases the risk of the partially excavated dam failing due to overtopping, resulting in a flood wave being released to the downstream reach. The flood wave could potentially result in loss of life or property downstream and larger than planned sediment releases.

For the reasons stated above, the probability of occurrence is judged to be 3 (Medium) and the severity of impact to be a 5 (Very High), resulting in a Risk Score of 15 (High). Mitigation strategies for this risk include the potential for contractual milestone requirements, permits that include flexibility for 24-hour work 7 days per week if needed for schedule recovery, and a technical evaluation to minimize embankment volumes to be excavated and assess maximum cofferdam heights to minimize public endangerment in the event of a breach.

Risk ID 68 - Greater than anticipated effect on downstream biological resources. There is a risk that the released reservoir sediments could have a greater than anticipated effect on downstream biological resources. Although the impact assessments previously completed for CEQA/NEPA anticipated a mortality event for fish, the risk is that the effect extends over a longer period or impacts a broader group of aquatic resources. Should monitoring during and after drawdown indicate that impacts are greater than anticipated, the root cause of the discrepancy will be evaluated, and there would be a potential for increased cost in an attempt to mitigate the impact.

The probability of occurrence for this risk is judged to be 3 (Medium) and the severity of impact to be a 5 (Very High), resulting in a Risk Score of 15 (High). There are numerous aquatic resource measures incorporated into the Project description to provide benefits to affected species, however, there is no way to effectively mitigation or avoid this risk.

3.2 Risks with Very High Consequence

Risks with a very high consequent (severity of impact score of 5) are listed below, and are organized per Risk ID number.

Risk ID 1 - Project budgets reduced or eliminated. Loss or significant reduction of Project budgets would limit the KRRC's ability to implement the Project. Although it is highly unlikely, it is worthy of tracking due to the significant consequence. The probability of occurrence is judged to be 1 (Very Low) with consequences being 5 (Very High), resulting in a Risk Score of 5 and a Risk Rating of High. Potential mitigation measures could include strict adherence to funding agreement requirements.

Risk ID 30 - Project costs are projected to exceed funding. Should projected Project costs exceed available funding, it would limit the KRRC's ability to implement the Project. The cost estimate and associated Monte Carlo analysis included in the Detailed Plan suggest this is highly unlikely. The probability of occurrence is judged to be 1 (Very Low) with consequences being 5 (Very High), resulting in a Risk Score of 5 and a Risk Rating of High. Potential mitigation measures include development of partial removal options in project description, timely updates to the cost estimate as new information becomes available, value engineering step during detailed design, and active risk management through ongoing risk assessments and reporting.

Risk ID 31 - Resident gets injured within construction site. The construction Contractor will be required to develop and implement a conservative and comprehensive health and safety plan for the construction site and adjacent areas. One aspect of that plan will include best management practices and project specific measures to protect the public. For these reasons, and from experience on similar projects, it is unlikely that individuals or local residents outside of KRRC and their consultants, PacifiCorp, and Contractor staff will have access to the work area without prior approval and training. Should a resident get injured onsite, it would constitute a tragedy for everyone involved, and could lead to significant issues in a number of categories. For these reasons, the probability of occurrence for this risk is judged to be 1 (Very Low) with consequences being 5 (Very High), resulting in a Risk Score of 5 and a Risk Rating of High. Potential mitigation measures include development of appropriate health and safety qualifications, experience and other requirements during the procurement process, as well as active overview and enforcement of the Contractor's health and safety plan.

Risk ID 34 - Dam or similar structure fails during drawdown. The drawdown period begins January 1 of the drawdown year, and will extend to mid-March of the same year. During this period, the reservoir water surface elevations at each reservoir will be lowered to the extent feasible to create a dry work area and release accumulated reservoir sediments. It is likely that significant rainfall events may occur during the drawdown period, temporarily re-filling some of the reservoirs until the storm recedes. Each dam and associated infrastructure was designed and has been maintained to allow for a wide range of reservoir levels, and the risk of failure during drawdown, outside a natural disaster (e.g. significant seismic event), is very low. In the event of a dam failure during drawdown, release of the reservoir volume could result in a flood wave being released to the downstream reach. The flood wave could potentially result in loss of life or property downstream and larger than planned sediment releases. For these reasons, the probability of occurrence for this risk is judged to be 1 (Very Low) with consequences being 5 (Very High), resulting in a Risk Score of 5 and a Risk Rating of High. Potential mitigation measures include a rigorous detailed design analysis surrounding dam safety during drawdown, completion of the FERC Potential Failure Modes Analysis (PFMA) process, and close coordination with the CA DWR Division of Safety of Dams (DSOD).

Risk ID 35 - Hazardous material release to river during construction. A potential hazardous material release could be associated with either an existing hydropower-related hazardous material, or a Contractor-related hazardous material (e.g. vehicle maintenance oil). A phase 1 hazardous waste assessment is currently underway to gain a better understanding of existing hazardous materials onsite, and the Contractor's health and safety plan will address hazardous material storage, spills etc. Release of a hazardous material to the river could result in significant adverse effects to biological resources, in addition to resulting in potential enforcement actions from regulatory agencies. For these reasons, the probability of occurrence for this risk is judged to be 1 (Very Low) with consequences being 5 (Very High), resulting in a Risk Score of 5 and a Risk Rating of High. Potential mitigation measures include completion of the phase 1 hazardous material assessments and follow-up analyses, development of appropriate health and safety qualifications, experience and other requirements during the procurement process, as well as active overview and enforcement of the Contractor's health and safety.

