RECLAMATION
Managing Water in the West

Detailed Plan for Dam Removal – Klamath River Dams

Klamath Hydroelectric Project
FERC License No. 2082
Oregon - California

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

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Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Peer Review Certification: This document has been peer reviewed in accordance with guidelines established by the Technical Service Center, Bureau of Reclamation, and is believed to be consistent with the project requirements and standards of the profession. Questions concerning this report should be addressed to Tom Hepler, Team Leader, Waterways and Concrete Dams Group (Code 86-68130), phone 303-445-3261, email thepler@usbr.gov.

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DETAILED PLAN FOR DAM REMOVAL
KLAMATH RIVER DAMS

Table of Contents

Attachments

Executive Summary

The Klamath Hydroelectric Project (Project) is owned by PacifiCorp, and includes four generating developments along the mainstem of the Upper Klamath River between river mile (RM) 190 and 228. The East Side and West Side Developments are located further upstream at the Bureau of Reclamation's (Reclamation's) Link River Dam at RM 254, and have been previously proposed by PacifiCorp for decommissioning. The Project also includes a re-regulation dam with no generation facilities at RM 233 (Keno Dam), and a small (2.2 MW) generating development on Fall Creek, a tributary to the Klamath River at RM 196.3. The installed generating capacity of the existing Project is 169 MW and, on average, the Project generates 716,800 MWh of electricity annually. PacifiCorp began relicensing proceedings before the Federal Energy Regulatory Commission (FERC) in 2000.

The Klamath Hydroelectric Settlement Agreement (KHSA) was completed in February 2010 for the express purpose of resolving the pending FERC relicensing proceedings by establishing a process for potential Facilities Removal and operation of the Project until that time. The KHSA addresses the proposed Secretarial Determination whether to proceed with Facilities Removal, defined as the "physical removal of all or part of each of the Facilities to achieve at a minimum a free-flowing condition and volitional fish passage, site remediation and restoration, including previously inundated lands, measures to avoid or minimize adverse downstream impacts, and all associated permitting for such actions." The Facilities were defined as the "specific hydropower facilities, within the jurisdictional boundary of FERC Project No. 2082: Iron Gate Dam, Copco No. 1 Dam, Copco No. 2 Dam, and J.C. Boyle Dam, and appurtenant works currently licensed to PacifiCorp." "Decommissioning" was defined as the physical disconnection of the facility from PacifiCorp's transmission grid, and the removal from a facility of any equipment and personal property that PacifiCorp determines has salvage value.

The KHSA describes the process for studies, environmental review, and participation by the signatory parties and the public to inform the Secretarial Determination. As a part of the basis for the Secretarial Determination, a Detailed Plan to implement Facilities Removal was required, to include the following components:

- The physical methods to be undertaken to effect Facilities Removal, including but not limited to a timetable for Decommissioning and Facilities Removal;
- As necessary and appropriate, plans for management, removal, and/or disposal of sediment, debris, and other materials;
- A plan for site remediation and restoration;
- A plan for measures to avoid or minimize adverse downstream impacts;
- A plan for compliance with all Applicable Laws, including anticipated permits and permit conditions;

- A detailed statement of the estimated costs of Facilities Removal;
- A statement of measures to reduce risks of cost overruns, delays, or other impediments to Facilities Removal; and
- The identification, qualifications, management, and oversight of a non-federal Dam Removal Entity (DRE), if any, that the Secretary may designate. (The Secretary may designate Interior to be the DRE.)

This report represents the Detailed Plan referenced above, for the potential removal of the four hydroelectric dams on the Klamath River (J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate Dams). Two dam removal alternatives are addressed in this report. The removal of all appurtenant features at each dam site, with the exception of buried features, represents the Full Removal alternative. Retention of certain project features, while providing the minimum removal limits to meet the requirements for a free-flowing river and for volitional fish passage through all four dam sites, represents the Partial Removal alternative. The physical methods for removal of each dam are described, including a plan for waste disposal, a proposed sequence and timing for draining the reservoirs to minimize downstream impacts, anticipated permitting requirements, the preparation of cost estimates for full and partial removal of the facilities, and the development of construction schedules for the work. Studies have been performed to quantify and to characterize the sediment impounded by the four dams and to evaluate the potential downstream effects of reservoir sediment release during dam removal. Potential mechanical removal of impounded sediments has been evaluated as a separate mitigation measure and is not included in this report. A reservoir management plan has been developed for the revegetation of the currently inundated lands following dam removal. Estimates for the removal of recreation facilities currently located along the reservoir shorelines and owned by PacifiCorp have been prepared. Other potential impacts to infrastructure, including the Yreka water supply pipeline, and potential mitigation measures are also addressed.

Chapter 1 provides a summary of the study objectives and project background leading to the development of this dam removal report. Chapter 2 provides descriptions of the existing project features at each dam. Chapter 3 describes the hydrologic conditions for the damsites, including stream flow data. Chapter 4 provides detailed dam removal plans for both alternatives, including removal limits, reservoir drawdown and streamflow diversion plans, proposed demolition methods and schedule, and waste disposal requirements. Chapter 5 summarizes the reservoir sediment studies, including the estimation of sediment thickness and volume, physical properties, and sediment release rates during reservoir drawdown. Chapter 6 describes the existing recreation facilities and their removal requirements. Chapter 7 provides the goals and objectives for reservoir restoration, revegetation estimates, invasive weed management plans, and a reservoir restoration schedule. Chapter 8 describes the Yreka City water supply pipeline and intake modifications included in the dam removal plans. Chapter 9 provides the basis for the construction cost estimates for both alternatives, including the methods used to develop feasibility-level cost estimates for all project features, and for non-contract costs including engineering, procurement, construction management, mitigation measures, and monitoring. Chapter 10 is a list of references used for development of this report. Attachments include drawings and maps of project features prepared for this study, reservoir storage and discharge capacity data, preliminary construction schedules, cost estimate worksheets, and supporting inspection reports.

The Most Probable cost estimates and forecast range of values for the Full Removal and Partial Removal alternatives prepared for the Detailed Plan are summarized in Tables ES-1 and ES-2 below. The Most Probable cost estimates were used for the cost-benefit analysis and are based on a July 2010 price level. The Forecast Range was generated from a Monte Carlo analysis and captures about 99 percent of the forecast values (i.e. 2.6 Standard Deviations from the Mean) for a particular project feature. The Minimum and Maximum values shown are the endpoints of the Forecast Range. Contingencies include Design Contingencies and Construction Contingencies. Engineering includes design data, engineering designs, permitting, procurement, construction management, and closeout activities. Mitigation includes environmental mitigation, monitoring, and cultural resources preservation. Life cycle costs cover long-term operation and maintenance costs for any remaining features under the Partial Removal alternative.

Table ES-1. Total Cost Summary for Full Removal Alternative (2020 dollars)

	Forecast Range		Most Probable Cost Estimate
	Minimum	Maximum	
Dam Facilities Removal			76,618,994
Recreation Facilities Removal			797,305
Reservoir Restoration			21,728,000
Yreka Water Supply Mods			1,765,910
Mobilization and Contingencies			50,728,393
Escalation to Jan 2020			36,461,398
TOTAL FIELD COST	157,600,000	301,200,000	188,100,000
Engineering @ 20%			37,600,000
Mitigation @ 35%			65,900,000
TOTAL CONSTRUCTION COST	**238,000,000**	**493,100,000**	**291,600,000**

Table ES-2. Total Cost Summary for Partial Removal Alternative (2020 dollars)

	Forecast Range		Most Probable Cost Estimate
	Minimum	Maximum	
Dam Facilities Removal			52,096,172
Recreation Facilities Removal			797,305
Reservoir Restoration			21,728,000
Yreka Water Supply Mods			1,765,910
Mobilization and Contingencies			38,830,385
Escalation to Jan 2020			27,582,228
TOTAL FIELD COST	116,600,000	230,200,000	142,800,000
Engineering @ 20%			28,400,000
Mitigation @ 45%			63,400,000
TOTAL CONSTRUCTION COST	**185,100,000**	**403,600,000**	**234,600,000**
TOTAL LIFE CYCLE COST	**9,000,000**	**26,800,000**	**12,350,000**

1.0 Study Objectives and Background

The Klamath River flows from its headwaters near Crater Lake, Oregon, to its confluence with the Pacific Ocean in northern California. The Klamath Hydroelectric Project (Project) is owned by PacifiCorp, and includes four generating developments along the mainstem of the Upper Klamath River between river mile (RM) 190 and 228. The East Side and West Side Developments are located further upstream at Reclamation's Link River Dam at RM 254, and have been previously proposed by PacifiCorp for decommissioning. The Project also includes a re-regulation dam with no generation facilities at RM 233 (Keno Dam), and a small (2.2 MW) generating development on Fall Creek, a tributary to the Klamath River at RM 196.3. PacifiCorp began relicensing proceedings before the Federal Energy Regulatory Commission (FERC) in 2000.

The Final Environmental Impact Statement (EIS) for the Klamath Hydroelectric Project (FERC No. 2082) was issued by FERC in November 2007. The Final EIS contains Staff evaluations of the proposal originally submitted by PacifiCorp for continued operation of five of the six Project generating developments with new environmental measures, in addition to alternatives developed by the Staff for relicensing the Project. Project alternatives proposed in the Final EIS included the Staff Alternative, which incorporated most of PacifiCorp's proposed environmental measures with some modifications; the Staff Alternative with Mandatory Conditions, which required the installation of fishways at each development; and two Staff dam removal alternatives, which included (1) the removal of Copco No. 1 and Iron Gate Dams, and the installation of fishways at Copco No. 2 Dam and J.C. Boyle Dam, and (2) the removal of J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate Dams.

The State Coastal Conservancy (Conservancy) of California contracted with an A/E firm, Gathard Engineering Consulting (GEC), and with Shannon and Wilson, Inc. (S&W) in 2006 to characterize the sediment impounded by the four dams, evaluate the potential downstream effects of reservoir sediment erosion, and develop a feasible method of removing the four dams, including the preparation of cost estimates and construction schedules. Costs for removing the four dams, providing water quality protection and construction management, and developing engineering and permitting documents were estimated to be approximately $88 million (in 2006 dollars) in the final GEC report dated November 2006. The GEC report was intended to provide an overview analysis of dam removal and its effects on downstream water quality, and acknowledged that additional analyses would be required to fully evaluate dam removal as a preferred management alternative.

The four Klamath River hydroelectric dams are located downstream of Reclamation's project features associated with the Klamath Basin Project. Reclamation's Technical Service Center (TSC) completed a review of the GEC report, cost estimates, and associated appendices and technical memoranda, and prepared a report documenting the findings of the TSC Review Team (Team) in February 2009. In summary, most assumptions and analyses included in the GEC report were found to be reasonable for an appraisal-level study[1]. However, additional work was recommended to fully address the potential impacts of dam removal at a feasibility level[2]. The work completed by GEC was considered sufficient to suggest that the project may be feasible and that the potential impacts of removing all four hydroelectric dams may be manageable; however, the overall costs estimated by GEC for dam removal and for environmental mitigation were believed to be low. An evaluation of the FERC Staff dam removal plans and cost estimates was beyond the scope of the 2009 TSC study.

PacifiCorp entered into an Agreement in Principle (AIP) with the United States, and with the States of Oregon and California, to address issues pertaining to the resolution of the FERC relicensing requirements and longstanding conflicts over resources in the Klamath Basin, including a path forward for possible Facilities Removal, in January 2009. The AIP provided that the parties would continue good-faith negotiations to reach a final settlement agreement in order to minimize adverse impacts of dam removal on affected communities, local property values, and businesses; to ensure that the interests of Indian tribes, environmental organizations, fishermen, water users, and local communities were addressed; and to specify substantive rights, obligations, procedures, timetables, agency and legislative actions, and other steps for Facilities Removal. The potential benefits for fisheries, water quality, and other resources were believed to outweigh the potential costs, risks, liabilities, and other adverse consequences of dam removal. Since the four hydroelectric dams are owned by PacifiCorp, and are operated in accordance with applicable State and Federal laws and regulations, PacifiCorp would have to decide whether the decommissioning and removal of its facilities is in the best interests of PacifiCorp and its customers. Reasonable long term utility rates, and protection from any liability for damages caused by Facilities Removal, would be central to PacifiCorp's willingness to surrender the dams and the renewable energy they produce, and to concur in the removal of the dams.

The Klamath Hydroelectric Settlement Agreement (KHSA) was completed in February 2010 for the express purpose of resolving the pending FERC relicensing proceedings by establishing a process for potential Facilities Removal and operation of the Project until that time. The KHSA addresses the proposed Secretarial Determination whether to proceed with Facilities Removal, defined as the "physical removal of all or part of each of the Facilities to achieve at a minimum a free-flowing condition and volitional fish passage, site remediation and restoration, including previously inundated lands, measures to avoid or minimize adverse downstream impacts, and all associated permitting for such

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[1] Appraisal-level designs and cost estimates represent an early stage of project development based on available data, and are used to determine whether more detailed investigations of a potential project are justified. Reclamation normally does not use appraisal-level cost estimates to seek Congressional authorization.

[2] Feasibility-level designs and cost estimates are based on information and data obtained during pre-authorization investigations. These investigations provide sufficient information to permit the preparation of preliminary layouts and designs from which feasibility-level quantities for each kind, type, or class of material, equipment, or labor may be obtained. Feasibility-level cost estimates are used to assist in the selection of a preferred plan, to determine the economic feasibility of a project, and to support seeking project authorization.

actions." The Facilities were defined as the "specific hydropower facilities, within the jurisdictional boundary of FERC Project No. 2082: Iron Gate Dam, Copco No. 1 Dam, Copco No. 2 Dam, and J.C. Boyle Dam, and appurtenant works currently licensed to PacifiCorp." "Decommissioning" was defined as the physical disconnection of the facility from PacifiCorp's transmission grid, and the removal from a facility of any equipment and personal property that PacifiCorp determines has salvage value.

The KHSA describes the process for studies, environmental review, and participation by the signatory parties and the public to inform the Secretarial Determination. As a part of the basis for the Secretarial Determination, a Detailed Plan to implement Facilities Removal was required, to include the following components:

- The physical methods to be undertaken to effect Facilities Removal, including but not limited to a timetable for Decommissioning and Facilities Removal;

- As necessary and appropriate, plans for management, removal, and/or disposal of sediment, debris, and other materials;

- A plan for site remediation and restoration;

- A plan for measures to avoid or minimize adverse downstream impacts;

- A plan for compliance with all Applicable Laws, including anticipated permits and permit conditions;

- A detailed statement of the estimated costs of Facilities Removal;

- A statement of measures to reduce risks of cost overruns, delays, or other impediments to Facilities Removal; and

- The identification, qualifications, management, and oversight of a non-federal Dam Removal Entity (DRE), if any, that the Secretary may designate. (The Secretary may designate Interior to be the DRE.)

The Public Utility Commission of Oregon ("Oregon PUC"), and the California Public Utilities Commission ("California PUC") have each established a non-bypassable customer surcharge (or tariff) for PacifiCorp's Oregon and California retail customers to generate funds up to $200 million for the purpose of Facilities Removal, known as the "Customer Contribution." Under KHSA, the State of California agrees to fund the difference between the Customer Contribution and the actual cost to complete Facilities Removal up to an additional $250 million, through bonds or other appropriate financing mechanisms. The Customer Contribution and the California Bond Funding represent the total State contribution and are referred together as the "State Cost Cap" (in nominal dollars).

The Secretary of Interior, in cooperation with the Secretary of Commerce and other Federal agencies as appropriate, will: (a) use existing studies and other appropriate data, including those in the FERC record for this project, including but not limited to environmental impact studies, EPA proceedings, and other pertinent material; (b) conduct further appropriate studies, including but not limited to an analysis of sediment content and quantity; (c) undertake related environmental compliance actions, including environmental review under NEPA; and (d) take other appropriate actions as necessary for the Secretarial Determination. By March 31, 2012, the Secretary shall use best efforts to determine whether, in his judgment, Facilities Removal (a) will advance restoration of the salmonid fisheries of the Klamath Basin, (b) is in the public interest, which includes but is not limited to consideration of potential impacts on affected local communities and Tribes, and (c) whether the costs of Facilities Removal as estimated in the Detailed Plan, including the cost of insurance, performance bond, or similar measures, will not exceed the State Cost Cap. However, any such determination shall not be made until the following conditions have been satisfied:

- Required Federal legislation has been enacted;
- The Secretary and PacifiCorp have agreed upon acceptable terms of transfer of the Keno facility (outside the scope of this report);
- The States of Oregon and California have authorized funding for Facilities Removal (or have provided satisfactory assurances that necessary funding will be timely available);
- The Parties have developed a plan to address the excess costs if the estimate of costs prepared as part of the Detailed Plan shows that there is a reasonable likelihood such costs are likely to exceed the State Cost Cap; and
- The Secretary has identified a DRE-designate, and, if the DRE-designate is a non-federal entity: (a) the Secretary has found that the DRE-designate is qualified; (b) the States have concurred in such finding; and (c) the DRE-designate has committed, if so designated, to perform Facilities Removal within the State Cost Cap.

If the above conditions are not satisfied, the Secretary shall not make a determination. Instead, the Secretary shall provide Notice to the Parties, who shall follow the Meet and Confer procedures under KHSA to consider potential modifications to the KHSA.

Only plans which remove all four hydroelectric dams and include the natural erosion of impounded sediment are addressed by this Detailed Plan report. Alternatives which would not remove all four hydroelectric dams have been developed for NEPA/CEQA[3] compliance, and are outside the scope of this Detailed Plan report. These include provisions for fish passage at all four dams; and provisions for fish passage at Copco No.

[3] National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA).

2 and J.C. Boyle Dams only, and the removal of Copco No. 1 and Iron Gate Dams. The mechanical removal of sediment from the reservoirs, either by clamshell or by dredging, has been evaluated for NEPA/CEQA compliance as a potential mitigation measure to reduce the effects of the natural erosion of sediment, but has been found by others to be infeasible (Lynch, 2011) and is beyond the scope of this report.

The relative cost of relicensing was to be compared with the relative cost of dam removal under KHSA by PacifiCorp. The primary economic analysis was to be prepared by PacifiCorp, to be relied upon by PacifiCorp to compare the present value revenue requirement impact of KHSA against the present value revenue requirement of relicensing of the Facilities under defined prescriptions based on the FERC Final Environmental Impact Statement dated November 2007, to be filed by PacifiCorp with the Oregon PUC and with the California PUC. In addition, the KHSA requires PacifiCorp to implement 21 specific interim measures to: adjust project operations and flow releases to improve environmental conditions, fund fish habitat enhancement projects and support fish disease research activities, and increase support for ongoing Iron Gate fish hatchery operations.

The signatory parties to the KHSA recognized that dam removal would not address all of the issues within the basin. As a result, all of the parties, except for Federal government and PacifiCorp, signed an accompanying agreement—the Klamath Basin Restoration Agreement (KBRA). The KBRA contains interrelated plans and programs intended to benefit fisheries throughout the basin, water and power users in the upper Klamath Basin, counties, Indian tribes, and basin communities. The KBRA negotiations brought many parties together to develop compromises needed to reach agreement that would allow them to support one another's efforts to restore fisheries in the Klamath Basin while providing for sustainable agriculture. The KBRA is intended to result in effective and durable solutions that address the limited availability of water to support agricultural, National Wildlife Refuges (NWRs), and fishery needs, and to resolve the water conflicts among the many users.

Implementation of the KBRA is intended to accomplish the following:

- Restore and sustain natural fish production and provide for full participation in ocean and river harvest opportunities of these fish.

- Establish reliable water and power supplies for agricultural uses, communities, and NWRs in the upper Klamath Basin.

- Contribute to public welfare and sustainability of all communities through reliable water supply; affordable electricity; programs to offset potential property tax losses and address economic development issues in counties; and, efforts to support tribal fishing and long-term economic self-sufficiency.

Many programs described in the KBRA function as an extension to existing restoration and monitoring actions being implemented by Federal and state agencies and other parties. The KBRA includes an adaptive management process (to be developed in the Fisheries Restoration Plan and Fisheries Monitoring Plan) whereby uncertainties associated with implementing restoration projects would be scientifically monitored, and the new information applied, ensuring that programs are maximally focused to achieve the short- and long-term goals and objectives of the KBRA. Proposed mitigation measures under the KHSA, as described in Chapter 9, are not intended to replace those already to be included under the KBRA.

2.0 Existing Feature Descriptions

The following feature descriptions are based on information and drawings provided by PacifiCorp for this study. All elevations are in the original project datum unless otherwise indicated.

2.1 J.C. Boyle Dam and Powerhouse

The J.C. Boyle Development (originally known as the Big Bend Development) consists of a reservoir, combination embankment and concrete dam, gated spillway, diversion culvert, water conveyance system, and powerhouse located on the Klamath River between RM 228 and RM 220, in Klamath County, Oregon. Refer to Figures 1, 2, and 3 in Attachment A for plan views of these features. Property boundaries are shown on Figure 1. J.C. Boyle Dam was completed in 1958 at RM 224.7, and is downstream of Keno Dam and upstream of Copco No. 1 Dam. The primary purpose of the facility is to generate hydroelectric power. Recreation facilities include Topsy Campground (managed by the Bureau of Land Management, or BLM), Pioneer Park (managed by PacifiCorp), and numerous smaller dispersed shoreline recreation sites. Structures at the site include an office building (known as the Red Barn), maintenance shop, fire protection building, communications building, and two occupied residences near the dam, and a large warehouse near the powerhouse. Site access is provided from Oregon Highway 66 by Topsy Grade Road and a network of unpaved project access roads. A small timber bridge crosses the Klamath River near the dam.

J.C. Boyle Dam impounds a narrow reservoir of 420 acres (J.C. Boyle Reservoir) and currently provides approximately 2,629 acre-feet of total storage capacity at reservoir water surface (RWS) elevation 3793.5. The maximum and minimum operating levels are between RWS elevations 3793 and 3788, a vertical operating range of 5 feet, although the reservoir is normally maintained at RWS elevation 3793, or 0.5 feet below the top of the spillway gates.

The earthfill embankment portion is 68 feet tall (at its maximum height above the original streambed on the dam axis at elevation 3732) with a 15-foot-wide crest and a crest length of 413 feet at elevation 3800. The zoned embankment has a central impervious clay core flanked by upstream and downstream shells composed of compacted sand and gravel, with a downstream filter blanket. The upstream face has a 2-1/2H:1V slope above elevation 3780 with a 3-foot-thick riprap layer, and a 3H:1V slope below elevation 3780. The downstream face has a 2-1/2H:1V slope, with a 2-foot-thick riprap layer below approximately elevation 3740. A 3-foot-high concrete cutoff wall is provided along the bedrock foundation about 7 feet upstream of the dam axis.

The concrete portion of the dam is 279 feet long and is composed of a 117-foot-long spillway section, a 48-foot-long intake structure, and a 114-foot-long concrete gravity section with a maximum height of 23 feet between the intake structure and the left abutment (looking downstream).

The spillway section is a concrete gravity overflow structure with three 36-foot-wide by 12-foot-high radial gates and upstream stoplog slots. The spillway crest is at elevation 3781.5, with the top of gates at elevation 3793.5 (0.5 feet above the normal operating level). A traveling gate hoist is provided for operation of the spillway gates. The spillway bay discharges onto a 13-foot-long concrete apron stepped at three elevations generally following the profile of the bedrock surface. Below the apron is a vertical drop of 15 feet to the discharge channel, which was excavated in rock. The discharge channel is generally unlined. The estimated spillway discharge capacity at RWS elevation 3793 with all three gates open is 16,000 ft^3/s.

A concrete box culvert with two 9.5- by 10-foot bays is located beneath the center and right spillway gates at invert elevation 3751.5 (30 feet below the spillway crest). This feature was used for diversion during construction of the dam, and has been sealed with concrete stoplogs at the upstream end. Approach and outlet channels for the diversion culvert were excavated in bedrock.

The intake structure is located to the left of the spillway and consists of a 40-foot-high reinforced concrete tower. It has four 11-foot, 2-inch-wide openings to the reservoir, each of which has a steel trash rack followed by a stoplog slot and a vertical traveling fish screen (with 0.25-inch square openings) with high pressure spray cleaners. Spray water along with any screened fish are collected and diverted downstream of the dam through a 340-foot-long, 24-inch-diameter fish screen bypass pipe, which provides approximately 20 ft^3/s to the Klamath River below the dam. A fabricated metal building was added to the intake structure in 1989. Beyond the intake traveling screens is the entrance to a 14-foot-diameter steel pipeline. A wheel-mounted slide gate and hoist, with upstream stoplog slots, is provided at the upstream end of the 14-foot pipeline for operation and maintenance purposes.

Upstream fish passage at the dam is provided by a pool and weir concrete fish ladder located along the abutment wall between the embankment and concrete sections. The fish ladder is approximately 569 feet long with a total of 63 pools. Reservoir releases to the fish ladder are regulated by a 24-inch slide gate. The fishway operates over a gross head range of approximately 55 to 60 feet.

The water conveyance system between the dam and the powerhouse has a total length of 2.56 miles. From the intake structure, the water flows through a 638-foot long, 14-foot-diameter steel pipeline, supported on steel frames where it spans the Klamath River. The downstream end of the pipeline is equipped with a 14- by 14-foot automated fixed-wheel gate within a concrete headgate structure completed in 2002, which discharges into an open power canal. The power canal is nearly 2.2 miles long and located along a bench cut in the face of the river canyon. Depending on the terrain, the canal is either a double- or single-walled concrete flume approximately 17-feet wide and 12-feet high, with shotcrete applied to the canyon walls where exposed. The power canal is provided with overflow structures at the upstream end (consisting of a siphon pipe) and at the downstream forebay (consisting of a gated overflow weir). The forebay overflow section or spillway is equipped with two float-operated automatic spill gates, which release water during the hydraulic surge from the canal following any load rejection at the powerhouse. The released water discharges through a short, concrete-lined chute and returns to the bypass reach of the Klamath River within a large eroded channel (or scour hole) in the hillside. A forebay sluiceway pipe has been abandoned in place.

Water for power generation is drawn from the forebay through a 60-foot-wide and 17.9-foot-high trash rack with 2-inch bar spacing before entering a 15.5-foot-diameter, concrete-lined, horseshoe-shaped tunnel, which is 1,660 feet long. The last 57-foot length of the tunnel before the downstream portal is steel-lined with the liner bifurcating into two 10.5-foot-diameter steel penstocks. The bifurcation is encased in a concrete anchor block, and includes a 78-foot-high, 30-foot-diameter steel surge tank. Descending to the powerhouse, the penstocks reduce in two steps to 9 feet in diameter. Each penstock is 956 feet in length and is supported by ring girders seated on concrete footings. A 108-inch-diameter butterfly valve is provided at the downstream end of each penstock.

A conventional outdoor-type reinforced concrete powerhouse is located on the right bank of the river and approximately 4.3 river miles downstream of the dam, at RM 220.4, and is the largest generating facility for the hydroelectric project. The two turbines are vertical-shaft, Francis-type units with a total rated discharge capacity of 2,850 ft^3/s. The turbines are rated at 75,700 hp for Unit 1 (replaced in 1994) and 63,900 hp for Unit 2, with a net head of 440 feet. No bypass capacity is provided. Four draft tube bulkhead gates and slots, with two hoists, are provided downstream of the units. A single 150-ton gantry crane is currently located at the J.C. Boyle powerhouse, but can also be used at the Iron Gate powerhouse.

The generators are rated at 53 MVA for Unit 1, with a 0.95 power factor (50 MW), and 50 MVA for Unit 2, with a 0.95 power factor (48 MW). Two three-phase transformers step up the generator voltage for transmission interconnection. The power from the powerhouse is transmitted a very short distance to the adjoining J.C. Boyle substation. There is also a second line that pre-dates the substation. The 0.24-mile 69-kV transmission line (PacifiCorp Line No. 98) connects the J.C. Boyle powerhouse to a tap point on PacifiCorp's Line No. 18. Line No. 58 and Line No. 59 are each 1.66 miles long and extend from the J.C. Boyle substation to a line tie.

2.2 Copco No. 1 Dam and Powerhouse

The Copco No. 1 Development consists of a reservoir, concrete dam, gated spillway, diversion tunnel, intake structure, and powerhouse, located on the Klamath River between approximately RM 204 and RM 198, in Siskiyou County, California, near the Oregon border. Refer to Figures 4 and 5 in Attachment A for plan views of these features. Property boundaries are shown on Figure 4. Copco No. 1 Dam was constructed between 1911 and 1922 at RM 198.6, and is downstream of J.C. Boyle Dam and upstream of Copco No. 2 Dam. The primary purpose of the facility is to generate hydroelectric power. Recreation facilities include Mallard Cove and Copco Cove (both managed by PacifiCorp), and smaller dispersed shoreline recreation sites. Numerous residences are located along the shoreline of Copco Reservoir. Structures at the site include an occupied residence with small garage, a vacant house, and a maintenance building. Site access is provided from Interstate 5 by Copco Road, and then by a steep and narrow access road to the dam and powerhouse. Ager-Beswick Road provides access to the left abutment of the dam, and is an extension of the Topsy Grade Road in Oregon.

Copco No. 1 Dam impounds a reservoir of approximately 1,000 acres (Copco Reservoir) and currently provides approximately 40,000 acre-feet of total storage capacity at RWS elevation 2607.5. The maximum and minimum reservoir operating levels are between RWS elevations 2607.5 and 2601.0, a vertical operating range of 6.5 feet, although the reservoir is normally maintained at RWS elevation 2606, or 1.5 feet below the top of the spillway gates.

The dam is a concrete gravity arch structure approximately 135 feet tall, with a 492-foot radius at the upstream face. The crest length between the rock abutments is approximately 410 feet at elevation 2613. The upstream face of the dam is vertical at the top, then battered at 1 horizontal to 15 vertical. The downstream face is stepped, with risers generally about 6 feet in height. A 224-foot-long, ogee-type overflow spillway is located on the crest of the dam, and is divided into 13 bays controlled by 14- by 14-foot radial (Tainter) gates, with a spillway crest at elevation 2593.5. Three traveling gate hoists are provided for operating the spillway gates, and stoplog slots are provided upstream of each opening. As originally designed, the spillway crest was approximately 115 feet above the original river bed. After construction began, the river gravel was found to be over 100 feet deep at the dam site, and was excavated and then backfilled with concrete, making the total structural height of the dam 230 feet, measured from the lowest depth of excavation to the spillway crest, or 250 feet to the top of the spillway deck. The estimated spillway discharge capacity at RWS elevation 2607.5 with all 13 gates fully open is 34,000 ft^3/s. The normal tailwater surface for operation of the powerhouse is maintained at elevation 2483 by Copco No. 2 Dam, located about 1/4 mile downstream.

A 16- by 18-foot diversion tunnel was excavated through the left abutment for streamflow diversion during construction, but was later sealed by the construction of a concrete plug approximately 200 feet upstream from the downstream tunnel portal. A gated concrete intake structure was provided upstream of the dam for flow regulation of diversion releases during construction, containing three upstream 72-inch-diameter flap (or clack) valves, three 72-inch-diameter butterfly regulating valves, and three 12-inch-diameter filling lines with valves. All valves were manually-operated from hoists located on a concrete deck upstream of the left abutment of the dam, using gate stems and wire ropes. The current condition of the valves and upstream tunnel is unknown. The existing hoists, stems, and wire ropes were abandoned in place and are not currently operational.

The intakes for the three penstocks are located at approximately invert elevation 2575.0 in the right abutment section of the dam. Two cast-iron slide gates are provided for each penstock, with electric motor hoists located in two concrete gatehouses. Two 10-foot-diameter (reducing to 8-foot-diameter) steel penstocks closest to the river feed Unit No. 1

in the powerhouse, while a single, 14-foot-diameter (reducing to two 8-foot-diameter) steel penstock feeds Unit No. 2. Additional facilities (consisting of two slide gates and a short penstock section) were provided to the right of the penstocks for possible future expansion of the powerhouse with the addition of a third unit, which was never constructed. Trashracks with bar spacings of 3 inches are provided in front of each intake.

The Copco No. 1 powerhouse is a reinforced-concrete substructure with a concrete and steel superstructure located at the base of Copco No. 1 Dam, on the right bank of the river. The two turbines are horizontal-shaft, double-runner Francis-type units with a total rated discharge capacity of 2,360 ft^3/s. Each turbine has a rated output of 18,600 hp with a net head of 125 feet. No bypass capacity is provided. The generators are each rated at 12,500 kVA with a 0.8 power factor (10 MW). Unit 1 has three indoor, single-phase 5,000-kVA, 2,300/72,000-V transformers, and Unit 2 has three indoor, single-phase 4,165-kVA, 2,300/72,000-V transformers, to step up the generator voltage for transmission interconnection. The Copco No. 1 powerhouse has four associated 69-kV transmission lines. PacifiCorp Line Nos. 26-1 and 26-2 are each approximately 0.07 mile long and connect the Copco No. 1 powerhouse to the Copco No. 1 switchyard, located on the right abutment above the powerhouse. PacifiCorp Line No. 15 is approximately 1.23 miles long and connects the Copco No. 1 switchyard to the Copco No. 2 powerhouse, and Line No. 3 is approximately 1.66 miles long and connects the Copco No. 1 switchyard to the Fall Creek powerhouse.

2.3 Copco No. 2 Dam and Powerhouse

The Copco No. 2 Development consists of a small reservoir, concrete diversion dam, embankment section, gated spillway, water conveyance system, and powerhouse, located on the Klamath River between approximately RM 199 and RM 196, in Siskiyou County, California. Refer to Figures 6, 7, 8, and 9 in Attachment A for plan views of these features. Property boundaries are shown on Figure 6. The dam was completed in 1925 approximately 1/4 mile downstream of Copco No. 1 Dam at RM 198.3, while the powerhouse is located at RM 196.8, upstream of Iron Gate Reservoir. The purpose of the facility is to generate hydroelectric power and to provide tailwater for operation of the Copco No. 1 powerhouse. No recreation facilities are provided. Structures in the vicinity of the powerhouse include a control center building, maintenance building, and oil and gas storage building. The nearby village includes a former cookhouse/bunkhouse, modern bunkhouse, garage/storage building, bungalow with garage, three occupied modular houses, four older ranch-style houses, and a school house/community center. Site access is provided from Interstate 5 by Copco Road, and then by a steep and narrow access road to the dam, or by Daggett Mountain Road to the powerhouse, crossing the Klamath River on a single-lane bridge. Ager-Beswick Road also provides access to the powerhouse from the south, and is an extension of the Topsy Grade Road in Oregon.

The reservoir created by Copco No. 2 Dam is approximately 1/4-mile long (unnamed), and has a total storage capacity of approximately 70 acre-feet at the normal operating

RWS elevation 2483, which ensures the minimum tailwater surface necessary for power generation at Copco No. 1. Copco No. 2 generation tracks Copco No. 1 generation.

The dam is a concrete gravity structure with a gated intake to a water conveyance tunnel on the left abutment, a central 145-foot-long spillway section with five 26- by 11-foot radial (Tainter) gates, and a 132-foot-long earthen embankment with gunite cutoff wall on the right abutment. The dam is 33 feet high, with an overall crest length of 335 feet and a crest width of 9 feet at elevation 2493. A manually-operated slide gate was provided to control a small sluiceway adjacent to the intake, but is not currently believed to be operational. A small corrugated metal pipe provides approximately 5 ft^3/s of flow to the bypass reach below the dam. The concrete gravity spillway crest is at elevation 2473, with a downstream apron at elevation 2456, between two concrete retaining walls. The estimated spillway discharge capacity at RWS elevation 2483 is 15,600 ft^3/s with the five spillway gates fully open. The remnant of a cofferdam is located upstream of the dam below the normal waterline. An old rock-filled timber crib is located high above the left abutment of the dam.

The intake structure incorporates a large trashrack and a 20- by 20-foot roller-mounted (caterpillar) gate at invert elevation 2456. The trash rack is 36.5- by 48-feet with a 4-inch bar spacing. The water conveyance system for the powerhouse includes 2,440 feet of concrete-lined tunnel (including an adit and air vent shaft), 1,313 feet of wood-stave pipeline, an additional 1,110 feet of concrete-lined tunnel, an underground surge tank (including an air vent and overflow spillway), and two steel penstocks. The diameter of the tunnel and wood stave pipeline sections is 16 feet. The two penstocks, one 405.5 feet long and one 410.6 feet long, range from 16 feet in diameter at the upstream ends to 8 feet in diameter at the turbine spiral cases. A 138-inch butterfly valve is provided near the downstream end of each penstock.

The Copco No. 2 powerhouse is a reinforced-concrete structure located 1.5 miles downstream of Copco No. 2 Dam on the left bank of the river. The two turbines are vertical-shaft, Francis-type units with a total rated discharge capacity of 2,676 ft^3/s. Each turbine has a rated output of 20,000 hp with a net head of 140 feet. No bypass capacity is provided. The synchronous generators are each rated at 15,000 kVA with a 0.9 power factor (13.5 MW). There are three outdoor, single-phase 10/20-MVA, 6,600/72,000-V transformers for each generator to step up the voltage. There are also three outdoor, single-phase 10/20-MVA, 73,800/230,000-V step-up transformers for interconnection to the transmission system. A 69-kV transmission line (PacifiCorp Line No. 15) is approximately 1.23 miles long and connects the Copco No. 2 powerhouse to the Copco No. 1 switchyard. A second 69-kV transmission line (also Line No. 15) is approximately 0.14 mile long and connects the Copco No. 2 powerhouse to the Copco No. 2 switchyard. Line No. 62 runs along the north side of Iron Gate reservoir for approximately 6.55 miles, to the Copco No. 2 switchyard.

2.4 Iron Gate Dam and Powerhouse

The Iron Gate Development consists of a reservoir, embankment dam, ungated side-channel spillway, diversion tunnel, intake structures, and powerhouse, located on the Klamath River between RM 197 and RM 190, about 20 miles northeast of Yreka, California, in Siskiyou County. Refer to Figures 10 and 11 in Attachment A for plan views of these features. Property boundaries are shown on Figure 10. The dam was completed in 1962 at RM 190.1. It is the farthest downstream hydroelectric facility of the Klamath Hydroelectric Project. The primary purpose of the Iron Gate facilities is to generate hydroelectric power. Recreation facilities include Fall Creek, Jenny Creek, Wanaka Springs, Camp Creek, Juniper Point, Mirror Cove, Overlook Point, and Long Gulch (each managed by PacifiCorp), and smaller dispersed shoreline recreation sites. Structures at the site include a communications building, restroom building, and two occupied residences. Site access is provided from Interstate 5 by Copco Road, and then by Lakeview Road to the dam crest and reservoir area, or by a project access road to the powerhouse. A single-lane bridge crosses the Klamath River downstream of the dam.

Iron Gate Dam impounds a reservoir of 944 acres (Iron Gate Reservoir) and currently provides approximately 53,800 acre-feet of total storage capacity at RWS elevation 2328. The maximum and minimum operating levels are between RWS elevations 2328 and 2324, a vertical operating range of 4 feet.

The dam is a zoned earthfill embankment with a current height of 189 feet from the rock foundation (elevation 2154) to the dam crest at elevation 2343. The dam crest is 20 feet wide and approximately 740 feet long. The embankment includes a central impervious clay core, with filter zones and a downstream drain, and is flanked by compacted pervious shells. The upstream face has a 2H:1V slope above elevation 2328, a 2-1/2H:1V slope between elevations 2328 and 2300, and a 3H:1V slope below elevation 2300, with a 29-foot-wide bench at elevation 2275. A 10-foot-thick riprap layer is provided on the upstream face for slope protection. The downstream face has a 1-3/4H:1V slope above elevation 2323, and a 2H:1V slope below elevation 2323, with a 10-foot-wide bench at elevation 2275. A 5-foot-thick riprap layer is provided on the downstream face for slope protection. The dam is founded on a sound basalt rock foundation, with a grout curtain beneath the impervious core. Modifications were completed in 2003 to raise the dam crest five feet from elevation 2338 to elevation 2343 by over-steepening the upstream and downstream slopes and decreasing the crest width from 30 feet to 20 feet. A sheet pile wall was also driven upstream of the dam centerline to extend five feet above the dam crest to provide freeboard, in addition to the 5-foot crest raise. The top of the sheetpile wall is at elevation 2348. Additional riprap materials were placed on the upstream face of the dam to protect those areas inundated by the higher reservoir elevations associated with large flood events.

There are fish trapping and holding facilities located on random fill at the downstream toe of the dam. The top of the random fill area is at elevation 2189.0. High- (elevation 2310) and low- (elevation 2250) level intakes for the fish facility cold water supply are incorporated in the dam on the left abutment. The fish facilities at the dam include six fish holding tanks, a spawning building, a fish ladder, and an aerator.

The spillway is excavated in rock on the right abutment, and consists of an ungated side-channel spillway crest with a concrete-lined chute. The spillway crest is at elevation 2328, or 15 feet below the raised dam crest. The spillway crest is 727 feet long and consists of a concrete ogee crest and slab placed over the excavated rock ridge. The upper part of the channel is partly lined with concrete. A 10- by 8-foot hinged trash/sluice gate is provided at the downstream end of the spillway crest for sluicing sediments and debris. A flip-bucket terminal structure is located at the downstream end of the spillway chute, approximately 2,150 feet beyond the toe of the dam. The spillway has a design discharge capacity of 26,200 ft^3/s at RWS elevation 2333.0. The modifications completed in 2003 included shotcrete protection at the top of the spillway crest and chute.

The diversion tunnel used during construction of the dam was driven through bedrock in the right abutment and terminates in a reinforced concrete outlet structure near the downstream toe of the dam. The diversion tunnel intake is a reinforced concrete structure equipped with four 10- by 33-foot trashracks and is located approximately 480 feet upstream from the dam axis near the upstream toe. Control of the flow in the tunnel is provided by a two-piece concrete slide gate located in a gate shaft approximately 112 feet upstream of the dam axis. The slide gate hoist and controls are housed in a reinforced concrete tower accessible by footbridge from the dam crest. Operation of the upper sluice gate is limited to an opening of 23.5 inches at RWS elevation 2328, with a corresponding discharge capacity of 1,750 ft^3/s; under emergency conditions, a full gate opening of 57 inches would produce a release of 2,700 ft^3/s[4]. The lower diversion gate is currently welded in place. Recent modifications added a 9-foot-diameter hinged blind flange and concrete ring approximately 20 feet downstream of the concrete slide gate (designed for full reservoir head) to permit underwater inspection of the gate.

The intake structure for the powerhouse is a 45-foot-high, free-standing, reinforced-concrete tower, located in the reservoir immediately upstream of the left abutment and accessible by footbridge from the abutment. It houses a 12- by 17-foot wheel-mounted slide gate, which controls the flow into a 12-foot-diameter, welded-steel penstock. The penstock is concrete-encased where it penetrates the dam approximately 35 feet below the normal maximum reservoir level. The penstock is supported on concrete supports down the dam abutment. There is a 17.5- by 45-foot trash rack at the penstock entrance with a 4-inch bar spacing.

The Iron Gate powerhouse is an outdoor-type facility located at the downstream toe of the dam on the left bank, and consists of a single vertical-shaft, Francis-type turbine with a rated discharge capacity of 1,735 ft^3/s. The turbine has a rated output of 25,000 hp with a net head of 154 feet. In the event of a turbine shutdown, a synchronized Howell-Bunger bypass valve located immediately upstream of the turbine diverts water around the turbine to maintain flows downstream of the dam. The synchronous generator is

[4] From PacifiCorp - Iron Gate Dam - Diversion Tunnel Gate Rating Curve dated February 26, 2008.

rated at 18,975 kVA with a 0.95 power factor (18 MW). There is a single outdoor, three-phase 19-MVA, 6,600/69,000-V step-up transformer at the powerhouse for interconnection to the transmission system. The Iron Gate powerhouse has one associated 69-kV transmission line. Line No. 62 runs along the north side of Iron Gate reservoir for approximately 6.55 miles, to the Copco No. 2 switchyard.

The Iron Gate fish hatchery was constructed in 1966 and is located on the left bank downstream of Iron Gate Dam, adjacent to the Bogus Creek tributary. The hatchery complex includes an office, warehouse, hatchery/incubator building, four fish rearing ponds, a fish ladder with trap, visitor information center, and four employee residences. Up to 50 ft^3/s of cold water is diverted from the Iron Gate reservoir to supply the 32 raceways and fish ladder. The hatchery produces Chinook salmon, steelhead trout, and Coho salmon. Annual production goals of the hatchery are 6 million Chinook, 200,000 steelhead, and 75,000 Coho. The hatchery is operated by the California Department of Fish and Game, with 100 percent of the operations and maintenance costs currently funded by PacifiCorp.

3.0 Hydrology

Several studies of the hydrology for the Klamath River basin were conducted and reports of these studies are detailed in Reclamation (2011). A brief summary of the hydrology for current conditions is given in this chapter.

3.1 Rainfall and Temperature

Monthly average temperature and precipitation data at Klamath Falls, Oregon and at Yreka, California are summarized in Figure 3.1 and Figure 3.2, respectively. The months with the highest temperatures are July, August, and September. The wettest months are November, December, and January. The average annual precipitation for the period from 1907 to 1997 at Klamath Falls was 13.4 inches and the average annual precipitation from 1959 to 2009 at Copco 1 was about 20 inches.

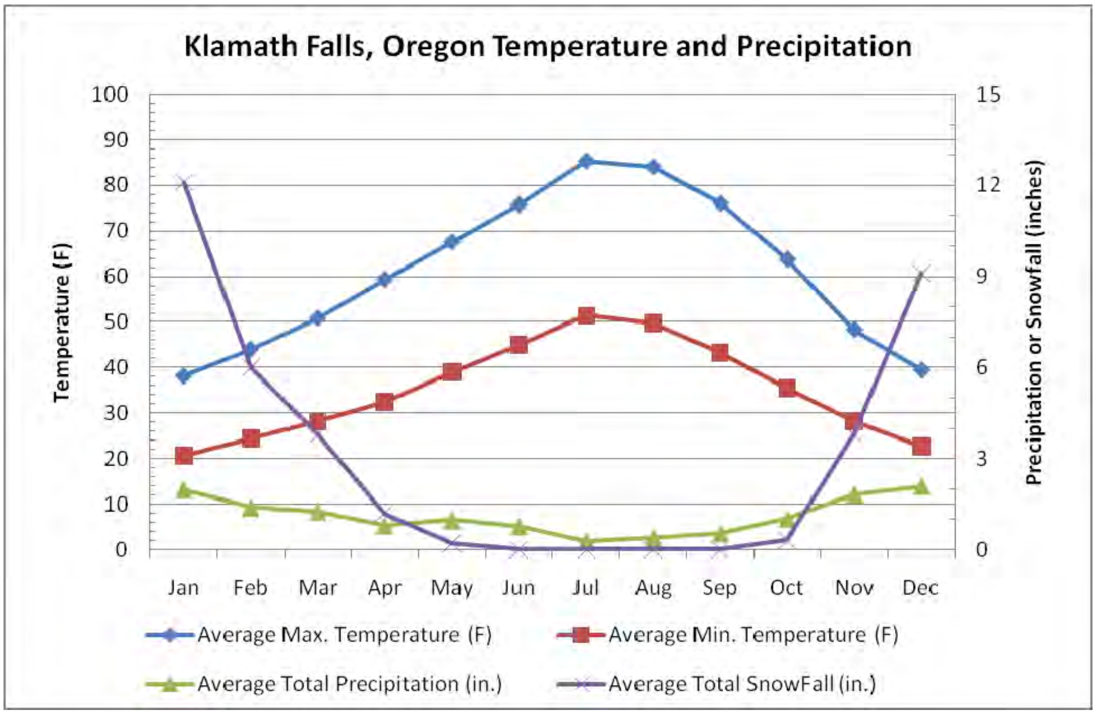


Figure 3.1. Average monthly temperatures and precipitation at Klamath Falls (gage # 354506 at 41.97972 N, 1222.33778 W). Period of record is from 5/11/1887 to 5/31/2001. Data obtained from Western Regional Climate Center (http://www.wrcc.dri.edu/).

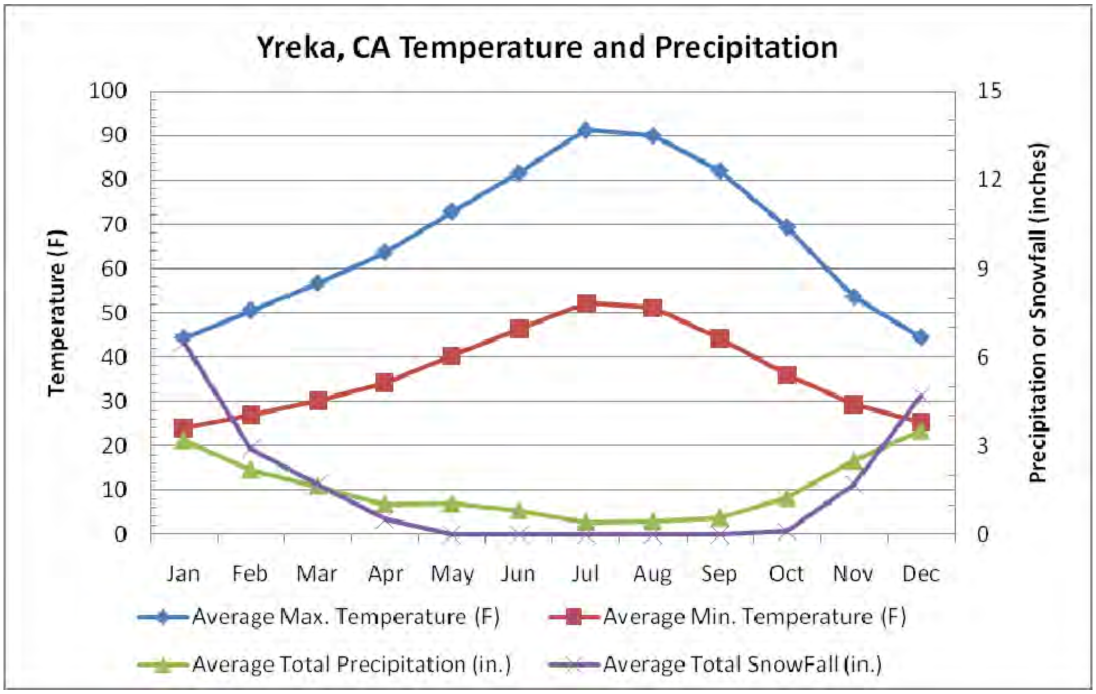


Figure 3.2. Average monthly temperatures and precipitation at Yreka, CA (gage # 049866). Period of record is from 2/1/1893 to 4/30/2010. Data obtained from Western Regional Climate Center (http://www.wrcc.dri.edu/).

3.2 Stream Flows

The United States Geological Survey (USGS) operates several stream gages on the Klamath River (Table 3.1). The median daily average flows on the Klamath River below Keno Dam, below Iron Gate Dam, near Seiad Valley, at Orleans, and near Klamath for the period of record from 10/1/1960 to 9/30/2009 is provided in Figure 3.3. The months of July through October generally have much lower flows than the months of the spring runoff. Also, the tributaries downstream of Iron Gate contribute significant amounts of flow during all times of the year. The specific ratio of the tributary contribution does change with time of the year, however. During the month of August, the median flow at Iron Gate is about 1,000 ft^3/s and the median flow at Orleans is about 1,800 ft^3/s (an increase of 80 percent). During the month of March, the median flow at Iron Gate is about 2,500 ft^3/s whereas the median flow at Orleans is greater than 11,000 ft^3/s (an increase of 340 percent). A flow duration analysis based upon daily average flows at the PacifiCorp dams is given in Table 3.2.

The daily flow statistics below J.C. Boyle Dam are shown in Figure 3.4 and below Iron Gate Dam are shown in Figure 3.5. The median flows are greatest in March, during spring runoff, but the largest of the peak flows occur in December and January.

The results of a flood frequency analysis at each of the gages are provided in Table 3.3. The peak flows at Iron Gate Dam are significantly greater than the peak flows at J.C. Boyle Dam. This is due to the tributaries that enter the Klamath River between the two dams. In particular, Jenny Creek contributes a large amount to the peak flow during the winter and spring months. The watershed area of Jenny Creek is 210 mi^2 and it is the largest single tributary between Keno Dam and Iron Gate Dam.

Because the deconstruction of Iron Gate and J.C. Boyle Dams will occur primarily during the period from July 1 through November 30, a separate flood frequency analysis was performed for this time period and the results are provided in Table 3.4. The 100-year peak discharge at Iron Gate is reduced from 31,460 ft^3/s on an annual basis (Table 3.3) to 8,390 ft^3/s on a seasonal basis (Table 3.4). The flood frequency analyses for August and September are provided in Table 3.5 and Table 3.6, respectively.

Table 3.7 contains the computed average daily discharge at Keno, J.C. Boyle, Copco, and Iron Gate Dams for every day of the year, based upon the flow record from WY 1961 to 2010.

Table 3.1. USGS gages on the Klamath River.