Risk ID 38 - Bald and Golden Eagle present within restriction buffer and halt construction. For certain protected species, such as bald and golden eagles, federal law requires that, if active eagle nests are present within 0.5 miles of construction areas, construction activities be halted until approval is obtained from the resource agencies to resume. Based on research, previous studies, and recent field surveys, it has been determined that eagles nests do existing in the proximity of the construction area, but that proposed avoidance and minimization measures will likely prevent take of the species. For these reasons, the probability of occurrence for this risk is judged to be 2 (Low) with consequences being 5 (Very High), resulting in a Risk Score of 10 and a Risk Rating of High. Potential mitigation measures include additional surveys to identify nest locations in the years leading up to construction, and implementation of the avoidance and minimization measures identified in Appendix E, Terrestrial Resource Measures (AECOM 2017).

Risk ID 43 - Unanticipated Native American burial site discovered during reservoir drawdown. It is anticipated that a significant volume of accumulated reservoir sediments will be evacuated from the reservoirs during drawdown. It is not anticipated that the pre-dam alluvium (below the accumulated sediments) will experience significant erosion or mobilization during drawdown. Although specific site locations are unknown, it is possible that Native American burial sites could exist beneath the pre-dam alluvium on the former floodplain areas. While unlikely, there is a risk of Native American burial sites being uncovered during drawdown. Should this occur, it could lead to costly mitigation actions to repair or move the affected resource. The probability of occurrence for this risk is judged to be 1 (Very Low) with consequences being 5 (Very High), resulting in a Risk Score of 5 and a Risk Rating of High.

Potential mitigation measures include identification of existing cultural resources to the extent feasible, ongoing coordination with Native American groups, and development of a rapid response plan to address the possibility of burial sites becoming exposed during drawdown.

Risk ID 44 - Unanticipated Native American burial site discovered during other construction activities. While previous reports and ongoing surveys will identify Native American burial sites within the limit of work to the extent feasible, there is a risk that additional site may exist and could become exposed during construction activities. The probability of occurrence for this risk is judged to be 1 (Very Low) with consequences being 5 (Very High), resulting in a Risk Score of 5 and a Risk Rating of High. Potential mitigation measures include identification of existing cultural resources to the extent feasible, ongoing coordination with Native American groups, and development of a plan to address the possibility of burial sites being discovered during construction.

Risk ID 50 - Resident gets injured in downstream channel during reservoir drawdown. The construction Contractor will be required to develop and implement a conservative and comprehensive health and safety plan for the construction site and downstream areas, as appropriate. One aspect of that plan will include best management practices and project specific measures to protect the public downstream during drawdown. The root cause of this risk would be that outreach to make the public aware of increased flows during reservoir drawdown and associated safety measures were insufficient. The planned reservoir dewatering limits flows being released through the Iron Gate Dam diversion tunnel to about 15,000 cfs, which is just above the 10-year peak flow (AECOM, 2017). The probability of occurrence for this risk is judged to be 2 (Low) with consequences being 5 (Very High), resulting in a Risk Score of 5 and a Risk Rating of High. Potential mitigation measures includes developing a comprehensive education and outreach plan, a detailed review and performance of quality assurance of the Contractor's safety program, and developing a Reservoir Dewatering Awareness Plan that will include procedures for notifying public of the schedule and anticipated flows for reservoir drawdown.

Risk ID 52 - Copco No. 1 or Iron Gate Dam large gate procurements delay installation resulting in delay of reservoir drawdown. The large gates proposed for infrastructure modification at both Copco No. 1 and Iron Gate dams require complex design information and a fairly long lead time to fabricate and procure. The root causes of this risk include errors in the design that require changes in the fabrication, omissions in the design requiring the gate fabricator to request additional information, errors during fabrication, scheduling issues with the design being completed late not allowing sufficient time for fabrication or the fabricator's work load being such that the time to fabricate is extended beyond the anticipated schedule date. Should a lengthy delay occur, there is a possibility it could delay the project up to a year, since drawdown needs to start on January 1. The probability of occurrence for this risk is judged to be 2 (Low) with consequences being 5 (Very High), resulting in a Risk Score of 10 and a Risk Rating of High. Potential mitigation measures include early detailed design, early involvement of the gate fabricator, and early Contractor input including planning underwater work to modify/demo the existing Iron Gate Dam gate structure.

Risk ID 54 - Copco No. 1 or Iron Gate diversion gate malfunctions during drawdown resulting in delay of reservoir drawdown. The root causes of this risk would be errors in design or construction of the large gates required at Copco No. 2 and Iron Gate dams for reservoir drawdown. A malfunction during reservoir drawdown could delay drawdown of Copco Lake or Iron Gate Reservoir beyond March 15 if the malfunction is able to be corrected, or until the following year. The probability of occurrence for this risk is judged to be 1 (Very Low) with consequences being 5 (Very High), resulting in a Risk Score of 5 and a Risk Rating of High. Potential mitigation measures includes proactive QA/QC during design, including backup systems for operating the gates in the design, and construction including special inspections and testing of the gates prior to drawdown.

Risk ID 55 - Copco No. 1 or Iron Gate diversion tunnel intake blocked by debris during drawdown reducing flow capacity. The root cause of this risk is that debris within the reservoir sediment, which is of unknown quantity and character, could be large enough to block the intakes of the diversion tunnels, thereby reducing the capacity of the tunnels. Reduced tunnel capacity could extend reservoir drawdown beyond March 15, resulting in greater than anticipated impacts to biologic resources. The probability of occurrence for this risk is judged to be 2 (Low) with consequences being 5 (Very High), resulting in a Risk Score of 10 and a Risk Rating of High. Potential mitigation measures include maximizing the size of the intakes to match the size of the gates, designing debris gratings for the intakes that would be intended to stop debris large enough to create a blockage with the ability to clear debris from the gratings.