USGS Gaging Station	Station Name	Drainage Area (mi^2)	Latitude	Longitude	Gage Elevation (feet)	Period of Record (Water Years)
11509500	Klamath River at Keno, OR	3,920	42°08’00”	121°57’40”	3,961	1905-1913 1930-2009
11510700	Klamath River below John C. Boyle Power Plant near Keno, OR	4,080	42°05’05”	122°04’20”	3,275	1959-2009
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	1961-2009
11520500	Klamath River near Seiad Valley, CA	6,940	41°51’14”	123°13’52”	1,320	1913-1925 1952-2009
11523000	Klamath River at Orleans, CA	8,475	41°18’13”	123°32’00”	356	1927-2009
11530500	Klamath River near Klamath, CA	12,100	41°30’40”	123°58’42”	5.6	1911-1927 1932-1994, 1996, 1998-2009

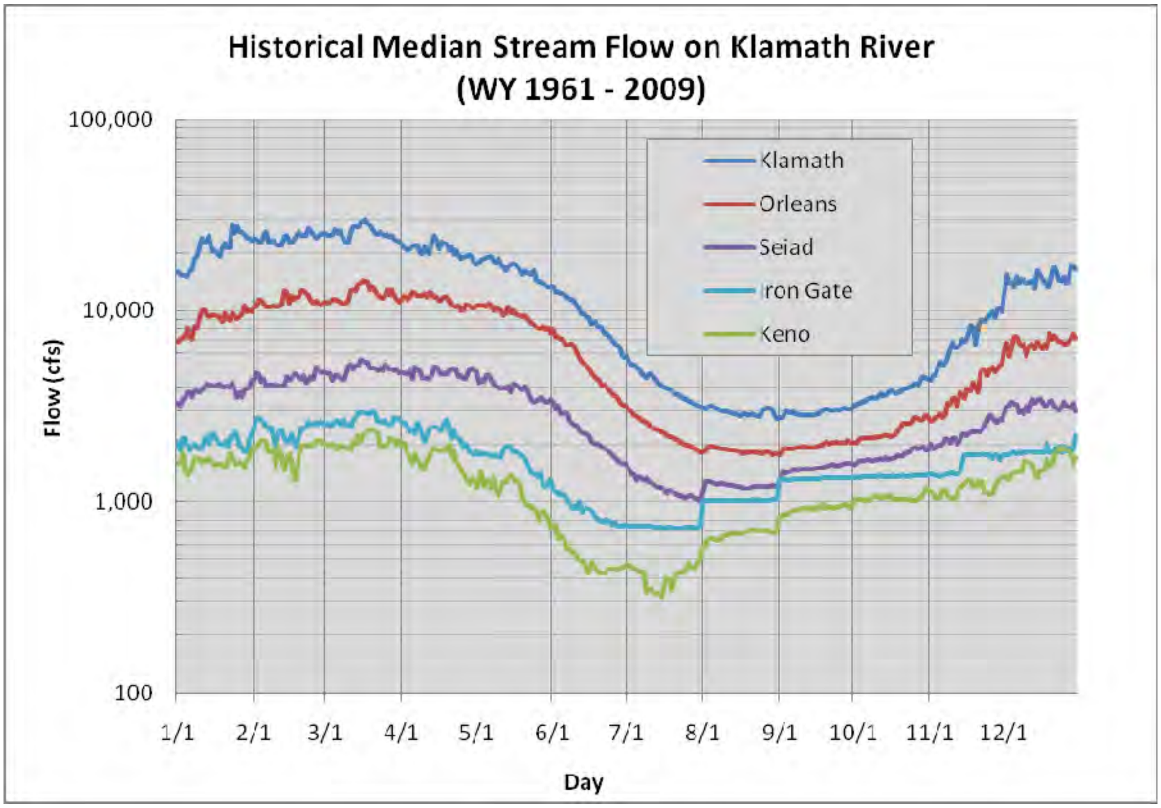


Figure 3.3. Median Flows at USGS stream gages on Klamath River.

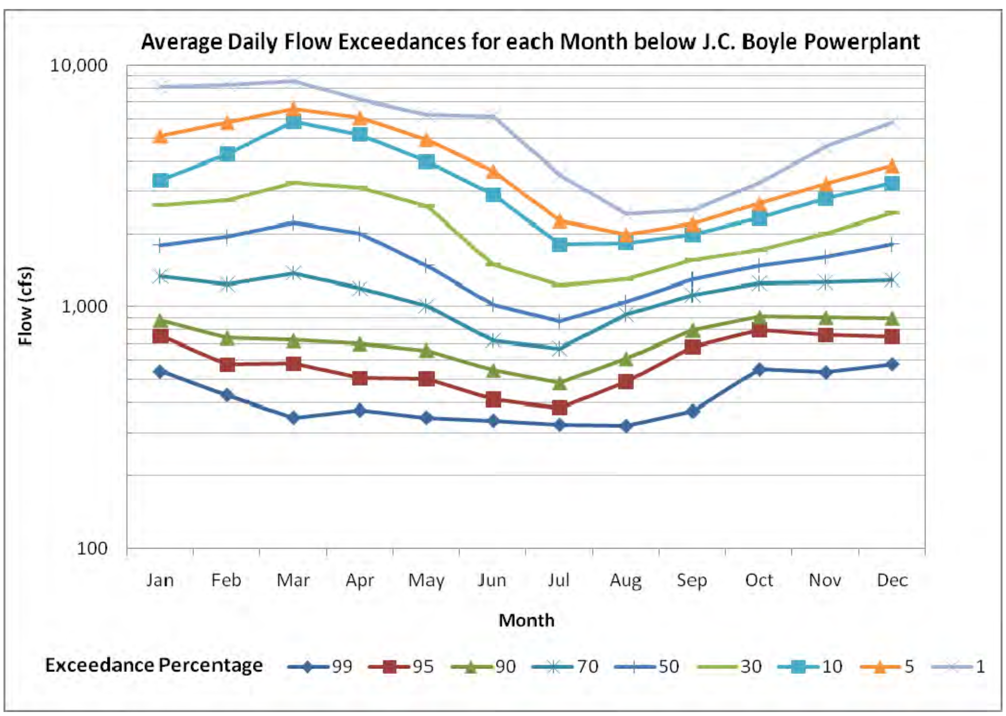


Figure 3.4. Stream Flow Statistics for JC Boyle Stream Gage below JC Boyle Dam, WY 1960 – 2009.

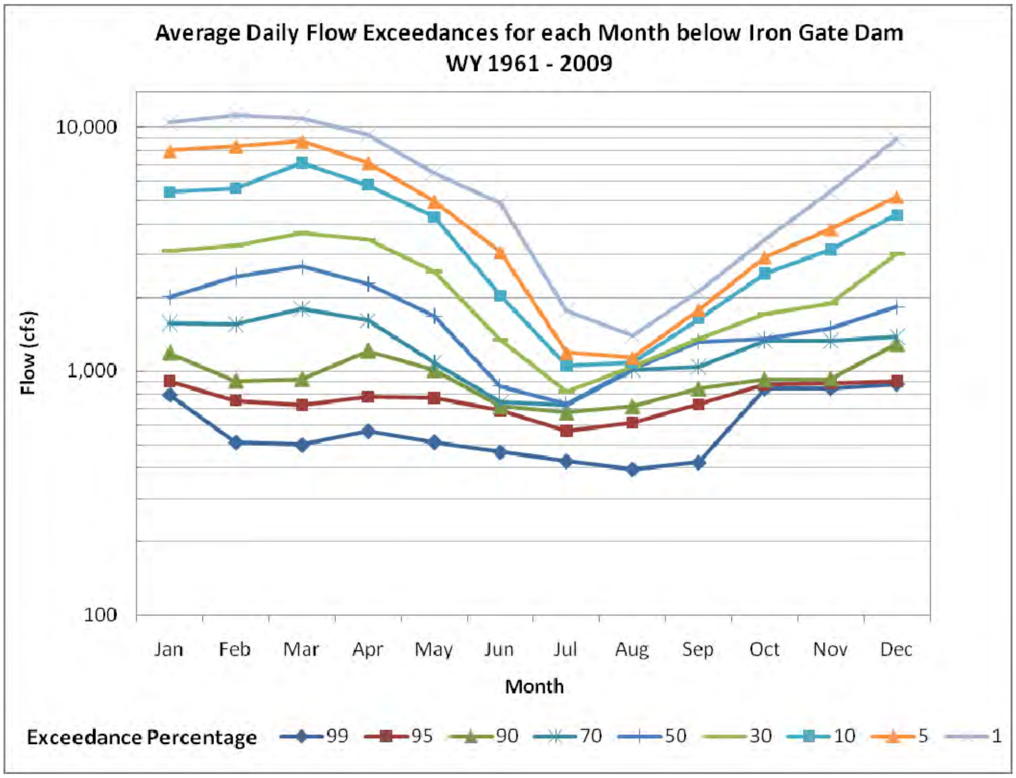


Figure 3.5. Daily average flow statistics for each month on the Klamath River at Iron Gate gage for the period of record WY 1961 – 2009.

Table 3.2. Daily Flow Duration – Annual and Seasonal (July 1 – November 30), based upon historical data.

% of time equaled or exceeded	Discharge (ft³/s)							
	Annual				Seasonal (July 1 – Nov 30)			
	Keno	Boyle	Copco	Iron Gate	Keno	Boyle	Copco	Iron Gate
99	152	331	290	528	147	325	294	441
95	297	522	529	716	292	473	524	701
90	431	635	643	741	417	592	604	725
80	645	802	882	955	621	725	823	846
70	821	962	1088	1040	737	856	973	1000
60	990	1130	1269	1320	901	960	1150	1030
50	1180	1260	1483	1360	1020	1060	1273	1130
40	1440	1480	1730	1700	1180	1180	1470	1320
30	1800	1810	2104	1977	1390	1280	1670	1350
20	2390	2660	2640	2980	1580	1490	1905	1510
10	3120	3200	3350	3870	1960	1890	2300	1840
5	4320	4530	4486	5500	2450	2710	2720	2920
1	6875	7660	7295	9167	3300	3970	3536	4350

Table 3.3. Annual Flood Frequency analysis on Klamath River for 10-yr to 100-yr floods.

Gaging Station	Drainage Area	Discharge (ft^3/s)				
		Gage Base	10-yr	25-yr	50-yr	100-yr
Keno	3,920	4,000	8,642	10,350	11,200	11,800
Boyle	4,080	4,000	9,058	11,050	12,220	13,150
Copco	4,370	5,400	10,750	12,720	13,730	14,470
Iron Gate	4,630	N/A	15,610	21,460	26,280	31,460
Seiad	6,940	N/A	56,540	93,400	131,000	179,300
Orleans	8,470	N/A	163,100	230,300	287,000	348,900
Klamath	12,100	N/A	298,300	392,900	466,900	543,300

Table 3.4. Klamath River Seasonal Peak Discharge Frequency (July 1 – November 30).

Gaging Station	Discharge (ft^3/s)				
	Gage Base	10-yr	25-yr	50-yr	100-yr
Keno	2,550	3,870	4,610	5,180	5,760
Boyle	3,300	4,560	5,250	5,770	6,300
Copco	4,350	5,540	6,200	6,720	7,270
Iron Gate	N/A	4,500	5,910	7,100	8,390

Table 3.5 – Klamath River August Peak Discharge Frequency.

Gaging Station	Discharge (ft^3/s)				
	Gage Base	10-yr	25-yr	50-yr	100-yr
Boyle	2,250	3,080	3,460	3,720	3,970
Iron Gate	N/A	2,290	2,420	2,500	2,590

Table 3.6 – Klamath River September Peak Discharge Frequency.

Gaging Station	Discharge (ft^3/s)				
	Gage Base	10-yr	25-yr	50-yr	100-yr
Boyle	2,600	3,340	3,590	3,730	3,840
Iron Gate	N/A	2,820	3,050	3,220	3,390

Table 3.7 – Average Daily Discharge on Klamath near PacifiCorp Dams.

Daily Klamath River at Keno, OR – Water Year 1961-2010 – Average Daily Discharge (ft3/s)

Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge
1-Jan	2108	1-Mar	2375	1-May	1744	1-Jul	597	1-Sep	795	1-Nov	1372
2-Jan	2132	2-Mar	2417	2-May	1731	2-Jul	584	2-Sep	836	2-Nov	1420
3-Jan	2163	3-Mar	2499	3-May	1727	3-Jul	573	3-Sep	842	3-Nov	1386
4-Jan	2128	4-Mar	2477	4-May	1677	4-Jul	547	4-Sep	853	4-Nov	1393
5-Jan	2104	5-Mar	2475	5-May	1660	5-Jul	539	5-Sep	834	5-Nov	1415
6-Jan	2102	6-Mar	2475	6-May	1643	6-Jul	512	6-Sep	825	6-Nov	1450
7-Jan	2128	7-Mar	2519	7-May	1642	7-Jul	487	7-Sep	843	7-Nov	1454
8-Jan	2123	8-Mar	2546	8-May	1727	8-Jul	485	8-Sep	856	8-Nov	1434
9-Jan	2104	9-Mar	2577	9-May	1702	9-Jul	463	9-Sep	878	9-Nov	1433
10-Jan	2044	10-Mar	2641	10-May	1682	10-Jul	445	10-Sep	878	10-Nov	1438
11-Jan	1985	11-Mar	2705	11-May	1697	11-Jul	439	11-Sep	891	11-Nov	1426
12-Jan	1937	12-Mar	2713	12-May	1727	12-Jul	427	12-Sep	879	12-Nov	1454
13-Jan	1975	13-Mar	2713	13-May	1757	13-Jul	407	13-Sep	842	13-Nov	1508
14-Jan	2009	14-Mar	2775	14-May	1805	14-Jul	410	14-Sep	852	14-Nov	1538
15-Jan	2022	15-Mar	2786	15-May	1787	15-Jul	419	15-Sep	876	15-Nov	1550
16-Jan	2028	16-Mar	2763	16-May	1712	16-Jul	424	16-Sep	900	16-Nov	1561
17-Jan	2038	17-Mar	2801	17-May	1692	17-Jul	433	17-Sep	937	17-Nov	1576
18-Jan	2079	18-Mar	2807	18-May	1665	18-Jul	441	18-Sep	952	18-Nov	1583
19-Jan	2101	19-Mar	2770	19-May	1525	19-Jul	448	19-Sep	933	19-Nov	1591
20-Jan	2100	20-Mar	2719	20-May	1437	20-Jul	445	20-Sep	930	20-Nov	1614
21-Jan	2115	21-Mar	2682	21-May	1409	21-Jul	439	21-Sep	947	21-Nov	1620
22-Jan	2200	22-Mar	2621	22-May	1385	22-Jul	446	22-Sep	943	22-Nov	1618
23-Jan	2275	23-Mar	2551	23-May	1360	23-Jul	451	23-Sep	941	23-Nov	1602
24-Jan	2305	24-Mar	2560	24-May	1317	24-Jul	453	24-Sep	948	24-Nov	1604
25-Jan	2282	25-Mar	2627	25-May	1273	25-Jul	463	25-Sep	970	25-Nov	1611
26-Jan	2264	26-Mar	2651	26-May	1276	26-Jul	472	26-Sep	976	26-Nov	1634
27-Jan	2261	27-Mar	2653	27-May	1276	27-Jul	473	27-Sep	963	27-Nov	1670
28-Jan	2295	28-Mar	2659	28-May	1256	28-Jul	472	28-Sep	980	28-Nov	1691
29-Jan	2265	29-Mar	2607	29-May	1210	29-Jul	475	29-Sep	976	29-Nov	1731
30-Jan	2253	30-Mar	2574	30-May	1159	30-Jul	501	30-Sep	967	30-Nov	1738
31-Jan	2213	31-Mar	2633	31-May	1101	31-Jul	520	1-Oct	1004	1-Dec	1737
1-Feb	2187	1-Apr	2599	1-Jun	1090	1-Aug	549	2-Oct	1040	2-Dec	1741
2-Feb	2181	2-Apr	2615	2-Jun	1106	2-Aug	555	3-Oct	1033	3-Dec	1759
3-Feb	2145	3-Apr	2602	3-Jun	1134	3-Aug	568	4-Oct	1037	4-Dec	1812
4-Feb	2168	4-Apr	2523	4-Jun	1128	4-Aug	590	5-Oct	1102	5-Dec	1837
5-Feb	2172	5-Apr	2497	5-Jun	1108	5-Aug	588	6-Oct	1144	6-Dec	1804
6-Feb	2203	6-Apr	2489	6-Jun	1078	6-Aug	588	7-Oct	1143	7-Dec	1812
7-Feb	2150	7-Apr	2399	7-Jun	1003	7-Aug	580	8-Oct	1140	8-Dec	1887
8-Feb	2075	8-Apr	2346	8-Jun	944	8-Aug	583	9-Oct	1194	9-Dec	1923
9-Feb	2068	9-Apr	2307	9-Jun	897	9-Aug	602	10-Oct	1187	10-Dec	1920
10-Feb	2012	10-Apr	2269	10-Jun	848	10-Aug	614	11-Oct	1192	11-Dec	1912
11-Feb	1999	11-Apr	2261	11-Jun	816	11-Aug	627	12-Oct	1199	12-Dec	1870
12-Feb	1990	12-Apr	2294	12-Jun	804	12-Aug	630	13-Oct	1244	13-Dec	1800
13-Feb	1974	13-Apr	2376	13-Jun	800	13-Aug	635	14-Oct	1254	14-Dec	1796
14-Feb	1982	14-Apr	2389	14-Jun	806	14-Aug	644	15-Oct	1236	15-Dec	1885
15-Feb	2051	15-Apr	2368	15-Jun	774	15-Aug	629	16-Oct	1233	16-Dec	1945
16-Feb	2103	16-Apr	2315	16-Jun	752	16-Aug	648	17-Oct	1216	17-Dec	1926
17-Feb	2120	17-Apr	2263	17-Jun	751	17-Aug	653	18-Oct	1199	18-Dec	1927
18-Feb	2191	18-Apr	2226	18-Jun	730	18-Aug	669	19-Oct	1223	19-Dec	1913
19-Feb	2318	19-Apr	2190	19-Jun	690	19-Aug	682	20-Oct	1234	20-Dec	1945
20-Feb	2381	20-Apr	2136	20-Jun	663	20-Aug	682	21-Oct	1228	21-Dec	1947
21-Feb	2393	21-Apr	2009	21-Jun	633	21-Aug	686	22-Oct	1229	22-Dec	1943
22-Feb	2417	22-Apr	1986	22-Jun	618	22-Aug	692	23-Oct	1259	23-Dec	1979
23-Feb	2445	23-Apr	1984	23-Jun	611	23-Aug	699	24-Oct	1240	24-Dec	2004
24-Feb	2436	24-Apr	1926	24-Jun	607	24-Aug	699	25-Oct	1235	25-Dec	1997
25-Feb	2406	25-Apr	1885	25-Jun	613	25-Aug	698	26-Oct	1261	26-Dec	2018
26-Feb	2376	26-Apr	1870	26-Jun	609	26-Aug	711	27-Oct	1277	27-Dec	2024
27-Feb	2344	27-Apr	1831	27-Jun	611	27-Aug	719	28-Oct	1304	28-Dec	2029
28-Feb	2336	28-Apr	1810	28-Jun	621	28-Aug	699	29-Oct	1338	29-Dec	2019
29-Feb	2508	29-Apr	1814	29-Jun	604	29-Aug	695	30-Oct	1370	30-Dec	2025
		30-Apr	1808	30-Jun	601	30-Aug	693	31-Oct	1355	31-Dec	2097
						31-Aug	722				

Klamath River below J.C. Boyle near Keno, OR – Water Year 1961-2010 – Average Daily Discharge (ft^3/s)

Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge
1-Jan	2324	1-Mar	2577	1-May	2044	1-Jul	852	1-Sep	1046	1-Nov	1594
2-Jan	2373	2-Mar	2638	2-May	2026	2-Jul	871	2-Sep	1068	2-Nov	1645
3-Jan	2376	3-Mar	2746	3-May	2042	3-Jul	816	3-Sep	1072	3-Nov	1599
4-Jan	2374	4-Mar	2705	4-May	1983	4-Jul	785	4-Sep	1085	4-Nov	1618
5-Jan	2352	5-Mar	2735	5-May	1946	5-Jul	808	5-Sep	1081	5-Nov	1617
6-Jan	2332	6-Mar	2688	6-May	1920	6-Jul	800	6-Sep	1068	6-Nov	1672
7-Jan	2341	7-Mar	2781	7-May	1909	7-Jul	748	7-Sep	1081	7-Nov	1700
8-Jan	2347	8-Mar	2788	8-May	2004	8-Jul	739	8-Sep	1100	8-Nov	1638
9-Jan	2342	9-Mar	2827	9-May	2021	9-Jul	708	9-Sep	1085	9-Nov	1636
10-Jan	2288	10-Mar	2861	10-May	1992	10-Jul	674	10-Sep	1130	10-Nov	1664
11-Jan	2215	11-Mar	2957	11-May	1972	11-Jul	660	11-Sep	1140	11-Nov	1633
12-Jan	2197	12-Mar	2943	12-May	2019	12-Jul	650	12-Sep	1116	12-Nov	1686
13-Jan	2202	13-Mar	2965	13-May	2035	13-Jul	648	13-Sep	1082	13-Nov	1712
14-Jan	2249	14-Mar	3018	14-May	2074	14-Jul	667	14-Sep	1092	14-Nov	1755
15-Jan	2282	15-Mar	3006	15-May	2076	15-Jul	650	15-Sep	1094	15-Nov	1757
16-Jan	2273	16-Mar	3019	16-May	2011	16-Jul	674	16-Sep	1116	16-Nov	1777
17-Jan	2284	17-Mar	3033	17-May	1961	17-Jul	686	17-Sep	1192	17-Nov	1780
18-Jan	2297	18-Mar	3040	18-May	1962	18-Jul	687	18-Sep	1203	18-Nov	1801
19-Jan	2292	19-Mar	2984	19-May	1840	19-Jul	699	19-Sep	1204	19-Nov	1785
20-Jan	2335	20-Mar	2958	20-May	1714	20-Jul	691	20-Sep	1191	20-Nov	1812
21-Jan	2308	21-Mar	2918	21-May	1691	21-Jul	703	21-Sep	1188	21-Nov	1813
22-Jan	2385	22-Mar	2849	22-May	1666	22-Jul	700	22-Sep	1192	22-Nov	1815
23-Jan	2468	23-Mar	2806	23-May	1608	23-Jul	667	23-Sep	1183	23-Nov	1806
24-Jan	2498	24-Mar	2788	24-May	1606	24-Jul	691	24-Sep	1182	24-Nov	1822
25-Jan	2469	25-Mar	2841	25-May	1551	25-Jul	709	25-Sep	1218	25-Nov	1837
26-Jan	2464	26-Mar	2894	26-May	1564	26-Jul	716	26-Sep	1228	26-Nov	1832
27-Jan	2435	27-Mar	2875	27-May	1554	27-Jul	724	27-Sep	1161	27-Nov	1867
28-Jan	2497	28-Mar	2903	28-May	1547	28-Jul	736	28-Sep	1212	28-Nov	1923
29-Jan	2484	29-Mar	2828	29-May	1499	29-Jul	732	29-Sep	1185	29-Nov	1929
30-Jan	2481	30-Mar	2837	30-May	1467	30-Jul	762	30-Sep	1236	30-Nov	1957
31-Jan	2450	31-Mar	2845	31-May	1344	31-Jul	744	1-Oct	1233	1-Dec	1962
1-Feb	2414	1-Apr	2839	1-Jun	1380	1-Aug	804	2-Oct	1275	2-Dec	1924
2-Feb	2413	2-Apr	2836	2-Jun	1352	2-Aug	798	3-Oct	1279	3-Dec	1983
3-Feb	2414	3-Apr	2847	3-Jun	1393	3-Aug	817	4-Oct	1276	4-Dec	2012
4-Feb	2391	4-Apr	2751	4-Jun	1389	4-Aug	820	5-Oct	1347	5-Dec	2028
5-Feb	2397	5-Apr	2745	5-Jun	1376	5-Aug	827	6-Oct	1373	6-Dec	2014
6-Feb	2395	6-Apr	2717	6-Jun	1359	6-Aug	844	7-Oct	1391	7-Dec	2003
7-Feb	2384	7-Apr	2691	7-Jun	1285	7-Aug	825	8-Oct	1351	8-Dec	2066
8-Feb	2289	8-Apr	2594	8-Jun	1196	8-Aug	849	9-Oct	1446	9-Dec	2119
9-Feb	2284	9-Apr	2545	9-Jun	1184	9-Aug	836	10-Oct	1420	10-Dec	2080
10-Feb	2243	10-Apr	2505	10-Jun	1107	10-Aug	853	11-Oct	1443	11-Dec	2101
11-Feb	2191	11-Apr	2506	11-Jun	1094	11-Aug	879	12-Oct	1446	12-Dec	2059
12-Feb	2193	12-Apr	2553	12-Jun	1088	12-Aug	851	13-Oct	1468	13-Dec	2021
13-Feb	2185	13-Apr	2602	13-Jun	1064	13-Aug	887	14-Oct	1467	14-Dec	1987
14-Feb	2191	14-Apr	2611	14-Jun	1091	14-Aug	891	15-Oct	1491	15-Dec	2069
15-Feb	2265	15-Apr	2613	15-Jun	1028	15-Aug	875	16-Oct	1460	16-Dec	2175
16-Feb	2301	16-Apr	2530	16-Jun	1015	16-Aug	923	17-Oct	1456	17-Dec	2116
17-Feb	2333	17-Apr	2517	17-Jun	1008	17-Aug	891	18-Oct	1418	18-Dec	2137
18-Feb	2402	18-Apr	2489	18-Jun	1007	18-Aug	891	19-Oct	1450	19-Dec	2108
19-Feb	2555	19-Apr	2436	19-Jun	950	19-Aug	940	20-Oct	1504	20-Dec	2137
20-Feb	2578	20-Apr	2412	20-Jun	919	20-Aug	935	21-Oct	1459	21-Dec	2143
21-Feb	2629	21-Apr	2328	21-Jun	894	21-Aug	930	22-Oct	1466	22-Dec	2190
22-Feb	2662	22-Apr	2232	22-Jun	872	22-Aug	923	23-Oct	1522	23-Dec	2240
23-Feb	2655	23-Apr	2265	23-Jun	880	23-Aug	930	24-Oct	1499	24-Dec	2277
24-Feb	2668	24-Apr	2244	24-Jun	858	24-Aug	933	25-Oct	1458	25-Dec	2238
25-Feb	2642	25-Apr	2172	25-Jun	851	25-Aug	928	26-Oct	1497	26-Dec	2280
26-Feb	2580	26-Apr	2126	26-Jun	869	26-Aug	943	27-Oct	1506	27-Dec	2271
27-Feb	2573	27-Apr	2137	27-Jun	861	27-Aug	957	28-Oct	1535	28-Dec	2281
28-Feb	2584	28-Apr	2097	28-Jun	881	28-Aug	963	29-Oct	1551	29-Dec	2275
29-Feb	2717	29-Apr	2094	29-Jun	863	29-Aug	972	30-Oct	1609	30-Dec	2286
		30-Apr	2095	30-Jun	856	30-Aug	929	31-Oct	1582	31-Dec	2345
						31-Aug	980				

Klamath River blw Fall Creek near Copco, CA – Water Year 1961-2010 – Average Daily Discharge (ft^3/s)

Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge
1-Jan	2411	1-Mar	2721	1-May	2063	1-Jul	862	1-Sep	1078	1-Nov	1669
2-Jan	2437	2-Mar	2765	2-May	2041	2-Jul	846	2-Sep	1105	2-Nov	1730
3-Jan	2490	3-Mar	2834	3-May	2038	3-Jul	837	3-Sep	1111	3-Nov	1691
4-Jan	2456	4-Mar	2799	4-May	1986	4-Jul	809	4-Sep	1122	4-Nov	1704
5-Jan	2431	5-Mar	2813	5-May	1969	5-Jul	811	5-Sep	1119	5-Nov	1702
6-Jan	2421	6-Mar	2813	6-May	1950	6-Jul	778	6-Sep	1109	6-Nov	1732
7-Jan	2444	7-Mar	2853	7-May	1944	7-Jul	752	7-Sep	1130	7-Nov	1760
8-Jan	2432	8-Mar	2884	8-May	2037	8-Jul	748	8-Sep	1137	8-Nov	1734
9-Jan	2431	9-Mar	2919	9-May	2013	9-Jul	722	9-Sep	1145	9-Nov	1739
10-Jan	2367	10-Mar	2982	10-May	1992	10-Jul	704	10-Sep	1145	10-Nov	1743
11-Jan	2307	11-Mar	3034	11-May	2007	11-Jul	708	11-Sep	1179	11-Nov	1729
12-Jan	2263	12-Mar	3044	12-May	2038	12-Jul	696	12-Sep	1162	12-Nov	1743
13-Jan	2295	13-Mar	3055	13-May	2068	13-Jul	668	13-Sep	1124	13-Nov	1791
14-Jan	2316	14-Mar	3136	14-May	2118	14-Jul	675	14-Sep	1134	14-Nov	1842
15-Jan	2330	15-Mar	3141	15-May	2099	15-Jul	678	15-Sep	1159	15-Nov	1857
16-Jan	2349	16-Mar	3128	16-May	2022	16-Jul	681	16-Sep	1168	16-Nov	1864
17-Jan	2356	17-Mar	3168	17-May	2000	17-Jul	698	17-Sep	1208	17-Nov	1887
18-Jan	2404	18-Mar	3141	18-May	1973	18-Jul	706	18-Sep	1238	18-Nov	1894
19-Jan	2427	19-Mar	3096	19-May	1828	19-Jul	714	19-Sep	1222	19-Nov	1889
20-Jan	2424	20-Mar	3083	20-May	1740	20-Jul	711	20-Sep	1219	20-Nov	1901
21-Jan	2429	21-Mar	3025	21-May	1711	21-Jul	705	21-Sep	1233	21-Nov	1930
22-Jan	2506	22-Mar	2962	22-May	1685	22-Jul	704	22-Sep	1230	22-Nov	1931
23-Jan	2605	23-Mar	2890	23-May	1654	23-Jul	709	23-Sep	1209	23-Nov	1897
24-Jan	2642	24-Mar	2899	24-May	1610	24-Jul	720	24-Sep	1211	24-Nov	1889
25-Jan	2617	25-Mar	2971	25-May	1565	25-Jul	730	25-Sep	1259	25-Nov	1943
26-Jan	2593	26-Mar	2995	26-May	1567	26-Jul	739	26-Sep	1264	26-Nov	1940
27-Jan	2589	27-Mar	2997	27-May	1570	27-Jul	741	27-Sep	1251	27-Nov	1962
28-Jan	2610	28-Mar	3005	28-May	1546	28-Jul	740	28-Sep	1269	28-Nov	1999
29-Jan	2585	29-Mar	2953	29-May	1499	29-Jul	733	29-Sep	1265	29-Nov	2045
30-Jan	2584	30-Mar	2922	30-May	1453	30-Jul	760	30-Sep	1234	30-Nov	2044
31-Jan	2545	31-Mar	2986	31-May	1395	31-Jul	789	1-Oct	1273	1-Dec	2057
1-Feb	2525	1-Apr	2931	1-Jun	1378	1-Aug	820	2-Oct	1312	2-Dec	2067
2-Feb	2520	2-Apr	2957	2-Jun	1403	2-Aug	825	3-Oct	1318	3-Dec	2055
3-Feb	2468	3-Apr	2945	3-Jun	1420	3-Aug	838	4-Oct	1336	4-Dec	2105
4-Feb	2480	4-Apr	2861	4-Jun	1420	4-Aug	862	5-Oct	1398	5-Dec	2155
5-Feb	2480	5-Apr	2834	5-Jun	1399	5-Aug	851	6-Oct	1441	6-Dec	2121
6-Feb	2539	6-Apr	2827	6-Jun	1368	6-Aug	851	7-Oct	1437	7-Dec	2124
7-Feb	2496	7-Apr	2734	7-Jun	1291	7-Aug	852	8-Oct	1419	8-Dec	2203
8-Feb	2431	8-Apr	2677	8-Jun	1230	8-Aug	856	9-Oct	1471	9-Dec	2243
9-Feb	2378	9-Apr	2633	9-Jun	1182	9-Aug	875	10-Oct	1487	10-Dec	2219
10-Feb	2317	10-Apr	2604	10-Jun	1125	10-Aug	887	11-Oct	1490	11-Dec	2213
11-Feb	2312	11-Apr	2592	11-Jun	1085	11-Aug	901	12-Oct	1499	12-Dec	2186
12-Feb	2310	12-Apr	2626	12-Jun	1080	12-Aug	895	13-Oct	1541	13-Dec	2113
13-Feb	2300	13-Apr	2711	13-Jun	1081	13-Aug	899	14-Oct	1542	14-Dec	2110
14-Feb	2316	14-Apr	2725	14-Jun	1086	14-Aug	919	15-Oct	1509	15-Dec	2203
15-Feb	2392	15-Apr	2693	15-Jun	1053	15-Aug	903	16-Oct	1509	16-Dec	2266
16-Feb	2427	16-Apr	2627	16-Jun	1031	16-Aug	923	17-Oct	1506	17-Dec	2232
17-Feb	2448	17-Apr	2596	17-Jun	1019	17-Aug	928	18-Oct	1498	18-Dec	2232
18-Feb	2500	18-Apr	2562	18-Jun	993	18-Aug	944	19-Oct	1528	19-Dec	2234
19-Feb	2637	19-Apr	2519	19-Jun	964	19-Aug	948	20-Oct	1533	20-Dec	2273
20-Feb	2720	20-Apr	2467	20-Jun	935	20-Aug	948	21-Oct	1528	21-Dec	2270
21-Feb	2720	21-Apr	2332	21-Jun	904	21-Aug	962	22-Oct	1505	22-Dec	2260
22-Feb	2756	22-Apr	2301	22-Jun	887	22-Aug	968	23-Oct	1537	23-Dec	2295
23-Feb	2789	23-Apr	2286	23-Jun	882	23-Aug	975	24-Oct	1537	24-Dec	2311
24-Feb	2774	24-Apr	2239	24-Jun	879	24-Aug	976	25-Oct	1535	25-Dec	2313
25-Feb	2726	25-Apr	2209	25-Jun	873	25-Aug	975	26-Oct	1562	26-Dec	2320
26-Feb	2690	26-Apr	2192	26-Jun	884	26-Aug	976	27-Oct	1573	27-Dec	2353
27-Feb	2678	27-Apr	2155	27-Jun	886	27-Aug	984	28-Oct	1607	28-Dec	2357
28-Feb	2667	28-Apr	2126	28-Jun	897	28-Aug	979	29-Oct	1616	29-Dec	2349
29-Feb	2846	29-Apr	2115	29-Jun	880	29-Aug	973	30-Oct	1649	30-Dec	2350
		30-Apr	2106	30-Jun	875	30-Aug	971	31-Oct	1656	31-Dec	2422
						31-Aug	1003				

Klamath River below Iron Gate Dam, CA – Water Year 1961-2010 – Average Daily Discharge (ft^3/s)

Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge	Day	Discharge
1-Jan	2886	1-Mar	3142	1-May	2414	1-Jul	918	1-Sep	1189	1-Nov	1728
2-Jan	2830	2-Mar	3205	2-May	2389	2-Jul	890	2-Sep	1176	2-Nov	1740
3-Jan	2858	3-Mar	3299	3-May	2352	3-Jul	898	3-Sep	1172	3-Nov	1747
4-Jan	2793	4-Mar	3256	4-May	2327	4-Jul	894	4-Sep	1173	4-Nov	1726
5-Jan	2754	5-Mar	3255	5-May	2336	5-Jul	898	5-Sep	1187	5-Nov	1713
6-Jan	2680	6-Mar	3240	6-May	2308	6-Jul	889	6-Sep	1192	6-Nov	1737
7-Jan	2623	7-Mar	3249	7-May	2293	7-Jul	870	7-Sep	1205	7-Nov	1818
8-Jan	2624	8-Mar	3290	8-May	2329	8-Jul	853	8-Sep	1212	8-Nov	1845
9-Jan	2636	9-Mar	3361	9-May	2362	9-Jul	840	9-Sep	1207	9-Nov	1860
10-Jan	2567	10-Mar	3401	10-May	2340	10-Jul	835	10-Sep	1210	10-Nov	1871
11-Jan	2556	11-Mar	3455	11-May	2332	11-Jul	832	11-Sep	1221	11-Nov	1839
12-Jan	2547	12-Mar	3456	12-May	2337	12-Jul	827	12-Sep	1219	12-Nov	1852
13-Jan	2613	13-Mar	3483	13-May	2399	13-Jul	811	13-Sep	1219	13-Nov	1849
14-Jan	2692	14-Mar	3544	14-May	2386	14-Jul	795	14-Sep	1221	14-Nov	1896
15-Jan	2755	15-Mar	3588	15-May	2404	15-Jul	790	15-Sep	1225	15-Nov	1952
16-Jan	3028	16-Mar	3546	16-May	2343	16-Jul	784	16-Sep	1215	16-Nov	1969
17-Jan	2984	17-Mar	3550	17-May	2317	17-Jul	791	17-Sep	1234	17-Nov	1984
18-Jan	2885	18-Mar	3641	18-May	2271	18-Jul	799	18-Sep	1264	18-Nov	1997
19-Jan	2822	19-Mar	3531	19-May	2160	19-Jul	805	19-Sep	1274	19-Nov	1982
20-Jan	2839	20-Mar	3487	20-May	2076	20-Jul	798	20-Sep	1284	20-Nov	1982
21-Jan	2835	21-Mar	3391	21-May	2037	21-Jul	795	21-Sep	1289	21-Nov	2014
22-Jan	2963	22-Mar	3330	22-May	1980	22-Jul	781	22-Sep	1287	22-Nov	2042
23-Jan	2989	23-Mar	3323	23-May	1927	23-Jul	784	23-Sep	1276	23-Nov	2066
24-Jan	2957	24-Mar	3354	24-May	1858	24-Jul	794	24-Sep	1277	24-Nov	2086
25-Jan	2862	25-Mar	3377	25-May	1842	25-Jul	795	25-Sep	1311	25-Nov	2143
26-Jan	2848	26-Mar	3401	26-May	1813	26-Jul	799	26-Sep	1313	26-Nov	2130
27-Jan	2921	27-Mar	3294	27-May	1835	27-Jul	801	27-Sep	1314	27-Nov	2115
28-Jan	2889	28-Mar	3366	28-May	1779	28-Jul	803	28-Sep	1327	28-Nov	2111
29-Jan	2877	29-Mar	3378	29-May	1764	29-Jul	789	29-Sep	1338	29-Nov	2115
30-Jan	2871	30-Mar	3411	30-May	1714	30-Jul	789	30-Sep	1328	30-Nov	2130
31-Jan	2853	31-Mar	3409	31-May	1652	31-Jul	821	1-Oct	1368	1-Dec	2177
1-Feb	2860	1-Apr	3433	1-Jun	1552	1-Aug	959	2-Oct	1401	2-Dec	2232
2-Feb	2877	2-Apr	3377	2-Jun	1534	2-Aug	958	3-Oct	1411	3-Dec	2221
3-Feb	2835	3-Apr	3348	3-Jun	1521	3-Aug	956	4-Oct	1429	4-Dec	2276
4-Feb	2824	4-Apr	3267	4-Jun	1565	4-Aug	958	5-Oct	1448	5-Dec	2328
5-Feb	2780	5-Apr	3232	5-Jun	1578	5-Aug	947	6-Oct	1471	6-Dec	2324
6-Feb	2795	6-Apr	3199	6-Jun	1570	6-Aug	945	7-Oct	1468	7-Dec	2338
7-Feb	2807	7-Apr	3190	7-Jun	1513	7-Aug	956	8-Oct	1458	8-Dec	2335
8-Feb	2800	8-Apr	3102	8-Jun	1426	8-Aug	958	9-Oct	1510	9-Dec	2372
9-Feb	2732	9-Apr	3036	9-Jun	1359	9-Aug	957	10-Oct	1544	10-Dec	2353
10-Feb	2672	10-Apr	3002	10-Jun	1291	10-Aug	958	11-Oct	1548	11-Dec	2349
11-Feb	2672	11-Apr	2983	11-Jun	1250	11-Aug	963	12-Oct	1591	12-Dec	2377
12-Feb	2649	12-Apr	2993	12-Jun	1233	12-Aug	956	13-Oct	1600	13-Dec	2400
13-Feb	2617	13-Apr	3096	13-Jun	1218	13-Aug	954	14-Oct	1561	14-Dec	2467
14-Feb	2686	14-Apr	3155	14-Jun	1235	14-Aug	964	15-Oct	1543	15-Dec	2437
15-Feb	2740	15-Apr	3088	15-Jun	1230	15-Aug	967	16-Oct	1572	16-Dec	2471
16-Feb	2794	16-Apr	3018	16-Jun	1216	16-Aug	973	17-Oct	1576	17-Dec	2479
17-Feb	2875	17-Apr	2953	17-Jun	1173	17-Aug	972	18-Oct	1582	18-Dec	2360
18-Feb	2966	18-Apr	2918	18-Jun	1121	18-Aug	972	19-Oct	1599	19-Dec	2443
19-Feb	3062	19-Apr	2863	19-Jun	1097	19-Aug	963	20-Oct	1616	20-Dec	2499
20-Feb	3172	20-Apr	2786	20-Jun	1063	20-Aug	971	21-Oct	1613	21-Dec	2579
21-Feb	3262	21-Apr	2711	21-Jun	1039	21-Aug	989	22-Oct	1581	22-Dec	2839
22-Feb	3200	22-Apr	2624	22-Jun	1025	22-Aug	992	23-Oct	1605	23-Dec	2787
23-Feb	3206	23-Apr	2634	23-Jun	1026	23-Aug	997	24-Oct	1657	24-Dec	2677
24-Feb	3130	24-Apr	2626	24-Jun	1000	24-Aug	1000	25-Oct	1657	25-Dec	2589
25-Feb	3081	25-Apr	2619	25-Jun	970	25-Aug	1002	26-Oct	1669	26-Dec	2561
26-Feb	3054	26-Apr	2529	26-Jun	975	26-Aug	1004	27-Oct	1672	27-Dec	2609
27-Feb	3039	27-Apr	2468	27-Jun	966	27-Aug	1011	28-Oct	1653	28-Dec	2602
28-Feb	3092	28-Apr	2439	28-Jun	958	28-Aug	1028	29-Oct	1643	29-Dec	2590
29-Feb	3413	29-Apr	2455	29-Jun	975	29-Aug	1025	30-Oct	1700	30-Dec	2694
		30-Apr	2450	30-Jun	980	30-Aug	1018	31-Oct	1705	31-Dec	2825
						31-Aug	1034				

4.0 Dam Removal Plans

Each of the following dam removal plans assumes that the natural release of sediment to the Klamath River from the three larger reservoirs (J.C. Boyle, Copco, and Iron Gate) would be initiated no earlier than January 1, 2020 by regulated releases from available gated spillways, powerhouse bypass facilities, and modified low-level outlets, in order to draw down the reservoirs in a controlled manner. A conservative assumption has been made that power production would cease once reservoir drawdown begins. Facilities Removal as defined by the KHSA to produce a free-flowing river at all four hydroelectric dam sites (J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate) would be completed prior to the specified December 31, 2020 completion date. Dam removal alternatives which would retain any of the four hydroelectric dams, or mitigation measures which would involve the mechanical removal of sediment from the reservoirs, are not included in this Detailed Plan report.

The removal of all appurtenant features at each dam site, with the exception of buried features, represents the “Full Facilities Removal” (or “Full Removal”) alternative. Retention of certain project features, while providing the minimum removal limits to meet the requirements for a free-flowing river and for volitional fish passage through all four dam sites, as defined below, represents the “Partial Facilities Removal” (or “Partial Removal”) alternative. Retention of any structures would involve long-term maintenance costs (except in the case of burial) which have been estimated for the Partial Removal alternative. It is assumed that any features remaining would be sealed or fenced under KHSA to prevent unauthorized entry and for public safety, or would be developed under other funding sources to provide a public benefit which is beyond the scope of this report. Hazardous materials are to be removed for both alternatives.

Quantity estimates for all features to be removed, including concrete volumes and weights of mechanical and electrical equipment, have been carefully prepared using detailed engineering drawings provided by PacifiCorp, which are believed to represent current, as-built conditions. Each damsite has been examined by members of the engineering design team to confirm the existence of project features for which quantities have been prepared for this level of design. However, no independent surveys or measurements of dam embankments, concrete structures, or equipment have been taken to confirm the PacifiCorp data. Additional surveys and measurements would be performed for final design. All elevations are in the original project datum, unless otherwise noted.

The following sections define the removal limits for each dam removal alternative, reservoir drawdown and streamflow diversion requirements, proposed demolition methods and schedules, and waste disposal requirements for each dam. Drawings have been prepared for each dam to define the proposed removal limits for the dam and for each appurtenant feature in plan view, and are included in Attachment A. Detailed removal limits in cross-sectional views cannot be included in public documents due to potential security concerns. Reservoir storage-elevation and discharge capacity data for each large dam are provided in Attachment B. Summary level construction schedules for each dam removal alternative (with supporting assumptions) are provided in Attachment C and have been prepared assuming the work at each dam would occur independently; however, a single negotiated-procurement construction contract is recommended for optimum coordination of dam removal activities. Cost estimate worksheets for each dam for both the Full and Partial Removal alternatives are provided in Attachment D. A report of the underwater examinations performed for this study is provided in Attachment E. Monte Carlo cost simulation information is provided in Attachment F.

4.1 J.C. Boyle Dam and Powerhouse

4.1.1. Removal Limits

J.C. Boyle Dam is located within a relatively narrow canyon on the Klamath River at RM 224.7. Minimum requirements for a free-flowing condition and for volitional fish passage on the Klamath River through the J.C. Boyle damsite would require the complete removal of the embankment section and concrete cutoff wall to the bedrock foundation, to ensure long-term stability of the site and to prevent the development of a potential fish barrier at the site in the future. The lower portion of the fish ladder would be removed to prevent potential stranding of fish during future flood events. The spillway gates, deck, piers, and crest structure would be removed to facilitate reservoir drawdown, and to ensure sufficient discharge capacity during dam removal to prevent a potential overtopping failure of the embankment. With the removal of the embankment and spillway sections, the left abutment wall (between the embankment and spillway) and the upper portion of the fish ladder could become unstable and would also be removed. The 14-foot-diameter steel pipeline could be used to provide additional low-level release capacity to the canal during dam removal, and could be retained for use as a footbridge across the Klamath River for the Partial Removal alternative, although long-term maintenance issues related to the steel pipeline and supports (which are assumed to include coatings containing heavy metals) should be addressed. The pipeline supports would remain within the 100-year floodplain. The canal intake (fish screen) structure and left abutment concrete gravity section could be retained at the damsite, as could selected buildings, for the Partial Removal alternative.

The concrete headgate structure, completed in 2002 on PacifiCorp property, could be retained for modification as an observation point, with access from the 14-foot-diameter pipeline, for the Partial Removal alternative. However, the 2.2-mile-long power canal (or flume) located on BLM property would be expected to collect rockfall and sustain structural damage over time, and would require some additional openings for drainage and for animal escape or migration, as would the forebay area. Therefore, the reinforced concrete walls for the power canal and forebay would be completely removed for the Partial Removal alternative, with the concrete floor slabs and shotcrete slope protection left in place. Retention of portions of the back wall only, where provided, could be considered to further reduce project costs, but is not included in the current plans. The communications equipment, engine-generator building, and propane tank at the forebay site would probably be removed by PacifiCorp. Other structures at the site, including the tunnel inlet portal structure and forebay spillway control structure, would be removed to avoid long-term maintenance issues, and the upstream tunnel portal would be plugged with reinforced concrete to avoid unauthorized entry. Extensive headcutting erosion has occurred within the forebay spillway discharge channel since construction, and this channel or scour hole could be backfilled and stabilized to restore most of the preconstruction slope on the right bank of the river channel for the Full Removal alternative, if necessary. The scour hole has been assumed to be available for concrete waste disposal. This would require a large quantity of material to backfill (up to an estimated 80,000 yd^3) and would be less practical for the Partial Removal alternative as there would be much less concrete rubble for disposal. Any concrete rubble disposed on site would be compacted by equipment travel and covered with a minimum of 2 feet of soil.

The 78-foot-tall steel surge tank and the 150-ton gantry crane at the powerhouse would be removed to prevent a potential future stability problem during a large seismic event, to avoid long-term maintenance issues, and for aesthetic reasons. The two penstocks would be removed for the Partial Removal alternative to avoid long-term maintenance issues related to the steel, which is assumed to include exterior coatings containing heavy metals, and to facilitate wildlife migration across its alignment. The downstream tunnel portal would be plugged with reinforced concrete to avoid unauthorized entry. Portions of the outdoor-type powerhouse which are below the roadway surface could be retained and sealed for the Partial Removal alternative. The large warehouse building would be removed to avoid future security and maintenance issues. The switchyard and any unused transmission lines would be removed, including fencing, poles, and transformers, to avoid long-term maintenance issues. The existing transmission lines cross over steep terrain in some areas and may be difficult to access.

Removal of the J.C. Boyle powerhouse for the Full Removal alternative would involve the following major mechanical and electrical equipment: two vertical-shaft Francis-type hydraulic turbine units, two turbine governor hydraulic control systems with oil storage reservoir and pressure tank, two turbine runner spiral casings and head covers/operating rings, four turbine gate hydraulic servomotors, two vertical turbine shafts, two turbine draft tubes, two electric oil sump pumps and tank, two draft tube bulkhead gates, two vertical sump pumps, bearing oil storage tank(s), and other miscellaneous mechanical equipment, piping, and valves; plant transformers, distribution equipment, unit breakers, two generators, conduit and cable, plant control equipment, and other miscellaneous electrical equipment. Removal of the J.C. Boyle switchyard would involve the removal of all transformers, breakers, switches, and take-off structures.

Retention of the lower portions of the J.C. Boyle powerhouse for the Partial Removal alternative would require the structure to be sealed and the tailrace channel to be at least partially backfilled. The paint on the downstream face of the concrete structure is assumed to contain heavy metals and would be carefully removed. Mechanical and electrical equipment could be left in place with all power connections to the outside removed; however, any oil in the turbine governor and hydraulic control systems, transformers, oil storage tanks, or other equipment would be removed. Other potentially hazardous materials, such as batteries, would also be removed. The tailrace channel between the powerhouse and the river channel could be backfilled to the pre-construction contours if necessary, which would eliminate the need to remove the concrete training walls. There would be no impacts to the 100-year floodplain at the powerhouse site.

Features to be removed or retained for the dam removal alternatives are summarized in Table 4-1.

Table 4-1 – J.C. Boyle Dam and Powerhouse, Removal Requirements

Feature	**Full Removal**	**Partial Removal**
Embankment Dam, Cutoff Wall	Remove	Remove
Spillway Gates and Crest Structure	Remove	Remove
Fish Ladder	Remove	Remove
Steel Pipeline and Supports	Remove	Retain
Canal Intake (Screen) Structure	Remove	Retain
Left Concrete Gravity Section	Remove	Retain
Power Canal (Flume)	Remove	Remove walls
Shotcrete Slope Protection	Remove	Retain
Forebay Spillway Control Structure	Remove	Remove
Tunnel Inlet Portal Structure	Remove	Remove
Surge Tank	Remove	Remove
Penstocks, Supports, Anchors	Remove	Remove
Tunnel Portals	Concrete Plug	Concrete Plug
Powerhouse Gantry Crane	Remove	Remove
Powerhouse Substructure/Slab	Remove	Retain
Powerhouse Hazardous Materials (transformers, batteries, insulation, petroleum products)	Remove	Remove
Tailrace Flume Walls	Remove	Retain
Tailrace Channel Area	Backfill	Partial Backfill
Canal Spillway Scour Area	Backfill	Partial Backfill
Three 69-kV Transmission Lines, 3.56 mi total	Remove	Remove
Switchyard	Remove	Remove
Warehouse, Support Buildings	Remove All	Remove Some

4.1.2. <u>Reservoir Drawdown</u>

The following reservoir drawdown and streamflow diversion plan is proposed to facilitate the removal of J.C. Boyle Dam, while minimizing flood risks and downstream impacts due to the release of impounded sediments. Refer to the Hydrology section for historic daily and monthly streamflow data and frequency floods for this site. There are no upstream reservoirs to be drawn down during dam removal. The proposed plan assumes power generation at J.C. Boyle Dam would end on January 1, 2020, as specified by the KHSA. Reservoir drawdown would not commence until that time. There are no differences in the reservoir drawdown and streamflow diversion plans for the Full and Partial Removal alternatives, unless otherwise indicated.

Because there are no structures around the reservoir rim that could be damaged by potential slope failures, the maximum drawdown of J.C. Boyle Reservoir would be controlled by the rate that would be safe for the embankment dam. A nominal drawdown rate of 1 ft/day for the reservoir water surface (RWS) would be very unlikely to cause a rapid drawdown failure, especially since the embankment shells are a mixture of compacted sand and gravel which should have a high strength and adequate permeability. A drawdown rate of 3 ft/day should be acceptable considering the relatively flat upstream slope and low height of the embankment; although the upstream shell material may not drain as quickly as for Iron Gate Dam. Faster drawdown rates could result in some pore pressure development and slope instability, although probably shallow, and would increase the total streamflow at downstream sites. The proposed streamflow diversion plan could result in rapid drawdowns of approximately 10 feet (between RWS elevations 3780 and 3770) and 8 feet (between RWS elevations 3770 and 3762) within less than 24 hours, but would each be followed by a sustained hold period of a week or more before any further drawdown for the dissipation of any high pore pressures within the embankment. Slope stability analyses of these conditions would be performed for final design to confirm acceptable performance of the embankment during the proposed reservoir drawdown. A preliminary assessment of the maximum drawdown rate for J.C. Boyle Dam was prepared by PanGEO (2008) and is consistent with the proposed plan. Downstream ramping rates (or rates of rise and fall of the river) may have to exceed current FERC license limits during some drawdown operations (such as cofferdam breach).

Sufficient freeboard would have to be maintained at all times between the elevation of the excavated embankment surface and the reservoir to reduce the potential for flood overtopping and potential embankment failure. The freeboard would be dictated by the amount of flood protection that is desired (in terms of flood return period) during the removal operation. Normally when the dam is higher and failure due to flood overtopping would cause a catastrophic release of reservoir water, the flood storage (freeboard) has to be larger. As dam removal nears completion and the reservoir impoundment is much smaller, the consequences of overtopping are not as great and less freeboard and flood protection would be acceptable. The proposed plan described below does not permit any excavation of the embankment section at J.C. Boyle Dam until after July 1, 2020 and requires completion by September 30, 2020 to minimize hydrologic risk. Seasonal frequency floods for this period have been developed to help assess this risk.

4.1.2.1. <u>Initiate reservoir drawdown and sediment release (January 2, 2020)</u>

a. Make controlled releases through gated spillway (crest elevation 3781.5) and power canal (intake invert elevation 3768) for drawdown from normal RWS elevation 3793 to about RWS elevation 3774 for a dry (90 percent exceedance) year, to about RWS elevation 3780 for a median (50 percent exceedance) year, or to about RWS elevation 3784 for a wet (10 percent exceedance) year. This assumes historic inflows and an average drawdown rate of about 1.3 ft/day, for an additional drawdown release of approximately 100 ft^3/s to the downstream channel. Power canal releases after decommissioning the powerhouse would be passed through the canal forebay spillway to the river at the existing scour hole location, which may require some additional stabilization measures for sustained releases. The existing siphon spillway at the concrete headgate structure is of limited capacity and would not be sufficient for this purpose.

b. With reservoir at the lowest possible level (depending upon inflow), remove the concrete stoplogs from one 9.5- by 10-foot diversion culvert (invert elevation 3751.5) by blasting if necessary. Releases would rapidly increase by between 2,600 and 3,200 ft^3/s, and reservoir would draw down to about RWS elevation 3760 for a dry (90 percent exceedance) year, to about RWS elevation 3767 for a median (50 percent exceedance) year, or to about RWS elevation 3776 for a wet (10 percent exceedance) year. A construction delay may be required for very high flow conditions. Suspend power canal flows by closing upstream gate for 14-foot pipeline (intake invert elevation 3768) to reduce total reservoir releases and rate of reservoir drawdown as needed.

c. With reservoir stabilized at lower level (depending upon inflow) and after a sufficient hold period to ensure slope stability (assumed one week), remove the concrete stoplogs from the other 9.5- by 10-foot diversion culvert (invert elevation 3751.5) by blasting if necessary. Releases would rapidly increase by between 1,100 and 2,700 ft^3/s, and reservoir would draw down to about RWS elevation 3757 for a dry (90 percent exceedance) year, to about RWS elevation 3760 for a median (50 percent exceedance) year, or to about RWS elevation 3768 for a wet (10 percent exceedance) year. 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, and should be completed by January 31, 2020 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.

d. With reservoir drawn down below the spillway crest (for any water year) remove all three spillway gates and operators, spillway bridge deck, and spillway piers in the dry. Continue removal of the concrete spillway crest structure in lifts by notching below the reservoir water surface to the lowest practical level (approximate elevation 3762.5, or 1 foot above crown of diversion culverts) for additional drawdown or to minimize potential reservoir refill if the reservoir is already low. Complete this work by March 15, 2020. Retain embankment dam crest and left abutment wall with fish ladder for flood protection until after spring runoff.

e. The downstream powerhouse can be removed as required any time after decommissioning by constructing a cofferdam in the tailrace channel for removal operations in the dry. Use sump pumps to unwater area as required. Retain cofferdam as partial backfill for tailrace channel. Remove penstocks and plug tunnel openings. Remove switchyard and warehouse building.

4.1.2.2. Begin dam removal after spring runoff (July 1, 2020)

a. Begin excavation of embankment dam section. As reservoir inflows decrease for the summer months, reservoir level would reduce to between RWS elevations 3757 and 3759 by August (regardless of water year), or below crown of diversion culverts (elevation 3761.5). Complete removal of pipeline and downstream water conveyance features for Full Removal alternative, and place concrete rubble and soil cover materials in scour hole below canal forebay spillway structure (up to 80,000 yd^3) as required.

b. Remove dam embankment in July and August to no lower than elevation 3767 (about 30 feet above bedrock at upstream toe) to provide an upstream cofferdam sufficient to ensure minimum 100-year flood protection (with freeboard) in September for flows up to about 3,500 ft^3/s through left abutment. Remove embankment materials downstream of required cofferdam limits to final channel grade, including concrete cutoff wall. Haul excavated materials to disposal area on right abutment. Place excavated rockfill (from stockpile) on downstream face of upstream cofferdam as required for controlled breach of cofferdam embankment to bedrock elevation 3737 at upstream toe, by notching below reservoir level (expected to be below RWS elevation 3760). Final reservoir drawdown would be achieved by natural erosion of the armored cofferdam and impounded sediments to the original streambed level. Much of the reservoir between RWS elevations 3737 and 3760 is filled with sediment and would be released with the cofferdam breach. The cofferdam breach at J.C. Boyle could release up to 5,000 ft^3/s or more and should be delayed until after the Iron Gate cofferdam has been breached, to minimize potential downstream impacts.

c. Remove left abutment wall with fish ladder during dam removal. Remove any remaining embankment materials from river channel in the wet, during low flow period, as required. Remove all other features as required. Restore dam site and waste disposal areas as required, including the placement of topsoil and seeding. Demobilize from site.

4.1.3. Demolition Methods and Schedule

The following demolition methods and sequence, construction equipment requirements, workforce requirements, and construction activity durations have been assumed for planning, scheduling, and cost estimating purposes, based on engineering judgment. Alternative methods, sequence, equipment, and durations which would also meet project requirements are possible. There are no significant differences in the assumed demolition methods and proposed construction schedules for the Full and Partial Removal alternatives, unless otherwise indicated. Removal of the structures to be retained under the Partial Removal alternative is generally not on the critical path for dam removal, and would therefore not impact the overall completion of the work.

The contractor would have to mobilize construction equipment to the site by October 2019, and improve existing access roads between the dam and on-site waste disposal areas for two-way traffic where required. The delivery of off-road construction equipment, including cranes, large excavators, loaders, and large capacity dump trucks would be by special tractor-trailer vehicles operating under “wide load” restrictions and at appropriate speeds. Equipment staging areas would include both abutments of the dam and in the vicinity of the downstream powerhouse. The reservoir log boom would be removed. The spillway gates and traveling hoists would be removed by a large crane for loading onto highway trucks and heavy-haul trailers, with the reservoir drawn down below the spillway crest. The reinforced concrete spillway bridge deck and piers could be removed in pieces by hydraulic excavators, or in sections by conventional or diamond-wire sawcutting. The upstream concrete stoplogs for the diversion culvert would be removed by blasting if they cannot be pulled out of their slots by a crane under reservoir head. The construction of a temporary cofferdam upstream of the diversion culvert would permit the replacement of the concrete stoplogs with single concrete bulkheads to facilitate removal under reservoir head at a controlled rate if required, but is not included as a specific item of work in the cost estimate. The design contingency allowance should be sufficient to cover potential additional items such as this.

The lower portion of the concrete spillway section would be removed by hoe-ramming or by drilling and blasting, working behind a temporary cofferdam if necessary for a wet year (left side first, with flows through diversion culvert). Drilling for blasting would include small- to mid-sized hydraulic track drills and perhaps air-track drills supported by 850 to 1200 ft^3/min air compressors. Considerable jack-leg and similar hand drilling would supplement the machine drilling for special shots. Reinforced concrete in deck, wall, and floor slabs for remaining features to be removed (including fish ladder, canal intake structure, power canal, forebay structures, and powerhouse) would be excavated by mechanical methods (e.g. hydraulic shears or hoe-ramming), or possibly in sections by conventional or diamond-wire sawcutting. Concrete rubble would be hauled in 25 to 30 ton articulated off-road trucks to an on-site disposal area, either near the dam or forebay. Mechanical and electrical equipment, and miscellaneous items would be hauled in a mixture of 12 to 15 ton tandem-axle highway trucks, 25 ton rock trailers, and conventional heavy-haul trailers to approved off-site disposal areas.

Conventional earthmoving equipment required to remove the embankment is assumed to consist of up to eight 25 to 30 ton articulated off-road trucks with two 4 yd^3 excavators to reach the required average production rate of 400 yd^3 per hour, or 16,000 yd^3 per week (5 days per week, single shift) for removal of the dam embankment within 8 to 9 weeks. An average haul distance to the on-site disposal area of 1 mile was assumed for construction scheduling purposes, with an average speed for the haul units of 20 mph empty and 10 mph loaded. Dozers are expected to be used for knockdown and grading at the disposal areas as well as to support higher production, mass excavation operations. Higher production rates would be required within the middle two-thirds of the embankment by height, to compensate for lower production rates near the crest and foundation. Some rockfill from the outer surfaces would be stockpiled for later use as slope protection for the upstream cofferdam. The upstream armored cofferdam would be breached and flushed downstream under a reservoir head of around 20 feet. Some removal of breached cofferdam materials may be required in the wet to restore the downstream channel.

Assumed equipment for the removal of J.C. Boyle Dam and Powerhouse and for restoration of the reservoir area includes:

- Crawler-mounted lattice boom crane, 150 to 200 ton, 160- to 200-foot boom
- Rough terrain hydraulic crane, 35 to 75 ton
- Hydraulic track excavators, 65,000 to 120,000 lb, with Cat H120 hoe-ram, thumb and shear attachments
- Cat 966 or Cat 988 wheel-loaders, 4 yd^3 bucket
- Cat 740 articulated rear dump trucks, 30 ton (22 yd^3)
- D-6 or D-8 standard crawler dozers
- Front-end wheel loader, integrated tool carrier, 25,000 lb
- Cat TL943 rough terrain telescoping forklift
- Rough terrain telescoping manlift
- Truck-mounted seed sprayer, 2500 gallon
- On-highway, light duty diesel pickup trucks, ½ ton and 1 ton crew
- On-highway flatbed truck with boom crane, 16,000 lb
- On-highway truck tractors, 45,000 lb
- Off-highway water tanker, 5,000 gallon
- Engine generators, 6.5 KW to 40 KW, diesel or gasoline
- Air compressors, 100 psi, 185 to 600 cfm, diesel
- Hand-held drilling, cutting, and demolition equipment
- Portable welders and acetylene torches
- 4-inch submersible trash pumps, electric

Imported materials that may be required for construction would include gravel surfacing for temporary haul roads (approximately 2,800 tons), soil cover for concrete waste disposal (approximately 13,000 yd^3, from required excavation), seed and mulch materials, and minor quantities of ready-mix concrete and reinforcing steel from local commercial sources for tunnel plugs.

An estimated average workforce of 25 to 30 people would be required for the construction activities, for an estimated duration of 12 months from site mobilization to construction completion for either dam removal alternative. The peak workforce required during excavation of the dam embankment could reach 40 to 45 people.

4.1.4. Waste Disposal

Estimated waste quantities for the Full Removal alternative for J.C. Boyle Dam and Powerhouse include nearly 140,000 yd^3 of earthfill, nearly 8,000 yd^3 of concrete, an estimated 500 tons of reinforcing steel, and nearly 700 tons of mechanical and electrical items at the dam (upstream of the concrete headgate structure at the power canal); and nearly 32,000 yd^3 of concrete, an estimated 1,900 tons of reinforcing steel, and over

2,300 tons of mechanical and electrical items from the power canal to the powerhouse. There are also a total of ten buildings at both sites with a combined area of over 12,000 ft^2 and estimated waste volume of 2,000 yd^3, and over 3.5 miles of 69-kV transmission lines. Total waste quantities for the Partial Removal alternative include 140,000 yd^3 of earthfill, 20,000 yd^3 of concrete, 1,200 tons of reinforcing steel, and 2,000 tons of mechanical and electrical items. Estimated quantities for individual items of work are shown in the attached cost estimate worksheets in Attachment D for each alternative. All volume estimates shown above are based on in-place conditions, without an allowance for bulking.

The use of the original borrow pits located on the right abutment of the dam for earth disposal areas has been assumed. Embankment materials would be hauled along existing routes to the larger of two potential disposal sites along the cleared transmission line corridor, covering an area of approximately 10 acres, and placed within a ravine well below the transmission lines. Some initial clearing and improvements to the existing unpaved access roads and disposal areas would be required, including the stockpiling of excavated topsoil for later use. Special precautions would be required for work below the high voltage transmission lines, but adequate clearance should be available. The disposal site would be covered with topsoil, graded, and sloped for drainage upon completion. Compaction other than by equipment travel would probably not be necessary. Some concrete rubble could also be buried at this site (with a minimum soil cover of 2 feet), after removal of reinforcing steel, or at an alternative site located on the left abutment of the dam. A temporary riprap stockpile site may be located adjacent to the disposal site for use during construction.

Concrete rubble from the dam, flume, forebay, and powerhouse was assumed for cost estimating purposes to be placed within the eroded scour hole below the forebay spillway structure, and covered by a minimum of 2 feet of soil. The scour hole is approximately 100 feet deep, with near vertical side slopes, and is required by BLM to be backfilled in such a way as to stabilize the hillside and stop the headcutting and erosion that has been occurring for many years. Although the entire scour hole does not have to be restored to the original contours for its full height, it should be backfilled to the maximum practicable extent for the dam removal alternative selected.

Reinforcing steel would be separated from the concrete rubble and hauled to a local recycling facility. All mechanical and electrical equipment would be hauled to a suitable dump site or salvage collection point outside the FERC project boundaries. The site assumed for this study is a Klamath County landfill facility located in Klamath Falls, Oregon, approximately 20 miles east from the damsite, and accessible by county road and state highway. The landfill accepts construction and demolition waste, asbestos, contaminated soils, and recyclables, and had an estimated remaining capacity of 435,000 yd^3 in 2010. An alternative landfill is located in Dorris, California, approximately 20 miles south from the damsite, accessible by county roads.

Potential hazardous materials at J.C. Boyle Dam and Powerhouse include asbestos, batteries, bearing and hydraulic control system oils, treated wood, and coatings containing heavy metals in the powerhouse and on the exterior surfaces of the steel penstock pipes, surge tank, bulkhead gate, generator gantry crane, and other painted equipment, which would need specialized abatement and disposal requirements. Contaminated soils may exist at the locations of painted exterior equipment and require remediation. Asbestos may be found in ceiling and floor tiles, roofing materials, and electrical wiring insulation. Although all transformers have tested negative for Polychlorinated biphenyl (PCB), some residual PCBs may exist in closed systems such as transformer bushings. Equipment containing over 37,500 gallons of various types of oils and fuels has been identified at the site. The Red Barn administration complex includes a hazardous materials building for the storage of materials regulated by the Environmental Protection Agency (EPA), and a fueling facility containing above-ground gasoline (1,000 gallon) and diesel (500 gallon) tanks which meet state and federal requirements. Underground septic systems are in use within the Red Barn complex of office and maintenance buildings and two residences and should be removed. The transportation and disposal of all waste materials will follow applicable federal, state, and local regulations, including those for spill prevention and containment. Most of the "hazardous" waste was not considered to be hazardous under the Resource Conservation and Recovery Act (RCRA) for cost estimating purposes (i.e. below defined toxicity levels for hazardous waste), and was assumed to go to the local landfill nearest the damsite.

Estimated quantities, numbers of truck trips, proposed haul routes to disposal sites, and approximate haul distances for waste disposal are summarized in Table 4-2 for the Full Removal alternative. This table assumes off-highway articulated rear dump trucks would be used for hauling earth and concrete materials on unpaved roads between the dam and proposed waste sites on PacifiCorp and BLM property, with a nominal load capacity of 20 cubic yards each, and truck tractor-trailers for hauling mechanical and electrical items, metals, and other waste materials on paved public roads (at posted speed limits), with a nominal load capacity of 12.5 tons, or 10 cubic yards each. A bulking factor of 30 percent for concrete rubble and 20 percent for earth materials has been assumed for determining the number of truck trips required for hauling loose materials. All values have been rounded. Miles shown are average for one round trip, from demolition site to disposal site and return. Total miles (not shown) would be computed from the estimated number of total trips shown multiplied by the average trip distance. Peak daily trips for each site are based on the number of vehicles (units) shown, operating within one 8-hour shift. Similar computations may be made for the Partial Removal alternative. A map of the proposed haul routes and local disposal sites for J.C. Boyle Dam is provided on Figure 4.1-1.

Table 4-2. – Waste Disposal for Full Removal of J.C. Boyle Dam

Waste Material	Bulk Quantity*	Disposal Site	Peak Daily Trips	Total Trips
Earth	170,000 yd^3	Right abutment borrow area	5 units/160 trips (unpaved road)	8,500 trips (1 mile RT)
Concrete	52,000 yd^3	Forebay spwy scour hole	2 units/50 trips (unpaved road)	2,600 trips (3 miles RT)
Metal and Rebar	5,400 tons	Landfill near Klamath Falls	2 units/10 trips (Highway 66)	430 trips (44 miles RT)

Building Waste	2,000 yd^3	Landfill near Klamath Falls	2 units/10 trips (Highway 66)	200 trips (44 miles RT)

* - Volumes increased 30 percent for concrete rubble, 20 percent for loose earth materials

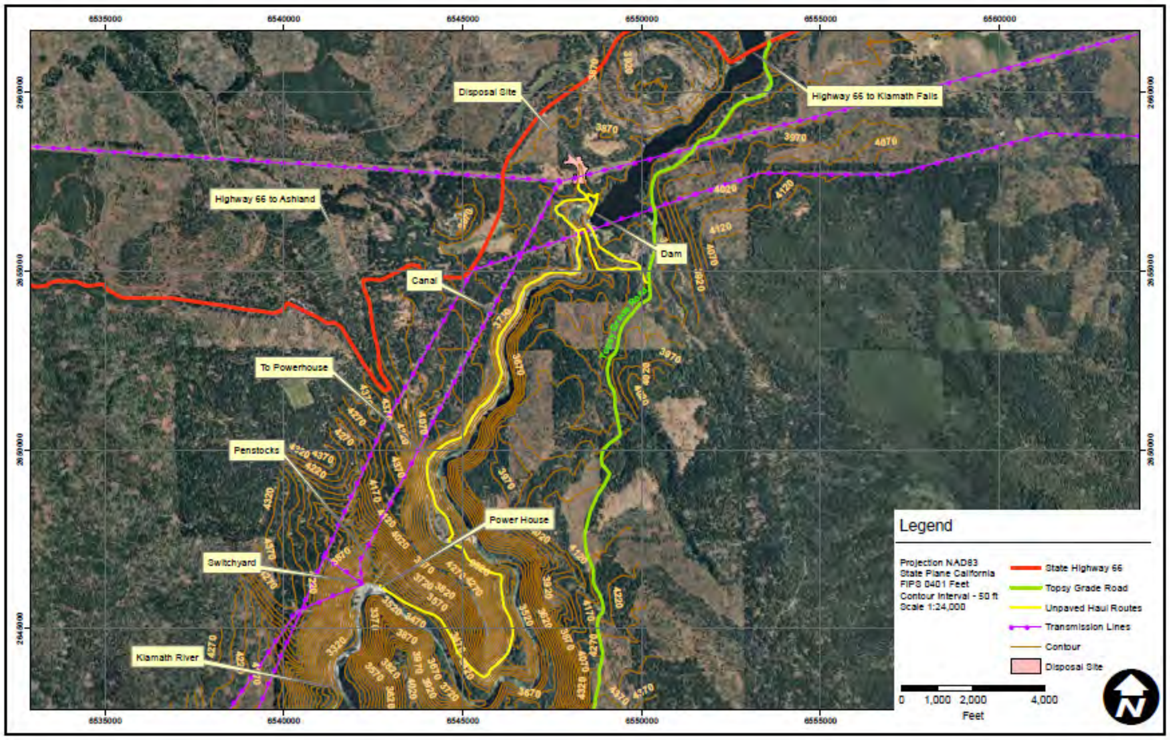


Figure 4.1-1. – Proposed Haul Routes and Disposal Sites for J.C. Boyle Dam.

4.2 Copco No. 1 Dam and Powerhouse

4.2.1. Removal Limits

Copco No. 1 Dam is located within a narrow canyon on the Klamath River at RM 198.6. Minimum requirements for a free-flowing condition and for volitional fish passage on the Klamath River through the Copco No. 1 damsite would require the complete removal of the concrete gravity arch dam between the left abutment rock contact and the concrete intake structure on the right abutment, to approximate elevation 2476, or up to five feet below the existing streambed level at the dam, to prevent the development of a potential fish barrier at the site in the future. The spillway gates, bridge deck, and piers would first be removed from the dam crest, followed by removal of the remaining portion of the concrete dam in lifts. Notching below reservoir levels would be performed as required to help maintain reservoir drawdown requirements. The two concrete gate houses on the right abutment intake structure may have to be removed to provide construction access and workspace for a large crane, although not assumed for the Partial Removal alternative. The large concrete intake structure, penstocks, and powerhouse could be retained for the Partial Removal alternative, provided any openings are sealed and security fencing is installed (unless retained for a public benefit with separate funding); however, retention of any structures would involve long-term maintenance costs, including the preservation of any exposed items with coatings containing heavy metals (such as the penstocks). The diversion tunnel control structure could also be retained for the Partial Removal alternative, provided the existing gate hoists, stems, and wire ropes are removed, and any unstable concrete support blocks are demolished. Retention of the diversion tunnel control structure and right abutment concrete intake structure would have little or no effect on the 100-year floodplain compared with the Full Removal alternative. The powerhouse would remain within the 100-year floodplain if left intact. The downstream tunnel portal would be plugged with reinforced concrete for either alternative to avoid unauthorized entry. The switchyard, located above the dam on the right abutment, and any unused transmission lines would be removed, including fencing, poles, and transformers, to avoid long-term maintenance issues. The maintenance building and residence located on the right abutment would have to be removed from the site of the proposed concrete waste disposal area prior to dam demolition activities.

Removal of the Copco No. 1 powerhouse for the Full Removal alternative would involve the following major mechanical and electrical equipment: two horizontal-shaft, double-runner Francis-type hydraulic turbine units, four turbine runner spiral casings and head covers/operating rings, two horizontal turbine shafts, two turbine governor hydraulic control systems with oil storage reservoir and pressure tank, two turbine draft tubes, vertical sump pump(s), bearing oil storage tank(s), two 40-ton and one 15-ton overhead traveling cranes and structural members, and other miscellaneous mechanical equipment, piping, and valves; six plant transformers, distribution equipment, unit breakers, two 10 MW generators, conduit and cable, plant control equipment, and other miscellaneous electrical equipment. Removal of the Copco No. 1 switchyard would involve the removal of all transformers, breakers, switches, and take-off structures. Removal of the steel penstocks would involve two 10-foot-diameter (reducing to two 8-foot-diameter) and one 14-foot-diameter (reducing to two 8-foot-diameter) turbine penstock pipes from the intake structure to the powerhouse, including three vertical air vent pipes. The tunnel portion of the 14-foot-diameter penstock would be plugged with concrete.

Retention of the Copco No. 1 powerhouse for the Partial Removal alternative would require the structure to be sealed and fenced, unless developed for public benefit as a historic structure (using an alternative funding source). The paint on the east (upstream) face of the concrete structure is assumed to contain heavy metals and would be carefully removed. Mechanical and electrical equipment could be left in place with all power connections to the outside removed; however, any oil in the turbine governor and hydraulic control systems, transformers, oil storage tanks, or other equipment would be removed. Other potentially hazardous materials, such as batteries and treated wood, would also be removed. Rockfill or concrete rubble could be placed along the right river bank just upstream of the powerhouse to improve the flow conditions past the structure.

Features to be removed or retained for the dam removal alternatives are summarized in Table 4-3.

Table 4-3 – Copco No. 1 Dam and Powerhouse, Removal Requirements

Feature	**Full Removal**	**Partial Removal**
Concrete Dam	Remove to 5 feet below channel	Remove to 5 feet below channel
Spillway Gates, Deck, Piers	Remove	Remove
Penstocks	Remove	Retain
Powerhouse Intake Structure	Remove	Retain
Gate Houses on Right Abutment	Remove	Retain
Diversion Control Structure	Retain	Retain
Tunnel Portals	Concrete Plugs	Close Gates (u/s) Concrete Plug (d/s)
Powerhouse	Remove	Retain
Powerhouse Hazardous Materials (transformers, batteries, insulation)	Remove	Remove
Four 69-kV Transmission Lines, 3.03 mi total	Remove	Remove
Switchyard	Remove	Remove
Warehouse and Residence	Remove	Remove

4.2.2. Reservoir Drawdown

The following reservoir drawdown and streamflow diversion plan is proposed to facilitate the removal of Copco No. 1 Dam, while minimizing flood risks and downstream impacts due to the release of impounded sediments. Refer to the Hydrology section for historic daily and monthly streamflow data and frequency floods for this site. Additional releases due to the concurrent drawdown at J.C. Boyle Dam may affect the drawdown of Copco Reservoir. The proposed plan assumes that limited reservoir drawdown from RWS elevation 2606 to below the gated spillway crest at elevation 2593.5 begins on November

1, 2019; however, no significant sediment release is anticipated until after January 1, 2020 when the reservoir is first drawn down below RWS elevation 2590. Power generation at Copco No. 1 Dam would have to end after the reservoir reaches the minimum operating level at RWS elevation 2601, which would be nearly 2 months before the January 1, 2020 date specified by the KHSA. This is necessary for removal of the concrete dam to near final grade before March 15, 2020 for environmental purposes, and would be more than offset by power generation at Copco No. 2 Dam for up to four months beyond the January 1, 2020 date. These operational changes would likely have to be approved by PacifiCorp and by the Public Utilities Commission (PUC). There are no differences in the reservoir drawdown and streamflow diversion plans for the Full and Partial Removal alternatives, unless otherwise indicated.

The drawdown of Copco Reservoir should be controlled to the extent necessary to prevent potential problems with slope stability around the reservoir rim that could result in property damage, including the loss or damage of residential homes. Although there does not appear to be any potentially significant stability issues around the reservoir rim that would be caused by a rapid drawdown, based on a preliminary assessment by PanGEO (2008), the fact that the reservoir is surrounded by residences and there are numerous exposed bluffs that show evidence of slumping should warrant further study. A drawdown rate of between 1.0 and 1.5 ft/day would be unlikely to cause failure of any existing slopes and was assumed for this plan for the upper 50 feet of the reservoir, which would be sufficiently controlled by gated releases through the existing spillway (above RWS elevation 2593.5) and through the modified diversion tunnel. Detailed studies of the geologic conditions and a slope stability analysis of the reservoir rim would be performed for final design. A greater drawdown rate should be acceptable for the lower portion of the reservoir where the rock types should be different and there would be limited control of reservoir releases. A maximum average drawdown rate of 3 ft/day was originally assumed for the lower portion of the dam for modeling purposes; however, an assessment of the probable demolition rate for the mass concrete in the dam suggested a lower average reservoir drawdown rate of 8 feet (or one lift) per week, or an average of about 1.1 ft/day, would be sufficient for as long as the modified diversion tunnel can accommodate the streamflow. Instantaneous drawdown rates at the time of notching would be greater, depending upon the size of the notch and the streamflow, unless diversion tunnel releases are reduced to offset the sudden increase in potential reservoir release capacity. A final notch would have to be excavated to drain the reservoir to RWS elevation 2483 by March 15, 2020, matching the current tailwater level below Copco No. 1 Dam and the normal reservoir level at Copco No. 2 Dam (which would still be operating at that time, if possible). The final notch could potentially be 37 feet deep (between elevations 2513 and 2476), but would require a reservoir drawdown of only 30 feet to the tailwater level. The final breach would be located at the bottom of the reservoir where there is very little storage, and only reservoir inflow and sediment would be passed. Potential notches are shown on Figure 4.2-1. Downstream ramping rates (or rates of rise and fall of the river) may have to exceed current FERC license limits during some drawdown operations (such as notching).

The excavated concrete dam crest can safely accommodate overtopping flows during dam removal without concern for frequency floods and freeboard, although demolition operations would have to be suspended. Notching of a concrete dam crest by blasting for controlled drawdown in stages has been used successfully for removal of Glines Canyon Dam on the Elwha River in Washington, having a similar annual average flow, and would be much more economical than constructing one or more new gated outlets through the dam. A maximum notch depth for Copco No. 1 Dam would be established based more on practical and hydraulic considerations than on what is required to maintain structural stability of the excavated concrete gravity section. The proposed plan assumes a minimum notch depth of 16 feet (or twice the lift height), with variable notch widths depending upon the sill elevation and release requirements. Notch excavation is assumed to be performed in the dry from the downstream face of the gravity section until reaching an acceptable distance from the upstream face required for stability of the remaining plug section, which would then be blasted under reservoir head to complete the notch. Subsequent notches would alternate locations from side to side to permit excavation of a new, deeper notch while passing flow through the existing notch. These locations could either be completely separate as originally proposed for removal of Glines Canyon Dam, or within a single wider location as considered for removal of Condit Dam (also located in Washington) which was adopted for this study. In order to facilitate the removal of concrete rubble at the downstream toe, the notches would be located in the left half of the dam along the rock abutment and a temporary training wall would be constructed on the downstream face to separate the diversion flow from the concrete loading and hauling operations on the right side. Construction access would be provided by a large crane located on either abutment, or by other means.

The proposed plan described below results in draw down of Copco Reservoir to RWS elevation 2483 by March 15, 2020, in order to minimize downstream environmental impacts resulting from the natural release of impounded sediments. The concurrent drawdown of both J.C. Boyle and Copco Reservoirs results in additional inflow to Iron Gate Dam at a time when the diversion release capacity at Iron Gate Dam is sufficiently high to accommodate it.

4.2.2.1. <u>Modify diversion tunnel to restore release capacity (July 2019)</u>

a. Mobilize barge-mounted crane from Iron Gate Reservoir (see 4.4.2) onto Copco Reservoir (assume normal RWS elevation 2606 – but anything less would reduce the depth for divers). Remove sediment from diversion tunnel intake using clamshell or suction dredge, as required.

b. Remove three existing 72-inch flap (or "clack") gates on upstream face of diversion intake structure (invert elevation 2489) under balanced head and no flow conditions, using hard hat divers (117 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- by 6-foot slide gates with hydraulic operators and remote controls at upstream face of diversion structure using divers. The removal of the dam is dependent upon the successful completion of these modifications to restore the discharge capacity of the diversion tunnel for low-level releases. The underwater work would be difficult and should be performed well in advance of the reservoir drawdown schedule to ensure completion and avoid any construction delay. No impacts to power generation are expected for this work.

c. With new upstream slide gates at diversion intake closed, drill drain and air vent holes through concrete tunnel plug from downstream side to unwater tunnel. Remove concrete tunnel plug in dry conditions. Inspect diversion tunnel for possible reinforcement or repairs (none assumed necessary). Remove (or open) three existing 72-inch butterfly valve disks from downstream side 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.

d. Retain barge-mounted crane as needed for removal of spillway gates and bridge deck.

4.2.2.2. <u>Initiate reservoir drawdown to spillway crest (November 1, 2019)</u>

a. Make controlled releases through gated spillway (crest elevation 2593.5) and from modified diversion tunnel to draw down reservoir below spillway crest. Continue releases to powerhouse for power generation for as long as possible (minimum operating level elevation 2601), although plant shutdown on November 1 has been assumed for this study. Limit reservoir drawdown to about 1 ft/day to maintain slope stability on reservoir, and hold at about elevation 2590 (for any water year). No significant sediment release is expected for this upper range of reservoir levels and rate of drawdown.

b. With reservoir drawn down to approximate elevation 2590, use barge-mounted crane to remove all 13 spillway gates and operators, spillway bridge deck, and spillway gate piers in the dry. Assume barge-mounted crane is then removed from the site, and a large crane is mobilized to the right abutment above the dam to provide construction support. (The left abutment would also be accessible from Ager-Beswick Road for mobilization of a large crane for construction support, if necessary.) Extension of existing boat ramp may be required to remove barge from lower water surface.

4.2.2.3 <u>Continue reservoir drawdown and initiate sediment release (January 1, 2020)</u>

a. Make controlled releases from modified diversion tunnel. Assume predicted streamflow, plus drawdown releases from J.C. Boyle Reservoir in January up to 100 ft^3/s (or about 200 acre-feet per day). Limit reservoir drawdown to between 1.0 and 1.5 ft/day, so as to maintain slope stability on reservoir and control drawdown releases from both upstream reservoirs to Iron Gate Dam.

b. Continue reservoir drawdown at between 1.0 and 1.5 ft/day until stabilizing at about RWS elevation 2505 for a dry (90 percent exceedance) year, at about RWS elevation 2529 for a median (50 percent exceedance) year, or at about RWS elevation 2585 for a wet (10 percent exceedance) year, based on assumed streamflow (without further drawdown releases from J.C. Boyle after January 31, 2020) and modified diversion tunnel discharge capacity. (Note that this drawdown can range from about 20 feet to 100 feet below the normal RWS – a major difference due to hydrologic variations).

c. As reservoir is drawn down, assume concrete dam is removed in 8-foot lifts between abutments in the dry, with rubble dropped to the toe of the dam and removed by truck on a temporary access road constructed within the river channel along the right bank at the powerhouse (assumed to remain in place until after dam removal for either alternative, for later demolition if required), or by using a large crane on the right abutment to deliver equipment and materials and to remove waste materials as required. Haul concrete rubble to concrete disposal area on right abutment (within one mile). As streamflow diversion capacity through tunnel decreases due to reduced reservoir head, blast minimum 16-foot-deep notches in concrete dam below reservoir levels for overtopping flow as needed (assume variable notch widths depending upon inflow, but with a minimum effective bottom width of 10 feet for a median year). 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 depend upon the streamflow, but was assumed for a median year to be at elevation 2529. Notching operations and weather conditions are expected to slow the demolition rate during the winter months and spring rainy season. The elevation of the final notch would be at elevation 2513 (regardless of water year), and would extend up to 37 feet to the final channel grade, but reservoir storage at those elevations is negligible and reservoir releases would match inflow. The reservoir must be drawn down to RWS elevation 2483 (reservoir level to be maintained at Copco No. 2 Dam) by March 15, 2020 to minimize downstream impacts due to sediment release. Retention of Copco No. 2 Reservoir would limit the head on the final notch blast to no more than 30 feet, and would permit continued power generation at the Copco No. 2 Powerhouse.

4.2.2.4. <u>Complete dam removal after spring runoff (May 15, 2020)</u>

a. Remove remaining concrete in dam below elevation 2513 to a level at or below elevation 2476, or about 5 feet below bedrock to avoid a potential future barrier to fish passage. This requires the drawdown of Copco No. 2 Reservoir to minimize the water surface at the Copco No. 1 Dam site, and cessation of power generation at Copco No. 2 Powerhouse. Excavate concrete in 8-foot lifts and remove remaining rubble from river channel during low flow period. Remove concrete in right abutment intake structure for the Full Removal alternative in the dry after reservoir has been drained, or concurrent with dam demolition if no impact to overall schedule. The temporary access road to the dam toe may be extended upstream for removal of the concrete rubble from the intake structure.

b. Construct or maintain temporary cofferdams in the river channel as required for removal of the powerhouse and of the diversion control structure in the dry during low flow period, for the Full Removal alternative. A similar cofferdam would likely be required along the right bank of the river channel for the Partial Removal alternative for dam removal while retaining the powerhouse. Demolish powerhouse if required and remove all rubble and equipment using trucks along access road, or using a large crane on the right abutment. Remove reinforcing steel, and mechanical and electrical items from site for disposal. Haul concrete rubble to concrete disposal area on right abutment (within one mile). Use sump pumps to unwater low areas as required. Remove cofferdams from river channel when no longer needed. Plug upstream intake for the Full Removal alternative and close the new slide gates for the Partial Removal alternative. The downstream portal of the diversion tunnel would be plugged with concrete for either alternative. Restore dam site and concrete disposal areas as required. Place topsoil and seed where required. Demobilize from site.

4.2.3. Demolition Methods and Schedule

The following demolition methods and sequence, construction equipment requirements, workforce requirements, and construction activity durations have been assumed for planning, scheduling, and cost estimating purposes, based on engineering judgment. Alternative methods, sequence, equipment, and durations which would also meet project requirements are possible. There are no significant differences in the assumed demolition methods and proposed construction schedules for the Full and Partial Removal alternatives, unless otherwise indicated. Removal of the structures to be retained under the Partial Removal alternative is generally not on the critical path for dam removal, and would therefore not impact the overall completion of the work.

The concrete dam and powerhouse are situated in a steep, narrow canyon. The existing access roads would require significant upgrading to handle the hauling of the mechanical and electrical equipment and excavated materials. The contractor would have to mobilize construction equipment to the site by June 2019, and improve the existing access roads between the dam, powerhouse, and on-site waste concrete disposal area on the right abutment. The delivery of off-road construction equipment, including cranes, large excavators, loaders, and large capacity dump trucks would be by special tractor-trailer vehicles operating under “wide load” restrictions and at appropriate speeds. Equipment staging areas would include both abutments of the dam and in the vicinity of the powerhouse for both alternatives. One-way traffic with turnarounds is assumed for the primary haul roads, for an average haul distance of 1.25 miles from the dam to the disposal site. Barge access to the reservoir would be provided at an existing boat ramp located at either Mallard Cove on the southern shore (off of Ager-Beswick Road) or Copco Cove on the western shore (off of Copco Road). The log boom would be removed to permit access to the spillway structure.

The spillway gates and traveling hoists would first be removed by a barge-mounted crane for loading onto trucks, with the reservoir drawn down below the spillway crest using the modified diversion tunnel. The reinforced concrete spillway bridge deck and piers could be removed in pieces by hydraulic excavators, or in sections by conventional or diamond-wire sawcutting. The barge-mounted crane would be removed from the site following removal of the spillway structure and modification of the diversion control structure. Early removal of the spillway structure is required to facilitate the removal of the dam necessary to breach the reservoir to elevation 2483 by March 15, 2020.

The concrete gravity arch dam was constructed with large (cyclopean) boulders placed in the concrete matrix, and reinforced throughout with 455 tons of 30-pound steel rails placed in horizontal mats and in vertical rows across construction joints (for an average weight of about 25 lb per yd^3 of concrete, distributed as shown on project drawings), which would complicate demolition activities. Dam demolition would likely be performed in horizontal lifts using conventional drilling and blasting methods. High production rates with a minimum of weather delays would be required to meet the proposed construction schedule. Drilling was assumed for the construction analysis to control overall production, with up to five drill crews required for each of two 8-hour shifts, each capable of drilling 175 linear feet of production blast holes per shift, with a 6-day work week. A minimum of 9 effective working shifts per week was assumed for scheduling purposes. Over 90,000 linear feet of production drilling was estimated for blast holes spaced 3 to 4 feet apart, using small air track or hydraulic track drills. Redrilling would likely be required where rail steel is encountered. Drilling pre-split holes is assumed to be primarily limited to notching and would be concurrent with production drilling. Production blasting is assumed to include shots between 288 ft^2 (12- by 24-feet) and 800 ft^2 (20- by 40-feet) per round, with an average between 3 and 6 shots per day for up to 15 weeks, during daylight hours. Assuming similar blast planning to that developed by Revey and Associates for the planning of Glines Canyon Dam removal in Washington, an underground, pre-packaged, detonator-sensitive, water resistant, emulsion-type explosive such as Magnafrac (Orica Explosives Technology) could be used, assuming a weight of 1.25 to 1.75 lb of explosives per yd^3 of concrete, with an approximate weight of explosives between 80 and 300 lb/round and from 35 to 80 lb/delay. The total weight of explosives required for removal of the concrete dam alone (having a volume of 36,000 yd^3) could range between 20 and 30 tons.

Quickly mucking and removing the shot rubble is important to achieving the production rates needed. Acetylene torches would be needed to cut rail steel in the dam. A large crawler-mounted crane could be used on the right abutment to help remove the concrete rubble and rail steel from the dam, or deliver equipment to the excavated surface. Crane access may also be available to the left abutment from Ager-Beswick Road. A sheet-pile or H-pile cofferdam could be constructed along the right bank of the river to isolate a portion of the dam toe and the powerhouse, providing an access road and a work pad to stage concrete rubble collection, loading, hauling, and plant demolition. Once the spillway structure has been removed and routine mass blasting is underway, cranes would no longer be used to support rubble removal. Depending upon the approach, the contractor may need to develop effective access around the notched areas during demolition and may need to alternate between active and under-construction notch alignments. Confining the notches to a single large slot at the left abutment may facilitate the demolition operations, as suggested on Figure 4.2-1 (not used in this analysis). Concrete rubble would be loaded into articulated off-road rock trucks having a haul capacity of 30 tons, using either a hydraulic track excavator with a 3.5 yd^3 bucket, or a front-end loader with a 5 to 6 yd^3 bucket. An average haul distance of 1.25 miles was assumed for construction scheduling purposes, with an average speed for the haul units of 12 mph. Over 700 tons of concrete rubble could be removed per day using two trucks making 12 rounds each during one 8-hour shift, with nearly 70,000 tons (or 36,000 yd^3

in-place volume) to be removed from the dam within approximately 16 weeks. Removal of the final concrete lifts may be delayed by up to two months for lower streamflow conditions and following reservoir drawdown at Copco No. 2 Dam.

Mass concrete in the right abutment intake structure would probably be removed in lifts as for the concrete in the dam, using similar methods but at a slower rate due to the embedded penstock pipes and mechanical equipment. The concrete rubble could be removed from the lift surface using a large crane, or from the bottom of the canyon using an extension of the lower haul road constructed for demolition of the dam, during the low flow period. Reinforced concrete in deck, wall, and floor slabs for remaining features to be removed for the Full Removal alternative (including powerhouse and diversion intake structure) would be excavated by mechanical methods (e.g. hydraulic shears and hoe-ramming).

Assumed equipment for the removal of Copco No. 1 Dam and Powerhouse and for restoration of the reservoir area includes:

- Crawler-mounted lattice boom crane, 200 ton, 160- to 200-foot boom
- Rough terrain hydraulic crane, 35 to 75 ton
- Mid-size hydraulic excavator, 28,000 to 60,000 lb, 1 to 2 yd^3 bucket
- Cat 336 hydraulic track excavator, 80,000 lb, 3.5 yd^3 bucket
- Hydraulic track excavators, 65,000 to 120,000 lb, with Cat H120 hoe-ram, thumb and shear attachments
- Cat 966 articulated wheel-loader, 52,000 lb, 5 yd^3 bucket, or
- Cat 980 articulated wheel-loader, 65,000 lb, 6 yd^3 bucket
- Cat 725 or Cat 730 articulated rear dump truck, 50,000 lb, 30 ton (20 yd^3)
- D-6 or D-7 standard crawler dozers
- Front-end wheel loader, integrated tool carrier, 25,000 lb
- Cat TL943 rough terrain telescoping forklift
- Rough terrain telescoping manlift
- Cat 140 motorgrader
- Flexifloat sectional barges
- Truck-mounted seed sprayer, 2,500 gallon
- On-highway, light duty diesel pickup trucks, ½ ton, ¾ ton, and 1 ton crew
- On-highway flatbed truck with boom crane, 16,000 lb
- On-highway truck tractors, 45,000 lb
- Off-highway water tanker, 5,000 gallon
- On-highway water truck, 4,000 gallon
- Wheel-mounted asphalt paver (for Most Probable High estimate only)
- Self-propelled rubber tire and drum vibratory compactor, 5 to 15 ton
- Engine generators, 6.5 KW to 40 KW, diesel or gasoline
- Air compressors, 100 to 150 psi, 850 to 1200 cfm, diesel
- Airtrack drill or hydraulic track drill
- Hand-held drilling, cutting, and demolition equipment
- Portable welders and acetylene torches

- 4-inch submersible trash pumps, electric
- Light plants, 2000 to 6000 watt, 10 to 25 hp, diesel

Imported materials that may be required for construction would include gravel surfacing for temporary haul roads (approximately 320 tons), soil cover for concrete waste disposal (approximately 23,000 yd^3), seed and mulch materials, and minor quantities of ready-mix concrete and reinforcing steel from local commercial sources for tunnel plugs.

An estimated average workforce of 30 to 35 people would be required for the construction activities, for an estimated duration of 16 months from site mobilization to construction completion for either dam removal alternative. The peak workforce required during demolition of the concrete dam could reach 50 to 55 people.

4.2.4. Waste Disposal

Estimated waste quantities for the Full Removal alternative for Copco No. 1 Dam and Powerhouse include nearly 62,000 yd^3 of concrete, an estimated 900 tons of rail and reinforcing steel, and over 1,200 tons of mechanical and electrical items at the dam and powerhouse. There are two buildings at the site with a combined estimated area of 1,600 ft^2 and estimated waste volume of 300 yd^3, and over 3 miles of 69-kV transmission lines. Total waste quantities for the Partial Removal alternative include 57,500 yd^3 of concrete, 600 tons of reinforcing steel, and 200 tons of mechanical and electrical items. Estimated quantities for individual items of work are shown in the attached cost estimate worksheets in Attachment D for each alternative. All volume estimates shown above are based on in-place conditions, without an allowance for bulking.

All concrete rubble is assumed to be buried on the right abutment within an on-site disposal area, covering an area of approximately 7 acres. Some initial clearing and improvements to the disposal area would be required, including the demolition of two structures (maintenance building and residence) and stockpiling of excavated topsoil for later use. Rail and reinforcing steel would be separated from the concrete and hauled to a local recycling facility. The on-site disposal areas would be covered with topsoil, graded, and sloped for drainage upon completion. Compaction other than by equipment travel would probably not be necessary.

All mechanical and electrical equipment would be hauled to a suitable dump site or salvage collection point outside the FERC project boundaries. A Class III sanitary landfill and medium volume transfer station is located in Yreka, California, in Siskiyou County, approximately 28 miles from the damsite, and is accessible by county road and federal highway (Interstate 5). The landfill accepts construction and demolition waste and mixed municipal waste, and had an estimated remaining capacity in 2010 of 3,924,000 yd^3. The transfer station accepts metals and mixed municipal recyclable materials.

Potential hazardous materials at Copco No. 1 Dam and Powerhouse include asbestos, batteries, bearing and hydraulic control system oils, treated wood, and coatings containing heavy metals in the powerhouse and on the exterior surfaces of the steel penstock and air vent pipes, as well as on other painted equipment, which would need specialized abatement and disposal requirements. Contaminated soils may exist at the locations of painted exterior equipment and require remediation. Asbestos may be found in electrical wiring insulation and possibly in other building materials. Mercury may exist in older light switches. Although all transformers have been tested negative for PCB, some residual PCB's may exist in closed systems such as transformer bushings. Equipment containing nearly 12,000 gallons of various types of oils has been identified at the site. The transportation and disposal of all waste materials will follow applicable federal, state, and local regulations, including those for spill prevention and containment. Most of the "hazardous" waste was not considered to be hazardous under RCRA for cost estimating purposes (i.e. below defined toxicity levels for hazardous waste), and was assumed to go to the local landfill nearest the damsite.

Estimated quantities, numbers of truck trips, proposed haul routes to disposal sites, and approximate haul distances for waste disposal are summarized in Table 4-4 for the Full Removal alternative. This table assumes off-highway articulated rear dump trucks would be used for hauling concrete materials on unpaved roads between the dam and proposed waste sites on PacifiCorp property, with a nominal load capacity of 20 cubic yards each, and truck tractor-trailers for hauling mechanical and electrical items, metals, and other waste materials on paved public roads (at posted speed limits), with a nominal load capacity of 12.5 tons or 10 cubic yards each. County roads may be subject to load restrictions during the rainy season (December through May). A bulking factor of 30 percent for concrete rubble has been assumed for determining the number of truck trips required for hauling loose materials. All values have been rounded. Miles shown are average for one round trip, from demolition site to disposal site and return. Total miles (not shown) would be computed from the estimated number of total trips shown multiplied by the average trip distance. Peak daily trips for each site are based on the number of vehicles (units) shown, operating within one 8-hour shift. Similar computations may be made for the Partial Removal alternative. A map of the proposed haul routes and local disposal sites for Copco No. 1 Dam is provided on Figure 4.2-2.

Table 4-4. - Waste Disposal for Full Removal of Copco No. 1 Dam

Waste Material	Bulk Quantity*	Disposal Site	Peak Daily Trips	Total Trips
Concrete	80,000 yd^3	Right abutment structure sites	2 units/50 trips (unpaved road)	4,000 trips (2 miles RT)
Metal and Rebar	2,100 tons	Transfer station near Yreka	1 unit/5 trips (Copco Road)	170 trips (62 miles RT)
Building Waste	300 yd^3	Transfer station near Yreka	1 unit/5 trips (Copco Road)	30 trips (62 miles RT)

* - Volumes increased 30 percent for concrete.

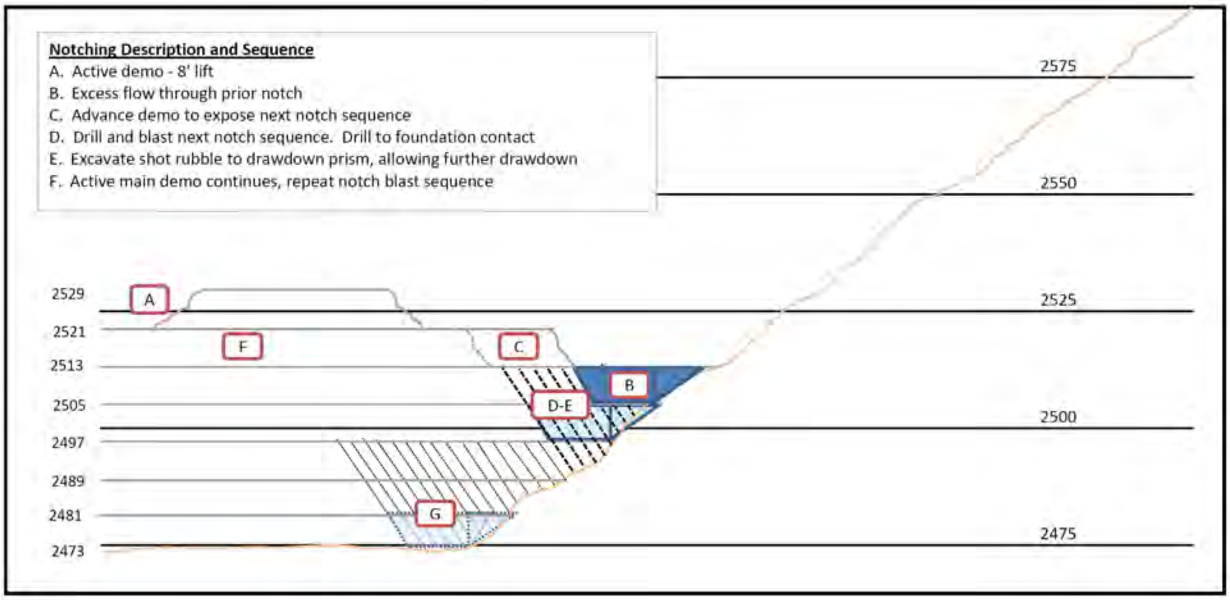


Figure 4.2-1 – Proposed Notching Sequence for Copco No. 1 Dam.