Risk ID 56 - Copco No. 1 diversion intake blocked by landslide. The geology of the canyon walls in the vicinity of the Copco No. 1 intake indicates that the landslide in this area is highly unlikely (AECOM, 2017). In addition, local operations staff has indicated that there is no record of landslides while the facility has been in operation. Should a landslide occur and block the diversion tunnel during drawdown, similar consequences as indicated in Risk ID #s 54, 55 and 68 could occur. The probability of occurrence for this risk is judged to be 1 (Very Low) with consequences being 5 (Very High), resulting in a Risk Score of 5 and a Risk Rating of High. Potential mitigation measures include a detailed geologic assessment of the canyon walls in the vicinity of the diversion intake to confirm the probability of a landslide, incorporation of design details to minimize the potential for blockage, and a comprehensive review of the final design.

Risk ID 61 - Iron Gate Dam diversion intake blocked by landslide. The geology of the canyon walls in the vicinity of the Iron Gate intake indicates that the landslide in this area is unlikely (AECOM, 2017). In addition, local operations staff has indicated that there is no record of landslides while the facility has been in operation. Should a landslide occur and block the diversion tunnel during drawdown, similar consequences as indicated in Risk ID #s 54, 55 and 68 could occur. The probability of occurrence for this risk is judged to be 2 (Very Low) with consequences being 5 (Very High), resulting in a Risk Score of 10 and a Risk Rating of High. Potential mitigation measures include a detailed geologic assessment of the canyon walls in the vicinity of the diversion intake to confirm the probability of a landslide, incorporation of design details to minimize the potential for blockage, and a comprehensive review of the final design.

Risk ID 62 - Iron Gate Reservoir rim experiences catastrophic slope failures that blocks Klamath River during reservoir drawdown. Preliminary assessments have indicated that the likelihood of a catastrophic slope failure at Iron Gate during drawdown in low (AECOM, 2017). The root cause of such a slope failure would be unknown geologic conditions that would be susceptible to failure during reservoir drawdown. Such a slope failure, if it were substantial enough to form a large dam across the Klamath River would delay dam removal because Iron Gate Dam would need to remain in place until the landslide dam is removed either by erosion with its accompanying water quality impacts or by mechanical means. The probability of occurrence is judged to be 2 (Low) with consequences being 5 (Very High) because it could add a second year of reservoir drawdown impacts. The resulting Risk Score is 10 and Risk Rating is High. Potential mitigation measures include comprehensive field investigations based on geologic mapping and slope stability analyses. However, because field investigations cannot be done everywhere and geologic conditions could be different than analyzed, the Contractor will be required to develop a Reservoir Rim Slope Failure Plan that will include the methodology for evaluating the impact of a landslide should it occur that addresses it's size, relationship to Iron Gate Dam removal, and associated impacts to public safety, water quality, and fish passage.

Risk ID 65 - Iron Gate Dam overtopped during excavation by storm water flows in excess of 100-year event resulting in dam failure. The root causes could be climate change and greater variability in precipitation patterns resulting in larger events occurring more frequently than historic precipitation would indicate. The Contractor will be required to maintain minimum dam elevations during excavation of Iron Gate Dam that will allow a 100-year event to be temporarily stored and passed through the diversion tunnel without overtopping the dam and potentially causing dam failure. A less frequent (larger) storm event could cause overtopping and dam failure depending on the amount of required freeboard (additional dam height over that required to safely pass the 100-year event). The probability of occurrence for this risk is judged to be 1 (Very Low) with consequences being 5 (Very High) because dam failure could potentially result in loss of life downstream of the dam. The resulting Risk Score is 5 and Risk Rating is High. Potential mitigation measures include incorporating a design requirement for sufficient freeboard that a 200-year event would be able to safely pass the dam through the diversion tunnel.

4. References

AECOM 2017. *California Environmental Quality Act (CEQA) and California and Oregon 401 Water Quality Certifications Technical Support Document*. September 2017.