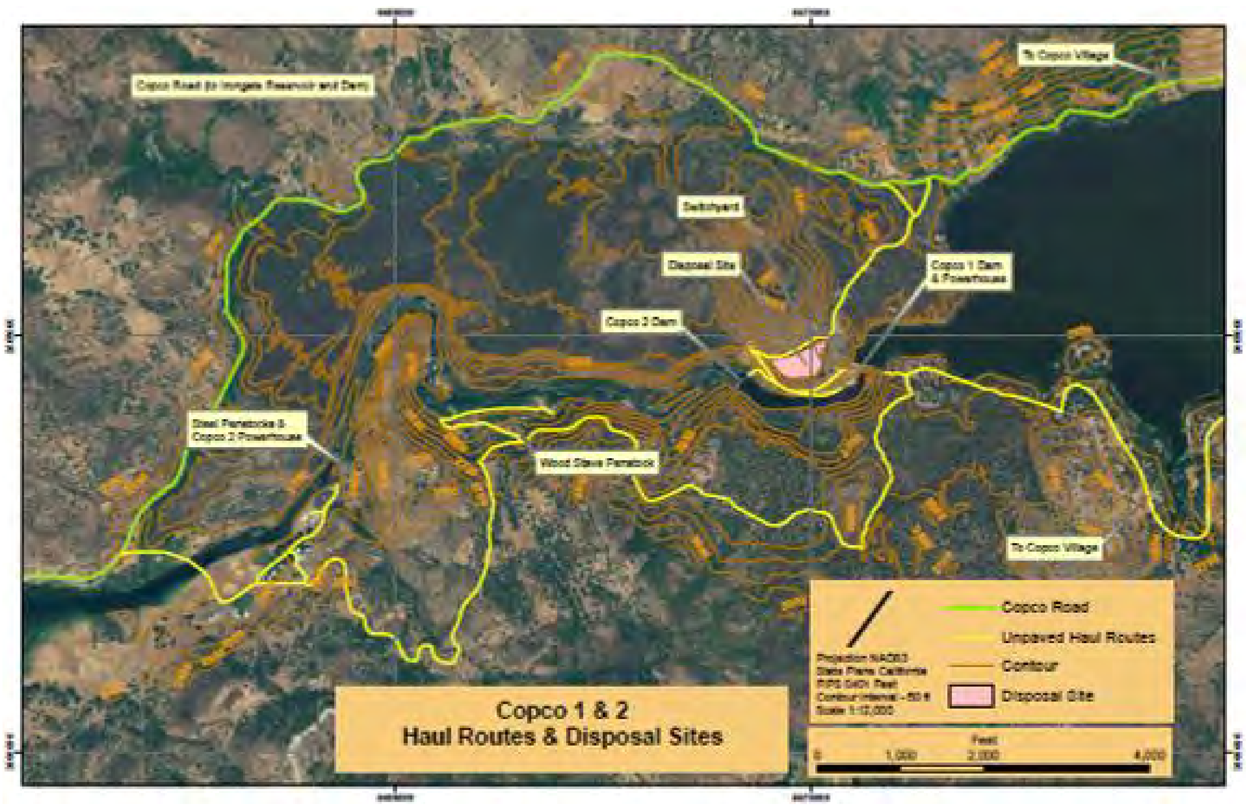


Figure 4.2-2 – Proposed Haul Routes and Disposal Sites for Copco No. 1 Dam.

4.3 Copco No. 2 Dam and Powerhouse

4.3.1. Removal Limits

Copco No. 2 Dam is located within a narrow canyon on the Klamath River at RM 198.3. Minimum requirements for a free-flowing condition and for volitional fish passage on the Klamath River through the Copco No. 2 damsite would require the removal of the concrete gated spillway structure and concrete end sill between the existing sidewalls. The spillway gates, bridge deck, piers, and crest structure would be removed to permit reservoir drawdown for restoration of the river channel. The right sidewall and embankment section could be retained for the Partial Removal alternative, but a portion of the basin apron slab would have to remain intact for structural stability of the sidewall. The right sidewall and embankment section would remain within the 100-year floodplain if left intact. Equipment on the right abutment embankment section would be removed to facilitate construction access to the gated spillway, and to restore the original appearance of the armored embankment. The left abutment power penstock intake structure and the downstream powerhouse could also be retained, provided any openings are sealed and security fencing is installed to prevent unauthorized entry. Retention of any structures would involve long-term maintenance costs, including the preservation of any items with coatings containing heavy metals. The wood-stave penstock located between the first and second tunnels consists of creosote-treated wood and would be hauled to an approved disposal facility in either White City, Oregon (about 70 miles away) or in Anderson, California (about 120 miles away, consistent with current PacifiCorp policy); however, the concrete penstock cradles and tunnel portal structures could be retained for the Partial Removal alternative to reduce project costs. The steel penstocks between the second tunnel and the powerhouse could be retained to preserve the appearance of the historical power generation features, although long-term maintenance issues related to the steel, which is assumed to include coatings containing heavy metals, would have to be addressed, and the penstocks would continue to provide a potential barrier to wildlife migration. All open tunnel and shaft portals would be plugged with reinforced concrete to avoid unauthorized entry. The excavated tailrace channel between the powerhouse and the river would be backfilled. The Copco No. 2 substation located at the powerhouse, and a 230 kV switchyard located on a bluff north of the river, must remain in service following dam removal. Any unused transmission lines would be removed, including poles and transformers. The existing transmission lines cross over steep terrain in some areas and may be difficult to access.

Removal of the Copco No. 2 powerhouse for the Full Removal alternative would involve the following major mechanical and electrical equipment: two vertical-shaft, Francis-type hydraulic turbine units, two turbine governor hydraulic control systems with oil storage reservoir and pressure tank, two turbine runner spiral casings and head covers/operating rings, four turbine gate hydraulic servomotors, two vertical turbine shafts, two turbine draft tubes, draft tube bulkhead gate(s), vertical sump pump(s), bearing oil storage tank(s), two 40-ton overhead traveling crane and structural members, and other miscellaneous mechanical equipment, piping, and valves; distribution equipment, unit breaker, two generators, conduit and cable, plant control equipment, and other miscellaneous electrical equipment. The existing plant transformers located within the Copco No. 2 substation are expected to remain in service. A new 800,000 lb transformer was recently delivered via special tractor-trailer to the 230 kV switchyard located across the river to the north, along County roads.

Retention of the Copco No. 2 powerhouse for the Partial Removal alternative would require the structure to be sealed and fenced, unless developed for public benefit as a historic structure (using a separate funding source). Mechanical and electrical equipment could be left in place with all power connections to the outside removed; however, any oil in the turbine governor and hydraulic control systems, transformers, oil storage tanks, or other equipment would need to be removed. Other potentially hazardous materials, such as batteries and treated wood, would also be removed.

Features to be removed or retained for the dam removal alternatives are summarized in Table 4-5.

Table 4-5. – Copco No. 2 Dam and Powerhouse, Removal Requirements

Feature	**Full Removal**	**Partial Removal**
Spillway Gates, Structure	Remove	Remove
Power Penstock Intake Structure	Remove	Retain
Tunnel Portals	Concrete Plug	Concrete Plug; Close Gate
Embankment Section	Remove	Retain
Wood-stave Penstock	Remove	Remove
Concrete Pipe Cradles	Remove	Retain
Steel Penstock, Supports, Anchors	Remove	Retain
Powerhouse	Remove	Retain
Powerhouse Hazardous Materials (transformers, batteries, insulation)	Remove	Remove
69-kV Transmission Line, 0.14 mi	Remove	Remove
Switchyard	Retain	Retain
Tailrace Channel	Backfill	Backfill

4.3.2. <u>Reservoir Drawdown</u>

The following reservoir drawdown and streamflow diversion plan is proposed to facilitate the removal of Copco No. 2 Dam, while minimizing flood risks and downstream impacts. Refer to the Hydrology section for historic daily and monthly streamflow data and frequency floods for the Copco No. 1 site located immediately upstream. The current plan assumes that 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 in order to minimize potential impacts to power generation. The original plan proposed by Gathard Engineering (2006) assumed that Copco No. 2 Dam would be removed prior to removal of the three larger dams; however, the potential loss of 6 months of power generation is now deemed to be economically infeasible. The proposed plan allows the generation of power at Copco No. 2 Dam (with sediment-laden flow) for up to four months after the January 1, 2020 date indicated by the KHSA (or until May 1) to help offset the potential loss of power generation at the Copco No. 1 site due to early reservoir drawdown. This assumes the generating equipment will be capable of operating under these conditions. Drawdown of Copco No. 2 Reservoir would not be necessary until after Copco No. 1 Dam has been breached (but not yet removed) to final grade, and final drawdown of Copco Reservoir for removal of the remaining portions of the dam is required. There are no differences in the reservoir drawdown and streamflow diversion plans for the Full and Partial Removal alternatives, unless otherwise indicated.

No drawdown rate limitations would apply to the removal of Copco No. 2 Dam. All streamflow at the site would be passed downstream to the bypassed river reach during demolition activities. The upstream reservoirs at J.C. Boyle and Copco No. 1 Dams would have already been mostly drained by the time removal work begins at Copco No. 2 Dam, and should not affect the streamflow at the Copco No. 2 damsite. The proposed plan described below would permit the removal of the dam and powerhouse between May and October 2020.

4.3.2.1. <u>Begin dam removal after spring runoff (May 1, 2020)</u>

a. Close caterpillar gate at power penstock intake structure to stop releases to Copco No. 2 Powerhouse and cease power generation. Make controlled releases through gated spillway (crest elevation 2473) during low flow period, for initial reservoir drawdown from RWS elevation 2483 to RWS elevation 2478 in one day, using the two spillway gates on the right-hand side. (This will complete the drawdown of Copco Reservoir.) Remove equipment and concrete pad from dike crest to provide room for demolition equipment and for construction access.

b. Construct a temporary cofferdam within the river channel to isolate the two left-hand spillway bays for removal to elevation 2454 in the dry, including spillway gates, hoists, bridge deck, and concrete crest structure. Remove temporary cofferdam and allow reservoir to stabilize at approximately RWS elevation 2460 through dam breach. Construct a second temporary cofferdam within the river channel to isolate the three remaining spillway bays on the right-hand side for removal to elevation 2454 in the dry, including the remaining spillway gates, hoists, bridge deck, and concrete crest structure. Leave right sidewall and portion of downstream apron intact as required for Partial Removal alternative. Remove temporary cofferdam.

c. Use small cofferdam at power penstock intake structure for removal of trashracks, caterpillar gate, and concrete structure, and to construct tunnel plug in the dry, as required for the Full Removal alternative. Leave cofferdam in place within approach channel to restore left river bank.

d. Complete any remaining demolition work as required. Restore damsite and on-site disposal area (shared with Copco No. 1 demolition) as required by October 2020, including the placement of topsoil and seeding. Demobilize from site.

4.3.2.2. Remove penstock and powerhouse

a. Remove wood-stave penstock and concrete features as required following closure of the upstream caterpillar gate and shutdown of the powerhouse. Construct reinforced concrete tunnel plugs at each open portal.

b. Construct cofferdam in tailrace channel for removal of powerhouse in the dry for the Full Removal alternative, during low flow period. Use sump pumps to unwater area. Leave cofferdam in place within tailrace channel and backfill to restore left river bank.

4.3.3. Demolition Methods and Equipment

The following demolition methods and sequence, construction equipment requirements, workforce requirements, and construction activity durations have been assumed for planning, scheduling, and cost estimating purposes, based on engineering judgment. Alternative methods, sequence, equipment, and durations which would also meet project requirements are possible. There are no significant differences in the assumed demolition methods and proposed construction schedules for the Full and Partial Removal alternatives, unless otherwise indicated. Removal of the structures to be retained under the Partial Removal alternative is generally not on the critical path for dam removal, and would therefore not impact the overall completion of the work.

The concrete dam is situated in a steep, narrow canyon. The existing access road would require significant upgrading to handle the hauling of the excavated concrete and provide access for a large crawler-mounted crane. The contractor would have to mobilize construction equipment to the site by March 2020, and improve the existing access road between the dam and on-site disposal area shared with Copco No. 1 Dam demolition. The delivery of off-road construction equipment, including cranes, large excavators, loaders, and large capacity dump trucks would be by special tractor-trailer vehicles operating under "wide load" restrictions and at appropriate speeds. Equipment staging areas would include the right abutment of the dam for either alternative, and in the vicinity of the downstream powerhouse for the Full Removal alternative. The access bridge across the Klamath River downstream of the powerhouse may require improvements to handle the construction equipment loads. A new bridge was assumed for development of the Most Probable High cost estimate for the Full Removal alternative, as described in Section 9 (Construction Cost Estimates).

The spillway gates and traveling hoists would be removed by a large crane for loading onto highway trucks and heavy-haul trailers, with the reservoir drawn down as much as possible. The reinforced concrete spillway bridge deck and piers could be removed in pieces by hydraulic excavators, or in sections by conventional or diamond-wire sawcutting. Removal of the remainder of the spillway concrete structure would likely be performed using conventional drilling and blasting methods as each portion is unwatered. Drilling for blasting would include small- to mid-sized hydraulic track drills and perhaps air-track drills supported by 850 to 1200 ft^3/min air compressors. Considerable jack-leg and hand drilling could be used to supplement the machine drilling for special shots. The loading and hauling equipment would be similar to that employed at Copco No. 1, but with fewer active crews. An average haul distance of 1.25 miles was assumed for construction scheduling purposes, with an average speed for the haul units of 12 mph. Reinforced concrete in deck, wall, and floor slabs for remaining features to be removed (including intake structure, gravity structure, sidewalls, apron, and powerhouse) would be excavated by mechanical methods (e.g. hydraulic shears or hoe-ramming).

Assumed equipment for the removal of Copco No. 2 Dam and Powerhouse includes:

- Crawler-mounted lattice boom crane, 200 ton, 160- to 200-foot boom
- Rough terrain hydraulic crane, 35 to 75 ton
- Mid-size hydraulic excavator, 28,000 to 60,000 lb, 1 to 2 yd^3 bucket
- Cat 336 hydraulic track excavator, 80,000 lb, 3.5 yd^3 bucket
- Hydraulic track excavators, 65,000 to 120,000 lb, with Cat H120 hoe-ram, thumb and shear attachments
- Cat 966 articulated wheel-loader, 52,000 lb, 5 yd^3 bucket
- Cat 730 articulated rear dump truck, 50,000 lb, 30 ton (20 yd^3)
- D-6 or D-7 standard crawler dozers
- Front-end wheel loader, integrated tool carrier, 25,000 lb
- Cat TL943 rough terrain telescoping forklift
- Rough terrain telescoping manlift
- On-highway, light duty diesel pickup trucks, ½ ton and 1 ton crew
- On-highway flatbed truck with boom crane, 16,000 lb
- On-highway truck tractors, 45,000 lb
- Off-highway water tanker, 5,000 gallon
- On-highway water truck, 4,000 gallon
- Self-propelled rubber tire and drum vibratory compactor, 5 to 15 ton
- Engine generators, 6.5 KW to 40 KW, diesel or gasoline
- Air compressors, 100 to 150 psi, 185 to 850 cfm, diesel
- Airtrack drill or hydraulic track drill
- Hand-held drilling, cutting, and demolition equipment
- Portable welders and acetylene torches
- 4-inch submersible trash pumps, electric

Imported materials that may be required for construction would include gravel surfacing for temporary haul roads, soil cover for concrete waste disposal, seed and mulch materials, and minor quantities of ready-mix concrete and reinforcing steel from local commercial sources for tunnel plugs.

An estimated average workforce of 25 to 30 people would be required for the construction activities, for an estimated duration of about 6 months from site mobilization to construction completion for either dam removal alternative. The peak workforce required during excavation of the dam and powerhouse could reach 35 to 40 people.

4.3.4. Waste Disposal

Estimated waste quantities for the Full Removal alternative for Copco No. 2 Dam and Powerhouse include nearly 1,500 yd^3 of earthfill, over 6,000 yd^3 of concrete, an estimated 300 tons of reinforcing steel, and nearly 500 tons of mechanical and electrical items at the dam (to the first tunnel portal); and over 6,000 yd^3 of concrete, an estimated 300 tons of reinforcing steel, over 1,500 tons of mechanical and electrical items, and 550 tons of treated wood (in wood-stave penstock) from the first tunnel portal to the powerhouse. There is also a large shop building with a total area of 3,600 ft^2 and estimated waste volume of 600 yd^3, and 0.14 mile of 69-kV transmission lines. Total waste quantities for the Partial Removal alternative include 4,500 yd^3 of concrete, 200 tons of reinforcing steel, 500 tons of mechanical and electrical items, and 550 tons of treated wood. Estimated quantities for individual items of work are shown in the attached cost estimate worksheets in Attachment D for each alternative. All volume estimates shown above are based on in-place conditions, without an allowance for bulking.

All concrete rubble and embankment material from the dam is assumed to be buried on the right abutment within an on-site disposal area prepared for the disposal of concrete rubble from Copco No. 1 Dam, covering an area of approximately 7 acres. Concrete rubble from the powerhouse may be buried within the existing tailrace channel. Reinforcing steel would be separated from the concrete and hauled to a local recycling facility. The on-site disposal areas would be covered with soil, graded, and sloped for drainage upon completion. Compaction other than by equipment travel would probably not be necessary.

All mechanical and electrical equipment would be hauled to a suitable dump site or salvage collection point outside the FERC project boundaries. A Class III sanitary landfill and medium volume transfer station is located in Yreka, California, in Siskiyou County, approximately 28 miles from the damsite, and is accessible by county road and federal highway (Interstate 5). The landfill accepts construction and demolition waste and mixed municipal waste, and had an estimated remaining capacity in 2010 of 3,924,000 yd^3. The transfer station accepts metals and mixed municipal recyclable materials.

Potential hazardous materials at Copco No. 2 Dam and Powerhouse include creosote-treated wood-stave (redwood) penstock and treated wood, asbestos, batteries, bearing and hydraulic control system oils, and coatings containing heavy metals in the powerhouse and on the exterior surfaces of the steel penstock and air vent pipes, which would need specialized abatement and disposal requirements. The treated wood materials would be hauled either 70 miles to White City, Oregon (assumed for the cost estimate) or 120 miles to Anderson, California (as performed by PacifiCorp in the past) for proper disposal. Contaminated soils may exist at the locations of painted exterior equipment and require remediation. Asbestos may be found in electrical wiring insulation and possibly in other building materials. Mercury may exist in older light switches. Although all transformers have been tested negative for PCB, some residual PCB’s may exist in closed systems such as transformer bushings. Equipment containing over 18,000 gallons of various types of oils and fuels has been identified at the site. The administration and control center includes a building for the storage of EPA-regulated materials, and a fueling facility containing above-ground gasoline (1,000 gallon) and diesel (500 gallon) tanks which meet state and federal requirements. Underground septic systems are in use for seven residences near the Powerhouse and should be removed. The transportation and disposal of all waste materials will follow applicable federal, state, and local regulations, including those for spill prevention and containment. Most of the "hazardous" waste was not considered to be hazardous under RCRA for cost estimating purposes (i.e. below defined toxicity levels for hazardous waste), and was assumed to go to the local landfill nearest the damsite.

Estimated quantities, numbers of truck trips, proposed haul routes to disposal sites, and approximate haul distances for waste disposal are summarized in Table 4-6 for the Full Removal alternative. This table assumes off-highway articulated rear dump trucks would be used for hauling concrete and earth materials on unpaved roads between the dam or powerhouse and proposed waste sites on PacifiCorp property, with a nominal load capacity of 20 cubic yards each, and truck tractor-trailers for hauling mechanical and electrical items, metals, and other waste materials on paved public roads (at posted speed limits), with a nominal load capacity of 12.5 tons or 10 cubic yards each. County roads may be subject to load restrictions during the rainy season (December through May). A bulking factor of 30 percent for concrete rubble and 20 percent for earth materials has been assumed for determining the number of truck trips required for hauling loose materials. All values have been rounded. Miles shown are average for one round trip, from demolition site to disposal site and return. Total miles (not shown) would be computed from the estimated number of total trips shown multiplied by the average trip distance. Peak daily trips for each site are based on the number of vehicles (units) shown, operating within one 8-hour shift. Similar computations may be made for the Partial Removal alternative. A map of the proposed haul routes and local disposal sites for Copco No. 2 Dam is provided on Figure 4.2-2.

Table 4-6. - Waste Disposal for Full Removal of Copco No. 2 Dam

Waste Material	Bulk Quantity*	Disposal Site	Peak Daily Trips	Total Trips
Earth	1,800 yd^3	Right abutment structures site	2 units/50 trips (unpaved road)	90 trips (2 miles RT)
Concrete at dam	8,000 yd^3	Right abutment structures site	2 units/50 trips (unpaved road)	400 trips (2 miles RT)
Concrete at powerhouse	8,000 yd^3	Tailrace area	Dispose at site (no hauling)	0
Metal and Rebar at dam	800 tons	Transfer station near Yreka, CA	1 unit/5 trips (Copco Road)	65 trips (62 miles RT)
Metal and Rebar at powerhouse	1,800 tons	Transfer station near Yreka, CA	2 units/10 trips (Copco Road)	145 trips (56 miles RT)
Building Waste	600 yd^3	Transfer station near Yreka, CA	2 units/10 trips (Copco Road)	60 trips (56 miles RT)

Treated Wood	550 tons	Landfill near Anderson, CA	1 unit/2 trips (Interstate 5)	45 trips (140 milesRT)

* - Volumes increased 30 percent for concrete rubble, 20 percent for loose earth materials

4.4 Iron Gate Dam and Powerhouse

4.4.1. Removal Limits

Iron Gate Dam is located in a relatively narrow canyon on the Klamath River at RM 190.1. Minimum requirements for a free-flowing condition and for volitional fish passage on the Klamath River through the Iron Gate damsite would require the complete removal of the zoned earthfill embankment and concrete cutoff walls between the rock abutments and to the bedrock foundation, to ensure long-term stability of the site and to prevent the development of a potential fish barrier in the future. The fish trapping and holding facilities located on random fill in the river channel below the dam would also have to be removed to restore the river channel. The concrete intake towers and access footbridges would be removed for public safety and to prevent potential future seismic stability concerns. The spillway side-channel inlet structure, chute, and terminal structure would be buried (requiring up to 300,000 yd^3 of backfill) to reduce project costs and to restore the pre-dam appearance of the right abutment for either alternative. The diversion intake structure would be removed, and the tunnel and vertical shaft portals would be plugged with reinforced concrete to avoid unauthorized entry for either alternative. The lower portion of the outdoor-type powerhouse could be retained for the Partial Removal alternative within the 100-year floodplain, provided any openings are sealed to prevent unauthorized entry. The steel penstock and water supply pipes between the intake structure and the powerhouse would be removed to accommodate removal of the dam embankment, and to avoid long-term maintenance issues related to the steel, which is assumed to include coatings containing heavy metals. The excavated tailrace channel between the powerhouse and the river would be backfilled as necessary, and the switchyard would be removed. Any unused transmission lines would be removed, including poles and transformers. The existing transmission lines cross over steep terrain in some areas and may be difficult to access.

The Iron Gate fish hatchery, located near Bogus Creek, is assumed to be retained for either dam removal alternative, in accordance with the KHSA (2010). An alternative water source would have to be found for the fish hatchery to remain operational, but is outside the scope of this Detailed Plan report. The existing 30-inch-diameter cold water supply distribution system from the penstock intake structure to the Iron Gate fish hatchery (including aerator) would be removed with the embankment dam sometime after June 2020.

Removal of the Iron Gate powerhouse for the Full Removal alternative would involve the following major mechanical and electrical equipment: one vertical-shaft, Francis-type hydraulic turbine unit, one turbine governor hydraulic control system with oil storage reservoir and pressure tank, one turbine runner spiral casing and head cover/operating ring, two turbine gate hydraulic servomotors, one vertical turbine shaft, one 96-inch-diameter bypass pipe from penstock around unit to tailrace, one turbine draft tube, three draft tube bulkhead gates, four vertical turbine pumps on powerhouse tailrace deck for fish ladder water supply, a vertical sump pump, bearing oil storage tanks, and other miscellaneous mechanical equipment, piping, and valves; three plant transformers, distribution equipment, unit breaker, one generator, conduit and cable, plant control equipment, and other miscellaneous electrical equipment. Removal of the Iron Gate switchyard for either alternative would involve the removal of all transformers, breakers, switches, and take-off structures. The 150-ton generator gantry crane for the Iron Gate Powerhouse is currently located at the J.C. Boyle Powerhouse and is assumed to be removed from that site.

Retention of the Iron Gate powerhouse for the Partial Removal alternative would require the structure to be sealed. Mechanical and electrical equipment could be left in place with all power connections to the outside removed; however, any oil in the turbine governor and hydraulic control systems, transformers, oil storage tanks, or other equipment would need to be removed. Other potentially hazardous materials, such as batteries and treated wood, would also be removed. The short tailrace channel between the powerhouse and the river channel could be backfilled to the pre-construction contours if necessary, effectively burying the remaining structure.

Features to be removed or retained for the dam removal alternatives are summarized in Table 4-7.

Table 4-7. – Iron Gate Dam and Powerhouse, Removal Requirements

Feature	**Full Removal**	**Partial Removal**
Embankment Dam, Cutoff Walls	Remove	Remove
Penstock Intake Structure	Remove	Remove
Penstock	Remove	Remove
Water Supply Pipes	Remove	Remove
Spillway Structure	Retain, Bury	Retain, Bury
Powerhouse	Remove	Retain, Bury
Powerhouse Hazardous Materials (transformers, batteries, insulation)	Remove	Remove
Powerhouse Tailrace Area	Backfill	Backfill
Fish Facilities on Dam	Remove	Remove
Fish Hatchery	Retain	Retain
Switchyard	Remove	Remove
Diversion Tunnel Intake Structure	Remove	Remove
Diversion Tunnel Portals	Concrete Plug	Concrete Plug
Diversion Tunnel Control Gate	Remove	Remove

4.4.2. Reservoir Drawdown

The following reservoir drawdown and streamflow diversion plan is proposed to facilitate the removal of Iron Gate Dam, while minimizing flood risks and downstream impacts due to the release of impounded sediments. Refer to the Hydrology section for historic daily and monthly streamflow data and frequency floods for this site. Additional releases due to concurrent drawdown at J.C. Boyle Dam and Copco No. 1 Dam may affect the drawdown of Iron Gate Reservoir. The proposed plan assumes that power generation at Iron Gate Dam ends on January 1, 2020, as specified by the KHSA. Reservoir drawdown would not commence until that time. There are no differences in the reservoir drawdown and streamflow diversion plans for the Full and Partial Removal alternatives, unless otherwise indicated.

The natural slopes on the reservoir rim usually control the allowable drawdown rate because natural slopes in soil are often not as stable as the engineered slopes of an embankment. Typically, rapid drawdown failures in soil are shallow slides that do not have significant impact. A preliminary review of the reservoir rim at Iron Gate Dam did not reveal obvious stability problems, nor were there any significant structures that could be impacted by rapid drawdown slope failures (PanGEO, 2008). The drawdown of Iron Gate Reservoir would therefore be controlled by the rate that would be safe for the embankment dam. A nominal drawdown rate of 1 ft/day would not impact the stability of Iron Gate Dam because the dam has wide, pervious outer shells that not only have high strength, but should also drain relatively quickly as the reservoir is drawn down. Increasing the drawdown rate beyond 1 ft/day would provide increased flexibility in the removal schedule as less time would be required for reservoir drawdown. Although a faster drawdown rate of 3 ft/day or more may be acceptable for the existing conditions, additional slope stability analyses and a much more detailed evaluation of the reservoir rim slopes would be required to confirm this condition. Faster drawdown rates could result in deeper slides which may present a greater safety concern due either to the slide or the potential for reservoir waves generated by the slide. For the drawdown modeling runs, an average drawdown rate of 3 ft/day was assumed for Iron Gate Reservoir, which would be confirmed by additional analyses for final design. Downstream ramping rates (or rates of rise and fall of the river) may have to exceed current FERC license limits during some drawdown operations (such as cofferdam breach).

Sufficient freeboard would have to be maintained at all times between the elevation of the excavated embankment surface and the reservoir to reduce the potential for flood overtopping and potential embankment failure. The freeboard would be dictated by the amount of flood protection that is desired (in terms of flood return period) during the removal operation. Normally when the dam is higher and failure due to flood overtopping would cause a catastrophic release of reservoir water, the flood storage (freeboard) has to be larger. As dam removal nears completion and the reservoir impoundment is much smaller, the consequences of overtopping are not as great and less freeboard and flood protection would be acceptable. The proposed plan described below does not permit any excavation of the embankment section at Iron Gate Dam until June 1, 2020, and requires completion by September 30, 2020, to minimize hydrologic risk. Seasonal frequency floods for this period have been developed to help assess this risk.

4.4.2.1. Modify diversion tunnel to increase total release capacity (June-July, 2019)

a. With upstream (upper sluice and lower diversion) concrete gates 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 gates to retain full reservoir head. (Preliminary analyses confirm the existing features would be capable of accommodating this loading condition.)

b. Raise upper sluice gate slowly to fill portion of downstream tunnel between concrete gates and blind flange. Provide air vent and drain valve through downstream concrete ring as necessary. Close air vent when filling has been completed.

c. Mobilize barge-mounted crane onto reservoir in June 2019. Raise upper sluice gate to top of control tower using the existing hoist and remove using barge-mounted crane. Send hard-hat divers to 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 lower diversion gate to top of control tower using existing hoist and remove using barge-mounted crane. Fabricate, deliver, and install new 16.5- by 18-foot roller gate into existing slots in gate shaft (with a 150-foot design head) using hard-hat divers and barge-mounted crane. Install new gate operator with remote controls. Close new roller gate. Move barge-mounted crane to Copco Reservoir by mid-July 2019.

d. 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. Complete any repairs to downstream tunnel lining as needed.

4.4.2.2. Begin reservoir drawdown and sediment release using modified tunnel (January 1, 2020)

a. Cease power generation and begin reservoir drawdown from RWS elevation 2328 on January 1, 2020. Make controlled releases through modified diversion tunnel. Assume predicted inflows, plus drawdown releases from upstream reservoirs up to about 500 ft^3/s.

b. Continue reservoir drawdown at an allowable drawdown rate (assumed for scheduling purposes at 3 feet per day) using modified diversion tunnel. Should reach RWS elevation 2202 or lower for a median (50 percent exceedance) or dry (90 percent exceedance) year, or about RWS elevation 2220 for a wet (10 percent exceedance) year, based on estimated release capacities; however, some refill should be expected for higher flows in March and April. (Note that elevation 2202 is 3 feet below original cofferdam crest.)

4.4.2.3. Begin dam removal after spring runoff (June 1, 2020)

a. Draw down reservoir, but maintain a minimum flood release capacity of approximately 7,700 ft^3/s in June (RWS elevation 2251), to accommodate the passage of at least a 100-year flood for that time of year. Remove fish facilities near downstream toe of embankment (including fish ladder and holding tanks) and dam crest sheet piles in the dry. Retain embankment dam crest at level needed for flood protection, and the existing access bridge to the gate control house for regulating tunnel releases.

b. Begin embankment excavation for dam removal, but maintain a minimum flood release capacity of approximately 7,000 ft^3/s in July (RWS elevation 2239) and 3,000 ft^3/s in August and September (RWS elevation 2191), to accommodate the passage of at least a 100-year flood for that time of year. Remove embankment materials (estimated 880,000 yd^3 without upstream cofferdam volume of 20,000 yd^3), 5-foot riprap on downstream face (30,000 yd^3), and 10-foot riprap on upstream face (80,000 yd^3) in the dry. Requires two shifts for excavation of 16,000 yd^3 per day (average 1,000 yd^3 per hour) and a 5-day work week. Assume left abutment disposal site (shown on drawings) for earth and concrete rubble, with approximately a 1 mile haul. Begin wasting earth and concrete materials in spillway chute and basin (up to 300,000 yd^3) after June, with dam crest below existing spillway crest (elevation 2328). Provide new access to gate control house between base of tower at elevation 2254 and deck at elevation 2338 (84 feet high – assume vertical stairway structure, or longer footbridge from spillway crest). Also consider remote operation of the roller gate for flow control.

c. Draw down reservoir to maximum extent (during minimum streamflow and with no upstream drawdown releases) by September 1, 2020 and place rockfill on downstream face of cofferdam (having a crest no lower than elevation 2191) for controlled breach of armored cofferdam embankment above the existing bedrock surface at elevation 2154, by notching below the reservoir level (expected to be below RWS elevation 2183). Remove remaining materials from the river channel in the wet, during the low flow period. Breach cofferdam at Iron Gate Dam prior to breach of cofferdam at J.C. Boyle Dam to minimize potential downstream impacts. Maximum breach outflow from cofferdam at Iron Gate Dam is estimated to be approximately 5,000 ft^3/s.

d. Remove diversion tunnel intake structure (invert elevation 2175), topple gate control tower for removal (base elevation 2251), and plug tunnel and shaft portals with reinforced concrete. Topple and remove penstock intake structure, and plug openings. Remove water supply features for fish facilities.

e. Construct cofferdam in tailrace channel for removal of powerhouse in the dry for Full Removal alternative. Use sump pumps to unwater area. Remove cofferdam when no longer needed. Demobilize from site when construction activities are complete.

4.4.3. Demolition Methods and Equipment

The following demolition methods and sequence, construction equipment requirements, workforce requirements, and construction activity durations have been assumed for planning, scheduling, and cost estimating purposes, based on engineering judgment. Alternative methods, sequence, equipment, and durations which would also meet project requirements are possible. There are no significant differences in the assumed demolition methods and proposed construction schedules for the Full and Partial Removal alternatives, unless otherwise indicated. Removal of the structures to be retained under the Partial Removal alternative is generally not on the critical path for dam removal, and would therefore not impact the overall completion of the work.

The contractor would have to mobilize construction equipment to the site by June 2019 for the diversion tunnel modifications and to improve the existing access roads between the dam and on-site waste disposal areas for two-way traffic where required. The delivery of off-road construction equipment, including cranes, large excavators, loaders, and large capacity dump trucks would be by special tractor-trailer vehicles operating under "wide load" restrictions and at appropriate speeds. Equipment staging areas would include both abutments of the dam and in the vicinity of the powerhouse. New haul routes from the dam would continually have to be constructed and maintained as the excavation level and shape changes. An average haul distance of 1.5 miles was assumed for construction scheduling purposes, with an average speed for the haul units of 20 mph empty and 10 mph loaded. During a site visit in October 2007, the morning fog was very thick until 10 am. If this were to occur during dam removal, it could impact the rate at which trucks could haul the excavated embankment materials due to reduced visibility on the haul road. The use of a conveyor belt may be considered as an alternative or supplement to truck hauling. The access bridge across the Klamath River downstream of the dam may also require improvements to handle the anticipated construction equipment loads. A conveyor belt was considered for development of the Most Probable Low cost estimate, and a new bridge was assumed for development of the Most Probable High cost estimate, as described in Section 9 (Construction Cost Estimates).

The successful removal of Iron Gate Dam would be highly dependent upon the modification and operation of the diversion tunnel for low-level releases to permit controlled reservoir drawdown, and a very high excavation production rate for removal of the embankment during the summer, low-flow months (June through September). The Iron Gate production assessment considers the approximate lift area by elevation and how many concurrent excavation operations could be occurring at that elevation. At the top, the lift surface is narrow and long and the needed overall average production rate would not be attainable. As the excavation descends, the footprint would become wider and additional equipment could be added to the equipment spread. The short and wide bottom lifts would also limit production, similar to the top. Consequently, very high production rates would be needed for the larger middle lifts. The removal of the riprap would most likely occur as the embankment is excavated down. Some rockfill would have to be stockpiled for later use as slope protection for the upstream cofferdam.

The contractor would probably use conventional earthmoving equipment consisting of excavators and off-road articulated or fixed-wheel haul units to reach the required average production rate of 1,000 cubic yards per hour. Key factors would be sizing the excavators to minimize the loading passes per haul unit, and selecting the maximum size haul units that can effectively negotiate the dam surface and haul route. To achieve the desired daily production rates, shift work would be required. The additional costs for overtime and equipment maintenance would be accounted for in the cost estimate. The potential for significant acceleration of the construction schedule may be very limited, if required, and may only be obtained by adding additional excavation time (increasing to 6 or 7 days per week, and/or longer shifts) and probably not by adding more equipment to the limited lift surfaces. The current assessment assumes 5 days per week and 1.75 shifts per day for 8 to 9 shifts per week, and assumes an average of twenty 35-ton haul units loaded by up to four 180,000 to 240,000 lb, 6 to 8 yd^3 excavators, to remove the dam embankment within about 16 weeks. This assessment could be revised to increase the number of shifts per week, the lengths of the shifts, and the size of the haul units, but would produce a best-case scenario that would probably not be consistently achievable. (It is interesting to note that the original placement of 1,100,000 yd^3 of embankment materials was completed within only 18 weeks in 1961.)

Reinforced concrete in deck, wall, and floor slabs for any structures to be removed (including intake structures, control structures, fish handling facilities, and powerhouse) would likely be excavated by mechanical methods (e.g. hydraulic shears or hoe-ramming). Removal of any mass concrete may be performed using conventional drilling and blasting methods.

Assumed equipment for the removal of Iron Gate Dam and Powerhouse and for restoration of the reservoir area includes:

- Crawler-mounted lattice boom crane, 200 ton, 160- to 200-foot boom
- Rough terrain hydraulic crane, 35 to 75 ton
- Hitachi hydraulic excavator, 180,000 to 240,000 lb, 6 to 8 yd^3 bucket
- Cat 336 hydraulic track excavator, 80,000 lb, 3.5 yd^3 bucket
- Hydraulic track excavators, 65,000 to 100,000 lb, with Cat H120 hoe-ram, thumb and shear attachments
- Cat 966 articulated wheel-loader, 52,000 lb, 5 yd^3 bucket, or
- Cat 980 or Cat 988 articulated wheel-loader, 65,000 lb, 6 or 10 yd^3 bucket
- Cat 735 articulated rear dump truck, 70,000 lb, 35 ton (22 yd^3), or
- Cat 770 fixed haul unit, 160,000 lb, 40 ton
- D-7 or D-9 standard crawler dozers, or
- D-8 support and knockdown dozer
- Front-end wheel loader, integrated tool carrier, 25,000 lb
- Cat TL943 rough terrain telescoping forklift
- Rough terrain telescoping manlift
- Cat 14 or Cat 16 motorgrader
- Truck-mounted seed sprayer, 2,500 gallon
- On-highway, light duty diesel pickup trucks, ½ ton, ¾ ton, and 1 ton crew
- On-highway flatbed truck with boom crane, 16,000 lb
- On-highway truck tractors, 45,000 lb
- Off-highway water tanker, 5,000 gallon
- On-highway water truck, 5,000 to 9,000 gallon
- Wheel-mounted asphalt paver (for Most Probable High estimate only)
- Self-propelled rubber tire and drum vibratory compactor, 5 to 15 ton
- Engine generators, 6.5 KW to 40 KW, diesel or gasoline

- Air compressors, 100 to 150 psi, 185 to 850 cfm, diesel
- Airtrack drill or hydraulic track drill
- Hand-held drilling, cutting, and demolition equipment
- Portable welders and acetylene torches
- 4-inch submersible trash pumps, electric
- Light plants, 2,000 to 6,000 watt, 10 to 25 hp, diesel

Imported materials that may be required for construction would include gravel surfacing for temporary haul roads (approximately 5,300 tons), soil cover for concrete waste disposal (if not from required excavation), seed and mulch materials, and minor quantities of ready-mix concrete and reinforcing steel from local commercial sources for tunnel and shaft plugs.

An estimated average workforce of 35 to 40 people would be required for the construction activities, for an estimated duration of 17 months from site mobilization to construction completion for either dam removal alternative. The peak workforce required during excavation of the dam embankment could reach 75 to 80 people.

4.4.4. Waste Disposal

Estimated waste quantities for the Full Removal alternative for Iron Gate Dam and Powerhouse include nearly 1,100,000 yd^3 of earthfill, nearly 12,000 yd^3 of concrete, an estimated 600 tons of reinforcing steel, and nearly 1,000 tons of mechanical and electrical items at the dam and powerhouse. In addition, there are four buildings at the site with a combined area of over 2,300 ft^2 and estimated waste volume of 400 yd^3. Total waste quantities for the Partial Removal alternative include nearly 1,100,000 yd^3 of earthfill, 8,000 yd^3 of concrete, 400 tons of reinforcing steel, and 500 tons of mechanical and electrical items. Estimated quantities for individual items of work are shown in the attached cost estimate worksheets in Attachment D for each alternative. All volume estimates shown above are based on in-place conditions, without an allowance for bulking.

A suitable disposal site for excavated embankment materials has been identified approximately 1 mile upstream from the dam on the left abutment, at an original borrow site, covering an area of approximately 29 acres. While not all land proposed for waste disposal is owned by PacifiCorp, this report is not a decision-making document for planning for land condemnation purposes. Should the Secretary make an affirmative determination, the exact location of this disposal site would be determined. Some initial clearing and improvements to this site would be required, including the stockpiling of excavated topsoil for later use. In addition, the existing concrete-lined side-channel spillway, chute, and flip-bucket terminal structure (located on the right abutment of the dam) would be filled with up to 300,000 yd^3 of excavated embankment material for disposal and restoration of the site. An adjoining area below the spillway along the right bank of the river (currently occupied by two PacifiCorp residences and some outbuildings) could be used for a riprap stockpile area or earth disposal site. The final disposal site location for all materials would have a significant impact on the costs to upgrade or construct the haul roads. Also, as the excavation descends, ramps out of the canyon would have to be constructed and maintained.

All concrete rubble is assumed to be buried within an on-site disposal area. Reinforcing steel would be separated from the concrete and hauled to a local recycling facility. The on-site disposal areas would be covered with topsoil, graded, and sloped for drainage upon completion. Compaction other than by equipment travel would probably not be necessary.

All mechanical and electrical equipment would be hauled to a suitable dump site or salvage collection point outside the FERC project boundaries. A Class III sanitary landfill and medium volume transfer station is located in Yreka, California, in Siskiyou County, approximately 25 miles from the damsite, and is accessible by county road and federal highway (Interstate 5). The landfill accepts construction and demolition waste and mixed municipal waste, and had an estimated remaining capacity in 2010 of 3,924,000 yd^3. The transfer station accepts metals and mixed municipal recyclable materials.

Potential hazardous materials at Iron Gate Dam and Powerhouse include asbestos, batteries, bearing and hydraulic control system oils, treated wood, and coatings containing heavy metals in the powerhouse and on the exterior surfaces of the steel penstock and air vent pipes, and other painted equipment, which would need specialized abatement and disposal requirements. Contaminated soils may exist at the locations of painted exterior equipment and require remediation. Asbestos may be found in electrical wiring insulation and possibly in other building materials. Although all transformers have been tested negative for PCB, some residual PCBs may exist in closed systems such as transformer bushings. Equipment containing nearly 5,000 gallons of various types of oils has been identified at the site. Underground septic systems are in use for the restroom and two residences near the dam and should be removed. The transportation and disposal of all waste materials will follow applicable federal, state, and local regulations, including those for spill prevention and containment. Most of the "hazardous" waste was not considered to be hazardous under RCRA for cost estimating purposes (i.e. below defined toxicity levels for hazardous waste), and was assumed to go to the local landfill nearest the damsite.

Estimated quantities, numbers of truck trips, proposed haul routes to disposal sites, and approximate haul distances for waste disposal are summarized in Table 4-8 for the Full Removal alternative. This table assumes off-highway articulated rear dump trucks would be used for hauling concrete and earth materials on unpaved roads between the dam and proposed waste sites on PacifiCorp property, with a nominal load capacity of 22 cubic yards each, and truck tractor-trailers for hauling mechanical and electrical items, metals, and other waste materials on paved public roads (at posted speed limits), with a nominal load capacity of 12.5 tons, or 10 cubic yards each. County roads may be subject to load restrictions during the rainy season (December through May). A bulking factor of 30 percent for concrete rubble and 20 percent for earth materials has been assumed for determining the number of truck trips required for hauling loose materials. All values have been rounded. Miles shown are average for one round trip, from demolition site to disposal site and return. Total miles (not shown) would be computed from the estimated number of total trips shown multiplied by the average trip distance. Peak daily trips for each site are based on the number of vehicles (units) shown, operating within two 8-hour shifts for earth materials, and one 8-hour shift for concrete rubble and metal. Similar computations may be made for the Partial Removal alternative. A map of the proposed haul routes and local disposal sites for Iron Gate Dam is provided on Figure 4.4-1.

Table 4-8. - Waste Disposal for Full Removal of Iron Gate Dam

Waste Material	Bulk Quantity*	Disposal Site	Peak Daily Trips	Total Trips
Earth	1,300,000 yd^3	Left and right abutment areas	12 units/800 trips (unpaved road)	60,000 trips (2 mile RT)
Concrete	15,000 yd^3	Left abutment borrow area	2 units/50 trips (unpaved road)	750 trips (2 miles RT)
Metal and Rebar	1,600 tons	Transfer station near Yreka, CA	1 unit/5 trips (Copco Road)	130 trips (54 miles RT)
Building Waste	400 yd^3	Transfer station near Yreka, CA	1 unit/5 trips (Copco Road)	40 trips (54 miles RT)

* - Volumes increased 30 percent for concrete rubble, 20 percent for loose earth materials

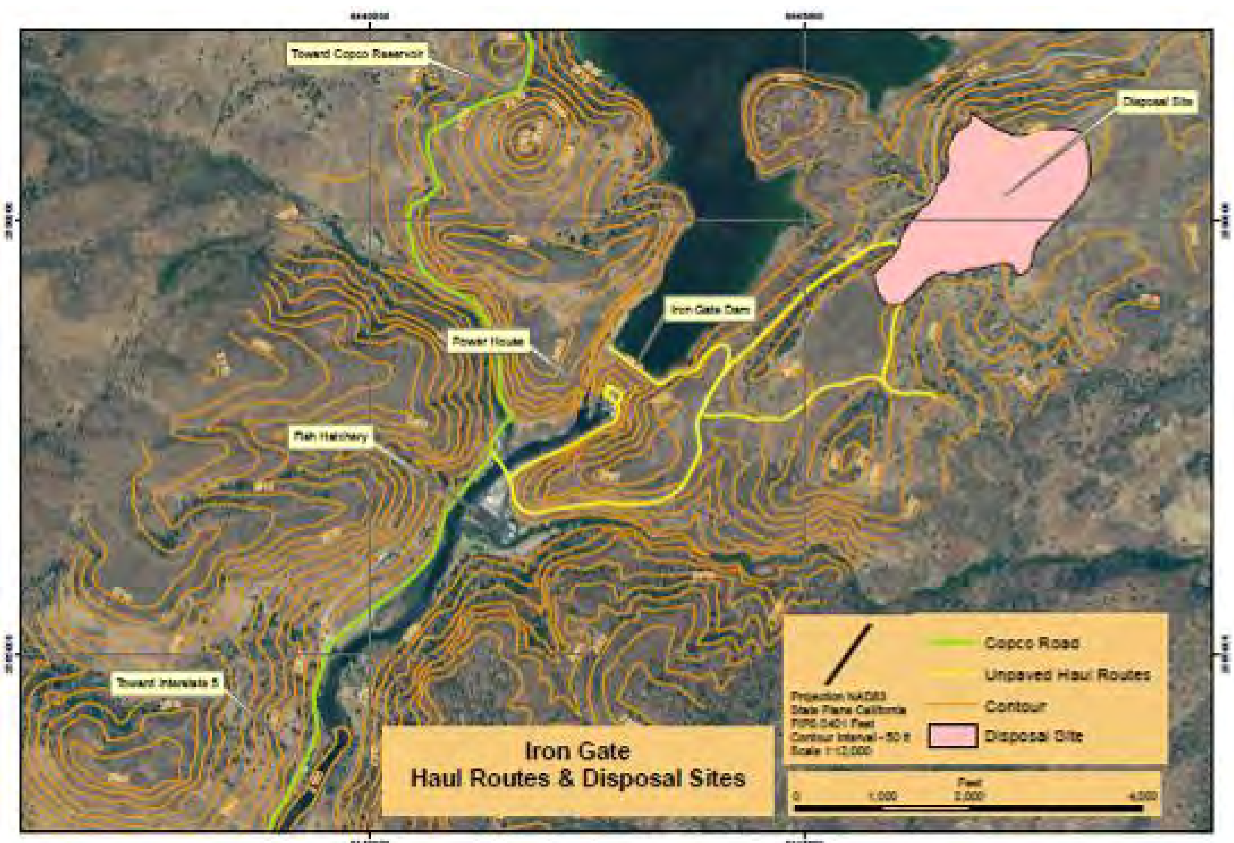


Figure 4.4-1. – Proposed Haul Routes and Disposal Sites for Iron Gate Dam.

5.0 Reservoir Sediment Studies

A detailed reservoir investigation is documented in Reclamation (2010a) and relevant results are discussed here. Previous reservoir investigations have been performed by JC Headwaters, Inc. (2003), and by Shannon and Wilson (2006).

The sediment in the reservoirs was characterized based on soil properties, grain size, desiccation properties, and critical shear stress. The soil properties, including grain size and critical shear stress, were determined from field sampling and laboratory testing.

Field investigations were conducted at J.C. Boyle, Copco No. l, Copco No. 2, and Iron Gate reservoirs, in the Klamath River Estuary at the mouth of the river, and for about seven miles upstream from the mouth of the river. Maps of the reservoir and the sample site locations are given in Figures 5.1, 5.2, 5.3, and 5.4 for J.C. Boyle, Copco No. 1, Iron Gate, and the Estuary, respectively. Phase 1 of the geologic investigations included in-reservoir drilling to collect comprehensive suites of samples of reservoir sediment (Qr) behind each dam. There were three main purposes of this work:

1. To collect samples for screening-level analysis of organic and inorganic chemical compounds within the reservoir sediment and, where present, to determine the level and extent of contamination;

2. To collect samples of reservoir sediment to determine a standard suite of physical properties and to collect undisturbed samples for analyses of engineering properties; and,

3. To help determine the thickness of reservoir sediment throughout all major sections of each reservoir.

The in-reservoir geologic investigations consisted of:

- Barge and boat platforms for Auger Drilling and Sampling;
- Barge and boat platforms for Push Tube Sampling;
- A boat platform for Vibracore Drilling and Sampling;
- A boat platform for Gravity Tube Sampling.

Barge and boat-supported drilling/sampling took place at fifty-five locations in J.C. Boyle, Copco No.1, and Iron Gate reservoirs. Sixty-nine samples of reservoir sediment and pre-reservoir deposits were collected for gradation analysis, Atterberg limits, and field moisture content; seventy-three samples of reservoir sediment were collected for chemical analysis; and nineteen undisturbed samples of reservoir sediment were collected in Lexan liners for engineering properties testing. In Copco No. 2 Reservoir, boat-supported sampling of reservoir sediment was attempted at sixteen locations, from the dam upstream for about 1,000 feet. In the Klamath River Estuary and up to seven miles upstream, boat-supported sampling took place at five locations, and characterization of fluvial deposits was conducted along seven miles of the river banks.

Fine-grained sediment in all of the reservoirs consisted primarily of elastic silt (MH), with lesser amounts of elastic silt with fine sand. The reservoir sediment is mostly an accumulation of silt-size particles of organic material such as algae and diatoms, and silt-size particles of rock loosely arranged in an open water-filled structure. Reservoir sediment hosts a higher percentage of silt, sand, and gravel in the upper reaches of each reservoir. Over several thousand feet downstream, this coarse sediment transitions into deposits of sandy elastic silt, then into elastic silt with trace sand.

Fine-grained reservoir sediment (elastic silt) throughout all reservoirs has the consistency of pudding. It is very soft and indents with very light finger pressure. Sediment firmed up a little in the range of 6 to 10 feet of thickness. On a microscopic scale, it has an open structure that holds a very high water content. Field moisture of samples of elastic silt were frequently 200 to 300 percent of the sample's dry weight, and ranged up to 700 percent moisture. Due to its high water content, most reservoir sediment not eroded during the initial stage of dam removal will likely take some time to dry out.

Fine-grained reservoir sediment has a low cohesion and is highly erosive. In each reservoir, fine-grained reservoir sediment was thinnest in the upstream portion of the reservoir and thickest near the dam. Reservoir sediment was also thin to nonexistent in narrow channels of the reservoirs, where water flow was greater than an estimated 2 to 4 miles per hour (or 3 to 6 ft/s). This was attributed to the sediment either remaining in suspension or eroding from the active channel, or both.

These investigations demonstrated that sediment deposition throughout all four reservoirs follows well understood principals of geology and of fluvio-lacustrine sedimentation. Geologic investigations did not encounter any unusual characteristics of the sediment or unique depositional environments that would require special consideration or explanation.

Methane gas is currently trapped in reservoir sediment behind each dam and this gas will escape during reservoir drawdown. A screening-level determination for all potential contaminants within the reservoir sediments was made by CDM (2011).

Surface geologic mapping and the installation of groundwater observation wells around each reservoir are planned for final design under Phase 2 of the investigation program. However, observations made during the current phase of geologic investigations indicate that when reservoirs are emptied:

1. Groundwater surrounding reservoirs will likely lower in elevation, and some domestic water well supplies will be significantly reduced; and,

2. Slope stability conditions around structures and domestic residences adjacent to the reservoirs will change when the dams are removed.

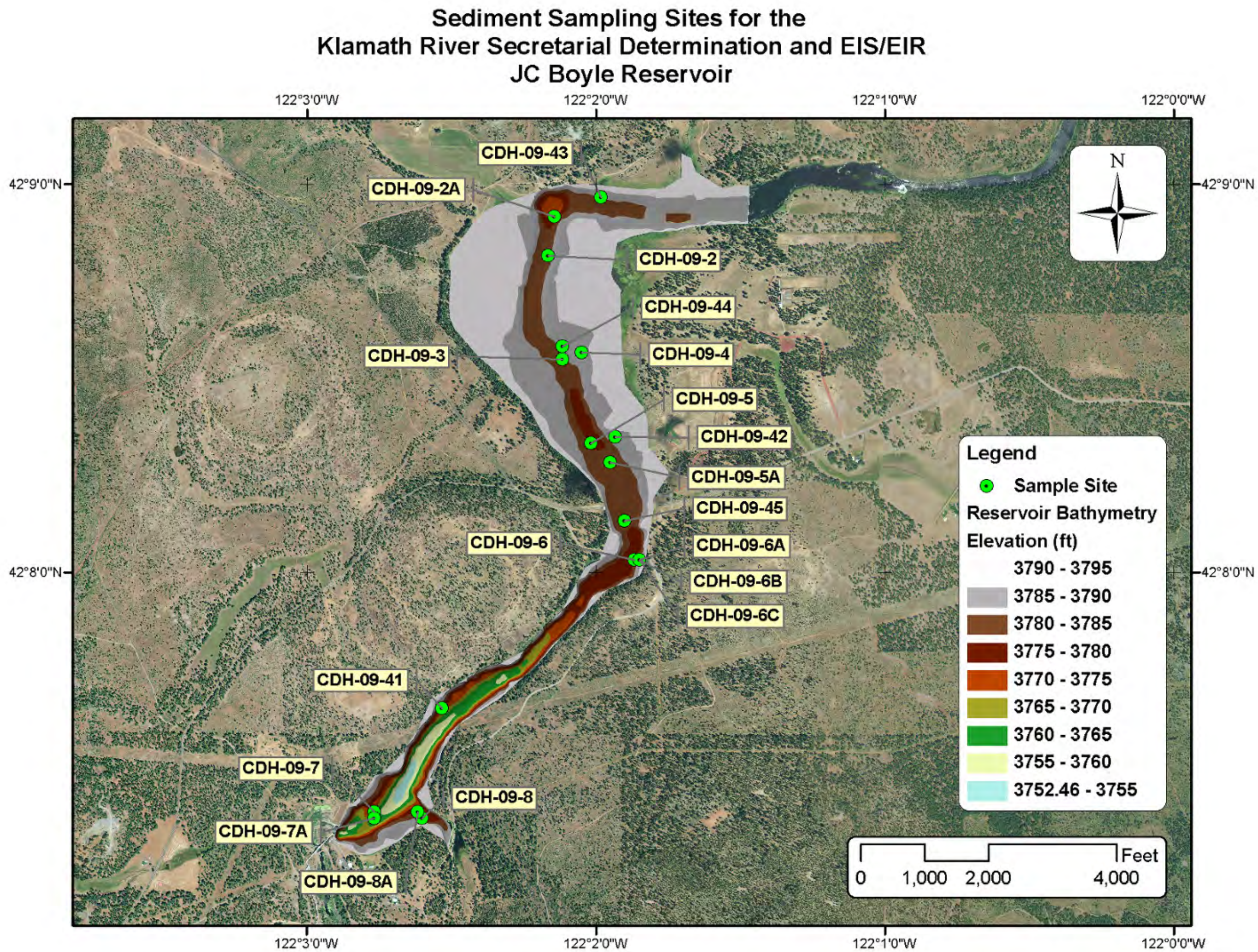


Figure 5.1. Bathymetry of JC Boyle Reservoir and 2009 Drill Hole Locations.

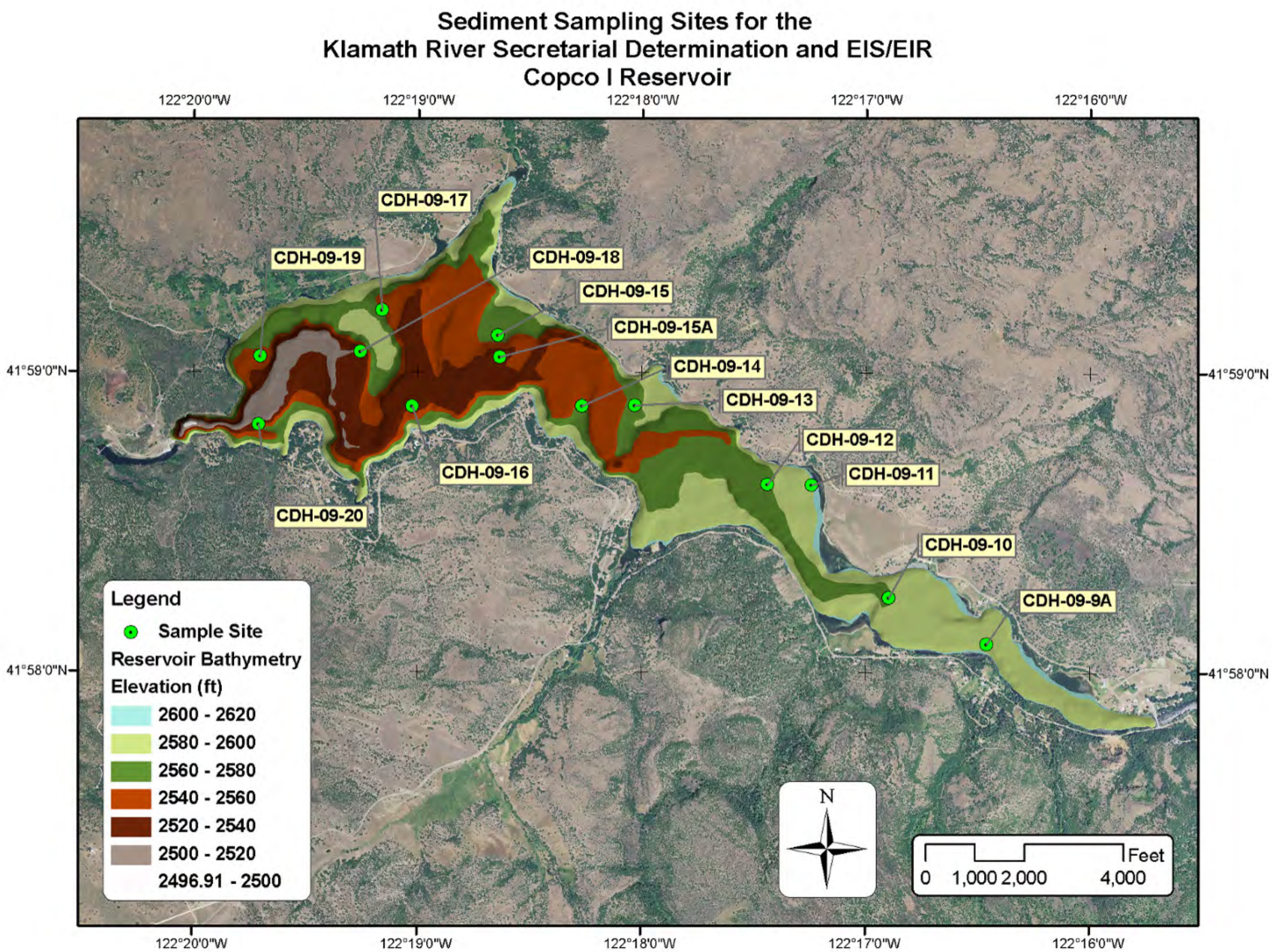


Figure 5.2. Bathymetry of Copco Reservoir and 2009 Drill Hole Locations.

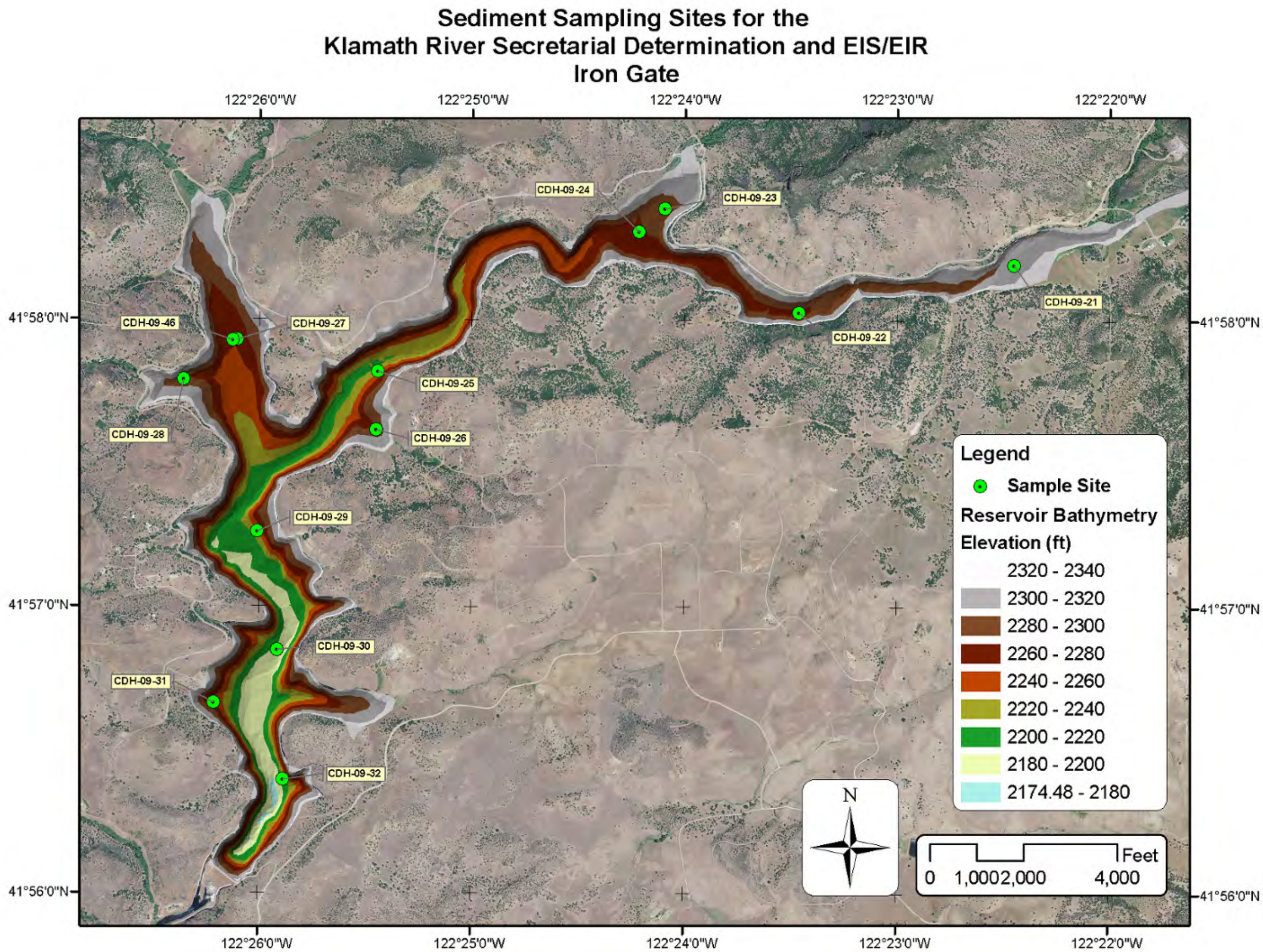


Figure 5.3. Bathymetry of Iron Gate Reservoir and 2009 Drill Hole Locations.

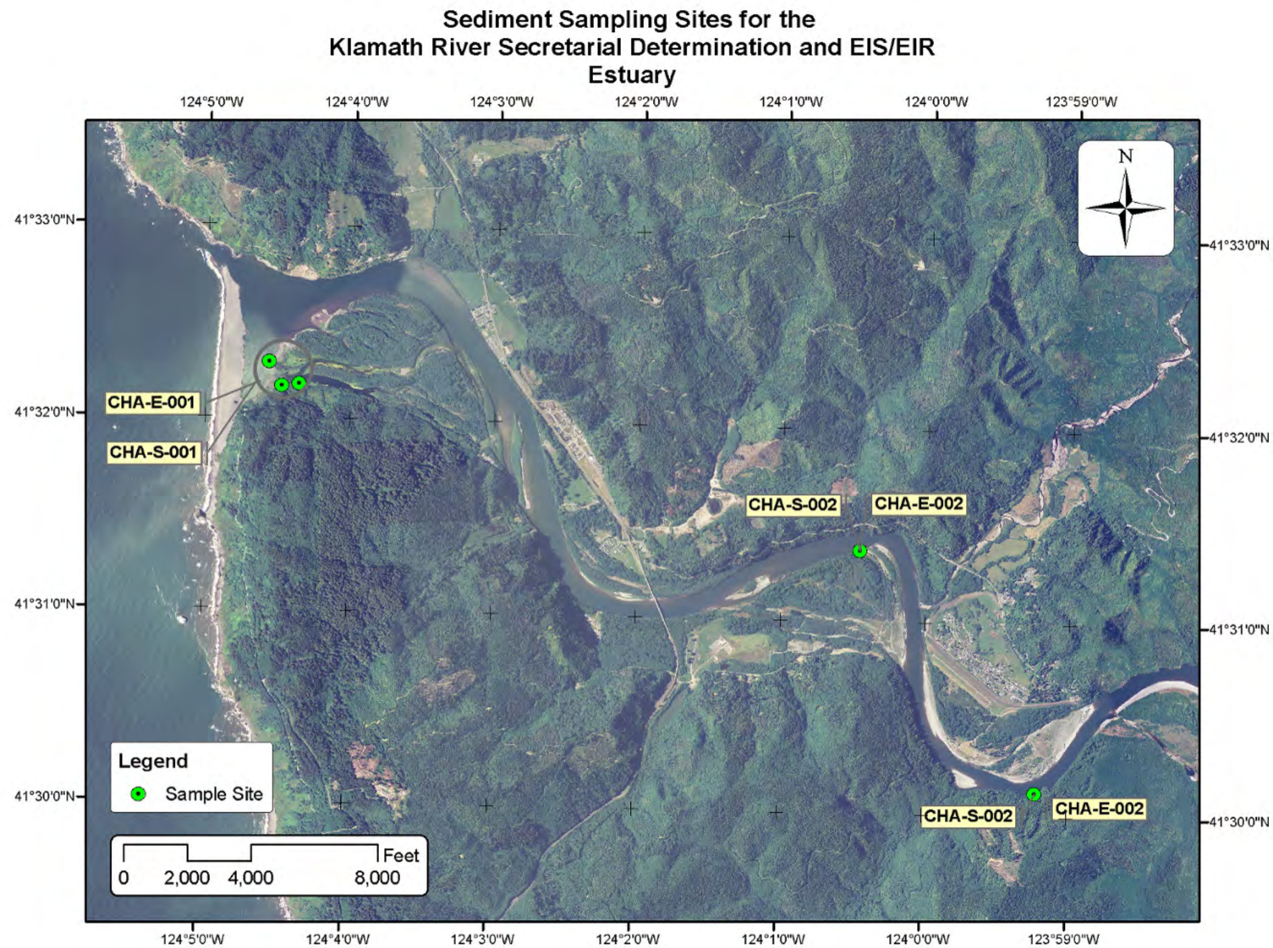


Figure 5.4. 2009 Sample site locations in Estuary

5.1 Sediment Volume and Thickness

The sediment volume was computed by interpolating between the measured thickness information from the drilling of sediment investigations performed in 2006 by Shannon and Wilson (2006) and that performed in 2009 by Reclamation (2010a). Details of the methodology are provided in Reclamation (2011) and the results for each reservoir are provided below. The total volumes in each reservoir are given in Table 5.1. No significant sediment volume was found in Copco No. 2 Reservoir.

5.1.1 J.C. Boyle Reservoir

The sediment depth at J.C. Boyle was determined by combining the sediment sample information with field observations. In the upper portions of the reservoir, little or no sediment was found during drilling except in one bend of the historical stream channel. An estimate of the extent of this sediment deposition was approximately drawn on the map to encompass the drill holes where the sediment was sampled. The extent of the deposition was limited to the historical stream channel.

In the lower portion of the reservoir, the sediment samples were used to determine the thickness. Between holes CDH-09-07 (near the dam) and CDH-09-6 (near the state highway bridge), the sediment thickness was linearly interpolated.

Figure 5.5 shows the map of reservoir thickness and the locations of the Shannon and Wilson (2006a) and 2009 sediment samples. The volume of trapped sediment was estimated to be 990,000 yd^3. Limited samples available where the sediment was the deepest near the dam contributed to the considerable uncertainty in this estimate. It is expected that the uncertainty of the estimate is about +/- 30 percent or 300,000 yd^3. The previous GEC estimate was 600,000 yd^3 and it is likely that the true value is somewhere in between this estimate and the current one. Additional drill holes in the areas where significant sediment is present could reduce this uncertainty. Specifically, more samples could be taken in the 4,000 feet nearest the dam and in the areas upstream of the bridge where some pockets of sediment exist.

5.1.2 Copco (No. 1) Reservoir

In order to estimate the sediment depths throughout Copco and Iron Gate reservoirs, a relationship was found between sediment depth and position within the reservoir for collected sediment samples. Samples were measured by Shannon and Wilson (2006a) and Reclamation (2010a). For Copco Reservoir, 28 samples were used. Figure 5.6 shows the map of reservoir thickness and the locations of the Shannon and Wilson (2006a) and 2009 sediment samples. The total sediment volume trapped in Copco Reservoir was estimated to be 7.44 million yd^3. An estimate of the uncertainty of this volume was computed by multiplying the average error of the regression equation by the area of the reservoir, which gave an uncertainty of +/-1.5 million yd^3, or about 20 percent.

5.1.3 Iron Gate Reservoir

The method for estimating the sediment depth in Iron Gate Reservoir was similar to that used for Copco Reservoir. A relationship was found between sediment depth and position within the reservoir for collected sediment samples. Samples were measured by Shannon and Wilson (2006) and Reclamation (2010a). For Iron Gate Reservoir, 18 samples were used within the main portion of the reservoir.

The sediment depth in the tributary arms was estimated by averaging over the approximate area of influence. Jenny Creek is the tributary that enters from the northeast. The average sediment thickness was 6.0 feet. Scotch Creek and Camp Creek enter the reservoir from the northwest. The average sediment thickness in this area is 3.0 feet. Figure 5.7 shows the map of reservoir thickness and the locations of the Shannon and Wilson (2006a) and 2009 sediment samples

The total sediment volume trapped in Iron Gate Reservoir was estimated to be 4.71 million yd^3. An estimate of the uncertainty of this volume was computed by multiplying the average error of the regression equation by the area of the reservoir. This equated to an uncertainty of +/-1.3 million yd^3 or about 29 percent.

Table 5.1. Reservoir volumes based upon drill holes (2010).

Reservoir	# holes 2006	# holes 2009	# holes Total	Estimated Volume (yd^3)	Estimated Uncertainty (+/- yd^3)
JC Boyle	5	26	31	990,000	300,000
Copco I	12	17	29	7,440,000	1,500,000
Copco II	0	0	0	0	
Iron Gate	9	19	28	4,710,000	1,300,000
TOTALS	26	62	88	13,140,000	3,100,000

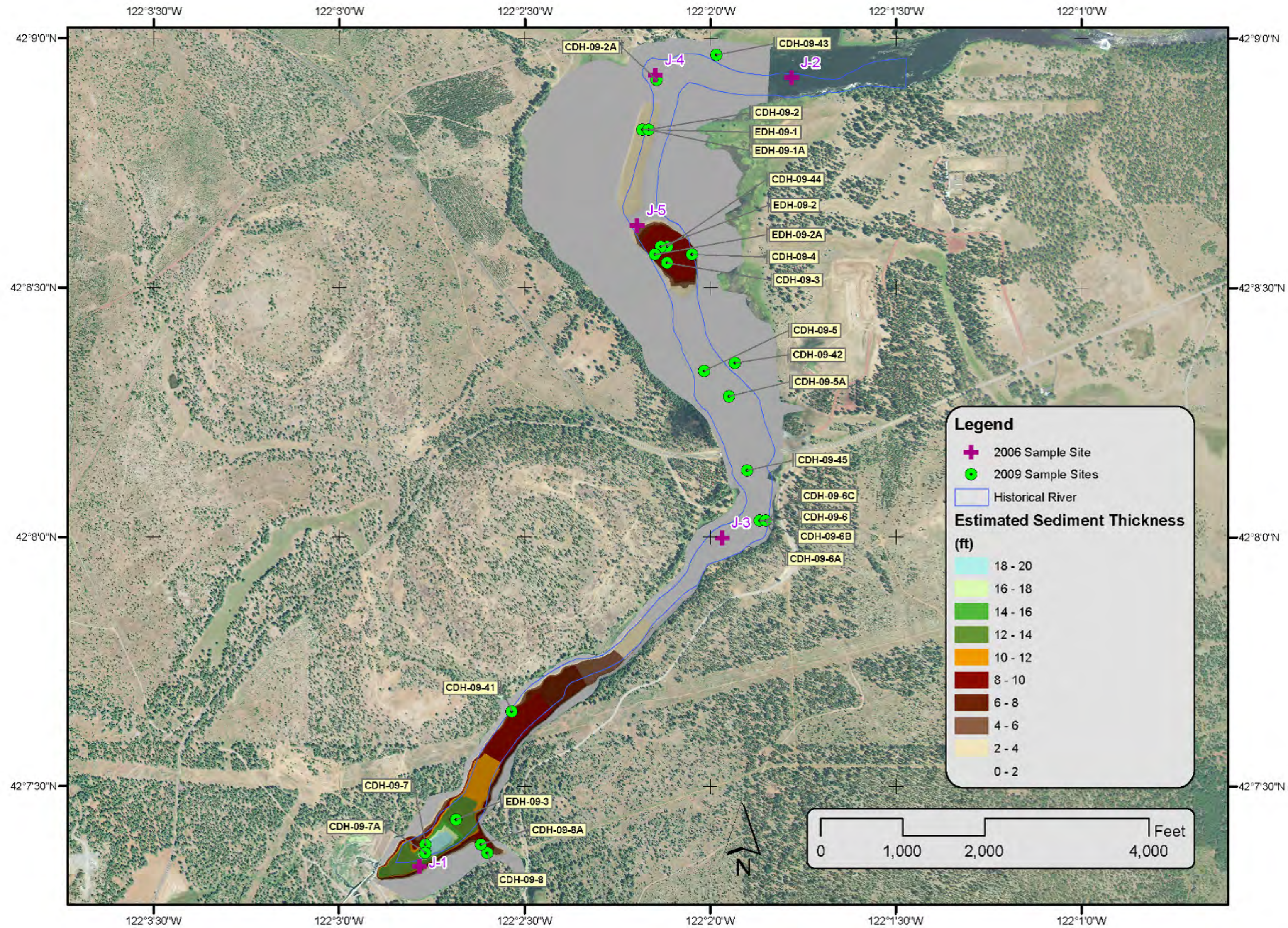


Figure 5.5. J.C. Boyle Reservoir Estimated Sediment Thickness and Sample Site Locations.

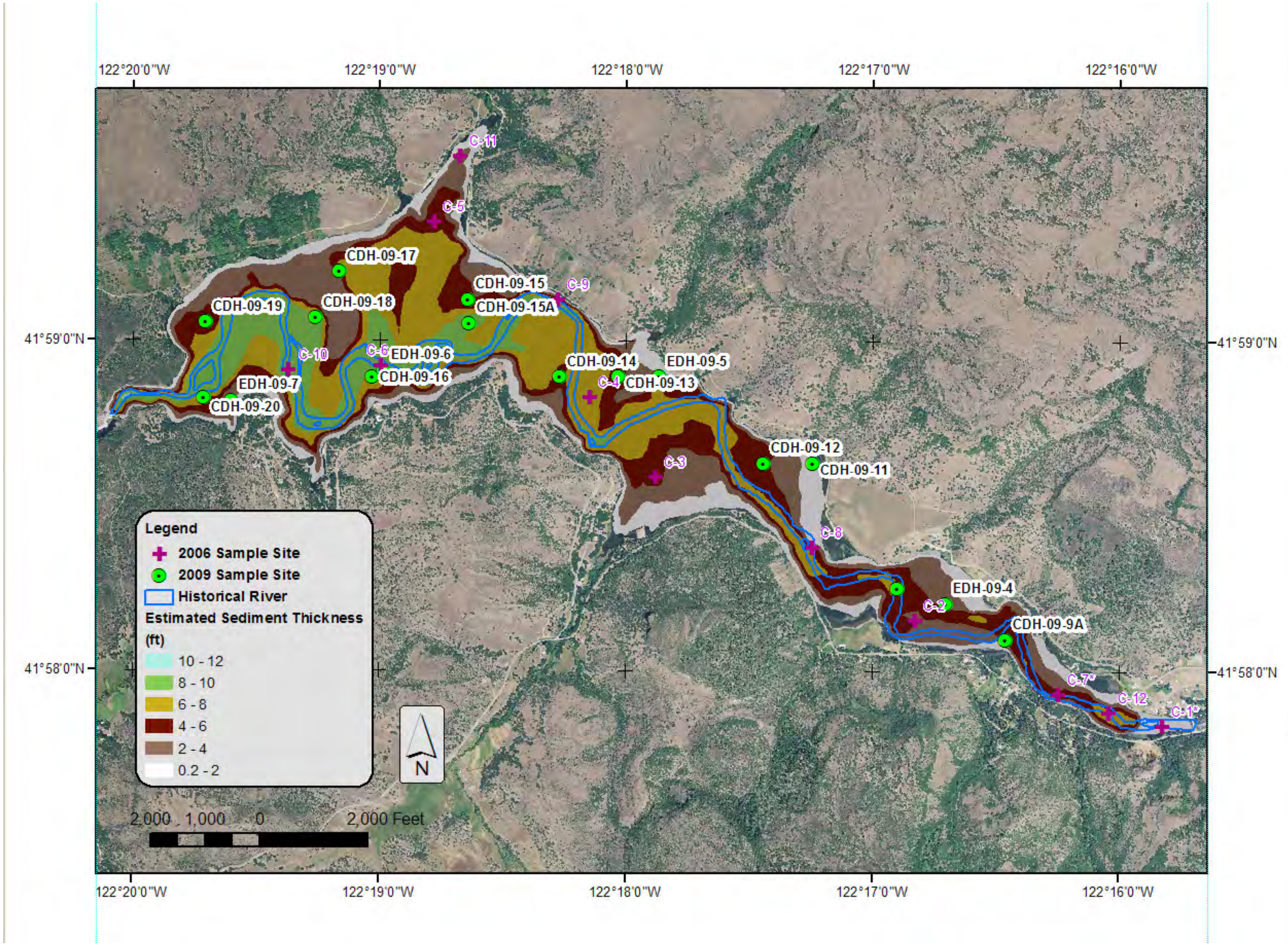


Figure 5.6. Copco Reservoir Estimated Sediment Thickness and Sample Site Locations.

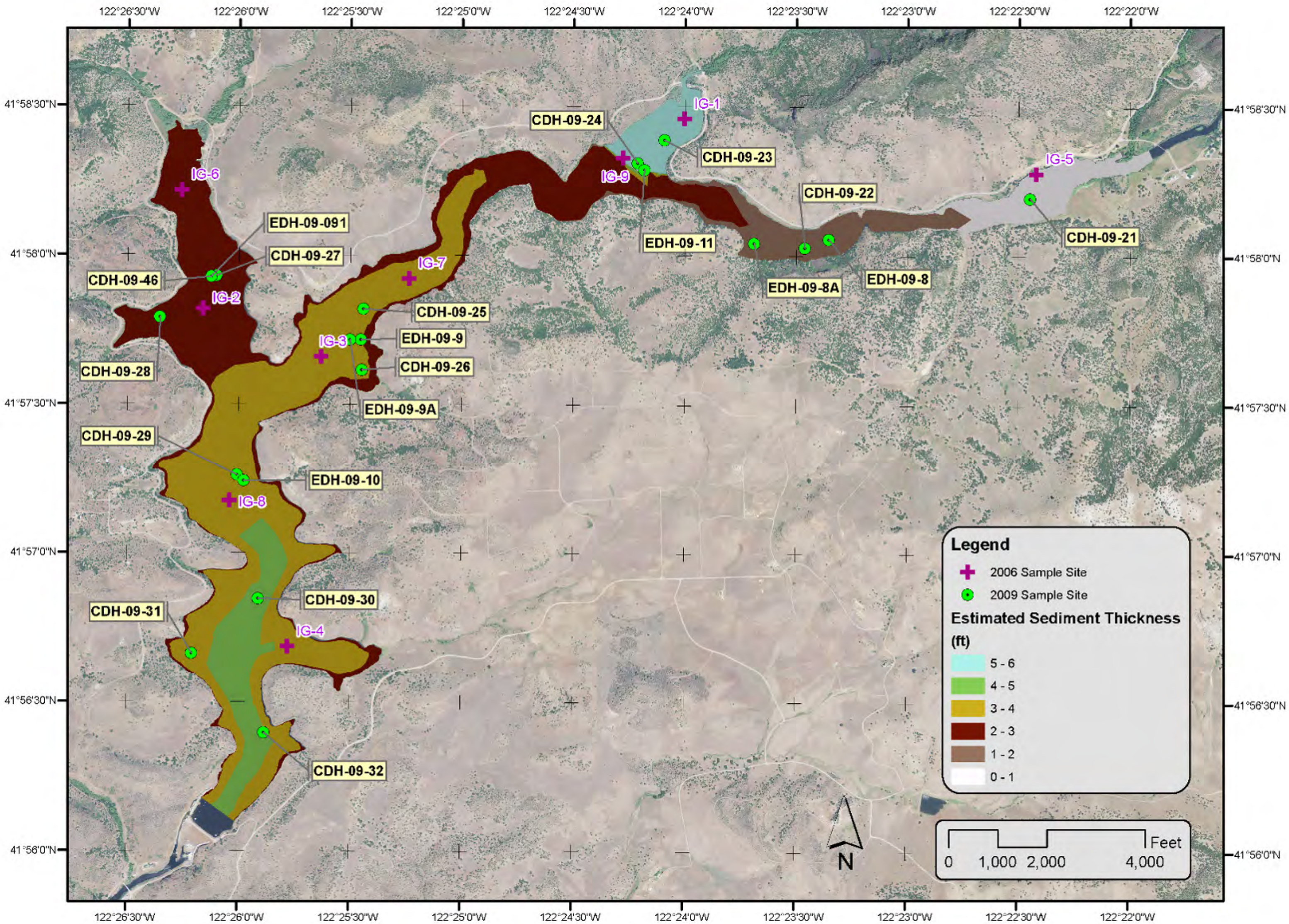


Figure 5.7. Iron Gate Reservoir Estimated Sediment Thickness and Sample Site Locations.

5.2 Physical Properties

Physical properties such as particle size, bulk density, and water content are important to defining the behavior of the reservoir sediment after dam removal. Particle size and basic engineering properties analyses were conducted on samples from each drill hole and details of the drilling investigation and laboratory analysis are given in Reclamation (2010). Average properties were computed for the upper and lower sections of each reservoir. In addition, the pre-reservoir sediment was averaged separately. At Iron Gate, the samples in the tributary arms were also averaged separately. The separation between upper and lower sections at J.C. Boyle Reservoir was between holes CDH-9-41 and CDH-9-6. At Copco Reservoir, it was between samples CDH-9-11 and CDH-9-10, and at Iron Gate Reservoir it was between samples CDH-9-25 and CDH-9-24. Results are summarized in Table 5.2.

There were two samples classified as MH (elastic silt) that were tested for specific gravity (*s*). The specific gravity of the material was 2.67 and 2.52, for an average specific gravity of 2.6 (Strauss, 2010).

Table 5.2. Average physical properties of reservoir sediment.

	#	Clay	Silt	Sand	Gravel	LL	PL	WC	η	ρ_d
		%	%	%	%	%	%	%	%	lb/fts
J.C. Boyle Reservoir										
Upper Reservoir	12	17.3	26.2	56.5	0.0	45.5	14.7	173	0.82	29.5
Lower Reservoir	17	38.2	49.7	12.1	0.0	173	60.6	345	0.90	16.3
Pre-reservoir	2	3.7	9.5	28.4	58.5	44.9	12.7	23.4	0.38	101
Copco Reservoir										
Upper Reservoir	4	27.9	46.8	25.1	0.2	109.3	49.3	287	0.88	19.2
Lower Reservoir	17	55.8	34.2	10.0	0.0	154.3	59.1	295	0.88	18.7
Pre-reservoir	6	35.6	42.2	22.2	0.0	105.0	41.5	153	0.80	32.6
Iron Gate Reservoir										
Upper Reservoir	7	35.4	43.1	21.6	0.0	70.9	29.9	192	0.83	27.0
Lower Reservoir	10	60.7	25.5	13.5	0.4	118.7	51.4	276	0.88	19.8
Pre-reservoir	8	33.6	16.9	20.4	29.1	60.6	32.5	37.9	0.50	81.8
Upper Tributary	7	31.8	42.7	25.5	0.0	60.7	22.7	102	0.73	44.4
Lower Tributary	6	61.8	32.0	6.1	0.0	112.2	49.6	284	0.88	19.3

Clay = 0 to 0.005 mm
Silt = 0.005 to 0.075 mm
Sand = #200 to # 4 sieve
Gravel = #4 to 3 inch
LL = Liquid limit
PL = Plasticity Index
ω = Moisture Content = Weight Water / Weight Solids
η = porosity
ρ_d = dry bulk density

5.2.1 Cohesion and Shear strength

The shear strength of the reservoir sediment will be important to understanding the behavior of the sediment upon drawdown. Sediment with low shear strength will slump downslope as it will be unable to resist the force of gravity. The shear strength of the sediment can be computed as:

$$\tau_f = c' + (\sigma - \mu_w)\tan\phi'$$

where, τ_f = soil shear stress
c' = effective cohesion
σ = normal stress
μ_w = pore water pressure
ϕ' = effective angle of internal friction

Strauss (2010) performed direct shear tests on three drill core samples taken from each reservoir, holes EDH-9-3, EDH-9-6, and EDH-9-9A. The measured friction angles (ϕ') were 29.8º, 27.3º and 32.3º, respectively. The measured cohesion values (c') were 1.1, 0.8, and 0.7 lbf/in^2. Because the material is so soft, it was difficult to obtain accurate estimates of its shear strength and Strauss (2010) stated that actual shear strength may be less than measured.

It is possible to calculate the stable depth of a section of the reservoir sediment assuming infinite slope using the US Army Corps of Engineers Slope Stability Engineering Manual (EM-1110-2-1902, USACOE, 2003). The analysis is described in Appendix E of the manual and assumes that the soil rests on top of a firm base. It accounts for seepage. Table 5.3 contains the estimated stable depth of reservoir sediment assuming different values of the cohesion and different slope values. It is assumed that the sediment is fully saturated and draining. As a conservative assumption, it was assumed that the minimum effective cohesion value would be 50 percent of the minimum measured value or 0.35 lbf/in^2. Therefore, on a slope of 10 percent, the stable depth is over 8 feet, which would encompass all of the sediment in Iron Gate and most of the off-channel sediment in Copco and J.C. Boyle.

Table 5.3. Stable depth of reservoir sediment assuming infinite slope and that the sediment is fully saturated. The minimum measured cohesion value was 0.7 lbf/ft^2.

Slope	**Stable Depth for Different *c*' Values**			
	***c*' (lbf/ft^2)**			
	0.2	**0.35**	**0.7**	**1**
0.1	4.6	8.1	16.2	23.1
0.2	2.4	4.2	8.3	11.9
0.3	1.7	2.9	5.8	8.3
0.4	1.3	2.3	4.7	6.7

5.2.2 Erosive properties

The most common equation form used to predict the erosion of cohesive sediment erosion is:

$$E = k_d\left(\tau - \tau_c\right)$$

where E = erosion rate,
k_d = erosion rate constant,
τ = shear stress, and
τ_c = critical shear stress.

There were two sets of tests on the sediment. One set consisted of tests on samples from 3.5 inch acrylic tube samples. These samples were collected as part of the geological investigation described in Strauss (2010), and were analyzed by the Bureau of Reclamation in Denver, Colorado.

Another set of samples was collected by a 9 inch Ponar sampler. These samples were repacked in the lab and tested using a jet test device described in Simons et al. (2010). The results are given in Reclamation (2011). Samples were tested under wet and dry conditions. The effects of drying on erosion resistance and erodibility (τ_c and k_d) were significant with reservoir-average values of τ_c increasing by at least an order of magnitude. Associated decreases in k_d also occurred with sample drying, but not to the extent of the increases in critical shear stress. The median value of the erodibility coefficient decreased by about 80 percent. The average erodibility of the moist reservoir sediment was similar to that of sand, while the average erodibility of the dried sediment was similar to that of gravel or cobbles. The median critical shear stress of the moist sediment was 0.2 Pa and the median critical shear stress of the dried sediment was 5.9 Pa.

5.2.3 Consolidation and Desiccation

The sediment is primarily water with an average water content of over 80 percent by volume. After the reservoir is drawn down, the sediment will dry and decrease in thickness. A simple test of the sediment consolidation was performed by placing wet sediment into free draining plastic containers. Holes were cut into the bottom of the container and gravel placed on the bottom so that the sample could drain freely. The sample was allowed to dry outside. The initial and final depths of the sample are given in Table 5.4. The desiccated depth of the sample was about 60 percent of the initial depth. Also, deep cracks developed in the soil and the samples pulled away from the container edges. The volume of the sample was estimated to have decreased by approximately 66 percent. The porosity changed from 0.82 to approximately 0.46. The bulk density increased from 29.5 lb/ft^3 to approximately 87 lb/ft^3.

Table 5.4. Change in depth after Klamath Sediment Desiccated in an Open Air and Freely Draining Container.

Container	Initial Depth (in)	Final Depth (in)	% of original depth
1	7.00	4.25	60
2	7.88	4.63	59
3	4.50	2.75	61

Figure 5.8. Picture of sediment from JC Boyle immediately after placement (left) and 15 days after placement (right).

5.3 Simulation of Reservoir Drawdown

There will be two major effects of the dam removal on sediment transport:

1. Short term release of fine sediment stored behind the dams, and

2. Long term resupply of natural fine and coarse sediment to the Klamath River that was previously trapped by the dams.

The short term release of fine sediment will occur as the reservoirs are drawn down. The rate of reservoir drawdown and response to high flows are largely determined by the low level outlet capacity at each dam, as shown in Figure 5.9 thru 5.11. Hydrologic routing during dam removal was performed using the RiverWare model. Simulations were performed for two year time periods. Every water year between 1961 and 2008 was simulated. KBRA operations were assumed to govern releases from Upper Klamath Lake and irrigation project deliveries.

Several drawdown scenarios were analyzed, but only the preferred scenario is discussed here. The primary goal in the selection of the drawdown scenario was to limit the duration of high sediment concentrations to the winter months when flows are the highest and biological activity is at a low point. Several start dates and drawdown rates were analyzed and these are detailed in Reclamation (2011).

The detailed downstream impacts associated with the release of the reservoir sediment are discussed in Reclamation (2011). The bed profile in the reach from Keno Dam to about 90 miles downstream of Iron Gate Dam is given in Figure 5.12. The river slope is significantly higher in the reach from J.C. Boyle to Iron Gate Reservoir. Downstream, the river slope is relatively consistent at about 0.002 to 0.003. The coarse sediment (gravel sized sediment and larger) supply to the project reach is severely limited by the presence of Upper Klamath Lake which allows no such sediment to enter the Klamath River. The lack of coarse sediment is reflected by the reservoir sediment samples which were dominated by silt and clay. Because the reservoir sediment is very fine and unconsolidated, it is very erodible and does not settle easily once it is suspended. Therefore, the majority of the reservoir sediment once eroded will be carried all the way to the Pacific Ocean.

There are some tributaries that enter the Klamath River downstream of Keno Dam which, along with some of the steep hill slopes, supply some coarse sediment to the Klamath River upstream of Iron Gate Dam. This sediment load has been trapped in the reservoirs and will be gradually resupplied to the downstream reaches after dam removal. The resupply of the coarse sediment will tend to make the bed more mobile than under current conditions.

Removal of the four PacifiCorp dams will release approximately 36 % to 57 % of the approximately 15 million yd^3 of sediment that will be stored in the reservoirs by 2020 (Figure 5.13). If there is a wet year, more material will be eroded, and if there is a dry year, less material will be eroded from the reservoirs. The river will return to its pre-dam alignment at each reservoir and have a similar width to pre-dam conditions. The sediment that is left behind in the reservoirs will raise the floodplain terraces above the pre-dam conditions and the floodplains are expected to be inundated less frequently than typical floodplains. High flows will gradually widen the floodplain, but this process is expected to occur slowly over several decades.

Over 80 percent of the reservoir sediment is fine sediment (silt, clays, and organics). Most of this material will be transported to the ocean during the period of primary drawdown which will last from January 1, 2020 to March 15, 2020. The maximum sediment concentrations during this period may be more than 10,000 mg/l downstream of Iron Gate if there is a dry year (Figure 5.14). During a median year, maximum sediment concentrations downstream of Iron gate will be near 10,000 mg/l and are expected to be over 1,000 mg/l from January 1 to the beginning of March (Figure 5.15). If there is a wet year, it may take longer to drain Iron Gate Reservoir because of its limited outlet capacity and there may be sediment concentrations larger than 1,000 mg/l as late as June (Figure 5.16).

Sediment concentrations are expected to return to background levels by the end of Summer 2020 regardless of type of hydrology present. There will be aggressive hydro seeding of the reservoir material immediately following dam removal which will stabilize the remaining sediment from erosion due to rainfall. In addition, the reservoir sediment dramatically increases its resistance to erosion once it dries out.

The bed material within the reservoirs and between Iron Gate 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. The flushing flow is expected to have to be at least 6,000 ft^3/s and of several days to weeks to return the bed to a bed dominated by cobble and gravel with a sand content less than 20 percent. After the flushing flow, the bed is expected to maintain fractions of sand, gravel, and cobble which would be expected under natural conditions.

The mobility of the bed downstream of Iron Gate Dam to Cottonwood Creek will be increased by the removal of the dams. The return of the natural gravel supply to this reach will increase the frequency of gravel mobilization from once every four years to once every two years.

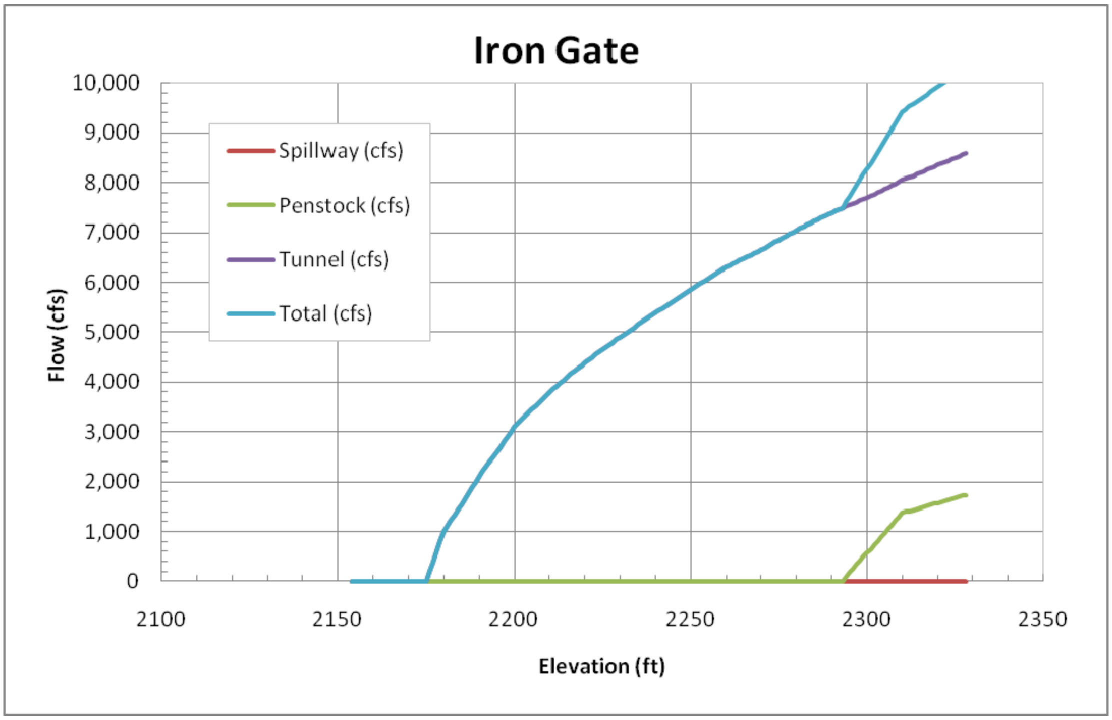


Figure 5.9. Outlet Capacities at Iron Gate.

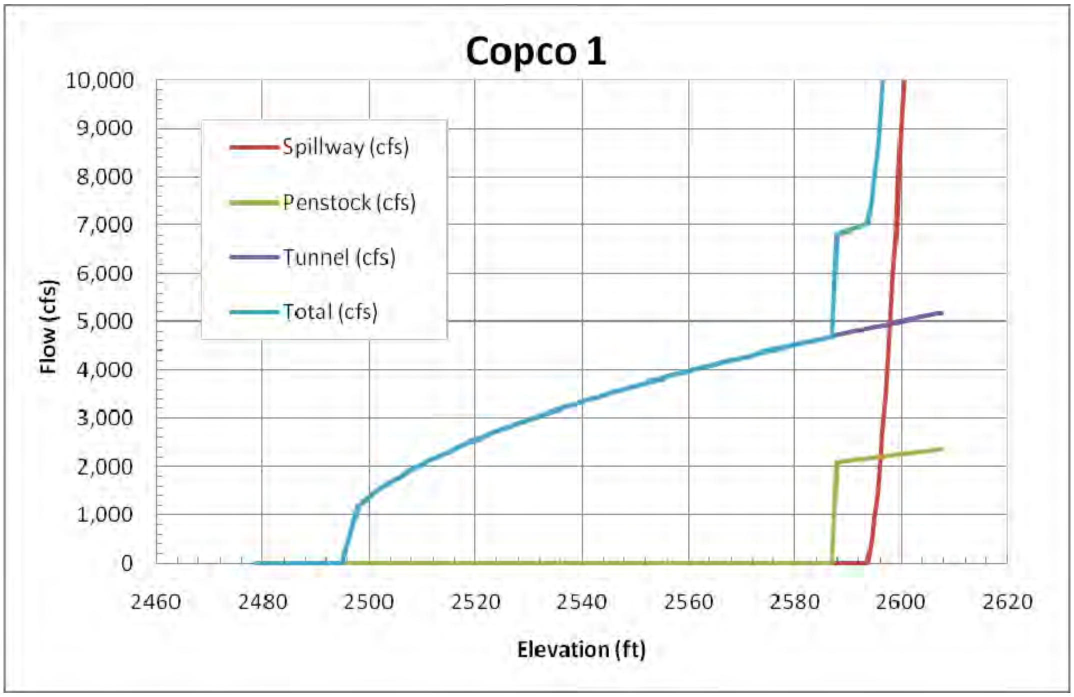


Figure 5.10. Outlet Capacities at Copco 1.

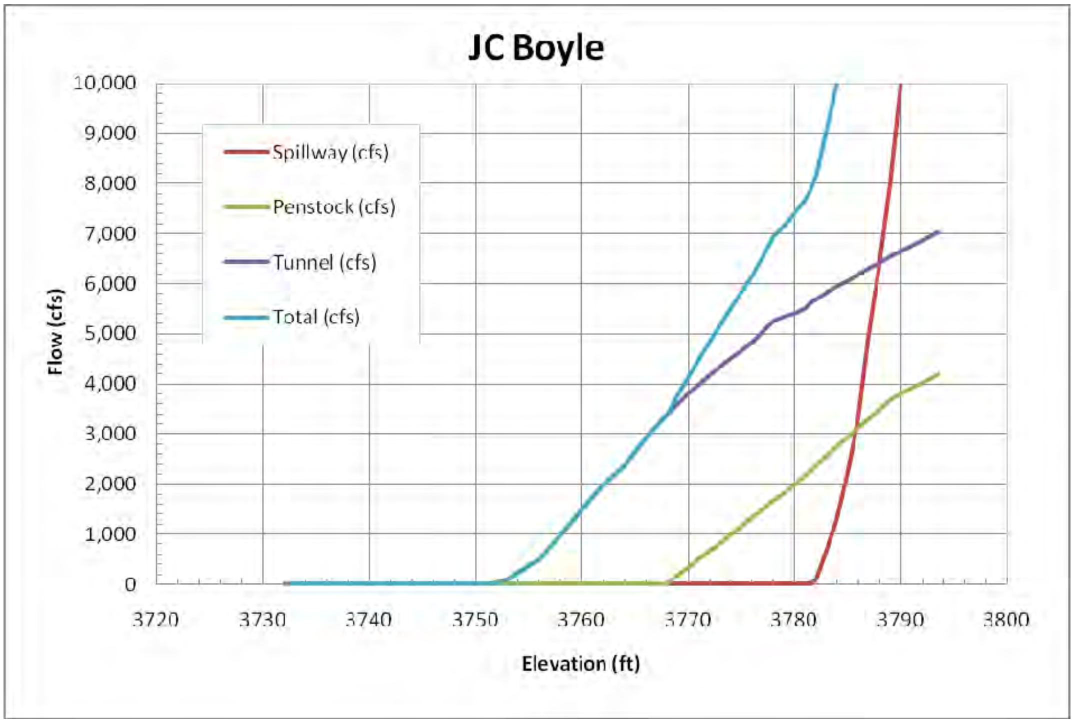


Figure 5.12. Outlet Capacities at J.C. Boyle.

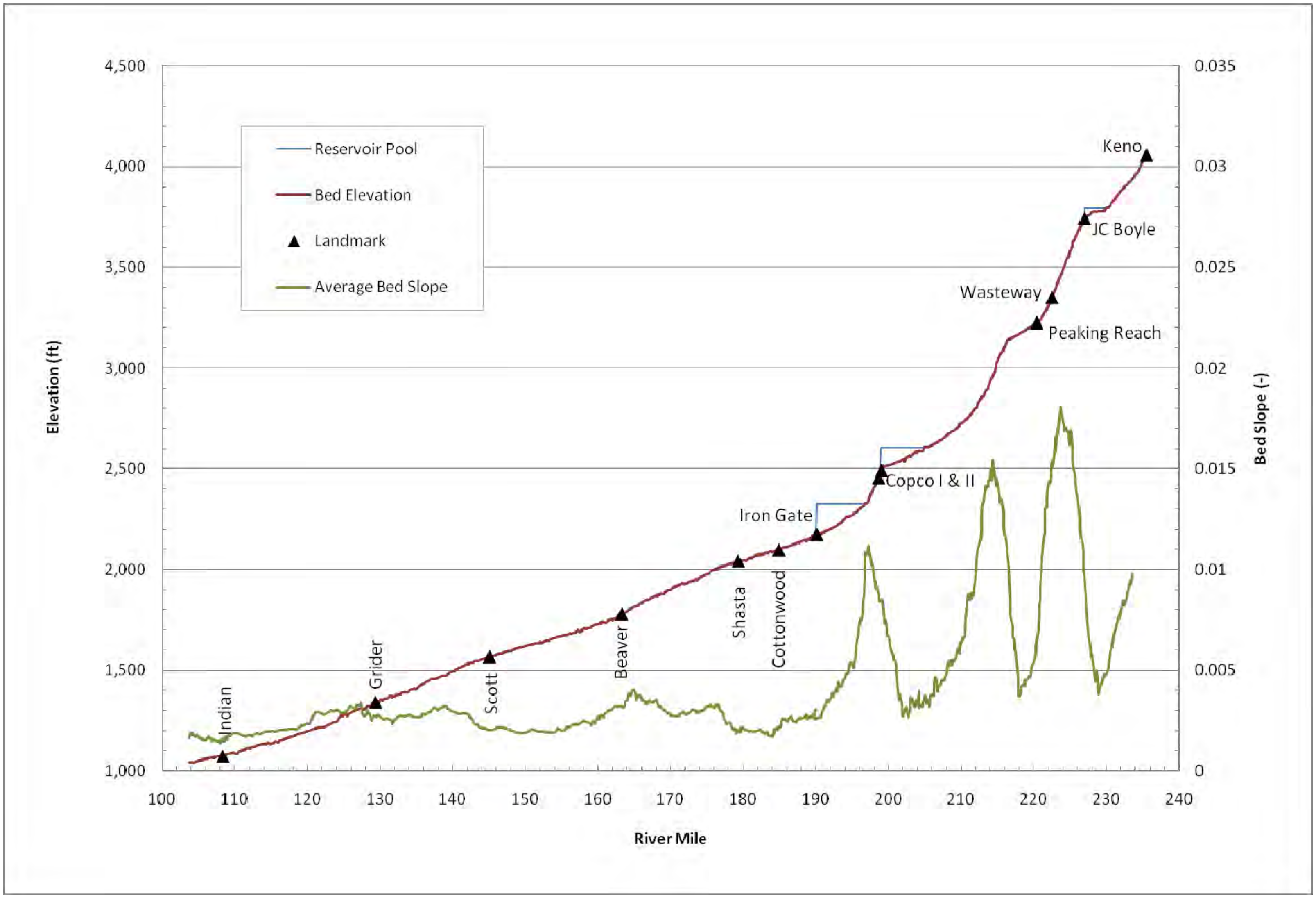


Figure 5.12. Bed Elevation Profile in Reach from Keno to Happy Camp.