Attachment P1 Risk Register

					Project Phases (Yellow - Mitigation can be developed Green - Phases in which risk can occur)												
Risk ID	**Phase**	**Risk Category**	**Risk Description**	**Root Cause(s)**	**Planning**	**Design**	**Construction**	**Post-Construction**	**Primary Aspect**	**Probability (P)**	**Impact (I)**	**Overall Risk Rating**	**Strategy**	**Mitigation Measure (Significant Risks only)**	**Risk Owner**	**Risk Status**
1	Planning	ORG	Project budgets reduced or eliminated	Budgetary or political issues					TIME	1=Very Low (1-9%)	5 =Very High	High	MITIGATE	Strict adherence to funding agreement requirements	Owner	Open
2	Planning	PERMIT	Litigation of CEQA Document	Outside entity sues the CEQA document					TIME	3=Med (20-39%)	5 =Very High	High	MITIGATE	Outreach and education; Local jobs plan; Attempt to negotiate local benefits; Close SWRCB coordination; Technical assessments can hold up to scrutiny	Owner	Open
3	Planning	PERMIT	Litigation of FERC dam decommissioning process	FERC process to decommission the dams is challenged					LEGAL	3=Med (20-39%)	5 =Very High	High	MITIGATE	Outreach and education; Local jobs plan; Attempt to negotiate local benefits; Technical assessments can hold up to scrutiny	Owner	Open
4	Planning	PERMIT	Unanticipated project requirements from agencies, FERC, DSOD, or BOC	Agency, FERC, DSOD, or BOC reviews result in unanticipated requirements					TIME	3=Med (20-39%)	4 =High	Med	ACCEPT	Close coordination where possible with referenced agencies	Owner	Open
5	Planning	PERMIT	Unanticipated permit requirements that increase bid price if not known at time of bidding	Permit process delayed such that not complete prior to bids; insufficient communication with regulators					COST	3=Med (20-39%)	3 =Med	Med	MITIGATE	Early and ongoing consultation with agencies; incorporate best understanding of permit requirements into RFP	Owner	Open
6	Planning	EXT	Funders or regulators do not approve procurement method, documents, or contract	Insufficient communication with funders and regulators					TIME	2=Low (10-19%)	4 =High	Med	MITIGATE	Early consultation with funders and regulators regarding procurement process	Owner/Force Majeure	Open
7	Planning	EXT	Significant changes in law occur during project implementation that impact the Project	Changes in law					COST	2=Low (10-19%)	3 =Med	Med	ACCEPT	None	Owner/Force Majeure	Open
8	Planning	PERMIT	Offsite mitigation requirement	Permitting agencies require significant offsite mitigation					COST	2=Low (10-19%)	3 =Med	Med	MITIGATE	Early consultation with agencies; sound approach to restoration	Owner	Open
9	Planning	EXT	Uncontrollable circumstances (e.g. force majeure, war, riots, terrorism, etc.)	Uncontrolled circumstances					TIME	1=Very Low (1-9%)	4 =High	Med	ACCEPT	Develop plan for uncontrolled circumstances if such were to occur during construction	Owner/Design-Builder/Force Majeure	Open
10	Planning	EXT	Residents along the rim of Copco Lake object to project	Traffic impacts; noise impacts; loss of lake					LEGAL	4=High (40-59%)	3 =Med	Med	MITIGATE	Public outreach, eminent domain	Owner	Open
11	Planning	PROC & CONST	Bid result (if traditional DB) or RFQ selection (if progressive DB) is protested	DB(s) not selected protest bid					LEGAL	2=Low (10-19%)	4 =High	Med	MITIGATE	Develop fair bid evaluation process that is clearly defined in RFP	Owner	Open
12	Planning	PROC & CONST	Procurement process fails to result in a contract	Negotiation of contract terms or price fails					LEGAL	2=Low (10-19%)	4 =High	Med	MITIGATE	Develop fair bid evaluation process that is clearly defined in RFP	Owner	Open
13	Design	EXT	Increased development within the floodplain	City/county allows construction permits to be issued to developers					LEGAL	1=Very Low (1-9%)	2 =Low	Low	ACCEPT	Coordination with city/county	Owner/Force Majeure	Open
14	Design	PERMIT	Litigation of local permits	Local permits are litigated					TIME	3=Med (20-39%)	4 =High	Med	MITIGATE	Early consultation with agencies; early permit submittal	Owner	Open
15	Design	PERMIT	Delay in permit acquisition	Agency unable to process permit to allow for required construction start date					TIME	4=High (40-59%)	3 =Med	Med	MITIGATE	Early consultation with agencies; early permit submittal	Owner	Open
16	Design	ORG	Engineer's estimate lower than low bids (if traditional DB)	Lack of competition; Project perceived as risky					COST	3=Med (20-39%)	4 =High	Med	ACCEPT	Robust Engineer's estimate to include Monte Carlo analyses; Independent review of Engineer's estimate, Include adequate contingency for project risk	Owner	Open
17	Design	PROC & CONST	Designer/Contractor dispute leads to schedule delays and cost increases	Design error or construction issues					TIME	2=Low (10-19%)	3 =Med	Med	MITIGATE	Consider contractual measures to maximize design/contractor collaboration such as require Designer to be a partner rather than a subcontractor	Design-Builder	Open
18	Design	PROC & CONST	Failure to agree to GMP during detailed design	Disconnect between DB and Owner					TIME	2=Low (10-19%)	4 =High	Med	SHARE	Close coordination and transparency on costs and associated assumptions as soon as DB or CMAR is under contract	Owner/Design-Builder	Open
19	Construction	PROC & CONST	General changed field condition geotechnical, existing utilities, hazardous materials, cultural and biological resources) leads to redesign, project delays and/or cost overruns	Field condition differs from documented findings					TIME	3=Med (20-39%)	3 =Med	Med	MITIGATE	Comprehensive field investigation and documentation	Owner	Open
20	Construction	EXT	Wetter-than-expected weather during construction increases costs and causes delays	Climate change; Hydrology					TIME	2=Low (10-19%)	4 =High	Med	ACCEPT	Consider defining anticipated rain days in contract as a number greater than average, contract requirement for contractor plan for wetter-than-expected weather	Owner/Force Majeure	Open
21	Construction	EXT	Flows higher than expected during instream construction window leads to schedule delays	Unanticipated river flows					TIME	2=Low (10-19%)	2 =Low	Low	ACCEPT	Rigorous flow analyses during planning/design; set performance requirement in contract (define return period of flow that contractor required to be prepared for)	Owner/Force Majeure	Open
22	Construction	EXT	Fire in watershed increases erosion and sediment	Lightning; Accidental; Arson; combined with storm					TIME	3=Med (20-39%)	4 =High	Med	ACCEPT	None	Owner/Force Majeure	Open