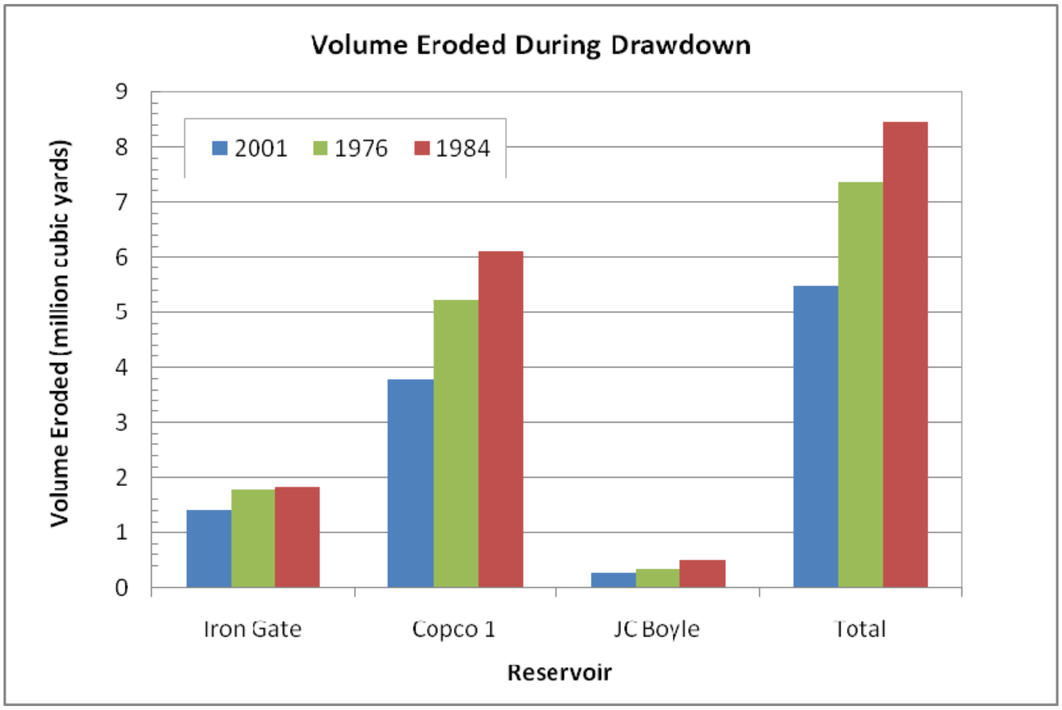


Figure 5-13. Volume of sediment erosion for preferred drawdown scenario.

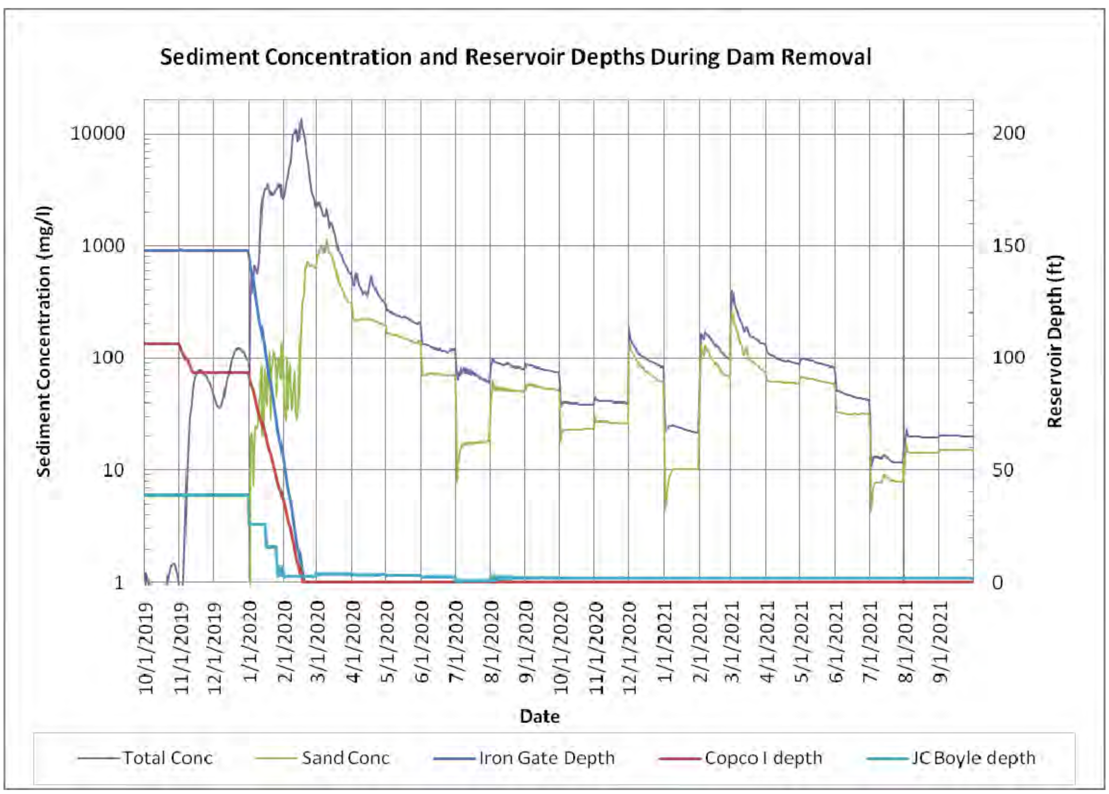


Figure 5.14. Reservoir depth and sediment concentrations downstream of Iron Gate Dam during drawdown for a dry year.

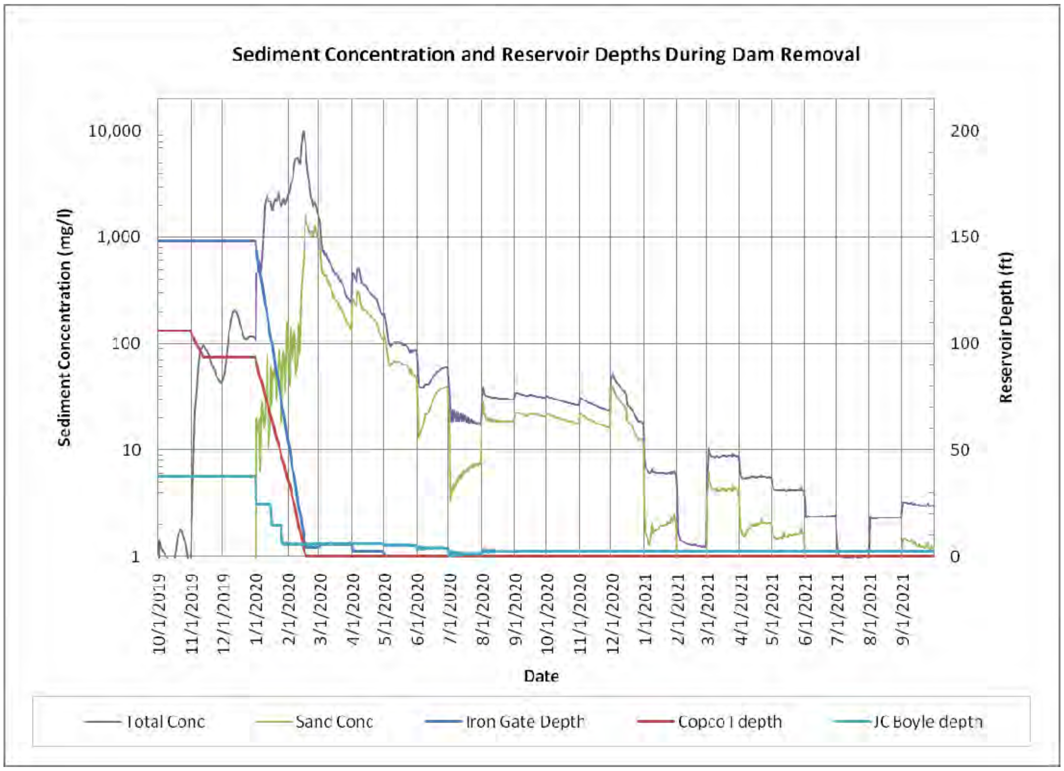


Figure 5.15. Reservoir depth and sediment concentrations downstream of Iron Gate Dam during drawdown for a median year.

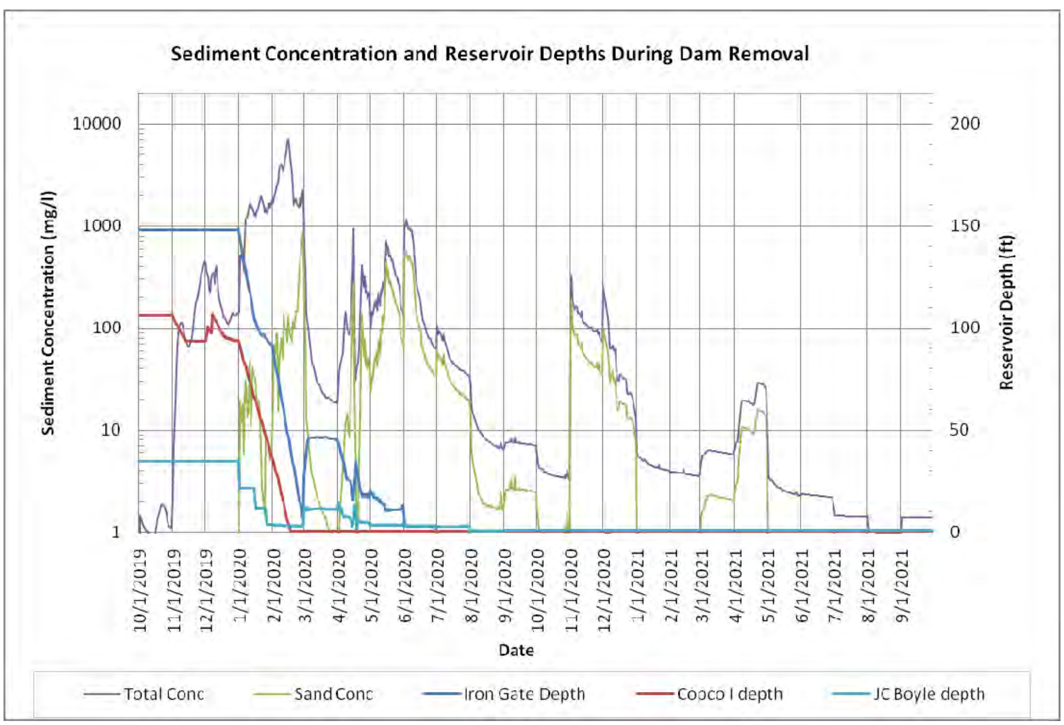


Figure 5.16. Reservoir depth and sediment concentrations downstream of Iron Gate Dam during drawdown for a wet year.

6.0 Recreation Facilities Removal

Recreation facilities are currently provided at J.C. Boyle Reservoir, Copco Reservoir, and Iron Gate Reservoir (FERC, 2007). There are no recreation facilities associated with Copco No. 2 Dam. Facilities meeting the accessibility requirements of the Americans with Disabilities Act (ADA) are located where indicated below.

6.1 J.C. Boyle Reservoir

Developed recreation sites at J.C. Boyle Reservoir include campgrounds, day use areas, and boat launches (see Figure 6.1-1). The key elements of these recreation sites are summarized below, including a description of the recreation facilities available at these developed sites, and proposed removal requirements. Developed public recreation sites discussed in this section include the following:

- Pioneer Park (East and West units)
- Topsy Campground

<u>Pioneer Park (East and West Units)</u>

Managed by PacifiCorp as part of the Project, Pioneer Park consists of two separate day use areas on the western and eastern shoreline of J.C. Boyle Reservoir. Both sites have access from SR 66 and are located on each side (west and east) of the SR 66 bridge over a narrow point of the reservoir. Estimated annual use in 2001/2002 was 16,700 recreation days for both sites.

Pioneer Park West has 12 picnic tables and 12 fire rings with grills. There are two portable toilets (one ADA-accessible), one trash receptacle, one trash dumpster, and informational signs at the site. The shoreline is used for fishing and an unimproved boat ramp is used primarily to launch car-top boats. The main access road into Pioneer Park West is 200 feet long and paved, but the undefined parking area is gravel and dirt and can accommodate approximately 25 vehicles without trailers.

Pioneer Park East has three interpretive signs with information regarding the Applegate Trail. The site had a concrete boat launch before the SR 66 bridge was replaced in 2005 by the Oregon Department of Transportation (ODOT). A large stretch of gravel along the shoreline provides car-top boat launching and shoreline fishing opportunities. The access road to Pioneer Park East and the parking area are gravel. While undefined, the parking area can accommodate approximately 40 vehicles without trailers or 15 to 20 vehicles with trailers.

Site restoration following dam removal would require all features to be removed and the access roads and parking areas to be regraded, seeded, and planted.

Topsy Campground

Managed by BLM, Topsy Campground (or Recreation Site) is located on the southeastern shoreline of J.C. Boyle Reservoir and can be accessed via the Topsy Grade Road off of SR 66. The site consists of a campground, small day use area, and a boat launch. All roads within the campground are asphalt. Estimated annual use in 2001/2002 was 5,600 recreation days for this site. User fees are collected by BLM at the site.

Topsy Campground has approximately 15 campsites, all of which have some degree of ADA-accessibility. All but two of the campsites have tent pads. Additionally, there are restroom facilities, an RV dump station, five water faucets, two drinking fountains, 14 trash receptacles, and one trash dumpster associated with the campground. These facilities are also shared by the day use and boat launch areas at the site. The small day use area provides two sites with a picnic table and grill, one of which is an ADA-accessible site. The boat launch has two concrete lanes, a concrete abutment, and a floating dock. There is also an ADA-accessible fishing pier with two benches. A paved parking area near the boat launch can accommodate three vehicles with trailers for day use parking.

Site restoration following dam removal would require removal of the boat launch, floating dock, and fishing pier, including approximately 68 cubic yards of concrete, and the affected area to be regraded, seeded, and planted. The remainder of the campground would be retained for public use.

6.2 Copco Reservoir

Developed recreation sites at Copco Reservoir include camping areas, day use areas, and boat launches (see Figure 6.2-1). The key elements of these recreation sites are summarized below, including a description of the recreation facilities available at these developed sites, and proposed removal requirements. Developed public recreation sites discussed in this section include the following:

- Mallard Cove
- Copco Cove

Mallard Cove

Located on the south shore of Copco Reservoir, off Ager-Beswick Road at Keaton Cove, Mallard Cove is owned and managed by PacifiCorp. The site consists of a day use/picnic area and a boat launch. While not an official campground, this site is also used for camping. The naturally wooded site has 8 wood-plank picnic tables, 12 cooking grills, and seven concrete fire rings or foundations. There is a toilet building with two vault toilets and two trash receptacles at the site. The boat launch has a 100-foot-long, 25-foot-wide single-lane concrete ramp. The site also has a 25-foot-long, 5-foot-wide dock made of composite decking and poly floats, with concrete abutment, located adjacent to the boat ramp, and a 20-foot-long, 5-foot-wide gangway with aluminum frame and pipe railing. There are six informational signs with concrete bases at the site. The access road and parking area are gravel. The parking area, while undefined, has eight concrete wheel-stops and parking for approximately 25 vehicles. Estimated annual use in 2001/2002 was 7,600 recreation days for this site.

Site restoration following dam removal would require all features to be removed, including approximately 106 cubic yards of concrete, and the 2.5-acre parking area to be regraded, seeded, and planted.

Copco Cove

Managed by PacifiCorp, Copco Cove is located on the western shoreline of Copco Reservoir, off of Copco Road. The site has a picnic area and a boat launch. While not an official campground, this site is also used for camping. The picnic area is naturally wooded and has two wood-plank picnic tables with one user-defined fire ring at each. The site has one portable toilet and one trash receptacle. The boat launch has an 80-foot-long, 25-foot-wide single-lane concrete ramp. While the boat ramp is in good condition, the approach is steep and maintaining a proper turning radius is difficult when there are other vehicles parked at the site. There is also a 14-foot-long, 5-foot-wide concrete boat dock adjacent to the boat ramp, with pipe railing. There are six informational signs with concrete bases at the site. The access road and parking area are gravel. There are approximately five spaces for vehicles in the undefined parking area. Estimated annual use in 2001/2002 was 1,250 recreation days for this site.

Site restoration following dam removal would require all features to be removed, including approximately 84 cubic yards of concrete, and the 2.3-acre parking area to be regraded, seeded, and planted.

6.3 Iron Gate Reservoir

Developed recreation sites at Iron Gate Reservoir include campgrounds, day use areas, and boat launches (see Figure 6.3-1). The key elements of these recreation sites are summarized below, including a description of the recreation facilities available at these developed sites, and proposed removal requirements. Developed public recreation sites discussed in this subsection include the following:

- Fall Creek (including Fall Creek Trail)
- Jenny Creek
- Wanaka Springs
- Camp Creek (including Dutch or Scotch Creek)
- Juniper Point
- Mirror Cove
- Overlook Point
- Long Gulch
- Iron Gate Fish Hatchery Public Use Areas

Fall Creek

Fall Creek is located on the far northeast shore of Iron Gate Reservoir and is primarily a day use area, although some camping does occur. The site has two picnic tables, two cooking grills, two fire rings, and one user-defined fire ring. There is also one trash receptacle, an older single-vault toilet building (closed in 2002), and one portable toilet at the site. User-defined trails provide access to shoreline fishing opportunities. Parking at this site is undefined and generally occurs along the interior gravel road. Approximately eight vehicles could be accommodated at this site. A newly graveled boat launch is also provided. Large pine trees provide shade. Estimated annual use in 2001/2002 was 4,150 recreation days for this site.

The recreation site at Fall Creek is located near the river channel and could be retained following the removal of Iron Gate Dam. The site is adjacent to the California Department of Fish and Game (CDFG) Fall Creek fish hatchery and provides access to the Fall Creek Trail, where visitors can hike up to Fall Creek Falls. No costs for removal of these facilities have been estimated.

Jenny Creek

Located between Copco Road and Jenny Creek on the northern shoreline of Iron Gate Reservoir, Jenny Creek is managed by PacifiCorp. The site provides primitive day use and camping opportunities. The site has six day use/campsites, four of which are separated by boulders at the southern end of the parking area, while the remaining two are located along the shoreline of Jenny Creek. There are four steel frame/wood plank picnic tables and four user-defined fire rings at the site. Additionally, the site has two trash receptacles, a storage building, and a single-vault toilet building with a 25-foot-long wooden privacy screen. Several user-defined trails provide shoreline fishing access to Jenny Creek. There are two informational signs with concrete bases at the site. The gravel parking area can accommodate approximately 20 vehicles. Estimated annual use in 2001/2002 was 3,700 recreation days for this site.

There is also a large gravel parking area across from this site, on the shoreline of the reservoir that is used for shoreline fishing access. This parking area can accommodate about 12 vehicles, but is not considered to be part of the Jenny Creek recreation site.

The recreation site at Jenny Creek with adjoining parking area could be retained following the removal of Iron Gate Dam, as it provides a creekside setting for picnicking and bank fishing. No costs for removal of these facilities have been estimated.

Wanaka Springs

Located on the north shore of Iron Gate Reservoir, Wanaka Springs is managed by PacifiCorp. The naturally wooded site is used for day use and camping and consists of a small upper use area and a larger lower use area. The upper use area can be accessed by vehicle via a gravel road through the lower use area and has two wood-plank picnic tables, a concrete fire ring, a trash receptacle, and provides parking for about two vehicles. The lower use area has a large gravel parking area that can accommodate approximately 16 vehicles, three wood-plank picnic tables and one concrete picnic table, two concrete fire rings, a trash receptacle, two single-vault toilet buildings, and a portable toilet. A dirt pedestrian trail connects the upper and lower use areas and provides access to the vault toilets. Additionally, a dirt pedestrian trail provides access to a 25-foot-long, 5-foot-wide wooden dock with concrete pier and pipe railing, 15-foot-long gangplank, and a concrete walkway on the reservoir shoreline. There are three informational signs with concrete bases at the site. Estimated annual use in 2001/2002 was 4,150 recreation days for this site.

Site restoration following dam removal would require all features to be removed, including approximately 28 cubic yards of concrete, and the 2.5-acre parking area to be regraded, seeded, and planted. The access road to the site is 15 feet wide and very steep. Most site access is by boat.

Camp Creek

Camp Creek is located on Copco Road along the northern shoreline of Iron Gate Reservoir and is managed by PacifiCorp. The site accommodates camping, day uses, and boat launching and is generally split into three use areas. The first use area is located on the shoreline and consists of developed campsites and a boat launch. The second use area is located across Copco Road from the first use area and is used as a day use area and for overflow camping and parking. The third use area is located on the shoreline to the northwest of the first use area and provides for day use activities, including ADA access to the shoreline, as well as overnight camping. There are seven informational signs with concrete bases at this site. Estimated annual use in 2001/2002 was 15,250 recreation days for all three sites.

The first use area at Camp Creek has about 12 developed campsites each with a concrete picnic table, concrete fire ring, and a parking space. Three-foot boulders separate the campsites. There are two water faucets, a 10- by 16-foot concrete block well house, and six trash receptacles at this use area. There is also a boat launch with an 80-foot-long, 25-foot-wide single-lane concrete ramp, and a wooden walkway leading to a 25-foot-long, 4-foot-wide boat dock with concrete abutment and piers, next to the boat ramp. The interior access road is used for parking and can accommodate approximately six to eight vehicles. Additionally, there are two 20-foot-long, 5-foot-wide floating boat docks with composite decking and aluminum frames located to the north and south (on an existing jetty) of the boat launch, each with a 20-foot-long, 5-foot-wide gangplank with composite decking and aluminum frame rails. Each of these boat docks provides shoreline fishing opportunities.

The second use area at Camp Creek is located directly across Copco Road from the first use area. The site has three concrete picnic tables and two steel frame/wood plank picnic tables with concrete foundations, two timber shelters for shade, one concrete fire ring, and at least five user-defined fire rings. An RV dump station with estimated 2,000-gallon buried concrete tank, a 10- by 16-foot wood-frame double toilet building, a portable toilet, a trash receptacle, and a water faucet are located in this area and are shared facilities with the other use areas at Camp Creek. Overflow camping occurs at this site when the developed campsites in the first use area are full. Additionally, a large grassy area provides overflow parking for the first use area. There is space for approximately 60 vehicles in the overflow parking area. There is an interpretive display at this use area that provides a brief discussion of the Wilkes Expedition that stopped at this site in 1841.

The third use area at Camp Creek is located along the reservoir shoreline to the northwest of the first use area, and has been referred to as the "Scotch Creek" or "Dutch Creek" site. This area is small and has one steel pipe/wood plank picnic table and a concrete fire ring. There is a 50-foot-long, 4-foot-wide ADA-accessible concrete fishing pier with pipe railing, and a boat ramp for launching car-top boats at this use area. This site often receives use as a single campsite and is occasionally used as a group campsite.

Site restoration following dam removal would require all features to be removed from these sites, including electric power lines on three poles and approximately 110 cubic yards of concrete. Approximately 4 acres of parking areas would have to be regraded, seeded, and planted. Additional earthwork would include the removal or regrading of an estimated 180-foot-long, 16-foot-wide, and 8-foot-high earth jetty, and the burial of approximately 75 boulders.

Juniper Point

Located on the northwestern shoreline of Iron Gate Reservoir, Juniper Point is managed by PacifiCorp and provides approximately nine semi-primitive campsites. The camping area has eight steel frame/wood plank and wooden picnic tables, one concrete picnic table, fifteen concrete fire rings and foundations, two 4- by 4-foot concrete single-vault toilets (located across Copco Road from this site), and two trash receptacles. There is also an I-shaped boat dock at this site for shoreline fishing opportunities, which consists of a 25-foot-long concrete abutment, a 50-foot-long composite dock with poly floats and pipe railing, and a 20-foot-long composite gangplank with pipe railing. There are four informational signs with concrete bases at the site. The gravel access road into this site is very steep. Estimated annual use in 2001/2002 was 4,700 recreation days for this site.

Site restoration following dam removal would require all features to be removed, including approximately 19 cubic yards of concrete, and approximately 2 acres of parking area would have to be regraded, seeded, and planted. Additional earthwork would include the removal or burial of approximately 50 boulders.

Mirror Cove

Mirror Cove, managed by PacifiCorp, is located on the western shoreline of Iron Gate Reservoir. The site has a camping area and a boat launch. The camping area has ten campsites, with 12 concrete fire rings and eight picnic tables, accessible by gravel road. This site has one 10- by 16-foot vault toilet building with concrete steps located across

Copco Road, a portable toilet in the parking area, and four trash receptacles. The boat launch at Mirror Cove has an 80-foot-long, 25-foot-wide concrete ramp with two lanes. Two 30-foot-long, 5-foot-wide composite gangplanks with aluminum frames and pipe railing lead to a 30-foot-long concrete boat dock and abutment with pipe railing adjacent to the boat ramp. There are seven informational signs with concrete bases at the site. The gravel parking area at this site can accommodate approximately 20 vehicles. Estimated annual use in 2001/2002 was 11,140 recreation days for this site.

Site restoration following dam removal would require all features to be removed, including approximately 89 cubic yards of concrete, and approximately 3 acres of gravel parking area would have to be regraded, seeded, and planted. Additional earthwork would include the removal or burial of approximately 120 boulders.

Overlook Point

Overlook Point, managed by PacifiCorp, is located on the western shoreline of Iron Gate Reservoir. The site has one concrete picnic table and one steel frame/wood plank picnic table. There are also one portable toilet and two trash receptacles at this site. An 800-foot-long, steep gravel road provides access to the site. Parking at this site is undefined, but can generally accommodate approximately six vehicles. Estimated annual use in 2001/2002 was 1,900 recreation days for this site.

Site restoration following dam removal would require all features to be removed, and approximately 0.5 acres of the site and access road to be regraded, seeded, and planted.

Long Gulch

Long Gulch, managed by PacifiCorp, is located on the southern shoreline of Iron Gate Reservoir. The site has a picnic area that is occasionally used for camping and a boat launch. The picnic area has two steel frame/wood plank picnic tables and two user-defined fire rings. The boat launch has an 80-foot-long, 25-foot-wide two-lane concrete ramp. The site has one portable toilet and two trash receptacles. The undefined gravel parking area at this site can accommodate approximately 16 vehicles. Estimated annual use in 2001/2002 was 5,200 recreation days for this site.

Site restoration following dam removal would require all features to be removed, including approximately 25 cubic yards of concrete, and approximately 0.05 acres of the site and access road to be regraded, seeded, and planted.

Iron Gate Hatchery Public Use Areas

The Iron Gate fish hatchery is located downstream of Iron Gate Dam and is operated by CDFG, with PacifiCorp currently providing funding for 100 percent of the fish hatchery's annual operating expenses. A public day use area is provided adjacent to the fish hatchery and an undeveloped boat launch is located across the river from the hatchery. Fishing is prohibited in this area and to 3,500 feet downstream of the dam. The day use area has a covered picnic shelter, six picnic tables, three trash receptacles, a small visitor center/interpretive kiosk (providing information on dam construction, salmon, and regional wildlife), two flush toilets in restrooms, and an ADA-accessible trail to the river shoreline (near Bogus Creek). A gravel parking area provides spaces for approximately 20 vehicles. The undeveloped boat launch is used primarily to launch car-top boats (hand launch); however, the launch does receive some boat trailer use. The gravel shoulder along Copco Road provides undefined parking for the boat launch. Estimated annual use in 2001/2002 was 2,200 recreation days for this site.

These facilities are expected to be unaffected by the removal of Iron Gate Dam, and no costs for removal of these facilities have been estimated.

6.4 Dispersed Recreation Sites in the Study Area

In addition to the developed recreation facilities in the study area, the undeveloped reservoir shorelines provide numerous dispersed recreational use opportunities, both for land-based and water-based activities. Many visitors and local residents use the reservoir shorelines for dispersed activities such as boating, fishing, swimming, sunbathing, and camping. Twenty-seven dispersed recreation sites or use areas on or adjacent to the reservoir or river shorelines were identified during a field inventory conducted in 2004. The majority (17) of dispersed sites were identified at J.C. Boyle Reservoir, while two were located at Copco Reservoir, and four were located at Iron Gate Reservoir. Many of the identified dispersed sites are located along roads on or near the reservoir shoreline, and appear to have been used for camping and day use activities, although camping is specifically prohibited at a few of the sites. Fires are limited seasonally at most dispersed sites in the study area. These sites do not have developed facilities such as picnic tables, grills, or boat launches. No costs have been estimated for restoration of these sites.

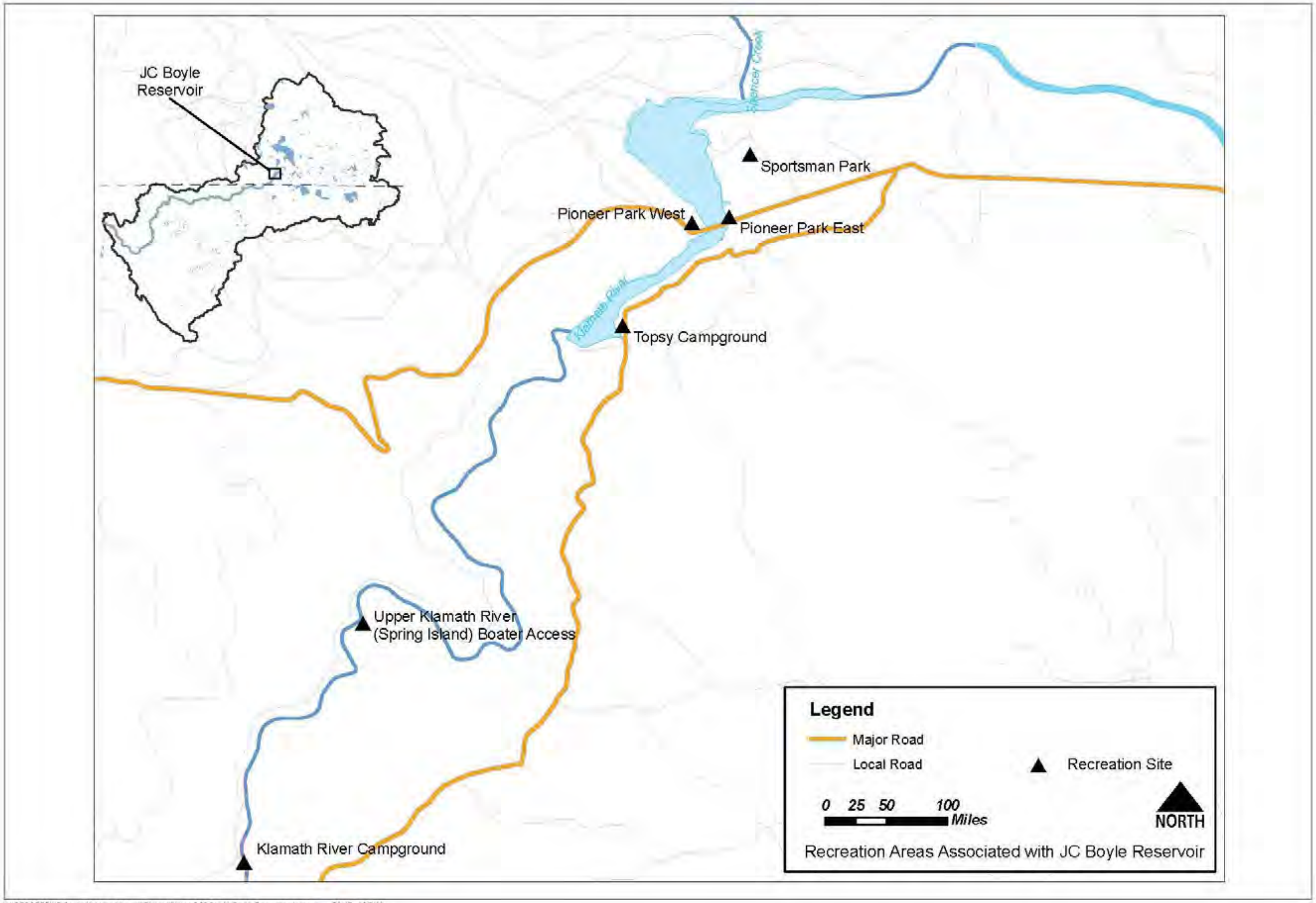


Figure 6.1-1. J.C. Boyle Reservoir Recreation Areas.

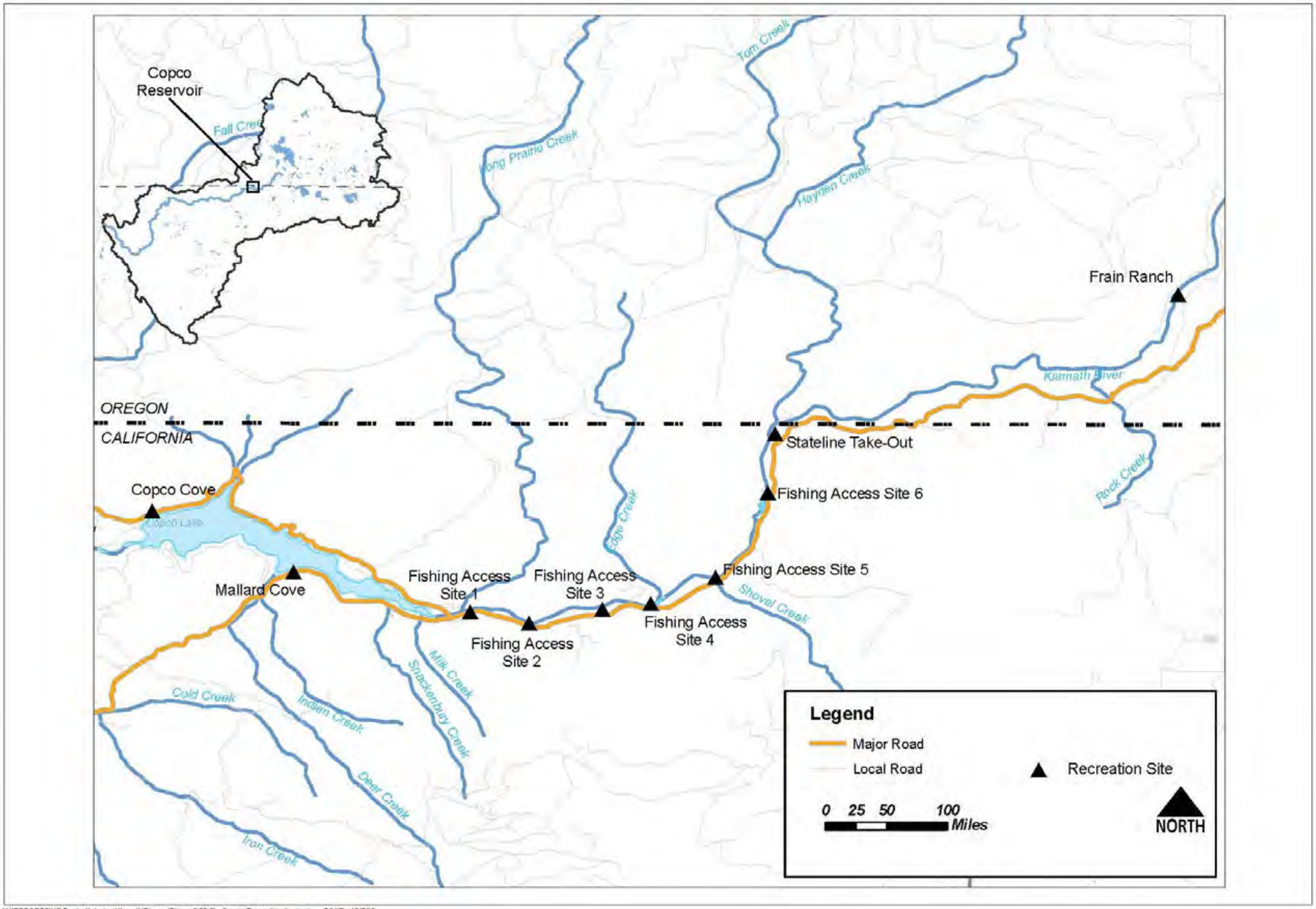


Figure 6.2-1. Copco Reservoir Recreation Areas.

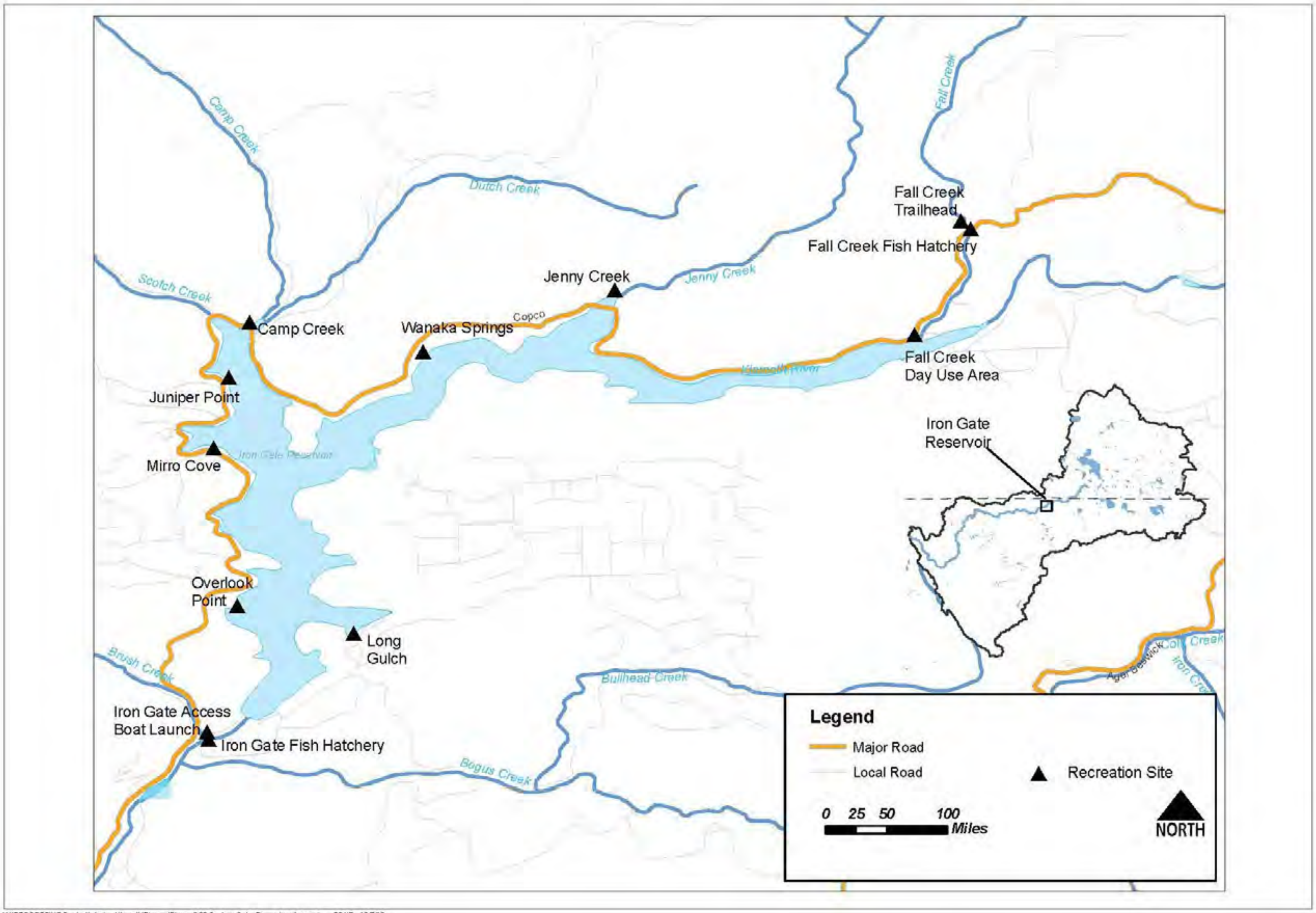


Figure 6.3-1. Iron Gate Reservoir Recreation Areas.

7.0 Reservoir Management Plans

7.1 Goals and Objectives

A list of reservoir management goals was developed as detailed in Reclamation (2011). Goals were written to incorporate the list of interdisciplinary objectives, and to create a framework for articulating, prioritizing, and planning a potentially large and complex suite of projects that may conflict with other objectives. The final set of goals and objectives are given in Table 7-1.

Based upon the stated goals, a list of potential projects to accomplish the stated objectives was developed:

1. Weed management around the reservoirs areas prior to dam removal;
2. Active revegetation of reservoir areas with native grasses immediately after reservoir drawdown;
3. Application of herbicides to further limit invasive species;
4. Planting of woody riparian species along the river banks in the reservoir areas; and
5. Monitoring of vegetation growth to ensure objectives are accomplished.

The following sections of this document describe these potential projects except for the first, active weed management prior to dam removal. There are weed management programs currently underway and there are specific projects identified under the KBRA to accomplish weed management around the reservoir areas.

Table 7-1. Compiled goals, objectives, and potential projects for managing the reservoir areas.

Period	**Goal**	**Objective**	**Potential Project**
Pre-construction period:	Control invasive weeds, and eliminate the invasive seed bank.	Reduce and minimize the local sources of invasive weeds.	A weed management program implemented under KBRA and with County involvement
Construction-period: (0 to 1 year)	Natural erosion of reservoir deposits, transport via the river, dispersal in the ocean.	Maximize erosion of reservoir deposits during drawdown	Allow erosion of deposit during reservoir drawdown. Do not stabilize reservoir deposit.
Short-term: (1-5 years after dam removal.)	Limit windblown dust and surface erosion from reservoirs.	Less than 25% of the reservoir areas will be exposed to erosion.	Active planting of native grasses and other species.*
	Establish native vegetation.*	75% of the reservoir areas will have native	Active planting of native grasses and other

		vegetation cover.	plant species.*
	Control invasive weeds on exposed areas.	Maintain vegetative cover at less than 5% for weed species.	Apply herbicides the first year following dam removal. Monitoring and management of weeds in subsequent years.
	Produce habitat along riparian edges for salmonid smolts.	Establish a minimum of 400 live shrub/tree species per acre within riparian-bank areas.	Active planting of native shrub and tree species within riparian-bank areas.*
Mid-term: (5-10 years).	Fish habitat within reservoir reaches on par with similar reaches found u/s or d/s.	Spawning and rearing habitat performing within 25% of similar us/ or d/s habitats.	Passive rehabilitation of riffles and pools. Natural resupply of gravel to reservoir reaches.
Long-term: (10-50 years.)	Establish sustainable riparian and fish habitat	No significant maintenance required to sustain fish habitat	Monitor vegetation growth along riparian corridor. Limit encroachment into riparian corridor.

* Native and genetically appropriate planting materials from local sources to be used if feasible.

7.2 Revegetation of Reservoir Areas

The revegetation of the reservoir areas presents many challenges and there are many uncertainties related to the dynamics of vegetation establishment after reservoir drawdown. Ideally, native grasses and riparian species on exposed reservoir deposits will establish immediately following reservoir drawdown. This will minimize the time the exposed reservoir deposits are vulnerable to invasive species, discourage erosion, take advantage of residual moisture for desirable species, and provide valuable habitat in a timely manner. Current scenarios designate initiation of drawdown by January 1, 2020 and the reservoirs should be largely drawn down by April 1 under median hydrologic conditions. Under wet conditions, J.C. Boyle and Iron Gate Reservoir may partially or fully refill. Therefore, the exact dates of the revegetation are subject to weather conditions and flow forecasts.

Hydroseeding is proposed to establish grasses on the entirety of the exposed reservoir areas after drawdown. For Copco and Iron Gate Reservoirs, use of existing and installation of temporary roads will allow areas with relatively low slopes (<20 percent to be seeded with ground equipment. Areas not accessible by ground equipment due to terrain, slope, and deposit instability will be conducted with a combination of barge and rotary/fixed-wing aircraft (aerial) for the Most Probable and Most Probable Low cost estimates. Hydroseeding from a barge will be accomplished by placing ground based hydroseeding equipment on one barge with another barge used to ferry materials from shore. A moveable pier or other engineered method of accessing the supply barge as the water level recedes will also be needed. Barge seeding will only be feasible up to a certain point during the drawdown at which depths are too shallow and/or the current too swift to maneuver the barge effectively (estimated at RWS elevation 2550 for Copco Reservoir and RWS elevation 2230 for Iron Gate Reservoir). Installation of a ramp and road access to remove the equipment is also included in the cost estimates. Aerial applications will be used to complete the application of hydromulch once the reservoir elevation is too low for barge seeding. Rotary aircraft will be necessary for precision applications of material near sensitive areas (to be defined pending subsequent reports) and the newly established river channel; fixed wing aircraft may also be used for the remaining areas if more cost effective. Exclusive use of aerial application equipment is used for the Most Probable High cost estimate for both Copco and Iron Gate reservoirs. The slopes, terrain, scale, and proximity to existing roads at J.C. Boyle Reservoir are more conducive to ground-applied hydroseed. The acreages of each hydroseeding method are given in Table 7-2.

Hydroseeding of grass species will be applied to the entire exposed area following drawdown. Ideally, hydroseeding will be applied as the reservoirs are drawn down (essential if barge seeding is implemented) and more importantly, before the reservoir deposit desiccates, in order to retain residual soil moisture and prevent crust formation.

The establishment rate for hydroseeding can be highly variable. Currently, there are not sufficient data to predict establishment success of grasses from hydroseeding on the exposed reservoir areas after removal of J.C. Boyle, Copco, and Iron Gate Dams. It is likely that the exposed deposit material will pose difficulties in revegetating as it will not immediately possess topsoil characteristics. Additional fall seedings to supplement areas where establishment was unsuccessful from the spring hydroseeding may be necessary and are included as a contingency in the cost estimate. Establishment rate estimates of 25, 50, and 75 percent are used for the Most Probable Low, Most Probable, and Most Probable High cost estimates, respectively. Possible causes for establishment failure over the first season could be seed dormancy mechanisms, environmental stresses after germination, herbivory, erosion/movement of the seed and/or mulch, or others. In cases where mulch has moved/degraded or otherwise exposed bare soil, aerial hydroseeding will be used again for the fall re-seeding. In other cases where establishment has failed yet the mulch remains intact, new seed material applications may need to be incorporated in order to re-establish seed/soil contact sufficient for germination. This can be done with ground equipment or by hand with labor crews, depending on the accessibility and terrain. Slopes were used to estimate the proportion of areas likely to lose mulch cover; slopes over 20 percent were considered to be at higher risk for mulch losses and slopes less than 20 percent were considered lower risk. The estimated failure rates are assumed to occur homogenously across the reservoirs; proportionate areas above and below 20 percent slopes were multiplied by the estimated reseeding coverages to estimate the areas suitable for aerial vs. ground re-seeding in the fall. The assumed areas with various spring establishment rates are given in Table 7-3.

Accelerated establishment of riparian woody species will be conducted by installing pole plantings in the riparian/wetland zone. Although these are critical revegetation areas that will serve to stabilize the river banks and provide habitat for fish and other species, it is impossible to install pole plantings until the reservoirs have been completely drawn down, the new river channel established, and banks stabilized. In addition, labor crews will need access to the riparian zones to properly install pole plantings, requiring the need for ground (or less preferably river) access to the riparian areas. Planting poles in the spring the year after drawdown will allow time for the river banks to establish and shorelines to stabilize, as well as time and suitable substrate for installation of access roads and/or boat ramps. This is also the preferable timing for establishment of woody species poles and transplants.

Areas predicted to support wetland species will be included in the grass-seeded/pole planted areas for the purposes of the cost estimates. Seed-bank studies have determined a relatively high density and diversity of viable wetland species seed exists in the inundated deposits at all three reservoirs (see Reclamation, 2011b). It is assumed that post-drawdown areas with the appropriate hydrology will not support the hydroseeded grasses or pole plantings and will ultimately revert to wetland vegetation without additional inputs. The total acreages of upland and wetland/riparian areas are given in Table 7-4.

Maps of the proposed seeding areas are given at the end of this section in Figure 7-1 thru 7-3 for the three reservoirs and are also described in Reclamation (2011b). The reservoir is separated into 5 zones:

1. Upland reseeding with ground based hydroseeding equipment

2. Upland reseeding with barge-based hydroseeding equipment – This is denoted in the figures as “Upland, above XXXX - no Ground Access”

3. Upland reseeding with aerial-based hydroseeding equipment - This is denoted in the figures as “Upland, below XXXX - no Ground Access”

4. Wetland/Riparian zones - Zone in which native wetland species will passively be allowed to revegetate and in which native riparian trees will be actively planted

5. Active Channel – No revegetation activities.

The exact locations of the hydroseeding method are considered preliminary and would be subject to further testing of various methods and investigation of the logistical problems associated with this effort.

Table 7-2. Hydroseeding application method coverage by reservoir and cost-estimate category.

J.C. Boyle

COST ESTIMATE	APPLICATION METHOD	COVERAGE (acres)
Low	Ground	247
Most Probable	Ground	247
High	Aerial	247

Copco

COST ESTIMATE	APPLICATION METHOD	COVERAGE (acres)
	Ground	420
Low	Barge	82
	Aerial	300
	Ground	420
Most Probable	Barge	82
	Aerial	300
High	Aerial	802

Iron Gate

COST ESTIMATE	APPLICATION METHOD	COVERAGE (acres)
	Ground	370
Low	Barge	296
	Aerial	159
	Ground	370
Most Probable	Barge	296
	Aerial	159
High	Aerial	825

Table 7-3. Fall re-seeding coverages (acres) by spring establishment success.

J.C. Boyle

SLOPE	SPRING SEEDING ESTABLISHMENT		
	75%	50%	25%
< 20%	52	105	157
> 20%	10	19	29

Copco

SLOPE	SPRING SEEDING ESTABLISHMENT 75%	50%	25%
< 20%	170	339	509
> 20%	31	62	93

Iron Gate

SLOPE	SPRING SEEDING ESTABLISHMENT 75%	50%	25%
< 20%	175	349	524
> 20%	32	63	95

Table 7-4. Reservoir revegetation vegetation category coverage.

J.C. Boyle

CATEGORY	COVERAGE (acres)
Wetland/Riparian	52
Upland	195
Total hydroseeded area	247

Copco

CATEGORY	COVERAGE (acres)
Wetland/Riparian	170
Upland	632
Total hydroseeded area	802

Iron Gate

CATEGORY	COVERAGE (acres)
Wetland/Riparian	50
Upland	775
Total hydroseeded area	825

Species selection for the purpose of this report is based on those known to be endemic to the area, expected to establish readily, and meet the goal criteria. It is likely that not all species will actually be suitable for this project; ideally small-scale studies will be conducted to determine the most effective species selection, seeding rate, timing, and other factors in order to meet the stated goals of the project.

Planting material collected on-site (from upland areas around existing reservoirs) to be used as planting material or as nursery stock to generate the required amounts is preferred. Local genotypes are best adapted to thrive and coexist with other species within the revegetation area and will likely have the highest establishment rate. Collections should be conducted in manners that will not cause significant detriment to the existing populations. In some areas, the existing species' populations may be insufficient for harvest and/or nursery production to the scale at which revegetation is desired. Off-site sources may be used to collect supplemental planting materials as needed and permitted. Indigenous genotypes reared by local commercial producers to generate larger amounts of planting material requires advanced planning and should be implemented some time in advance of planting (several years). Time and/or budget constraints may also make it necessary to acquire materials from commercial seed companies or nurseries. This is potentially a less costly source on a per-plant basis but may end up increasing overall costs if establishment success is low or if genotypes are aggressive and suppress natural succession in adjacent areas. Given the scale of the project it is understood that commercial seed and/or nursery stock sources for planting material may be necessary.

Investigations for improved germination of seed material should be conducted accordingly, regardless of source. This includes scarification, stratification, imbibition, and others.

7.2.1 Grass Seeding

Grass seed in a hydromulch mixture will be placed over the entire exposed area of each reservoir as soon as possible after drawdown. Native cool season grass species common to the Klamath basin typically germinate in the fall to take advantage of winter monsoons. Spring seedings of cool season grasses have also been known to be successful, although generally early plantings (March-April) have greater establishment success than those done in late spring/early summer. Delayed drawdowns due to wet weather would push the planting date past this optimum window, although increased soil moisture from such weather may mitigate establishment failure to some degree. This is especially the case if a sufficient layer of mulch can be installed in a timely manner to retain soil moisture.

Grass seeding rates are presented in Table 7-5 in pounds pure live seed (PLS) per acre. Commercial plant cultivars produced in large-scale are often bred for high germination rates (low dormancy) and seed viability. Locally collected "wild" varieties of plant species often have seed dormancy mechanisms as an adaptation for survival in adverse or catastrophic conditions, and not all seeds produced are viable. In addition, relatively small-scale production and processing methods can incorporate inert materials (chaff, stems, etc.) into the bulk seed, rendering it less than completely "pure". PLS is the product of the measured purity (in percent) and germination (in percent) of bulk seed, and is used in lieu of bulk seed for seeding rates in order to ensure the desired planting density is achieved.

It should be noted that seeding rates are generally toward the higher end of recommended rates from literature sources for the purpose of cost estimation and due to the number of unknown variables affecting successful seeding establishment. Ideally, small-scale and site-specific studies will be conducted to determine the most efficient seeding rate to be incorporated into future revisions of the revegetation plan.

In addition to the seed material, wood mulch and tackifier will be added to the hydroseed mix with a water carrier (supplied from the reservoirs/river or tankers). The wood mulch and tackifier will be applied at 2,000 and 120 lbs per acre, respectively, although rates may vary by site conditions and slope.

Table 7-5. Grass seeding rate (PLS) and total pounds PLS – spring planting

J.C. Boyle

COMMON NAME	SCIENTIFIC NAME	SEEDING RATE	TOTAL POUNDS PLS
Idaho fescue	*Festuca idahoensis*	4	988
Blue wildrye	*Elymus glaucus*	4	988
Small fescue	*Vulpia microstachys*	4	988
Bluebunch wheatgrass	*Pseudoroegneria spicata*	6	1,482
Sandberg bluegrass	*Poa secunda*	0.5	124
Spike bentgrass	*Agrostis exarata*	0.25	62

Copco

COMMON NAME	SCIENTIFIC NAME	SEEDING RATE	TOTAL POUNDS PLS
Idaho fescue	*Festuca idahoensis*	4	3,208
Blue wildrye	*Elymus glaucus*	4	3,208
Small fescue	*Vulpia microstachys*	4	3,208
Bluebunch wheatgrass	*Pseudoroegneria spicata*	6	4,812
Sandberg bluegrass	*Poa secunda*	0.5	401
Spike bentgrass	*Agrostis exarata*	0.25	201
Western needlegrass	*Achnatherum occidentale*	4	3,208
California brome	*Bromus carinatus*	8	6,416
Squirreltail	*Elymus elymoides*	4	3,208

Iron Gate

COMMON NAME	SCIENTIFIC NAME	SEEDING RATE	TOTAL POUNDS PLS
Idaho fescue	*Festuca idahoensis*	4	3,300
Blue wildrye	*Elymus glaucus*	4	3,300
Small fescue	*Vulpia microstachys*	4	3,300
Bluebunch wheatgrass	*Pseudoroegneria spicata*	6	4,950
Sandberg bluegrass	*Poa secunda*	0.5	413
Spike bentgrass	*Agrostis exarata*	0.25	206
Western needlegrass	*Achnatherum occidentale*	4	3,300
California brome	*Bromus carinatus*	8	6,600
Squirreltail	*Elymus elymoides*	4	3,300

Additional Materials

RESERVOIR	WOOD MULCH (lbs)	TACKIFIER (lbs)
J.C. Boyle	494,000	29,640
Copco	1,604,000	96,240
Iron Gate	1,650,000	99,000

Species mixes and seeding rates for fall re-seeding are identical to those used in the spring seeding, with the potential addition of incorporation methods for areas where mulch layers persist (Table 7-6). This will require equipment and/or labor crew access to these areas.

Table 7-6. Grass seeding materials for fall re-seeding (total pounds PLS) based upon the spring establishment success.

J.C. Boyle

COMMON NAME	SPRING SEEDING ESTABLISHMENT		
	75%	50%	25%
Idaho fescue	247	494	741
Blue wildrye	247	494	741
Small fescue	247	494	741
Bluebunch wheatgrass	371	741	1,112
Sandberg bluegrass	31	62	93
Spike bentgrass	15	31	46

Copco

COMMON NAME	SPRING SEEDING ESTABLISHMENT		
	75%	50%	25%
Idaho fescue	802	1,604	2,406
Blue wildrye	802	1,604	2,406
Small fescue	802	1,604	2,406
Bluebunch wheatgrass	1,203	2,406	3,609
Sandberg bluegrass	100	201	301
Spike bentgrass	50	100	150
Western needlegrass	802	1,604	2,406
California brome	1,604	3,208	4,812
Squirreltail	802	1,604	2,406

Iron Gate

COMMON NAME	SPRING SEEDING ESTABLISHMENT		
	75%	50%	25%
Idaho fescue	825	1,650	2,475
Blue wildrye	825	1,650	2,475
Small fescue	825	1,650	2,475
Bluebunch wheatgrass	1,238	2,475	3,713
Sandberg bluegrass	103	206	309
Spike bentgrass	52	103	155
Western needlegrass	825	1,650	2,475
California brome	1,650	3,300	4,950
Squirreltail	825	1,650	2,475

Additional materials (> 20% slope only)
J.C. Boyle

SPRING ESTABLISHMENT	WOOD MULCH (lbs)	TACKIFIER (lbs)
75%	19,000	1,140
50%	38,000	2,280
25%	57,000	3,420

Copco

SPRING ESTABLISHMENT	WOOD MULCH (lbs)	TACKIFIER (lbs)
75%	61,692	3,702
50%	123,385	7,403
25%	185,077	11,105

Iron Gate

SPRING ESTABLISHMENT	WOOD MULCH (lbs)	TACKIFIER (lbs)
75%	63,462	3,808
50%	126,923	7,615
25%	190,385	11,423

7.2.2 Riparian Planting

Riparian (and wetland) extents were determined using a variety of techniques. These included model assessments based upon reasonable biological parameters with subsequent comparison to river geomorphic maps of the reservoirs developed from historical photography.

Initial assessments were determined using two parameters, slope and height above river. Slopes were derived from bathymetric data adjusted for post dam removal desiccation. Height above river was determined by subtracting a modeled river elevation from the bathymetric elevations. Three initial classes were developed: Wetland, inland riparian, and bank riparian. Inland riparian areas were those with a slope of less than 3 percent.

Potential wetlands were modeled with slopes less than 2 percent and height less than one foot above the river. Bank riparian was modeled using slopes less than 5 percent and height above river less than 5 feet.

These modeled vegetation extents were then compared to river geomorphology maps and further adjusted. The modeling produced a mosaic of wetland and riparian areas that were determined to be more variable than what natural conditions might produce. These areas were combined using mapped terraces and bars as a guide. Wetland or riparian areas disconnected from the river were eliminated. All wetland and riparian areas were combined into one wetland/riparian class, all of which were treated as riparian for purposes of the cost estimate.

Revegetation species will be native riparian woody tree and shrub cuttings and transplants (seedlings/saplings). Planting densities within the riparian-bank areas may be variable, but will be assumed on average to be at approximately 400, 700, and 1,000 plants per acre for the Most Probable Low, Most Probable, and Most Probable High cost estimates, respectively. Total materials per species are then calculated by estimated proportion desired. The species mix is given in Table 7-7.

Table 7-7. Riparian revegetation species and planting proportions

J.C. Boyle

COMMON NAME	SCIENTIFIC NAME	MATERIAL UNIT	PROPORTION
Narrowleaf willow	*Salix exigua*	Cutting	70%
Arroyo willow	*Salix lasiolepis*	Cutting	10%
Shining willow	*Salix lucida*	Cutting	10%
Western serviceberry	*Amelanchier alnifolia*	Cutting/rhizome	5%
Chokecherry	*Prunus virginiana*	Transplant	5%

Copco

COMMON NAME	SCIENTIFIC NAME	MATERIAL UNIT	PROPORTION
Narrowleaf willow	*Salix exigua*	Cutting	60%
Arroyo willow	*Salix lasiolepis*	Cutting	10%
Shining willow	*Salix lucida*	Cutting	10%
Three-leaf sumac	*Rhus trilobata*	Cutting	10%
Western serviceberry	*Amelanchier alnifolia*	Cutting/rhizome	5%
Chokecherry	*Prunus virginiana*	Transplant	5%

Iron Gate

COMMON NAME	SCIENTIFIC NAME	MATERIAL UNIT	PROPORTION
Narrowleaf willow	*Salix exigua*	Cutting	70%
Arroyo willow	*Salix lasiolepis*	Cutting	20%
Shining willow	*Salix lucida*	Cutting	10%

Additional materials needed to increase the successful establishment of riparian-bank species include herbivore protection (such as screens and chemical deterrents) and polymers (for transplants only). Herbivore protection is vital to successful establishment of planted cuttings and seedlings, as young plant cuttings and transplants are highly susceptible to mortality from herbivory before root and shoot systems can sufficiently establish and are also often preferred browse material. Addition of polymer (e.g. vermiculite) to soils around seedling transplants can support root development through extensive summer dry periods and increase successful establishment. The quantities necessary for revegetation for each reservoir are given in Table 7-8.

Table 7-8. Riparian revegetation planting materials

J.C. Boyle

COMMON NAME	COST ESTIMATE SCENARIO		
	LOW	MOST PROBABLE	HIGH
Narrowleaf willow	14,560	25,480	36,400
Arroyo willow	2,080	3,640	5,200
Shining willow	2,080	3,640	5,200
Western serviceberry	1,040	1,820	2,600
Chokecherry	1,040	1,820	2,600

Copco

COMMON NAME	COST ESTIMATE SCENARIO		
	LOW	MOST PROBABLE	HIGH
Narrowleaf willow	40,800	71,400	102,000
Arroyo willow	6,800	11,900	17,000
Shining willow	6,800	11,900	17,000
Three-leaf sumac	6,800	11,900	17,000
Western serviceberry	3,400	5,950	8,500
Chokecherry	3,400	5,950	8,500

Iron Gate

COMMON NAME	COST ESTIMATE SCENARIO		
	LOW	MOST PROBABLE	HIGH
Narrowleaf willow	14,000	24,500	35,000
Arroyo willow	4,000	7,000	10,000
Shining willow	2,000	3,500	5,000

Additional Materials

J.C. Boyle

COST ESTIMATE SCENARIO	HERBIVORE SCREENS	CHEMICAL DETERENT (gal)	POLYMER (lbs)
Low	20,800	416	66
Most probable	36,400	728	115
High	52,000	1,040	164

Copco

COST ESTIMATE SCENARIO	HERBIVORE SCREENS	CHEMICAL DETERENT (gal)	POLYMER (lbs)
Low	68,000	1,360	214
Most probable	119,000	2,380	375
High	170,000	3,400	536

Iron Gate

COST ESTIMATE SCENARIO	HERBIVORE SCREENS	CHEMICAL DETERENT (gal)	POLYMER (lbs)
Low	20,000	400	0
Most probable	35,000	700	0
High	50,000	1,000	0

Although estimates of groundwater depths and fluctuations are not available, the water table is expected to be relatively shallow in proximity to the newly established river channel in some areas. Other areas may have terraces along the river channel that are higher than they once were due to reservoir sediment. Therefore, it may not be possible in all cases to plant poles of riparian species with immediate connections to groundwater. In order to enhance riparian restoration success, supplemental irrigation of riparian vegetation is included in the cost estimates. Irrigation of 50 percent of the riparian areas is assumed most probable, while the low estimate assumes 25 percent of riparian areas will be irrigated, and the high estimate assumes 75 percent will be irrigated, for these two reservoirs. Further studies are recommended to determine appropriate planting depths for riparian species in light of groundwater levels over extended time periods in order for successful long-term establishment. Water for irrigation is assumed to be available at no additional cost for all estimates.

7.2.3 Wetland Areas

Many sites within the inundated reservoirs are expected to support wetland vegetation more readily than the grass species in the seeding mix. The seed bank germination study indicated a high degree of viability and variability of wetland species seed in the reservoir deposit (see Reclamation, 2011b), even after many years or even decades under water. This suggests wetland areas will re-vegetate naturally and relatively quickly where hydrology is favorable, and therefore active revegetation of wetland areas will not be conducted.

7.3 Control of Invasive Species

Several aggressive invasive weed species currently infest areas in relative proximity to the reservoir shorelines. Although hydromulching should theoretically suppress a good degree of weed infestations that would otherwise hinder revegetation efforts, further weed management will likely be necessary. Monitoring and management activities should commence as soon as deposits are stable enough to support application equipment and ground crew activities, as well as prevent chemically treated soils from entering the river. Management activities should mesh with any ongoing efforts by state, local, or federal agencies in the area prior to dam removal, but will likely involve chemical and mechanical methods.

Herbicides with low soil mobility and/or use rates as well as low toxicity to fish and aquatic organisms are necessary, and should be applied using techniques to avoid drift during application. Glyphosate is one potential herbicide with such characteristics; it is deactivated by soil contact and would not be a pollutant hazard or harm revegetation species. Once grasses are established, spot treatments of post-emergent herbicides will be applied to invasive species within the revegetation areas and may be re-applied the following year if further treatments are necessary. Spot treatments are estimated to be applied over 25, 50, and 75 percent of the total reservoir areas for the Most Probable Low, Most Probable, and Most Probable High cost estimates, respectively.

Mechanical control would consist of discing, mowing, and hand-weeding. Limited access and sloping areas will limit discing and mowing to rights of way and possibly some of the flatter terraces, and would need to be combined with chemical treatments to be fully effective. Hand-weeding is highly labor intensive and unpleasant due to the spiny nature of some of the invasive species, but may be the only option to control weeds in sensitive and/or high-priority areas. Estimates of mechanically controlled areas are estimated to be minimal and considered to fall under the contingency budget for the purposes of the cost estimate.

Estimates of chemical treatments in total active ingredient (AI) applied (lbs) are presented in Table 7-9. These estimates are based on 2 lb AI per acre treatments, although actual applications may be spray-to-wet based on a percent concentration. This is a general guideline for cost estimation purposes and does not indicate the specific herbicide product. Use of herbicides is to be addressed in the environmental documents and will facilitate further discussion and ultimate determination of herbicides treatment method to be used in the revegetation effort.

Table 7-9. Estimated chemical treatment quantities.

J.C. Boyle

COST ESTIMATE SCENARIO	TREATED AREA (acres)	TOTAL AI APPLIED (lbs)
Low	62	124
Most probable	124	247
High	185	371

Copco

COST ESTIMATE SCENARIO	TREATED AREA (acres)	TOTAL AI APPLIED (lbs)
Low	201	401
Most probable	401	802
High	602	1,203

Iron Gate

COST ESTIMATE SCENARIO	TREATED AREA (acres)	TOTAL AI APPLIED (lbs)
Low	206	413
Most probable	413	825
High	619	1,238

7.4 Pre- and Post-revegetation Activities

7.4.1 Pre-revegetation

As has been implied throughout the document, the revegetation plan presented here is a rough estimation of activities required to revegetate the exposed reservoir deposit in order to meet the stated goals for the purposes of estimating costs for the Secretarial Determination. Many uncertainties still exist and the current plan cannot be guaranteed to meet these goals. Emphasis is placed on further determination of knowledge gaps and appropriate study in order to formulate a more refined revegetation plan based on site and temporally specific data, and therefore with a greater degree of confidence in its success. Potential future information collection topics are:

- Conduct extensive vegetation surveys at reservoirs and adjacent river reaches and tributaries.
- Determine feasible restorative condition(s) based on current vegetative status in similar local areas.

- Ascertain the potential for successful active and passive establishment of desired species in reservoir deposits: methods, rates, species, timing, etc.
- Modify planting material requirements based on revised goals, quantities, and availability.
- Coordinate with appropriate agencies on immediate and long-term weed management strategies.
- Revise uncertainties with respect to new data and formulate contingency plans.

7.4.2 Post-revegetation

Monitoring and maintenance of revegetation efforts will be conducted for a minimum of 4 years following revegetation. These activities may ultimately be included as part of a larger overall dam removal monitoring program, but for the purpose of cost estimation they are presented here. Development of specific monitoring protocols will be based on the goals of the project. Per the currently stated goals these would generally include assessment of successful plant establishment and coverage for both desired and invasive species.

Maintenance activities for the revegetation effort would follow up with appropriate re-seeding/planting, invasive plant management, and other activities as situations arise (e.g. installation of erosion mitigation materials). Actions will be adapted per the monitoring results and amendments to goals on a regular basis. Cost estimates are based on four consecutive years of hydroseeding and weed control over 10 percent of revegetation areas per year.

7.5 Summary Schedule of Vegetation Activities

The overall schedule of the revegetation plan is presented in Table 7-11. This time line should be considered as a general guide for the current revegetation schedule. Further small-scale and site-specific studies are recommended to further refine the schedule for best possible establishment of revegetation species.

Table 7-11.Schedule of revegetation activities.

• At least one year (preferably more) prior to drawdown	
	o Begin revegetation seed material collection/acquisition/propagation and germination testing
• Drawdown initiated	
	o January 1 , 2020
• Drawdown completion estimates (weather dependent)	
	o J.C. Boyle – February 1 to May 1, 2020 o Copco – March 15, 2020 o Iron Gate – March 1 to May 1, 2020
• Immediately following drawdown or as suitable areas are exposed	

- Ground, barge and/or aerial hydroseeding - grasses
- Fall of year 1
  - Re-seeding of failed establishment areas
  - Spot applications of herbicide
- Fall of year 1 to early spring year 2
  - Begin revegetation cutting and transplant material collection (from local sources or nurseries)
- Spring to summer, year 2
  - Install revegetation cutting and transplant materials in riparian zones
- Years 2 through 5
  - Monitoring and maintenance
  - Revegetation of select areas

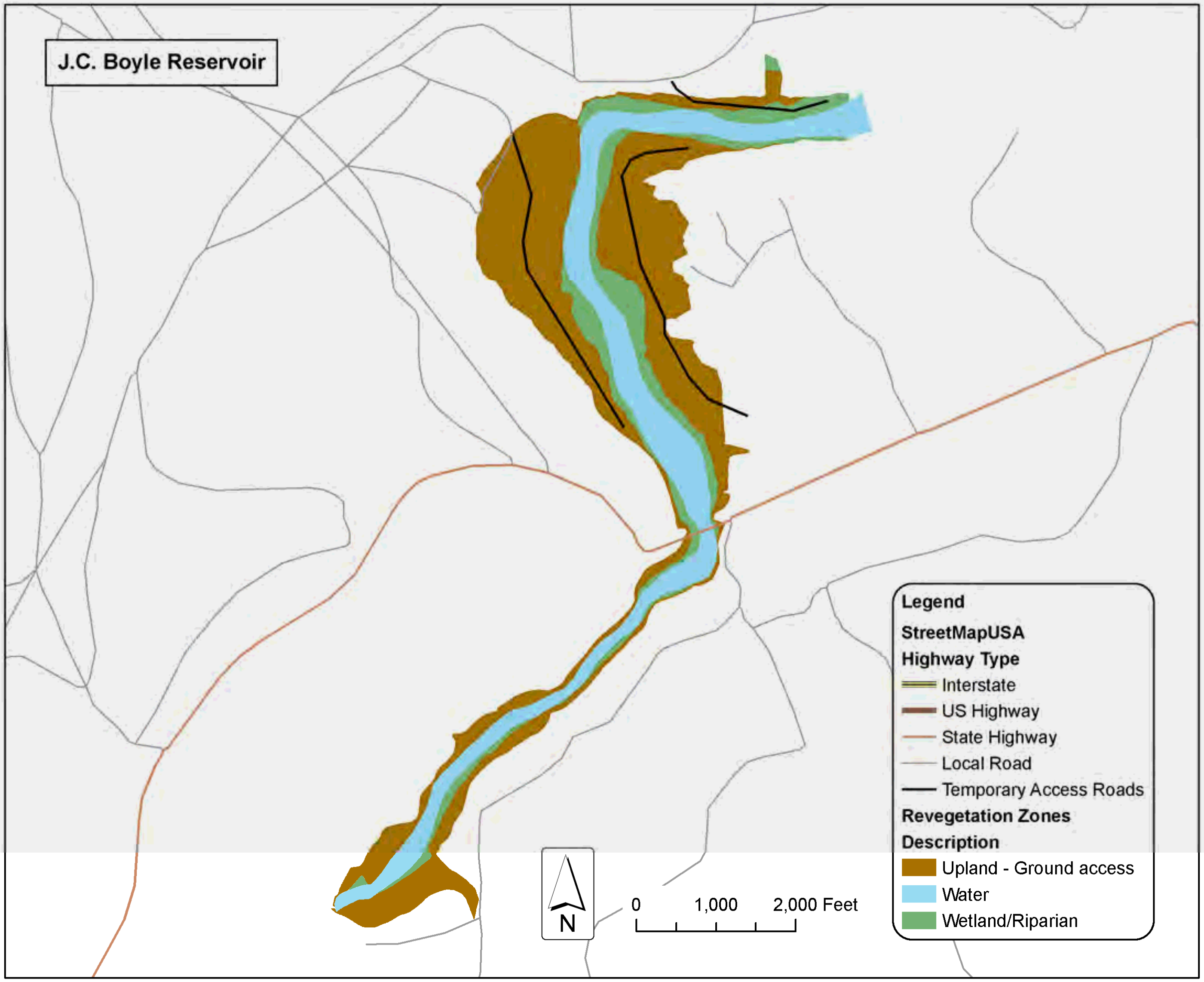


Figure 7-1 Revegetation zones for J.C. Boyle Reservoir.

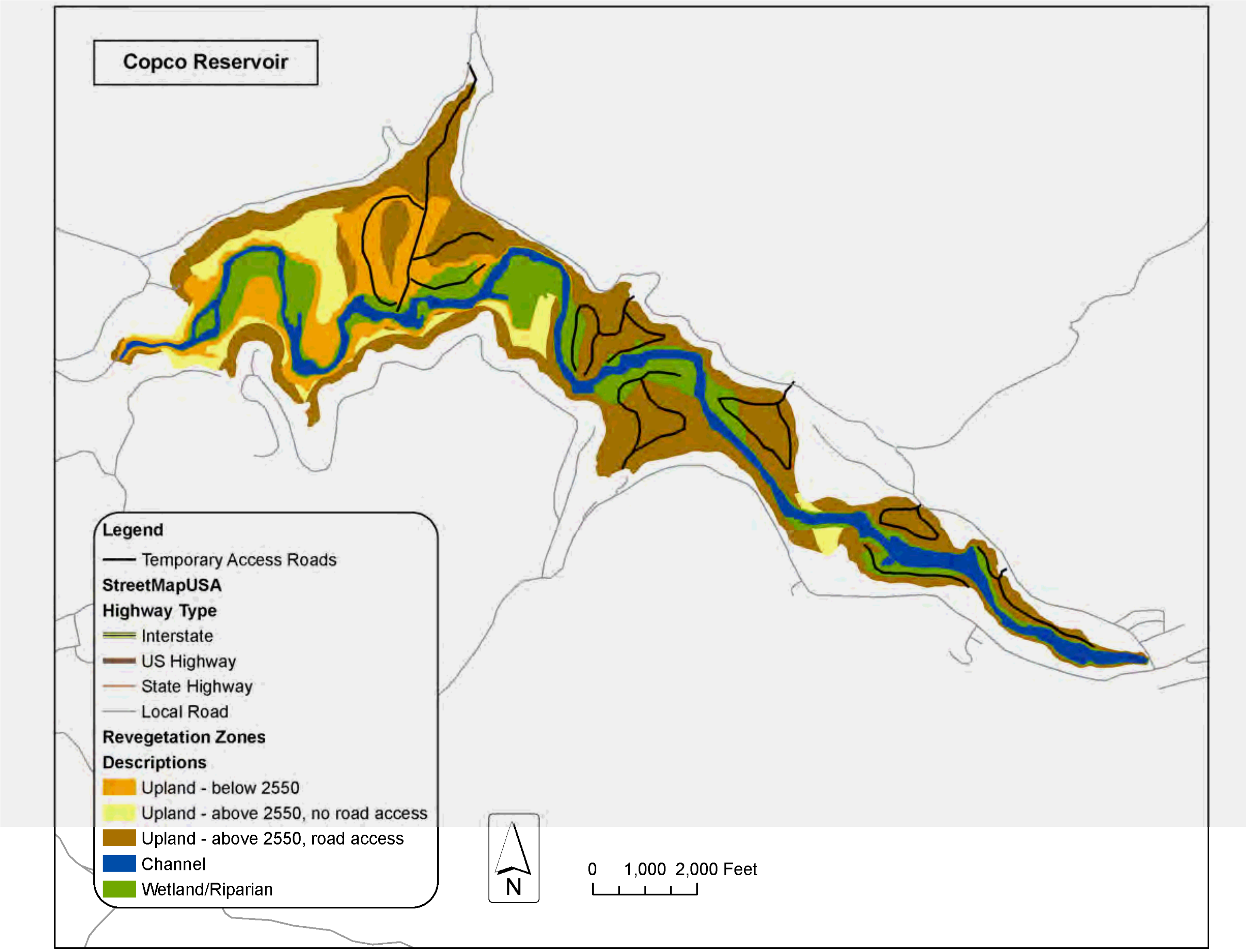


Figure 7-2. Revegetation zones for Copco Reservoir.

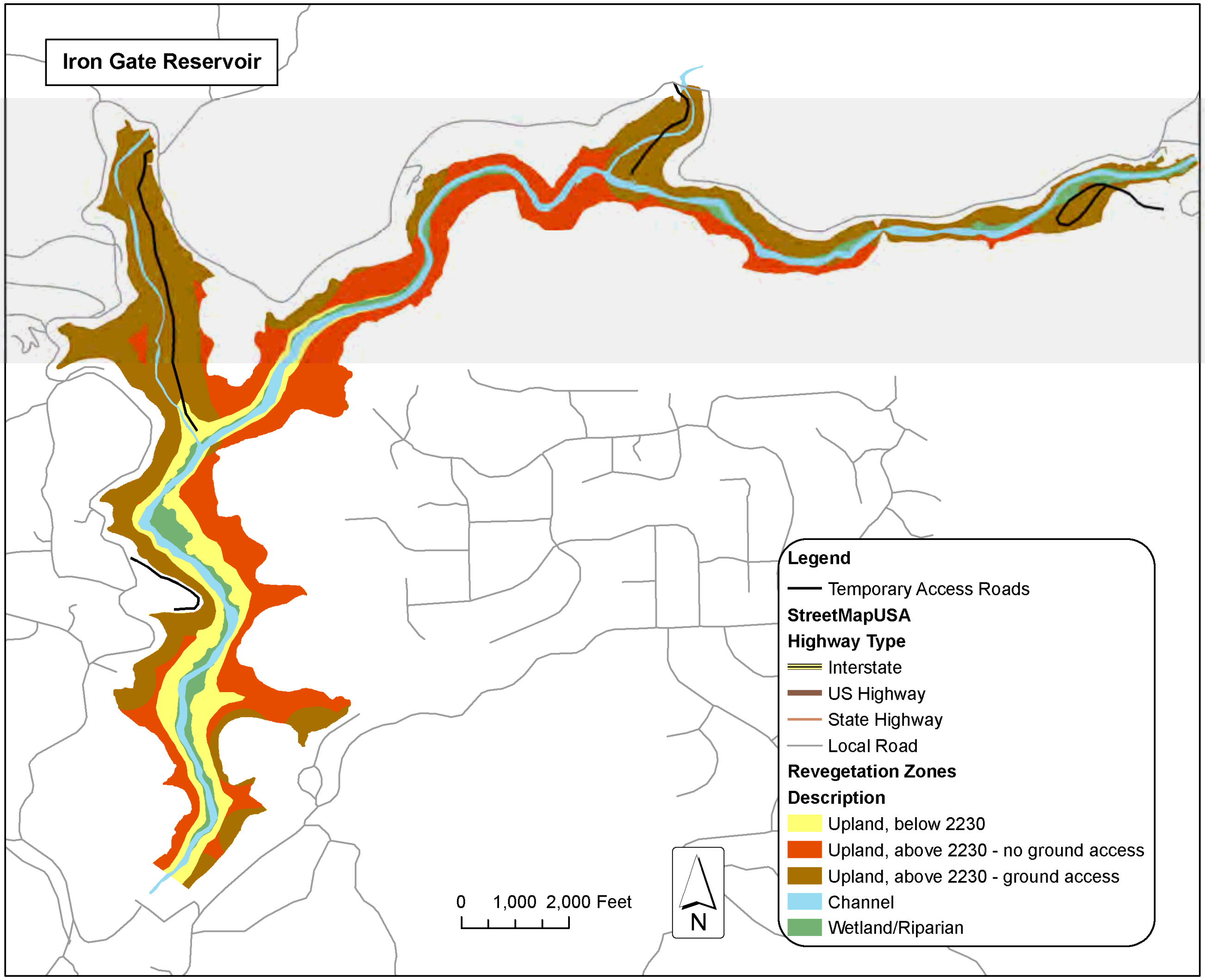


Figure 7-3. Revegetation zones for Iron Gate Reservoir.

8.0 Yreka City Water Supply

The City of Yreka's General Plan (2003) contains specific language regarding the City's water supply from the Fall Creek intakes and pumping station. The City's objective is to continue to improve the efficiency of the water treatment and distribution system and to promote expansion that serves both new growth and the water system as a whole. The General Plan does not specifically mention the removal of dams and the subsequent need to change the City's water supply facilities; however, the City's municipal code allows their utilities to be relocated, replaced, or buried in compliance with state and local building codes. The proposed modifications described below are in accordance with the requirements of AASHTO LRFD Bridge Design Specifications for the pipe bridge, and in accordance with the requirements of ACI 318 for the concrete structures. Final designs for the fish screens would be in accordance with criteria from NMFS, USFWS, and CDFG. These modifications would be the same for either dam removal alternative, and were developed at an appraisal-level using information provided by the City; however, the City was not directly involved in the development of the proposed design features for this study. In the event of a positive Secretarial Determination, any further design studies would include full participation by the City of Yreka.

8.1 Pipeline Modifications

A 24-inch-diameter water supply pipeline for the City of Yreka, California, crosses the Klamath River near the upstream end of the reservoir impounded behind Iron Gate Dam. The steel pipe is minimally buried in the creek bed. When the dam is removed, the pipe would become exposed to high velocity river flows and would likely sustain damage. A HEC-RAS model was used to estimate the hydraulic properties at the pipe crossing, and predicted scour ranged from 5 to 10 feet (Reclamation, 2011a). A replacement pipe crossing is needed before dam removal and reservoir drawdown. Due to difficulties in constructing a buried pipeline under water to the required depth of burial of more than 12 feet, which would likely require underwater rock excavation using divers, a pipe crossing on a bridge constructed above the existing reservoir surface was selected for cost estimating purposes for this level of study.

The proposed prefabricated steel 7.5-foot-wide box truss bridge would be just wide enough to accommodate the new 24-inch-diameter pipeline. The height would provide a minimum of three feet of freeboard above the eventual water surface for the 100-year flood in the river channel. Three bridge spans were selected, with a center span of 200 feet and end spans of 100 feet each to minimize the height of the two concrete support piers. The two ends would be supported on reinforced concrete abutments. The bridge abutments and piers would be founded upon drilled shafts backfilled with concrete. The prefabricated bridge would be designed by the construction contractor for the specified loads, which is typical Reclamation practice. The existing cathodic protection system for the pipeline would be retained and upgraded as necessary, and protection against vandalism would be provided.

The bridge would be aligned parallel to, but offset from the existing pipeline to avoid damage to the existing pipeline during construction. Access into the river for bridge pier construction would be from clean, dumped gravel access pads placed in the river and extending from the banks. The gravel access pads would be removed after construction.

The new pipeline would be connected to the existing buried pipeline at each end of the bridge by horizontal bends. Valves could be installed at each end to divert water from the old to the new pipe crossings. A short water delivery outage would be required to make the final connections and to install the valves following construction of the new pipe crossing. After completion of the new pipe crossing, the valves would be operated to divert flow from the old to the new pipe. The City has sufficient water storage capacity to accommodate the short outage necessary for this work. For cost estimating purposes, the old pipeline was assumed to be removed in the dry after reservoir drawdown. If pipeline removal is required before reservoir drawdown, a crane and divers would be used for an additional cost. See Figure 8-1 for details of the proposed pipe bridge crossing the Klamath River.

Appraisal-level quantities and cost estimates for the proposed pipe bridge are included in Attachment D.

8.2 Intake Modifications

8.2.1 Existing Conditions

Water is diverted to the City of Yreka's water supply system from Fall Creek, a tributary to the Klamath River. The primary diversion, called Dam A, is located just downstream from a PacifiCorp powerhouse on Fall Creek and consists of a low concrete dam with spillway notch and sluice gate. The dam provides head for diversion to a 24-inch-diameter supply pipe through a concrete headworks structure. The headworks structure has four 3-foot-wide bays. Up to three bays can be used for screening water into the intake with removable fish screen panels. Two bays also include an adjustable upstream slide gate/weir, positioned where the bottom of the gates are kept a few inches below the water surface to block surface debris from collecting on the screens. These bays connect into a common channel leading to the gated supply pipeline. The City's water right and diversion capacity at the site is 15 ft^3/s. Electric power is currently not provided to Dam A.

A secondary diversion point on Fall Creek is used whenever the power plant is shut down. This diversion, called Dam B, supplies water through a pipeline to bay 4 within the headworks structure at Dam A. A manually-operated slide gate is opened at Dam B to discharge water through the Dam B trashracked intake and into the pipeline. A bulkhead is opened in bay 4 at Dam A so that water can flow into the dam forebay, then through the Dam A fish screens to the Yreka water supply pipeline. Electric power is currently not provided to Dam B.

8.2.2 Proposed Modifications

The existing flat panel fish screens for the water supply intakes at Dams A and B do not meet current regulatory agency screen criteria for anadromous fish. The following modifications have been developed for cost estimating purposes in accordance with the provisions of the KHSA. The proposed replacement fish screens are shown on Figures 8-2 and 8-3.

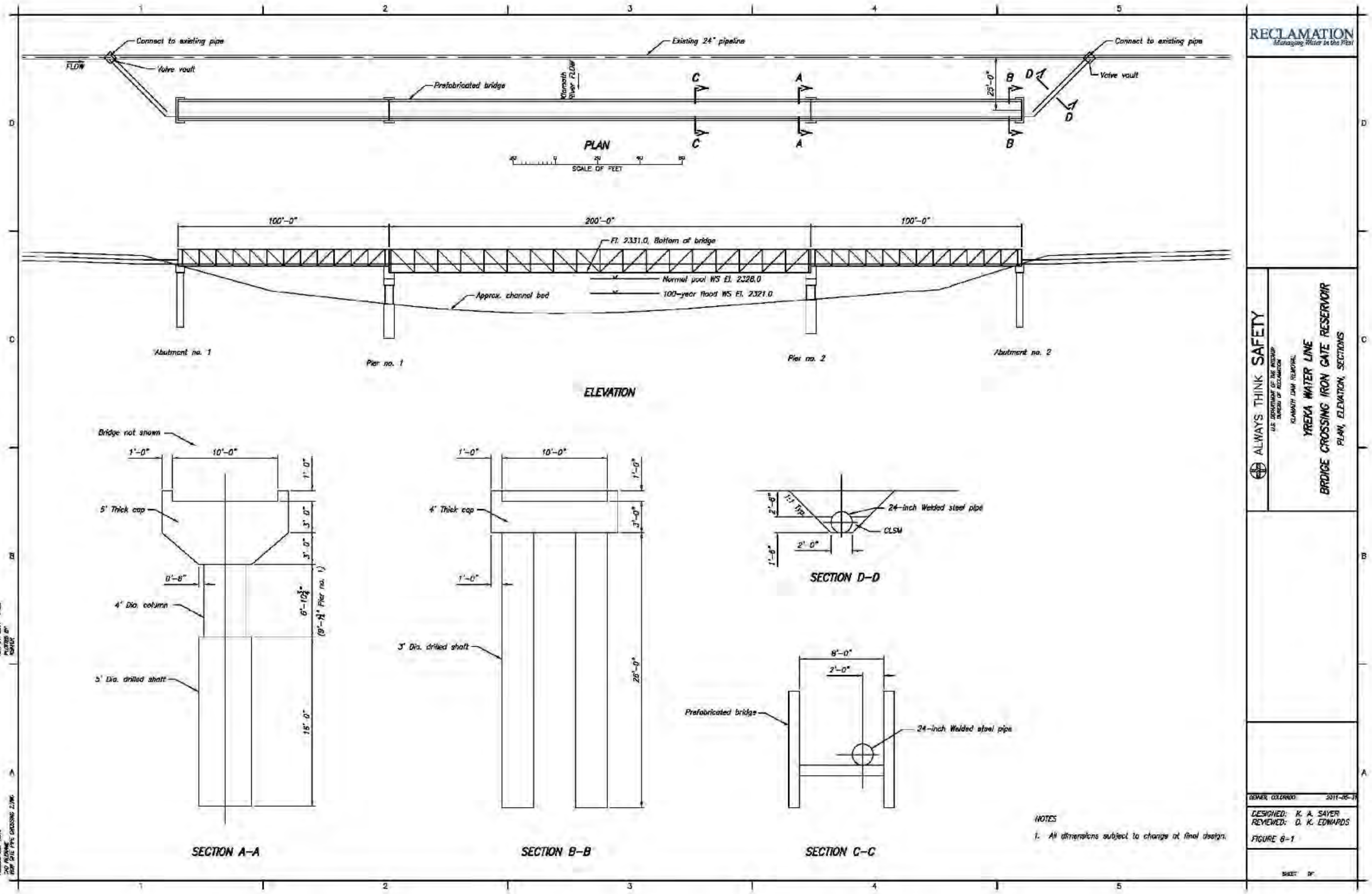
The replacement fish screen at each dam location would consist of a cylindrical Tee screen having a diameter of 30 inches and a length of 128 inches. Each Tee screen would be sized for a design flow of 15 ft^3/s. To meet the screen criteria, the Tee screen would provide an approach velocity not greater than 0.33 ft/s, and the screening cylinder at each end of the Tee would use stainless steel wedge or profile wire screen surfaces with 1.75 mm slot openings. Water flows through the screen cylinders, into the common screen header, and then into the intake bay. For cleaning, the cylinders rotate on their horizontal axis and are powered by internal geared propeller drives turned by water moving through the screen. Internal and external brushes remove trash from the screen surfaces as they rotate. The Tee screen is mounted onto a track frame and can be raised out of the water for maintenance and inspection using a battery-powered winch. During maintenance, a slide gate can be closed to stop flow from entering the intake or the flow can pass through the open slide gate and trashrack built into the screen track frame.

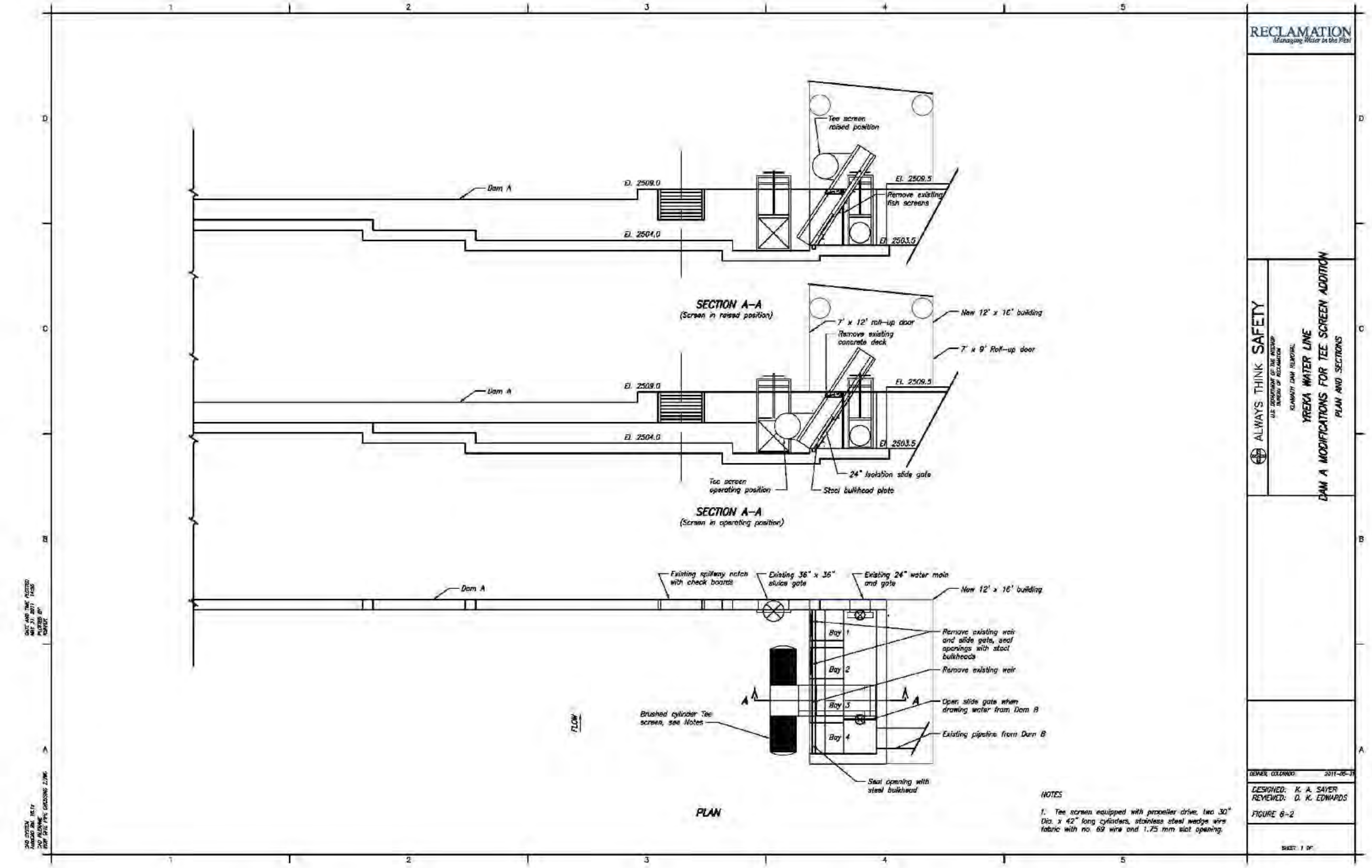
At Dam A, the existing upstream slide gates/weirs and fish screen panels would be removed and bays 1, 2, and 4 would be sealed by three steel bulkheads. The Tee screen would discharge through bay 3. A manually-operated 30- by 42-inch slide gate would be added between bays 3 and 4 and opened when Dam B is used for diversions.

To install the Tee screen system for Dam A, a small concrete deck over bay 3 would be removed. It is assumed that all construction work at Dam A would be accomplished without the need for cofferdams. To accommodate the raising and lowering of the Tee screen, a new building enclosure would be required at Dam A with a roll-up door over the Tee screen. The existing wood-frame building would be demolished and replaced by a new 12- by 16-foot wood-frame building. The new building would have a second roll-up door on the opposite wall, similar to the existing building.

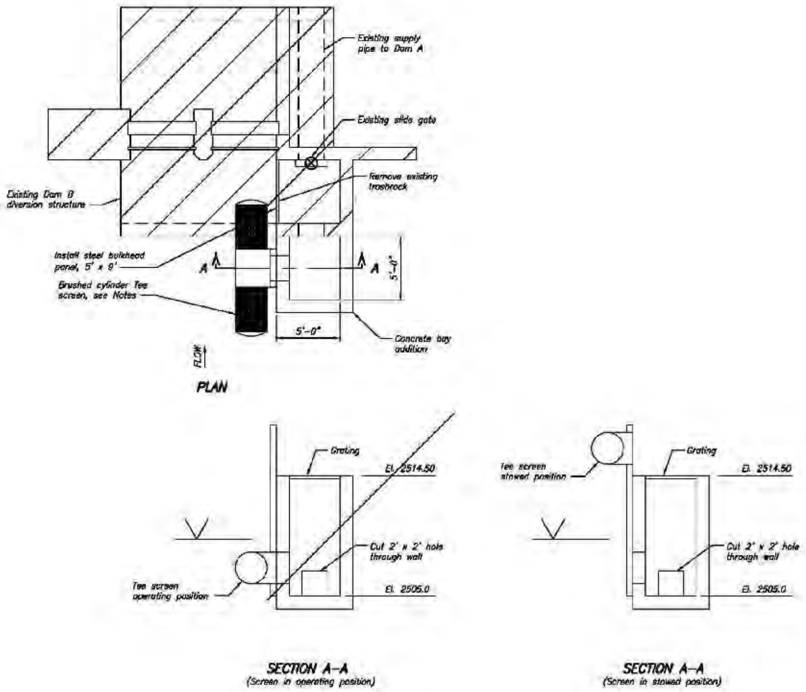
At Dam B, the existing trashracked intake would be modified to accommodate the cylindrical Tee screen system. The existing trashracks would be removed and the bay would be sealed with a steel bulkhead. An additional intake bay would be added at the upstream end and a 2-foot-square opening would be cut through the upstream wall of the existing intake connecting the two bays. It is assumed that a cofferdam would be required in the stream at Dam B during construction, and that access improvements to the site would be required. The Tee screen and a 12-foot-long mounting track/frame would be installed at the new intake bay. The Tee screen would only be lowered into position when operation of the Dam B supply pipeline is required.

Appraisal-level quantities and cost estimates for the proposed intake modifications are included in Attachment D.


Connect to existing pipe
Existing 24" pipeline
Valve vault
Prefabricated bridge
Klamath River FLOW
PLAN
SCALE OF FEET
100'-0"
200'-0"
El. 2331.0, Bottom of bridge
Normal pool WS El. 2328.0
100-year flood WS El. 2321.0
Approx. channel bed
Abutment no. 1
Pier no. 1
Pier no. 2
Abutment no. 2
ELEVATION
Bridge not shown
5' Thick cap
4' Dia. column
5' Dia. drilled shaft
SECTION A-A
4' Thick cap
3' Dia. drilled shaft
SECTION B-B
24-inch Welded steel pipe
CLSM
SECTION D-D
Prefabricated bridge
SECTION C-C
NOTES
1. All dimensions subject to change at final design.
RECLAMATION
Managing Water in the West
ALWAYS THINK SAFETY
YREKA WATER LINE
BRIDGE CROSSING IRON GATE RESERVOIR
PLAN, ELEVATION, SECTIONS
DESIGNED: K. A. SAYERI
REVIEWED: D. K. EDWARDS
FIGURE 8-1



RECLAMATION
Managing Water in the West
Tee screen raised position
Dam A
El. 2509.0
El. 2509.5
Remove existing fish screens
El. 2504.0
El. 2503.5
SECTION A–A
(Screen in raised position)
7' x 12' roll-up door
New 12' x 16' building
Remove existing concrete deck
7' x 9' Roll-up door
Tee screen operating position
24" isolation slide gate
Steel bulkhead plate
SECTION A–A
(Screen in operating position)
Existing spillway notch with check boards
Existing 36" x 36" sluice gate
Existing 24" water main and gate
Bay 1
Bay 2
Bay 3
Bay 4
Remove existing weir and slide gate, seal openings with steel bulkheads
Remove existing weir
Open slide gate when drawing water from Dam B
Existing pipeline from Dam B
Brushed cylinder Tee screen, see Notes
Seal opening with steel bulkhead
FLOW
PLAN
NOTES
1. Tee screen equipped with propeller drive, two 30" Dia. x 42" long cylinders, stainless steel wedge wire fabric with no. 69 wire and 1.75 mm slot opening.
ALWAYS THINK SAFETY
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
KLAMATH DAM REMOVAL
YREKA WATER LINE
DAM A MODIFICATIONS FOR TEE SCREEN ADDITION
PLAN AND SECTIONS
DENVER, COLORADO
DESIGNED: K. A. SAYER
REVIEWED: D. K. EDWARDS
FIGURE 8-2
SHEET 1 OF



NOTES

1. Tee screen equipped with propeller drive, two 30" Dia. x 42" long cylinders, stainless steel wedge wire fabric with no. 69 wire and 1.75 mm slot opening.

RECLAMATION
Managing Water in the West

ALWAYS THINK SAFETY

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

KLAMATH DAM REMOVAL

YREKA WATER LINE

DAM B MODIFICATIONS FOR FLAT SCREEN ADDITION

PLAN

DENVER, COLORADO 2011-05-31

DESIGNED: K. A. SAYER
REVIEWED: D. K. EDWARDS

FIGURE 6-3

SHEET 1 OF

9.0 Basis of Construction Cost Estimates

All construction cost estimates for this study were prepared by Reclamation's Technical Service Center - Estimating, Specifications, and Construction Management Group in Denver, Colorado. The estimates were prepared in accordance with Reclamation Manual Directives and Standards FAC 09-01, FAC 09-02, and FAC 09-03.

9.1 General Approach

The feasibility-level construction cost estimates for the Klamath River dam removals study include two alternatives and five separate features. The two alternatives consist of the Full Removal and the Partial Removal of all facilities at each of the four hydroelectric dams, and modifications to the City of Yreka's water supply system, which together represent the five features. These estimates were intended to capture the most current pricing for materials, wages and salaries, accepted productivity standards, and typical construction practices, procurement methods, current construction economic conditions, and site conditions for the current level of design. The cost estimates were prepared for less than complete designs (at feasibility- and appraisal-levels) and have inherent levels of risk and uncertainties. The Most Probable cost estimates represent a compilation of pay items, quantities, and unit prices representing the Designer's and Cost Estimator's best opinion and assessment of the scope of work and cost for the project. Most Probable Low (MPL) and Most Probable High (MPH) estimates were prepared to help evaluate the potential uncertainties for the Most Probable cost estimates using a Monte Carlo analysis (see section 9.8 below). The MPL and MPH estimates represent more optimistic and more conservative opinions of project costs, respectively.

The Most Probable cost estimate worksheets for the Full and Partial Removal alternatives are provided in Attachment D, and were used for the economic analyses. The MPL and MPH cost estimate worksheets, and the Monte Carlo analysis results, are provided in a separate volume, as Attachment F to this report. All cost estimates were prepared to help inform the Secretarial Determination, and will be updated prior to such determination.

9.1.1 Feasibility-Level Cost Estimates

The feasibility-level cost estimates for dam removal are based on information and data obtained during the design investigations. These investigations provided sufficient information to permit the preparation of structure layouts and removal limits, and the development of streamflow diversion and demolition plans, from which approximate quantities for each kind, type, or class of material, equipment, or labor were obtained. These estimates are suitable for use in the selection of a preferred project alternative and to determine the economic feasibility of the project in accordance with the provisions of the KHSA.

The quantity estimates for all dams and appurtenant structures to be removed, including concrete volumes and weights of mechanical and electrical equipment, have been carefully prepared using detailed engineering drawings provided by PacifiCorp, which are believed to represent current, as-built conditions. Each damsite has been inspected by members of the Engineering Subteam to confirm the existence of project features for which quantities have been prepared; however, no independent surveys or measurements have been taken. The designs for the Yreka water supply pipeline and intake modifications were based on drawings and photographs provided by the City of Yreka, site inspections, and applicable design criteria for the hydraulic structures, and were prepared at an appraisal-level but represent a small portion of the overall project.

All weight estimates for the gates, stoplogs, and valves for the feasibility-level estimates are based on design graphs developed by Reclamation, in addition to other sources as appropriate. Weights for the hydraulic turbines were estimated using information contained in Engineering Monograph No. 20 (Reclamation, 1976). Since much of the design data used are of the same vintage as that of the units being disassembled, the weights should be sufficiently accurate for this study. Weights also had to be estimated for all electrical equipment using available references. Removal of large mechanical equipment such as the runners, spiral cases, draft tubes, and penstocks, and of large electrical equipment such as the generators and transformers, would require the equipment to be broken down into manageable parts which can be lifted by a crane and loaded onto a truck for disposal offsite. However, the spiral cases, draft tubes, and portions of the penstocks encased in concrete may be difficult to disassemble.

Hazardous materials that are encountered during the removal of the dams must be handled properly and disposed in an approved location. For cost estimating purposes, any equipment that would normally contain petroleum products was identified. This would include all hydraulic valves, gates, hoists, and stems; most of the mechanical equipment in the powerhouses and switchyards (including pumps and turbines); and fish screen operating equipment. Submerged surfaces of gates and valves were assumed to be coated with coal-tar enamel. Any surfaces that would normally be painted were assumed to have coatings containing heavy metals such as red lead, including structural steel used in foot bridges, powerhouses, bulkheads, stoplogs, and rails; hydraulic valves, gates, and hoists; most of the mechanical items in the powerhouses and switchyards, including pumps and turbines; vent pipes; water bearing pipes, such as penstocks and surge tanks; miscellaneous metalwork, such as handrails and gratings; and fish screens. Trashracks and transition manifolds were not assumed to contain any hazardous materials for the Most Probable cost estimates. While there may be minor amounts of polychlorinated biphenyls (PCBs) at the sites, removal of PCBs has not been included in the cost estimates, since PacifiCorp has previously certified their facilities as being PCB-free. Most of the “hazardous” waste was not considered to be hazardous under RCRA for cost estimating purposes (i.e. below defined toxicity levels for hazardous waste), and was assumed to go to the local landfill nearest the damsite, with the exception of treated wood.

The feasibility-level unit prices were developed using a detailed method. Specific construction activities were identified for major cost drivers. Costs for labor, equipment, materials, and other resources were developed. Production rates, overhead, and taxes were applied to develop the applicable unit prices. Vendor quotations were obtained for major equipment, supplies, and other items. Minor cost items were developed using historical bid and industry standard reference cost data.

9.1.2 Price Level

Price levels for Reclamation cost estimates are based on quarterly data. All prices shown in the cost estimates provided in Attachment D are in July 2010 dollars. An update of the cost estimates is planned prior to the Secretarial Determination. Assumptions for the escalation of costs to 2020 dollars are described in section 9.1.5.

9.1.3 Mobilization

A value of 5 ± percent was utilized in the cost estimates for mobilization. Mobilization costs include contractor performance bonds, insurance, and the costs of mobilizing contractor personnel and equipment to the project site during initial project setup. The assumed 5 ± percent value in the cost estimates is based upon past experience of similar jobs, and is applied to the subtotal of all individual pay items.