					Project Phases (Yellow - Mitigation can be developed Green - Phases in which risk can occur)											
Risk ID	**Phase**	**Risk Category**	**Risk Description**	**Root Cause(s)**	**Planning**	**Design**	**Construction**	**Post-Construction**	**Primary Aspect**	**Probability (P)**	**Impact (I)**	**Overall Risk Rating**	**Strategy**	**Mitigation Measure (Significant Risks only)**	**Risk Owner**	**Risk Status**
23	Construction	EXT	Fire in watershed during construction causes construction delays	Lightning; Accidental; Arson; combined with storm					TIME	3=Med (20-39%)	4 =High	Med	ACCEPT	None	Owner/Force Majeure	Open
24	Construction	EXT	Earthquake damages temporary construction	None					COST	1=Very Low (1-9%)	2 =Low	Low	ACCEPT	Consider defining a contract defined design earthquake for temporary construction	Owner	Open
25	Construction	DESIGN	Design errors or omissions lead to Project delays or cost overruns	Designer does not have sufficient budget or 'skin in the game'					COST	3=Med (20-39%)	3 =Med	Med	TRANSFER	Consider contract requirement that EOR is partner and not subcontractor; Comprehensive design review; proactive QA/QC	Design-Builder	Open
26	Construction	PROC & CONST	Construction errors (quality control)	EOR fails to properly inspect or direct work in the field; QC failures					COST	2=Low (10-19%)	4 =High	Med	TRANSFER	Clear contract requirements; rigorous Owner QA	Design-Builder	Open
27	Construction	PROC & CONST	DB unable to obtain construction permits (e.g. County encroachment permits) in time for construction	poor planning, insufficient communication, difficulty negotiating requirements					LEGAL	2=Low (10-19%)	4 =High	Med	TRANSFER	Proactive communication with Counties, contingency planning for delayed start during first year of construction	Design-Builder	Open
28	Construction	PERMIT	ROW denied to modify access roads	Insufficient communication and compromise with access road owner					LEGAL	2=Low (10-19%)	3 =Med	Med		Proactive communication with access road owners, contingency planning for use of access roads without modification	Owner's Engineer/ Design-Builder	Open
29	Construction	EXT	Quantity overruns on earthwork, concrete demolition, etc.	Existing as-built data, exploratory data not adequate or accurate					TIME	3=Med (20-39%)	2 =Low	Med	TRANSFER	Obtain new topographic and bathymetric data for use by designer and Contractor; rigorous QA by Owner on design calculations and assumptions related to earthwork volumes	Design-Builder	Open
30	Construction	ORG	Project costs are projected to exceed funding	Changes during construction and risk register projection suggest potential funded level exceedance					COST	1=Very Low (1-9%)	5 =Very High	High	MITIGATE	Development of partial removal options in project description, timely updates to the cost estimate as new information becomes available, value engineering step during detailed design, and active risk management through ongoing risk assessments and reporting	Owner	Open
31	Construction	PROC & CONST	Resident gets injured within construction site	Public safety measures insufficient to keep out public					PUBLIC SAFETY	1=Very Low (1-9%)	5 =Very High	High	SHARE	Development of appropriate health and safety qualifications, experience and other requirements during the procurement process, as well as active overview and enforcement of the Contractor's health and safety plan.	Owner's Engineer/ Design-Builder	Open
32	Construction	DESIGN	Local slope failure along access roads during construction results in delays	Slope instability, inadequate access road condition assessment prior to construction					TIME	2=Low (10-19%)	3 =Med	Med	SHARE	Comprehensive field investigation and design review; develop plan to address slope failures along Copco Road if they were to occur during reservoir drawdown	Owner/Design-Builder	Open
33	Construction	DESIGN	Failure of temporary cofferdams result in demolition delays	Conservative design of cofferdam; unanticipated foundation conditions					TIME	2=Low (10-19%)	3 =Med	Med	TRANSFER	Comprehensive field investigation, review of original construction, and design review	Design-Builder	Open
34	Construction	DESIGN	Dam or similar structure fails during drawdown	Failure mode not investigated or analyzed properly					PUBLIC SAFETY	1=Very Low (1-9%)	5 =Very High	High	TRANSFER	Rigorous detailed design analysis surrounding dam safety during drawdown, completion of the FERC Potential Failure Modes Analysis process, and close coordination with the CA Division of Safety of Dams (DSOD).	Design-Builder	Open
35	Construction	ENV	Hazardous material release to river during construction	Contractor activities result in unanticipated release of hazardous material into river					ENVIRONMENTAL IMPACT	1=Very Low (1-9%)	5 =Very High	High	TRANSFER	Completion of the phase 1 hazardous material assessments and follow-up analyses, development of appropriate health and safety qualifications, experience and other requirements during the procurement process, as well as active overview and enforcement of the Contractor's health and safety.	Design-Builder	Open
36	Construction	DESIGN	Reservoir sediment more difficult to access than anticipated, causing construction delays (restoration)	Lack of material properties understanding					COST	2=Low (10-19%)	2 =Low	Low	TRANSFER	Comprehensive investigation and testing during planning and design phase	Design-Builder	Open
37	Construction	ENV	Special-status species presence delays construction	Unanticipated species found onsite cause stop work					ENVIRONMENTAL IMPACT	2=Low (10-19%)	4 =High	Med	MITIGATE	Pre-construction surveys, design planning, require work areas to be cleared prior to nesting season; proactive surveys for nesting activity during nesting season; proactive nesting mitigation measures during nesting season	Owner/Design-Builder	Open

					Project Phases (Yellow - Mitigation can be developed Green - Phases in which risk can occur)											
Risk ID	**Phase**	**Risk Category**	**Risk Description**	**Root Cause(s)**	**Planning**	**Design**	**Construction**	**Post-Construction**	**Primary Aspect**	**Probability (P)**	**Impact (I)**	**Overall Risk Rating**	**Strategy**	**Mitigation Measure (Significant Risks only)**	**Risk Owner**	**Risk Status**
38	Construction	ENV	Bald and Golden Eagle present within restriction buffer and halt construction.	Did not identify birds prior to construction					TIME	2=Low (10-19%)	5 =Very High	High	MITIGATE	Additional surveys to identify nest locations in the years leading up to construction, and implementation of the avoidance and minimization measures identified in Appendix E, Terrestrial Resource Measures (AECOM 2017)	Design-Builder	Open
39	Construction	ENV	Loss of all freshwater mussels in 1st year of demolition.	Suspended sediment and bedload movement.					ENVIRONMENTAL IMPACT	3=Med (20-39%)	3 =Med	Med	MITIGATE	Obtain latest research on relocation techniques and bring in industry experts during detailed design	Owner/Force Majeure	Open
40	Construction	PERMIT	Construction mitigation permit requirements not satisfied	Limited environmental mitigation measures available do not meet time and budget constraints					ENVIRONMENTAL IMPACT	3=Med (20-39%)	3 =Med	Med	TRANSFER	Coordination between designer, Contractor, and permitting agencies	Owner/Design-Builder	Open
41	Construction	ENV	Cultural resource discovery leads to schedule delays	Resource not identified during planning					TIME	2=Low (10-19%)	4 =High	Med	MITIGATE	Identification of existing cultural resources to the extent feasible, ongoing coordination with tribes	Owner/Force Majeure	Open
42	Construction	ENV	Known cultural resource damaged during construction.	Mitigation measures fail to protect resource					LEGAL	2=Low (10-19%)	4 =High	Med	MITIGATE	Identification of existing cultural resources to the extent feasible, ongoing coordination with tribes	Design-Builder	Open
43	Construction	ENV	Unanticipated Native American burial site discovered during reservoir drawdown.	Burial site not disclosed or already known about.					TIME	1=Very Low (1-9%)	5 =Very High	High	MITIGATE	Identification of existing cultural resources to the extent feasible, ongoing coordination with Native American groups, and development of a rapid response plan to address the possibility of burial sites becoming exposed during drawdown	Owner/Force Majeure	Open
44	Construction	ENV	Unanticipated Native American burial site discovered during other construction activities	Burial site not disclosed or already known about.					TIME	1=Very Low (1-9%)	5 =Very High	High	MITIGATE	Identification of existing cultural resources to the extent feasible, ongoing coordination with Native American groups, and development of a plan to address the possibility of burial sites being discovered during construction	Owner/Force Majeure	Open
45	Construction	PROC & CONST	Reservoir dewatering impacts water quality more severely than anticipated causing project regulatory shutdown	Permit conditions and/or inadequate modeling of water quality					ENVIRONMENTAL IMPACT	3=Med (20-39%)	4 =High	Med	ACCEPT	Perform comprehensive water quality studies prior to construction and obtain flexible permit conditions if possible	Owner's Engineer/ Design-Builder	Open
46	Construction	DESIGN	Reservoir drawdown and subsequent operation results in greater than anticipated erosion at bridges or along channel creating passage barrier	Local hydrodynamics result in greater than modeled erosion or scour					COST	2=Low (10-19%)	3 =Med	Med	ACCEPT	Comprehensive design review; design additional scour protection for bridges if determined to be needed; develop monitoring and mitigation plan for during and post reservoir drawdown	Owner's Engineer	Open
47	Construction	PROC & CONST	Reservoir dewatering and subsequent operations have greater than anticipated effects on diversion intakes for irrigation/livestock, resulting in public resentment and cost increases	Greater than predicted suspended sediment and bedload movement.					COST	3=Med (20-39%)	2 =Low	Med	SHARE	Comprehensive field investigation and design review; develop plan for monitoring/mitigating intakes during reservoir drawdown	Owner/Design-Builder	Open
48	Construction	DESIGN	Reservoir dewatering and subsequent operation has greater than anticipated effects on groundwater wells, resulting in public resentment and cost increases (reservoir and downstream)	Difficult to investigate and analyze groundwater relationships					COST	2=Low (10-19%)	4 =High	Med	SHARE	Comprehensive field investigation and design review; develop plan for evaluating changes in groundwater post-reservoir drawdown and plan to proactively mitigate impacted wells	Owner/Design-Builder	Open
49	Construction	ENV	Reservoir dewatering and subsequent operations have greater than anticipated effect on downstream channel aggradation/flooding leads to increased cost or litigation	Evacuated coarse sediment is greater than anticipated leading to increased flooding					LEGAL	4=High (40-59%)	3 =Med	Med	ACCEPT	Rigorous assessment on transport and flooding during design; monitoring post-drawdown; Raise awareness that active channel management program needed; proactive public information	Owner	Open
50	Construction	EXT	Resident gets injured in downstream channel during reservoir drawdown	Outreach and public safety measures insufficient to keep out public					PUBLIC SAFETY	2=Low (10-19%)	5 =Very High	High	MITIGATE	Comprehensive education and outreach plan; Detailed review and QA of safety program; develop specific plan for notifying public of reservoir drawdown schedule and anticipated flows	Owner/Design-Builder	Open
51	Construction	DESIGN	J.C. Boyle embankment experiences slope failure of upstream shell during reservoir drawdown	Upstream shell material less pervious than assumed in design; error in rapid-drawdown slope stability analyses					PUBLIC SAFETY	1=Very Low (1-9%)	4 =High	Med	MITIGATE	Comprehensive field investigation and design review; develop slope monitoring plan for implementation during drawdown; stockpile riprap for repairs of slope if local failures occur.	Owner/Design-Builder	Open
52	Construction	PROC & CONST	Copco No. 1 or Iron Gate Dam large gate procurements delay installation resulting in delay of reservoir drawdown	Design error; scheduling error; manufacturer requires additional information; construction error					TIME	2=Low (10-19%)	5 =Very High	High	MITIGATE	Early detailed design; early involvement of manufacturer, early DB input including planning underwater work to modify/demo existing intake	Design-Builder	Open
53	Construction	PROC & CONST	Copco. No.1 and Iron Gate Dam tunnel modifications are more difficult to construct causing schedule and cost overruns	Changed site condition or design omission					TIME	3=Med (20-39%)	3 =Med	Med	TRANSFER	Comprehensive field investigation and design review; early Contractor input	Design-Builder	Open

					Project Phases (Yellow - Mitigation can be developed Green - Phases in which risk can occur)											
Risk ID	**Phase**	**Risk Category**	**Risk Description**	**Root Cause(s)**	**Planning**	**Design**	**Construction**	**Post-Construction**	**Primary Aspect**	**Probability (P)**	**Impact (I)**	**Overall Risk Rating**	**Strategy**	**Mitigation Measure (Significant Risks only)**	**Risk Owner**	**Risk Status**
54	Construction	PROC & CONST	Copco No. 1 or Iron Gate Dam diversion gate malfunctions during drawdown resulting in delay of reservoir drawdown	Design or Construction error					TIME	1=Very Low (1-9%)	5 =Very High	High	TRANSFER	Proactive QA/QC; special inspection; including backup systems for operating the gates in the design; testing of gate prior to drawdown	Design-Builder	Open
55	Construction	EXT	Copco No. 1 or Iron Gate Dam diversion tunnel intake blocked by debris during drawdown reducing flow capacity	Debris within reservoir blocks intake					ENVIRONMENTAL IMPACT	2=Low (10-19%)	5 =Very High	High	SHARE	Maximizing the size of the intakes to match the size of the gates; design debris grating for intake with ability to clear debris from grating	Owner/Design-Builder	Open
56	Construction	EXT	Copco No. 1 diversion intake blocked by landslide	Rapid drawdown failure of slope above intake; Seismic event during construction					ENVIRONMENTAL IMPACT	2=Low (10-19%)	5 =Very High	High	SHARE	Detailed geologic assessment of the canyon walls in the vicinity of the diversion intake to confirm the probability of a landslide, incorporation of design details to minimize the potential for blockage, and a comprehensive review of the final design	Owner/Design-Builder	Open
57	Construction	PROC & CONST	Copco Lake reservoir rim experiences catastrophic slope failure during reservoir drawdown impacting resident safety, access conditions, etc.	Design analyses unable to be made for all geologic conditions and slope geometries; insufficient data					PUBLIC SAFETY	1=Very Low (1-9%)	4 =High	Med	ACCEPT	Comprehensive field investigation and design review; develop reservoir rim monitoring plan to be implemented during drawdown to proactively look for potential slope failures	Owner	Open
58	Construction	PROC & CONST	Copco No. 1 concrete demolition production not adequate to meet project schedule	Inadequate equipment, staff, environmental issues, unfavorable weather					TIME	2=Low (10-19%)	3 =Med	Med	TRANSFER	Contract requirements including milestones; request permit flexibility for 24hr work 7 days per week for recovery, obtain concrete cores for strength testing to inform DB assumptions regarding drilling and blasting,	Design-Builder	Open
59	Construction	PROC & CONST	Copco No. 2 cannot continue to generate power after January 2020	Insufficient water available in Klamath River or water quality too poor					COST	2=Low (10-19%)	3 =Med	Med	ACCEPT	Confirm allowable water quality for operation; evaluate Klamath River flows for potential for too little water	Owner	Open
60	Construction	PROC & CONST	Iron Gate Dam 16.5-ft x 18-ft diversion gate cannot be installed due to as-built drawings of gate guides not matching existing conditions	Unable to survey gate slot until demo complete					TIME	2=Low (10-19%)	4 =High	Med	TRANSFER	Early gate fabrication and installation with sufficient float to allow time for gate modifications, if needed.	Design-Builder	Open
61	Construction	EXT	Iron Gate Dam diversion intake blocked by landslide	Rapid drawdown failure of slope above intake; Seismic event during construction					ENVIRONMENTAL IMPACT	2=Low (10-19%)	5 =Very High	High	SHARE	Detailed geologic assessment of the canyon walls in the vicinity of the diversion intake to confirm the probability of a landslide, incorporation of design details to minimize the potential for blockage, and a comprehensive review of the final design	Owner/Design-Builder	Open
62	Construction	EXT	Iron Gate Reservoir rim experiences catastrophic slope failures that blocks Klamath River during reservoir drawdown	Design analyses unable to be made for all geologic conditions and slope geometries; insufficient data					ENVIRONMENTAL IMPACT	2=Low (10-19%)	5 =Very High	High	ACCEPT	Comprehensive field investigation and design review; develop plan for evaluating impact of landslide to public safety, water quality, and fish passage if Iron Gate Dam is removed; if large enough could delay removal of Iron Gate Dam	Owner	Open
63	Construction	DESIGN	Iron Gate Dam embankment experiences slope failure of upstream shell during reservoir drawdown	Upstream shell material less pervious than assumed in design; error in rapid-drawdown slope stability analyses					PUBLIC SAFETY	1=Very Low (1-9%)	4 =High	Med	SHARE	Comprehensive field investigation and design review; develop slope monitoring plan for implementation during drawdown; stockpile riprap for repairs of slope if local failures occur.	Owner/Design-Builder	Open
64	Construction	PROC & CONST	Iron Gate Dam excavation production less than required to complete excavation by required date	Inadequate planning, equipment, staff, or unforeseen environmental issues, unfavorable weather					PUBLIC SAFETY	3=Med (20-39%)	5 =Very High	High	TRANSFER	Contractual requirements including milestones, request permit flexibility for 24hr work 7 days per week for recovery, evaluate if higher cofferdams for planned breach are feasible without significant public endangerment	Design-Builder	Open
65	Construction	EXT	Iron Gate Dam overtopped during excavation by stormwater flows in excess of 100-year event resulting in dam failure	Climate change; increased variability in precipitation patterns					PUBLIC SAFETY	1=Very Low (1-9%)	5 =Very High	High	ACCEPT	Require sufficient freeboard over minimum required elevations during dam removal to pass 200-year event	Owner/Force Majeure	Open
66	Construction	ENV	Iron Gate Hatchery shutdown do to inadequate water supply	New water supply or treatment facilities do not provide suitable supply for hatchery operations, resulting in lowered production					ENVIRONMENTAL IMPACT	3=Med (20-39%)	3 =Med	Med	MITIGATE	Rigorous design of replacement supply; pilot treatment technology; proactive QA/QC during construction	Owner	Open
67	Operation	EXT	Public perception that Project responsible for negative post-project conditions	Lack of project knowledge; Public opposition					LEGAL	4=High (40-59%)	3 =Med	Med	SHARE	Proactive public outreach and education	Owner/Design-Builder	Open
68	Operation	ENV	Greater than anticipated effect on downstream biological resources	Effect of suspended sediment causes greater than anticipated impact to given species					ENVIRONMENTAL IMPACT	3=Med (20-39%)	5 =Very High	High	MITIGATE	Coordination with regulatory agencies on issue and plan.	Owner	Open
69	Operation	ENV	Limited recovery of fish species of concern	Fish recovery does not meet agency expectations					ENVIRONMENTAL IMPACT	2=Low (10-19%)	2 =Low	Low	MITIGATE	Aquatic Resource (AR) measures included in Project	Owner	Open

AECOM

					Project Phases (Yellow - Mitigation can be developed Green - Phases in which risk can occur)											
Risk ID	Phase	Risk Category	Risk Description	Root Cause(s)	Planning	Design	Construction	Post-Construction	Primary Aspect	Probability (P)	Impact (I)	Overall Risk Rating	Strategy	Mitigation Measure (Significant Risks only)	Risk Owner	Risk Status
70	Operation	ENV	Bald and Golden Eagle net loss within 5 years of construction completion.	Mitigation and rehabilitation measures provided insufficient protection.					ENVIRONMENTAL IMPACT	3=Med (20-39%)	4 =High	Med	ACCEPT	Proactively monitor species before and during construction	Owner	Open
71	Operation	ENV	Bat roosts do not meet success criteria requiring additional mitigation.	Predictive model of bat roost effectiveness is incorrect					ENVIRONMENTAL IMPACT	3=Med (20-39%)	2 =Low	Med	MITIGATE	Agency input into performance requirements in DB contract and design, proactive QA/QC during construction	Owner	Open
72	Operation	ENV	Habitat restoration goals not satisfied in field.	Constructed project component does not meet agency expectations					ENVIRONMENTAL IMPACT	2=Low (10-19%)	2 =Low	Low	TRANSFER	Agency input into performance requirements in DB contract and design, proactive QA/QC during construction	Design-Builder	Open
73	Operation	EXT	Large seismic event up to design Maximum Credible Earthquake (MCE) occurs after project completion that results in blockage of Klamath River	None					PUBLIC SAFETY	1=Very Low (1-9%)	2 =Low	Low	TRANSFER	None.	Owner/Force Majeure	Open
74	Design	DESIGN	Coordination or other design delays related to City of Yreka water system design	Lack of coordination or agreement on design process or details					TIME	2=Low (10-19%)	4 =High	Med	MITIGATE	Proactive coordination with City engineers on process and design requirements. Should the City retain design control, strict adherence to schedule milestones and KRRC QA process.	Owner	Open
75	Design	PERMIT	Process delays or unanticipated input from Board of Consultants	Unanticipated input from BOC					TIME	3=Med (20-39%)	3 =Med	Med	MITIGATE	Proactive coordination with BOC and clear identification of review goals and expectations; Proactive follow-up on conflict resolution	Owner	Open
76	Planning	PERMIT	FERC schedule longer than anticipated, resulting in significant Project delay and associated increased cost	FERC schedule delays					TIME	3=Med (20-39%)	4 =High	Med	MITIGATE	Proactive response to FERC requests and strict adherence to FERC standard protocol and processes	Owner	Open
77	Planning	ORG	Available insurance is not acceptable to FERC to process transfer application	Insurance options to not meet FERC expectation					COST	2=Low (10-19%)	4 =High	Med	MITIGATE	Proactive response to FERC insurance related requests and negotiation with insurance companies on policy	Owner	Open
78	Operation	O&M	Unanticipated maintenance or repair required during regulatory monitoring and reporting period (e.g. plant establishment, tributary passage blockage, etc.)	Agency success criteria not met during post-construction period					COST	3=Med (20-39%)	3 =Med	Med	SHARE	Development of management plans to clearly identify success criteria, maintenance triggers and overall approval process.	Owner/Design-Builder	Open

aecom.com