9.1.4 Design Contingency

Design contingencies are intended to account for three types of uncertainties which directly affect the estimated cost of a project as it advances from the planning stage through final design. These include: (1) minor unlisted items, (2) minor design and scope changes, and (3) minor cost estimating refinements. Based upon the apparent completeness of the listed items for the dam removal estimates, the design contingency was set at 10 ± percent of the listed items for each of the dams, which is a typical value for a feasibility-level estimate. A value of 15 ± percent was utilized for the design contingency for the estimates associated with the Yreka water supply system, reflecting a lower, appraisal-level of design detail and a greater potential for design changes.

9.1.5 Escalation

For projects which are to be developed over an extended period of time, or at some distant time in the future, it is prudent to consider the time value of money. There are two distinct periods of time that must be considered for the escalation of costs. First, the time from when the cost estimate is prepared until notice to proceed, and second, the duration of the construction contract. The cost estimates include escalation during construction in the unit prices developed for the pay items. An allowance for escalation for a period of approximately 10 years, from the July 2010 price level to January 2020, was included in the cost estimate. Future refinements to the cost estimate should escalate only to the anticipated project notice to proceed milestone, which would be sometime before June 2019. The Most Probable cost estimates used an escalation rate of 3 percent per year, compounded annually, over 10 years. The 3 percent annual escalation rate used to measure the effects of inflation for future construction costs from July 2010 through January 2020 was based on Reclamation's Construction Cost Trends, OMB Circular No. A-94, other published historical data, and professional judgment.

9.1.6 Allowance for Procurement Strategies

A line item allowance for procurement strategies (or considerations) may be included in feasibility-level cost estimates to account for additional costs when solicitations would be advertised and awarded under other than full and open competition. These include solicitations that would be set aside under socio-economic programs, along with solicitations that may limit competition or allow award to other than the lowest bid or proposal, such as the case for a negotiated procurement contract. The cost estimates for this study assume full and open competition, and receipt of sealed bids, with award to the lowest responsive and responsible bidder. The Allowance for Procurement Strategies (APS) was therefore set at zero percent. This assumption may be reconsidered for final design, as negotiated procurement is more typical for a large dam removal project, which could result in an adjustment to the cost estimates.

9.1.7 Construction Contingency

Feasibility- and appraisal-level cost estimates include a percentage allowance for construction contingencies as a separate item to cover minor differences in actual and estimated quantities, unforeseeable difficulties at the site, changed site conditions, possible minor changes in plans, and other uncertainties during the construction period. The allowance is based on engineering judgment of the major pay items in the estimate, reliability of the data, adequacy of the estimated quantities, and general knowledge of the site conditions. A value of 20 ± percent was utilized for design contingencies for the dam removal estimates, which is a typical value for a feasibility level estimate. A value of 25 ± percent was utilized for the construction contingency for the estimates associated with the Yreka water supply system, reflecting a lower, appraisal-level of design detail and a greater potential for uncertainties. The construction contingency is applied to the total contract cost, after all other allowances have been applied, to produce the total field cost.

9.1.8 Non-Contract Costs

Non-contract costs generally include allowances expressed as a percentage of the total field cost for the following items.

- Planning (or investigations), including studies and surveys (collection, assembly, and analysis of design data, and preparation and review of reports such as environmental impact studies, cultural resources studies, mitigation studies, etc.).
- Engineering and other costs, including final designs and specifications, procurement, construction engineering and management, and other related costs (such as general office salaries, supplies and expenses, general transportation expenses, security, environmental oversight, legal services, etc.)
- Services facilities including camps, construction roads, utility systems, temporary plants used for construction, etc.
- Environmental permitting, mitigation, monitoring, and restoration
- Cultural resources preservation

Non-contract costs were estimated to be 20 ± percent of the total field cost, based on typical non-contract cost percentage ranges from past large Reclamation projects, plus an allowance for the estimated total cost of the specific mitigation measures described in section 9.7 (including cultural resources preservation) and the estimated total cost of post-construction monitoring described in section 9.8. The total non-contract cost allowance is applied to the total field cost to produce the total construction cost. Land acquisition or relocation of property by others is not included in non-contract costs and would have to be added to the total construction cost. No allowance for land acquisition was included in the cost estimates prepared for this study.

The non-contract cost allowance for the feasibility- and appraisal-level cost estimates includes the following:

Component	Non-Contract Cost as Percentage of Field Cost
Design Data	1
Engineering Designs	4
Procurement	1
Construction Management	10
Permitting	3
Closeout	1
Total of Percentages Above	20

Based on the estimated total field costs and on the estimated total cost of mitigation measures from section 9.7, and on the estimated total cost of monitoring from section 9.8, the additional allowance for mitigation measures was computed as 35 percent of the total field cost for the Full Removal alternative and 45 percent for the Partial Removal alternative. The allowance is higher for the Partial Removal alternative due to the lower total field cost compared to the Full Removal alternative, for a fixed estimated field cost for monitoring and mitigation measures. This resulted in total non-contract allowances of 55 percent for the Full Removal alternative and 65 percent for the Partial Removal alternative with the addition of the 20 percent allowance computed above.

The life cycle cost for long-term maintenance of features retained under the Partial Removal alternative (discussed in section 9.6) includes a total non-contract allowance of 30 ± percent based on the following assumptions: engineering designs, 5 percent; maintenance service contract, 5 percent; procurement, 2 percent; environmental and cultural mitigation, 7 percent; inspections, 10 percent; and closeout, 1 percent. The life cycle cost is added to the total construction cost for the Partial Removal alternative to produce the total overall cost for this alternative.

9.2 Dam Removal Estimates

The following assumptions have been made for preparation of the Most Probable, MPL, and MPH estimates of construction cost for the Full and Partial Removal alternatives at each of the four damsites. All estimates described in this report are assumed to be Most Probable unless indicated otherwise. The quantity estimates are the same for all cost estimates of each feature except as noted below. The identification, removal, and disposal of hazardous materials are discussed in section 9.1.1 for the Most Probable cost estimates for all sites. See Chapter 4 for further discussion of the structures to remain in place under the Partial Removal alternative.

9.2.1 J.C. Boyle Dam and Powerhouse

The majority of the excavated embankment material from J.C. Boyle Dam was assumed for all estimates to be disposed of in a waste area near the right abutment of the dam beneath high voltage powerlines. It was assumed that the right abutment waste area could be used without interference with the powerlines. A portion of the excavated embankment material would be used to fill the wasteway (or forebay) scour hole to original contours for the MPH estimates, which would reduce the area needed to be cleared and grubbed on the right abutment for the disposal of the embankment material. Concrete rubble from the dam was assumed to be disposed of in a waste area on the left abutment of the dam for the MPL estimates, and disposed of in the scour hole downstream of the wasteway for the Most Probable and MPH estimates. Preparation of the waste area on the left abutment (including clearing and grubbing) was therefore not required for the Most Probable and MPH estimates. Concrete rubble from the flume, forebay, penstocks, and powerhouse was assumed to be disposed of in the wasteway scour hole for all estimates. A 2-foot-thick embankment cover over the concrete rubble in the scour hole was assumed for the Most Probable estimates. A 30 percent bulking factor was applied to the in-place concrete quantities to determine the volume of concrete rubble. The 4-inch gravel surfacing for the proposed haul roads was eliminated from the MPL estimates. The Partial Removal alternative would result in much less concrete rubble and therefore less material to be wasted in the wasteway scour hole. Steel anchors and reinforcement was assumed to be removed from the concrete and hauled to a recycling facility.

All lumber and timber quantities to be removed were assumed to be pressure-treated, requiring a haul distance of at least 70 miles to an appropriate disposal facility. For the Most Probable and the MPH estimates, painted metal surfaces were assumed to contain heavy metals (lead paint). For the MPL estimates, painted metal surfaces were assumed to not contain heavy metals. For the Most Probable estimates, some mechanical items were assumed to contain petroleum products. For the MPH estimates, some mechanical items were assumed to contain petroleum products and some asbestos. The MPL estimates assumed no hazardous materials associated with the mechanical items.

Since so little is known about the traveling water screens within the intake structure, product data were consulted to estimate weights for the Full Removal alternative. Each draft tube at the powerhouse was assumed to have its own set of stoplogs for estimating purposes. For all estimates, the 150-ton gantry crane would be disassembled and transported from the site as has been performed in the past, since the crane is shared with the Iron Gate powerhouse.

Following decommissioning of the J.C. Boyle powerhouse, PacifiCorp would tie together the existing transmission lines that head south into J.C. Boyle. All of the transmission structures heading from the line tie-in to the J.C. Boyle substation would be removed, along with the J.C. Boyle substation and J.C. Boyle powerhouse. It was assumed for cost estimating purposes that PacifiCorp would salvage the major substation equipment. The powerhouse would be removed down to the springline of the turbines (elevation 3324) for the Full Removal alternative, including all mechanical and electrical equipment. The remaining structure would be buried. For the Partial Removal alternative, the powerhouse was assumed to remain in place.

The Most Probable cost estimates and forecast range of values (from the Monte Carlo analysis discussed in section 9.9) for removal of J.C. Boyle Dam and Powerhouse are summarized in Tables 9-1 and 9-2, based on a July 2010 price level.

Table 9-1 – Cost Summary for Full Removal of J.C. Boyle Dam and Powerhouse (2020 dollars)

	Forecast Range		Most Probable Cost Estimate
	Minimum	Maximum	
Dam Facilities Removal			17,769,070
Recreation Facilities Removal			89,480
Reservoir Restoration			2,738,500
Mobilization and Contingencies			9,958,175
Escalation to Jan 2020			7,444,775
TOTAL FIELD COST	30,900,000	63,900,000	38,000,000
Engineering @ 20%			7,600,000
Mitigation @ 35%			13,400,000
TOTAL CONSTRUCTION COST	**47,400,000**	**98,300,000**	**59,000,000**

Table 9-2 – Cost Summary for Partial Removal of J.C. Boyle Dam and Powerhouse (2020 dollars)

	Forecast Range		Most Probable Cost Estimate
	Minimum	Maximum	
Dam Facilities Removal			10,824,805
Recreation Facilities Removal			89,480
Reservoir Restoration			2,738,500
Mobilization and Contingencies			6,417,935
Escalation to Jan 2020			4,929,280
TOTAL FIELD COST	19,900,000	45,100,000	25,000,000
Engineering @ 20%			5,000,000
Mitigation @ 45%			11,000,000
TOTAL CONSTRUCTION COST	**31,800,000**	**76,400,000**	**41,000,000**
TOTAL LIFE CYCLE COST	**4,900,000**	**14,700,000**	**6,800,000**

9.2.2 Copco No. 1 Dam and Powerhouse

Concrete rubble from the dam and powerhouse was assumed to be wasted in a disposal area above the right abutment of the dam. This would be the same concrete disposal area for Copco No. 2 Dam. The concrete rubble would be covered with a 2-foot-thick soil cover. Steel anchors and reinforcement was assumed to be removed from the concrete and hauled to a recycling facility.

For road improvements at Copco No. 1, the assumption was made that 4 inches of gravel surfacing would be required on the access and haul roads for the Most Probable and MPH estimates, but not for the MPL estimates. Chip seal treatment for improving the 22 miles of county roads after construction was assumed for the Most Probable and MPL estimates, and a 3-inch asphalt overlay was assumed for the MPH estimates. The amount of soil and rock excavation, and the amount of soil backfill and cover in the concrete waste disposal area, was increased for the MPH estimates to account for uncertainty.

Two gate hoists were assumed for all thirteen spillway radial gates, and only one set of eight stoplogs was provided with thirteen sets of guides for the thirteen gates, based on the drawings. Each horizontal generator has two horizontal Francis units. Based on the total power output, head, and flow, the horizontal units and appurtenant equipment were estimated as if they were one vertical Francis turbine per generator. Two 40-ton bridge cranes were assumed for all estimates.

For the Most Probable and the MPH estimates, painted metal surfaces were assumed to contain heavy metals (lead paint). For the MPL estimates, painted metal surfaces were assumed to not contain heavy metals. For the Most Probable estimates, some mechanical items were assumed to contain petroleum products. For the MPH estimates, some mechanical items were assumed to contain petroleum products and some asbestos. The MPL estimates assumed no hazardous materials associated with the mechanical items. The Copco No. 1 switchyard has two 69kV lines – one to Fall Creek and one to Copco No. 2 powerhouse. Those lines and the switchyard at Copco No. 1 would be removed for all estimates. Weights were estimated for the AC generators, excitation equipment, surge protection equipment, neutral grounding equipment, generator switchgear, station service switchgear, unit and plant control switchboard, battery system, raceways, conduit and cable, miscellaneous power and control boards, step-up transformers, travelling crane motors, overhead crane motors, control equipment and festoon cable. The powerhouse electrical equipment would be removed and disposed for the Full Removal alternative estimates. Weights were also estimated for the spillway gate motor, control panel, distribution equipment, and panel boards. The spillway electrical equipment would be removed and disposed for all estimates.

The powerhouse would be removed down to the top of rock (elevation 2482.75) for the Full Removal alternative, including all mechanical and electrical equipment. The remaining structure would be buried. For the Partial Removal alternative, the powerhouse was assumed to remain in place.

The Most Probable cost estimates and forecast range of values (from the Monte Carlo analysis discussed in section 9.9) for removal of Copco No. 1 Dam and Powerhouse are summarized in Tables 9-3 and 9-4, based on a July 2010 price level.

Table 9-3 – Cost Summary for Full Removal of Copco No. 1 Dam and Powerplant (2020 dollars)

	Forecast Range		Most Probable Cost Estimate
	Minimum	Maximum	
Dam Facilities Removal			26,710,485
Recreation Facilities Removal			187,100
Reservoir Restoration			9,658,000
Mobilization and Contingencies			18,236,105
Escalation to Jan 2020			13,208,310
TOTAL FIELD COST	60,100,000	106,400,000	68,000,000
Engineering @ 20%			13,500,000
Mitigation @ 35%			23,500,000
TOTAL CONSTRUCTION COST	**89,400,000**	**169,700,000**	**105,000,000**

Table 9-4 – Cost Summary for Partial Removal of Copco No. 1 Dam and Powerplant (2020 dollars)

	Forecast Range		Most Probable Cost Estimate
	Minimum	Maximum	
Dam Facilities Removal			15,770,000
Recreation Facilities Removal			187,100
Reservoir Restoration			9,658,000
Mobilization and Contingencies			13,128,356
Escalation to Jan 2020			9,256,544
TOTAL FIELD COST	40,800,000	75,200,000	48,000,000
Engineering @ 20%			9,500,000
Mitigation @ 45%			21,500,000
TOTAL CONSTRUCTION COST	**64,700,000**	**136,700,000**	**79,000,000**
TOTAL LIFE CYCLE COST	**1,300,000**	**3,900,000**	**1,750,000**

9.2.3 Copco No. 2 Dam and Powerhouse

Concrete rubble from the dam was assumed to be wasted in a disposal area above the right abutment of Copco No. 1 Dam, which is also to be used as the concrete disposal area for Copco No. 1 Dam. The concrete rubble would be covered with a 2-foot-thick soil cover. Steel anchors and reinforcement was assumed to be removed from the concrete and hauled to a recycling facility.

For the MPH estimate for the Full Removal alternative, the access road bridge across the Klamath River downstream of the Copco No. 2 powerhouse was assumed to be removed and replaced with a stronger bridge to handle the construction traffic. The new bridge would be constructed of precast concrete girders, and would have two spans of 120 feet each, supported by two concrete abutments and a single concrete pier founded on bedrock. The bridge deck would have a total width of 31 feet to accommodate two lanes of traffic, plus shoulders, and would have an HS-20 design load. The Most Probable and MPL estimates assumed that any necessary modifications to the existing bridge to handle construction traffic would be covered in the design contingency allowance for removal of the dam and powerhouse, or that any necessary modifications would be performed by others for maintenance purposes prior to dam removal. The Partial Removal alternative does not include the removal of the Copco No. 2 powerhouse and was assumed to not require modifications to the access road bridge.

A wheel-mounted gate design graph was used to estimate the weight of the 20- by 20-foot Caterpillar gate at the diversion intake structure for the Full Removal alternative estimate, due to a lack of design details. The stoplog weights were also estimated using design graphs. The wood-stave penstock was understood to have been treated with creosote, and was assumed to include an estimated 148 concrete cradles at 1,960 lbs each, with 4,322 steel bands. Although the treated wood and steel bands are removed for all estimates, the concrete cradles are assumed to remain for the Partial Removal alternative. The underground steel surge tank pipe was assumed to remain in place for all estimates, with the outlet plugged with concrete. The steel supports for the air vent pipe were assumed to be the same weight as an I-beam of the same size for estimating purposes.

All lumber and timber quantities to be removed were assumed to be pressure-treated, requiring a haul distance of at least 70 miles to an appropriate disposal facility. For the Most Probable and the MPH estimates, painted metal surfaces were assumed to contain heavy metals (lead paint). For the MPL estimates, painted metal surfaces were assumed to not contain heavy metals. For the Most Probable estimates, some mechanical items were assumed to contain petroleum products. For the MPH estimates, some mechanical items were assumed to contain petroleum products and some asbestos. The MPL estimates assumed no hazardous materials associated with the mechanical items.

PacifiCorp would disconnect the Copco No. 2 powerhouse from the Copco No. 2 substation, which would allow the powerhouse to be removed for the Full Removal alternative, along with the buried electrical line from the powerhouse to the substation. The 230kV Switchyard is located on a bluff north of the Copco No. 2 powerhouse, and is a transmission system facility independent of the hydroelectric project and must remain. Weights were estimated for the AC generators, excitation equipment, surge protection equipment, neutral grounding equipment, generator switchgear, station service switchgear, unit and plant control switchboard, battery system, raceways, conduit and cable, miscellaneous power and control boards, step-up transformers, travelling crane motors, control equipment and festoon cable. The powerhouse electrical equipment would be removed and disposed for the Full Removal alternative estimates. Weights were also estimated for the spillway intake gate motor, tainter gate motors, trashrake motor, festoon cable control panels, distribution equipment, and panel boards. The spillway electrical equipment would be removed and disposed for all estimates.

The powerhouse would be removed down to the springline of the turbines (elevation 2338) for the Full Removal alternative. The remaining portions of the structure would be buried. For the Partial Removal alternative, the powerhouse was assumed to remain in place.

The Most Probable cost estimates and forecast range of values (from the Monte Carlo analysis discussed in section 9.9) for removal of Copco No. 2 Dam and Powerhouse are summarized in Tables 9-5 and 9-6, based on a July 2010 price level.

Table 9-5 – Cost Summary for Full Removal of Copco No. 2 Dam and Powerplant (2020 dollars)

	Forecast Range		Most Probable Cost Estimate
	Minimum	Maximum	
Dam Facilities Removal			8,436,910
Recreation Facilities Removal			0
Reservoir Restoration			0
Mobilization and Contingencies			4,017,054
Escalation to Jan 2020			3,046,036
TOTAL FIELD COST	13,500,000	27,700,000	15,500,000
Engineering @ 20%			3,100,000
Mitigation @ 35%			5,400,000
TOTAL CONSTRUCTION COST	**19,600,000**	**46,600,000**	**24,000,000**

Table 9-6 – Cost Summary for Partial Removal of Copco No. 2 Dam and Powerplant (2020 dollars)

	Forecast Range		Most Probable Cost Estimate
	Minimum	Maximum	
Dam Facilities Removal			3,872,090
Recreation Facilities Removal			0
Reservoir Restoration			0
Mobilization and Contingencies			1,929,171
Escalation to Jan 2020			1,398,739
TOTAL FIELD COST	6,100,000	10,300,000	7,200,000
Engineering @ 20%			1,500,000
Mitigation @ 45%			3,300,000
TOTAL CONSTRUCTION COST	**9,700,000**	**18,100,000**	**12,000,000**
TOTAL LIFE CYCLE COST	**2,800,000**	**8,200,000**	**3,800,000**

9.2.4 Iron Gate Dam and Powerhouse

The amount of excavation required for removal of the dam embankment was increased for the MPH estimates to account for uncertainty in the estimated volume. The size of the concrete cutoff wall within the dam embankment was increased from the MPL, to the Most Probable, to the MPH estimates to account for uncertainty. Haul road construction was assumed for the Most Probable and MPH estimates to transport the excavated embankment material to the waste disposal area above the left abutment by large trucks, while a conveyor belt was assumed for transport of the excavated material for the MPL estimate, following a similar route. The amount of rock excavation needed to construct the haul roads was increased for the MPH estimates to account for uncertainty. Approximately 300,000 cubic yards of excavated dam embankment was assumed to be disposed of in the spillway in order to bury this structure.

The access road bridge across the Klamath River downstream of Iron Gate Dam was assumed to be removed and replaced with a stronger bridge to handle the construction traffic in the MPH estimates for both the Full Removal and Partial Removal alternatives. The new bridge for the

MPH estimates would be constructed of precast concrete girders, and would have two spans of 120 feet each, supported by two concrete abutments and a single concrete pier founded on bedrock. The bridge deck would have a total width of 31 feet to accommodate two lanes of traffic, plus shoulders, and would have an HS-20 design load. The Most Probable and MPL estimates assumed that any necessary modifications to the existing bridge to handle construction traffic would be covered in the design contingencies, or that necessary modifications would be performed by others for maintenance purposes prior to dam removal.

There appear to be four vertical pump motors on the tailwater side of the powerhouse. Since none of this equipment was detailed in the drawings or information provided, the estimated weights were based on current pump weights of motors of the same size. In future studies, more information would be necessary to estimate the pump weights and intake bulkheads more accurately. Also, none of the piping equipment for the pumps was estimated due to the lack of information.

All lumber and timber quantities to be removed were assumed to be pressure-treated, requiring a haul distance of at least 70 miles to an appropriate disposal facility. For the Most Probable and the MPH estimates, painted metal surfaces were assumed to contain heavy metals (lead paint). For the MPL estimates, painted metal surfaces were assumed to not contain heavy metals. For the Most Probable estimates, some mechanical items were assumed to contain petroleum products. For the MPH estimates, some mechanical items were assumed to contain petroleum products and sometimes asbestos. The MPL estimates assumed no hazardous materials associated with the mechanical items.

There is a 69 kV line from Iron Gate to the Copco No. 2 powerhouse substation. This line is assumed to be left in place for all estimates because of underbuilt equipment. The substation would be removed for all estimates. Weights were estimated for the AC generator, excitation equipment, surge protection equipment, neutral grounding equipment, generator switchgear, station service switchgear, unit and plant control switchboard, battery system, raceways, conduit and cable, miscellaneous power and control boards, transformers, governor oil pump motors, and vertical motors. The powerhouse electrical equipment would be removed and disposed for the Full Removal alternative estimates. The powerhouse would be removed down to the crown of the draft tube and/or to the floor of the sump pump access room for the Full Removal alternative. The remaining structure would be buried. For the Partial Removal alternative, the powerhouse was assumed to remain in place. Steel anchors and reinforcement was assumed to be removed from the concrete and hauled to a recycling facility.

Weights were also estimated for the hydraulic pump motor, control panel, distribution equipment, junction boxes, power cable and conduit for the diversion tunnel gate intake structure electrical equipment, and for the overhead trolley crane motor, controls, distribution equipment, junction boxes, power cable and conduit for the penstock intake structure electrical equipment, which would be removed and disposed for all estimates. Weights were included for miscellaneous motors, control panels, cables and conduit for the fish facilities electrical equipment.

The Most Probable cost estimates and forecast range of values (from the Monte Carlo analysis discussed in section 9.9) for removal of Iron Gate Dam and Powerhouse are summarized in Tables 9-7 and 9-8, based on a July 2010 price level.

Table 9-7 – Cost Summary for Full Removal of Iron Gate Dam and Powerplant (2020 dollars)

	Forecast Range		Most Probable Cost Estimate
	Minimum	Maximum	
Dam Facilities Removal			23,702,529
Recreation Facilities Removal			520,725
Reservoir Restoration			9,331,500
Mobilization and Contingencies			17,320,559
Escalation to Jan 2020			12,124,687
TOTAL FIELD COST	51,100,000	97,600,000	63,000,000
Engineering @ 20%			12,700,000
Mitigation @ 35%			22,300,000
TOTAL CONSTRUCTION COST	**78,100,000**	**169,000,000**	**98,000,000**

Table 9-8 – Cost Summary for Partial Removal of Iron Gate Dam and Powerplant (2020 dollars)

	Forecast Range		Most Probable Cost Estimate
	Minimum	Maximum	
Dam Facilities Removal			21,629,277
Recreation Facilities Removal			520,725
Reservoir Restoration			9,331,500
Mobilization and Contingencies			16,158,423
Escalation to Jan 2020			11,360,075
TOTAL FIELD COST	47,800,000	94,000,000	59,000,000
Engineering @ 20%			11,700,000
Mitigation @ 45%			26,300,000
TOTAL CONSTRUCTION COST	**75,400,000**	**162,900,000**	**97,000,000**
TOTAL LIFE CYCLE COST	**0**	**0**	**0**

9.3 Recreation Facilities Removals

Quantity estimates for all recreation facilities to be removed were prepared and provided by the Recreation Subteam for cost estimating purposes, based on a field inventory by BLM of the facilities at each recreation site. No variations in quantities were assumed at this level of study for the MPL and MPH estimates. The facilities indicated below are to be removed for both the Full Removal and the Partial Removal alternatives, and the cost estimates are the same for both alternatives. There are no recreation facilities associated with Copco No. 2 Dam.

9.3.1 J.C. Boyle Reservoir

Cost estimates were prepared for removal of the recreation facilities at Pioneer Park (East and West units), including removal of the paved access road and restoration of 0.5 acres of land, and for removal of selected facilities at Topsy Campground related to the reservoir. Topsy Campground would otherwise remain following removal of the dam and restoration of the reservoir site. These estimates are summarized in Tables 9-1 and 9-2 above.

9.3.2 Copco Reservoir

Cost estimates were prepared for removal of the recreation facilities at Mallard Cove and Copco Cove, including the restoration of nearly 5 acres of land. No existing recreation facilities would remain following removal of the dam and restoration of the reservoir site. These estimates are summarized in Tables 9-3 and 9-4 above.

9.3.3 Iron Gate Reservoir

Cost estimates were prepared for removal of the recreation facilities at Wanaka Springs, Juniper Point, Camp Creek (including Dutch Creek), Mirror Cove, Overlook Point, and Long Gulch, including the restoration of over 12 acres of land. Existing recreation facilities would remain at Fall Creek, Jenny Creek, and the Iron Gate fish hatchery following removal of the dam and restoration of the reservoir site. These estimates are summarized in Tables 9-7 and 9-8 above.

9.4 Reservoir Restoration

The design assumptions and cost estimates for reservoir restoration or revegetation are the same for both the Full Removal and the Partial Removal alternatives. No reservoir restoration or revegetation activities are needed for the small impoundment behind Copco No. 2 Dam.

9.4.1 J.C. Boyle Reservoir

Under the reservoir management plan, the acreage of riparian-bank revegetated with cuttings and transplants remains the same for each estimate. However, the planting density of cuttings and transplants increases from the MPL, to the Most Probable, to the MPH estimates. Planting densities within the riparian-bank areas were assumed to be at approximately 400, 700, and 1,000 plants per acre for the MPL, Most Probable, and MPH estimates, respectively. The amount of herbivore screen, chemical herbivore deterrent, and polymer (vermiculite) was also assumed to increase from the MPL, to the Most Probable, to the MPH estimates.

For restoration of the upland areas, the acreage remained the same for all estimates. The amount of seed, wood mulch, and tackifier being applied was also constant for all estimates. However, the method for applying hydroseed was ground based for the Most Probable and MPL estimates and aerial for the MPH estimate. Additional acreage for fall re-seeding (ground based hydroseeding identical to spring seeding) was based on assumed establishment rates of 25 percent, 50 percent, and 75 percent for the MPL, Most Probable, and MPH estimates, respectively. Maintenance costs for seeding 10 percent of the reservoir area for years 2 through 5 were consistent for all estimates.

Weed management cost estimates were based on herbicide application at 2 lbs active ingredient per acre, although some mechanical or other control methods may be performed. Spot herbicide treatments are estimated to be applied over 25 percent, 50 percent, and 75 percent of the total reservoir area for the MPL, Most Probable, and MPH cost estimates, respectively. Maintenance costs for spot application of herbicides over 10 percent of the reservoir area for years 2 through 5 were consistent for all estimates.

The Most Probable cost estimates for reservoir restoration associated with the removal of J.C. Boyle Dam are summarized in Tables 9-1 and 9-2 above.

9.4.2 Copco Reservoir

Under the reservoir management plan, the acreage of riparian-bank revegetated with cuttings and transplants remains the same for each estimate. However, the planting density of cuttings and transplants increases from the MPL, to the Most Probable, to the MPH estimates. Planting densities within the riparian-bank areas were assumed to be at approximately 400, 700, and 1,000 plants per acre for the MPL, Most Probable, and MPH estimates, respectively. The amount of herbivore screen, chemical herbivore deterrent, and polymer (vermiculite) was also assumed to increase from the MPL, to the Most Probable, to the MPH estimates.

For restoration of the upland areas, the acreage remained the same for all estimates. The amount of seed, wood mulch, and tackifier being applied was also constant for all estimates. However, the method for applying hydroseed utilized a combination of ground, barge, and aerial application for the low and Most Probable estimates, but was entirely aerial based for the MPH estimate. Additional acreage for fall re-seeding (ground based hydroseeding identical to spring seeding) was based on assumed establishment rates of 25 percent, 50 percent, and 75 percent for the MPL, Most Probable, and MPH estimates, respectively. Maintenance costs for seeding 10 percent of the reservoir area for years 2 through 5 were consistent for all estimates.

Weed management cost estimates were based on herbicide application at 2 lbs active ingredient per acre, although some mechanical or other control methods may be performed. Spot herbicide treatments are estimated to be applied over 25 percent, 50 percent, and 75 percent of the total reservoir area for the MPL, Most Probable, and MPH cost estimates, respectively. Maintenance costs for spot application of herbicides over 10 percent of the reservoir area for years 2 through 5 were consistent for all estimates.

The Most Probable cost estimates for reservoir restoration associated with the removal of Copco No. 1 Dam are summarized in Tables 9-3 and 9-4 above.

9.4.3 Iron Gate Reservoir

Under the reservoir management plan, the acreage of riparian-bank revegetated with cuttings and transplants remains the same for each estimate. However, the planting density of cuttings and transplants increases from the MPL, to the Most Probable, to the MPH estimates. Planting densities within the riparian-bank areas were assumed to be at approximately 400, 700, and 1,000 plants per acre for the MPL, Most Probable, and MPH estimates, respectively. The amount of herbivore screen, chemical herbivore deterrent, and polymer (vermiculite) was also assumed to increase from the MPL, to the Most Probable, to the MPH estimates.

For restoration of the upland areas, the acreage remained the same for all estimates. The amount of seed, wood mulch, and tackifier being applied was also constant for all estimates. However, the method for applying hydroseed utilized a combination of ground, barge and aerial application for the MPL and Most Probable estimates and was entirely aerially based for the MPH estimate. Additional acreage for fall re-seeding (ground based hydroseeding identical to spring seeding) was based on assumed establishment rates of 25 percent, 50 percent, and 75 percent for the MPL, Most Probable, and MPH estimates, respectively. Maintenance costs for seeding 10 percent of the reservoir area for years 2 through 5 were consistent for all estimates.

Weed management cost estimates were based on herbicide application at 2 lbs active ingredient per acre, although some mechanical or other control methods may be performed. Spot herbicide treatments are estimated to be applied over 25 percent, 50 percent, and 75 percent of the total reservoir area for the MPL, Most Probable, and MPH cost estimates, respectively. Maintenance costs for spot application of herbicides over 10 percent of the reservoir area for years 2 through 5 were consistent for all estimates.

The Most Probable cost estimates for reservoir restoration associated with the removal of Iron Gate Dam are summarized in Tables 9-7 and 9-8 above.

9.5 Yreka City Water Supply Modifications

The design assumptions and cost estimates for the Yreka City water supply modifications are the same for both the Full Removal and the Partial Removal alternatives. These modifications are required under the provisions of the KHSA to ensure a dependable water supply for the City of Yreka following removal of Iron Gate Dam and Reservoir.

The Most Probable cost estimate and forecast range of values (from the Monte Carlo analysis discussed in section 9.9) for the Yreka City water supply modifications are summarized in Table 9-9, based on a July 2010 price level.

Table 9-9 – Cost Summary for Yreka City Water Supply Modifications (2020 dollars)

	Forecast Range		Most Probable Cost Estimate
	Minimum	Maximum	
Dam A Intake Screen			208,860
Dam B Intake Screen			212,950
Pipeline River Crossing			1,344,100
Mobilization and Contingencies			1,196,500
Escalation to Jan 2020			637,590
TOTAL FIELD COST	2,000,000	5,600,000	3,600,000
Engineering @ 20%			700,000
Mitigation @ 35%			1,300,000
TOTAL CONSTRUCTION COST	**3,500,000**	**9,500,000**	**5,600,000**

9.5.1 Water Supply Pipeline Modifications

For cost estimating purposes, the Most Probable estimate is based on a 7.5-foot-wide box truss bridge just wide enough to accommodate the new 24-inch-diameter pipeline. The MPH estimate is based on an open truss bridge wide enough to accommodate both the pipeline and an adjacent walkway on the deck. The MPL estimate would reroute the water supply pipeline across the existing roadway bridge located upstream of the existing crossing, thus eliminating the need for a separate pipe bridge.

9.5.2 Intake Modifications

For cost estimating purposes, the MPH estimate for Dam A would require temporary cofferdams and cast-in-place reinforced concrete walls to be constructed to seal bays 1, 2, and 4 rather than the steel bulkheads assumed for the Most Probable estimate, and line power would be extended to the site to run the hydraulic pump and motors to rotate the Tee screen cylinders during cleaning. No changes to the design were assumed for the MPL estimate for Dam A.

For cost estimating purposes, the MPH estimate for Dam B would require a cast-in-place reinforced concrete wall to be constructed in the bay with the existing trash rack rather than the steel bulkhead assumed for the Most Probable estimate, and line power would be extended to the site to run the hydraulic pump and motors to rotate the Tee screen cylinders during cleaning. No changes to the design were assumed for the MPL estimate for Dam B.

9.6 Life Cycle Cost

Life Cycle Cost (LCC) is the long-term cost of ownership over a defined period of time. Since all facilities are to be removed under the Full Removal alternative, only the Partial Removal alternative would require facilities maintenance over the life of the project. The study period assumed for the Partial Removal alternative is 50 years. The objective of LCC analysis is to select the most cost effective approach to achieve the lowest long term cost of ownership. LCC includes any initial capital investment, operation, maintenance, periodic replacement costs over the analysis period (if needed), and final decommissioning at the end of the study period. All costs included in LCC are represented as net present value (net worth of dollars), at a specific interest rate. Long term assumptions to determine LCC were applied to each of the Partial Removal alternative dam removal estimates, to be used for cost risk modeling using a Monte Carlo based simulation process. No LCC was computed for Iron Gate Dam and Powerhouse, since no features would be left in place which would require future maintenance.

The LCC cost estimates utilized a planning interest rate of 4.125 percent from the Natural Resources Conservation Service, which defines dollars at a uniform purchasing power. Utilizing the planning interest rate simplifies the LLC analysis by excluding the effects of inflation, without having to perform complex gradient analysis. Change in the value of money over time would be accounted for by the use of the planning interest rate. The Partial Removal alternative estimates calculated the LCC for the periodic costs and the annual operation and maintenance costs assuming competitively bid contracts. No LCC estimates are included for the Yreka City water supply modifications, as it is assumed that the City of Yreka would continue to be responsible for the operation and maintenance of those facilities; provided the maintenance requirements are comparable to those for which the City is currently responsible.

The life cycle cost estimates for the Partial Removal of J.C. Boyle Dam, Copco No. 1 Dam, and Copco No. 2 Dam are summarized in Tables 9-2, 9-4, and 9-6, respectively, and are based on a July 2010 price level.

9.6.1 J.C. Boyle Dam and Powerhouse

Activities for the J.C. Boyle sites include an initial capital investment for the installation of chain link fencing around the intake structure and 14-foot-diameter pipeline for security purposes, and the removal of lead-based paint from the downstream face of the powerhouse structure prior to burial. Long-term maintenance includes periodic replacement of the chain link fencing and repainting the exposed surfaces of metal equipment, using a three-man maintenance crew under contract for the work. Road maintenance and construction materials for other repair work are assumed to represent an additional 25 percent of the annual cost of the maintenance crew and truck. The MPL and MPH estimates assume the fence replacement and repainting is performed less and more frequently, respectively.

9.6.2 Copco No. 1 Dam and Powerhouse

Activities for the Copco No. 1 site include an initial capital investment for the installation of chain link fencing along the downstream side of the powerhouse structure for security purposes, and the removal of lead-based paint from the upstream face of the powerhouse structure. Long-term maintenance includes periodic replacement of the chain link fencing and repainting the exposed surfaces of metal equipment, using a three-man maintenance crew under contract for the work. Road maintenance and construction materials for other repair work are assumed to represent an additional 25 percent of the annual cost of the maintenance crew and truck. The MPL and MPH estimates assume the fence replacement and repainting is performed less and more frequently, respectively.

9.6.3 Copco No. 2 Dam and Powerhouse

Activities for the Copco No. 2 sites include an initial capital investment for the installation of chain link fencing around the intake structure and powerhouse for security purposes. Long-term maintenance includes periodic replacement of the chain link fencing and repainting the exposed surfaces of metal equipment, using a three-man maintenance crew under contract for the work. Road maintenance and construction materials for other repair work are assumed to represent an additional 25 percent of the annual cost of the maintenance crew and truck. The MPL and MPH estimates assume the fence replacement and repainting is performed less and more frequently, respectively.

9.7 Costs for Mitigation Measures

Environmental compliance for this project would require numerous mitigation measures for the Proposed Action, as identified in the Final Environmental Impact Statement/Environmental Impact Report (FEIS/EIR). The following potential mitigation measures include assumptions from which preliminary cost estimates have been developed. These cost estimates were used to help establish the non-contract cost allowance described in section 9.1. There are no significant differences in the total estimated costs for mitigation measures between the Full and Partial Removal alternatives; however, a lower percentage was used for the Full Removal alternative due to the higher total field cost in order to maintain the same dollar amount. No differences in the total mitigation measure costs have been assumed for the MPL and MPH estimates at this time due to the uncertainties inherent in the assumptions used. Mitigation measures for which no cost estimates were prepared are believed to be relatively minor and are not expected to significantly affect the total project cost. Future cost estimates may include a variation of the estimated costs for mitigation measures.

9.7.1 Aquatic Resources

AR-1: Protection of mainstem spawning.

This mitigation measure would capture and relocate spawning fish. It is anticipated that short-term effects of dam removal (from both suspended sediment and bedload movement) will result in up to 100% mortality of fall Chinook and coho salmon embryos and pre-emergent alevin within redds that were constructed in the mainstem in the fall of 2019. In addition, any steelhead or Pacific lamprey migrating within the mainstem Klamath River after December 30, 2019 could be directly affected. Around 4,600 fall-Chinook salmon redds are predicted to be affected, as well as around 13 redds from the Upper Klamath River Population Unit for coho salmon.

Deleterious short-term effects of the Proposed Action on mainstem spawning could be reduced by capturing migrating adult fish (Chinook, coho, steelhead, or Pacific lamprey) in the mainstem Klamath River and relocating them to suitable habitat. Capture of adult fish could be accomplished with the use of an Alaskan-style weir and box trap, similar to that currently used at the Willow Creek, Trinity River site. The most suitable location for the trap appears to be directly upstream of the Shasta River, where the mainstem Klamath is small enough to effectively trap, and would ensure that fish returning to key tributaries downstream of, and including the Shasta River would not be interrupted. The weir would be installed at the beginning of the fall migration and continue past the initial dam drawdown period until high flows require the trap to be dismantled. Captured fish would periodically be transported to receiving tributaries. Fish could be released either in under-seeded tributaries downstream of Iron Gate Dam (e.g., Scott River), or in tributaries upstream of Iron Gate Dam if that were consistent with post-dam removal management goals. The relocated fish would then spawn naturally in the tributary streams and their progeny would not be affected by the suspended sediments and bedload movement during the dam removal process. In addition, the trap would only be operated periodically, so that some volitional passage upstream of the Shasta River would occur, allowing fish to return to Bogus Creek and the hatchery during 2019.

Additional surveys in the mainstem downstream of Shasta River could be conducted to locate coho salmon spawning in the mainstem. Any identified adult coho, Chinook, steelhead, or Pacific lamprey could be captured using dip-nets, electrofishing, or seines and transported to tributary habitat. Surveys should be conducted in December 2019, immediately prior to the first release of sediment associated with dam removal.

A detailed plan describing capture techniques, release locations, and monitoring methods would be developed by the DRE prior to 2019. For cost estimating purposes, a crew of about 4 technicians should be assumed to conduct the operations. Weirs could be operated to allow some fish to pass upstream to areas like Bogus Creek, and would allow the capture of migrating adults prior to the immediate onset of spawning, which would improve their chances for transport and relocation. Costs for trucking would need to be developed depending on the number of fish targeted, capacity of the truck, and distance hauled. A release location upstream of Upper Klamath Lake may be more effective. This should be a relatively simple exercise to be performed by the state resource agencies. Since the fish would be trucked across state lines, coordination would be required between California Department of Fish and Game (CDFG) and Oregon Department of Fish and Wildlife (ODF&W), and this action should be addressed in reintroduction plans for the upper basin. Overall effectiveness of the adult relocation operation would be measured by using radio-tagged individuals to determine spawning success and location and could be included in the Biological Monitoring Plan required under KBRA. No cost estimates have been prepared for this mitigation measure; however, the potential cost is assumed to have no significant effect on the total cost of all mitigation measures assumed for the project cost estimate.

AR-2: Protection of outmigrating juveniles.

This mitigation measure would capture and relocate outmigrating juveniles. It is anticipated that short-term effects of dam removal will result in mostly sublethal, and in some cases lethal impacts to a portion of the juvenile Chinook, coho, steelhead, and Pacific lamprey that are outmigrating from tributary streams to the Klamath River upstream of Orleans during late winter and early spring of 2020.

Deleterious short term effects on outmigrating juveniles could be reduced by capturing juveniles outmigrating from tributaries prior to their entry into the mainstem. This measure includes the installation of downstream migrant traps on up to 13 key tributary streams downstream of Iron Gate Dam including Bogus Creek, Dry Creek, Walker Creek, Shasta River, Seiad Creek, Oneil Creek, Scott River, Grider Creek, Tom Martin Creek, Horse Creek, Beaver Creek, Cottonwood

Creek, and Humbug Creek. Results of spawning surveys in fall 2019 could be used to focus trapping efforts within these or other tributaries. Trapping on all of these streams is proposed to help preserve the genetic integrity and varied life history tactics that are represented by this group of streams that have a high diversity with respect to size, channel types, water temperature regimes, geographic distribution, and other attributes.

The trapping would involve the standard CDFG/USFWS rotary screw trap/fyke net/pipe trap methods currently in use. However, placement of a second trap downstream of the first would increase the number of captures. Captured fish could then be placed in aerated tank trucks and transported to a release site in the Klamath River downstream of the Trinity River or other locations that have suitable water quality. However, the procedures of trapping, handling, trucking, and releasing outmigrating salmonids could result in harm or mortality to some individuals, and releasing fish at downstream locations could reduce natal cues and increase stray rates. Therefore fish will be captured and transported only if conditions within the mainstem are as poor as predicted. Due to the uncertainties with suspended sediment modeling, water quality monitoring during spring 2020 would be used to trigger the initiation and cessation of the capture program and inform suitable release locations. Release locations should be varied to prevent predators from congregating at release locations. Alternatively, juveniles could be held in temporary facilities within tributaries and released when suspended sediment concentrations in the mainstem were non-stressful. This would prevent any decrease in the natal cue, as well as any potential associated effects of fish transport.

A detailed plan describing trapping techniques, release locations, and monitoring methods would be developed by the DRE prior to 2019. For cost estimating purposes, one trap per tributary was assumed, except the Shasta and Scott Rivers would require two and four traps respectively, for a total of 17 collection locations. Collected fish would be released below the Trinity River. Trapping and hauling operations would be conducted 7 days per week from January 1 through June 30, 2020. Ten trucks were assumed to be required, each capable of 10 miles/gallon with fuel costs based on $5 per gallon. Estimated costs of purchasing versus leasing trucks were evaluated. Estimated costs include labor, insurance, staff benefits, training, personal protection and safety gear, transportation to and from worksite, vehicle maintenance, miscellaneous expenses and overhead, and were based on 2011 dollars. Adult Coho carcass surveys should occur during Fall 2019 in identified streams as required under the operating plan being developed for Iron Gate Fish Hatchery to help direct the trapping efforts. Final planning, protocols, and logistics of the trapping efforts would be refined in Spring 2019 prior to dam removal. Overall effectiveness of this mitigation measure would be largely dependent upon the trap efficiency, which is not likely to exceed 30 percent. A preliminary cost estimate was prepared for this mitigation measure. A range of 10 ± percent was used for the MPH and MPL estimates since these estimates were prepared for this project.

AR-3: Fall flow pulses.

This mitigation measure would increase streamflow prior to dam removal. It is anticipated that short-term effects of the Proposed Action will result in sublethal effects for green sturgeon adults remaining in the mainstem Klamath River during fall 2019, mortality for mainstem spawning fall-run Chinook salmon, mortality for migrating adult winter steelhead, and sublethal effects for adult coho salmon remaining in mainstem prior to entering tributaries.

Deleterious short-term effects on adults could be reduced by augmented flows during fall 2019 prior to dam removal. It has been observed that fall pulse flows result in the downstream migration of post-spawned green sturgeon out of the Klamath River, and increased flows during fall prior to dam removal may increase the rate and proportion of fall-run Chinook salmon, steelhead, and coho salmon spawning in tributaries, and thus reducing the proportion of the population spawning in the mainstem or being exposed to suspended sediment in the mainstem during migration.

Water releases in the fall prior to dam removal should mimic the natural hydrograph that would have existed in the Klamath River during a wet year prior to the Reclamation project, consistent with recommendations from the National Research Council (NRC, 2008). However, if the water year during dam removal is dry, managers will need to balance the benefits of increased flows during fall with the risk of impacts to the basin if less water is available during the following spring (during smolt outmigration). Increases in fall flows would likely be most successful if conducted synchronously with increased flows in unregulated tributaries, to help create enough of a pulse of water to encourage migration. Doing so will also ensure that adults that are attracted up the mainstem by increasing fall flows are not blocked from accessing their natal streams due to natural low flow conditions.

A detailed plan describing target flows and monitoring methods would be developed by the DRE prior to 2019. Fall flow variability is currently required by the 2010 Biological Opinion (BO) and if the volumes identified in the BO are adequate to simulate the magnitude of flow required to attract salmonids into the tributaries and to encourage adult sturgeon to emigrate, there would not be any additional cost associated with this mitigation measure.

AR-4: Iron Gate Fish Hatchery management.

This mitigation measure would adjust fish hatchery operations to minimize potential impacts on fish. It is anticipated that short-term effects of dam removal will result in mostly sublethal, and in some cases lethal impacts to a portion of the juvenile Chinook, coho, and steelhead smolts outmigrating from tributary streams to the Klamath River upstream of Orleans during late winter and early spring of 2020.

Deleterious short-term effects on outmigrating hatchery Chinook and coho salmon smolts could be reduced by adjustments to hatchery management. Hatchery managers could adjust the timing of hatchery releases during spring 2020. Although it would be out of synch with natural life history timing, if smolts are released later in the spring (e.g., mid-May), survival is anticipated to be higher based on current conditions, as well as avoiding the peak in spring release of sediment in the year following dam removal. An alternative to adjusting the hatchery release timing would be to allow the sub-yearling and yearling smolts to imprint at the hatchery and then truck them to release locations downstream where suspended sediment concentrations may be muted by tributary accretion flow. Trucking could be accomplished during the normal releasing timing period. The implementation of this mitigation measure is dependent on the hatchery remaining open and having a suitable cold water supply.

A detailed plan describing adjustments to hatchery management would be developed by the DRE prior to 2019. This mitigation measure is full of uncertainty and difficult to price at this time. PacifiCorp is required to maintain current mitigation levels and should be conducting analyses to allow for continued hatchery operations, alternative water supplies, and sufficient capacities. If the Iron Gate fish hatchery remains operational during and after reservoir drawdown, the existing facility would have to provide adequate space and flow to keep sub-yearling and yearling coho and steelhead through June, in addition to adequate space for newly emerging fry. If there is not adequate space to rear these fish through June as expected, then suitable alternatives would have to be identified, which could include trucking downstream, development of off-site rearing ponds in tributaries downstream, or construction of new facilities. No cost estimates have been prepared for this mitigation measure; however, the potential cost is assumed to have no significant effect on the total cost of all mitigation measures assumed for the project cost estimate.

AR-5: Pacific lamprey capture and relocation.

This mitigation measure would capture and relocate Pacific lamprey. Based on predictions of low dissolved oxygen and the analysis of suspended sediment concentrations that was conducted, high rates of mortality are predicted in the short term as a result of dam removal. An action to mitigate this deleterious short term effect would be to salvage and relocate lamprey ammocoetes from 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 areas downstream of Iron Gate Dam. The focus of relocation efforts would be within about 2 miles of Iron Gate Dam, where suspended sediment concentrations are predicted to be highest, and dissolved oxygen levels would be lowest. However, the density of lamprey within this reach is not known, and reconnaissance surveys should be conducted prior to the implementation of this measure to assess if enough ammocoetes are present to warrant mitigation. The salvage operation, if implemented, would be conducted by first identifying preferred (and high risk) areas and then utilize a specialized electrofisher to capture ammocoetes. Collection of lamprey ammocoetes has been demonstrated in the Klamath River (Karuk Tribe and USFWS unpublished data). Captured individuals would be transported to suitable locations (with current low occurrences of lamprey) within upstream tributaries or upstream of Keno Dam.

A detailed plan describing lamprey capture and relocation would be developed by the DRE prior to 2019. A range of cost estimates for this mitigation measure could be developed by CDFG given their experience with these types of activities in the basin. Cost estimates for this measure would likely include a couple of electrofishing crews and transport trucks, and would depend upon the miles driven to final release points and the duration of the required effort. An assessment of the effectiveness of this mitigation measure would consist of reporting the number of individuals captured, release location, and their condition upon release. No cost estimates have been prepared for this mitigation measure; however, the potential cost is assumed to have no significant effect on the total cost of all mitigation measures assumed for the project cost estimate.

AR-6: Sucker rescue and relocation.

This mitigation measure would capture and relocate suckers. It is anticipated that short-term effects of dam removal will result in mostly sublethal, and in some cases lethal impacts to Lost River and shortnose suckers within reservoirs in the Hydroelectric Reach. Under this measure, adult Lost River and shortnose suckers in reservoirs downstream of Keno Dam could be captured and relocated to Upper Klamath Lake.

If deemed feasible in 2019 prior to dam removal, Klamath smallscale suckers will be collected directly downstream of J.C. Boyle Dam and terminating approximately 2 miles downstream in the approximate area of the current powerhouse. Fish will be collected using electro-fishing techniques. Salvaged Klamath smallscale sucker will be relocated to Spencer Creek immediately downstream of the Spencer Creek hook up road (upper limits for sucker in Spencer creek). Smallscale suckers will not be relocated upstream of Keno Dam.
Both shortnose suckers and Lost River suckers are known to exist in J.C. Boyle Reservoir. Previous studies have found large numbers of shortnose sucker adults in Copco Reservoir, but very few Lost River suckers. Only small numbers of shortnose sucker adults have been found in Iron Gate Reservoir. Radio transmitters can be inserted in 30 shortnose suckers in Copco Reservoir and tracked for two years prior to dam removal to determine where they would be concentrated when removal by trammel netting begins. Lost River and shortnose suckers captured from all three reservoirs would be placed in aerated tank trucks and transported to suitable release sites in Upper Klamath Lake.

A detailed plan describing sucker rescue and relocation would be developed by the DRE prior to 2019. For cost estimating purposes, this effort was assumed to be comparable to the two-week long sucker salvage that was performed by Reclamation at Tule Lake in Spring 2010 at a cost of approximately $70,000. The cost is assumed to be higher for Copco No. 1 Reservoir due to the longer haul to Upper Klamath Lake. Another difference is that the sucker rescue could be done by the regulatory agencies for the Klamath project, whereas the Tule Lake sucker rescue operations were performed by a private contractor. It is assumed that sucker rescue would require 56 hours of netting at J.C. Boyle Reservoir, 40 hours of netting at Copco Reservoir, and a minimal effort of 24 hours of netting at Iron Gate Reservoir, each by one crew, for transport to Upper Klamath Lake. Normal rescue operations for all fish in connection with unwatering construction areas in order to facilitate dam demolition are assumed to be included in the construction contract work with no significant effect on the overall project cost. A preliminary cost estimate was prepared for this mitigation measure. A range of +50 percent and – 30 percent was used for the MPH and MPL estimates, respectively, since the Most Probable cost was for a different project (Tule Lake).

AR-7: Freshwater mussel relocation.

This mitigation measure would capture and relocate freshwater mussels. Freshwater mussels in the Hydroelectric Reach and in the Lower Klamath River, downstream of Iron Gate Dam, are likely to be deleteriously affected by prolonged suspended sediment concentrations and bedload movement during the later part of reservoir drawdown and subsequent dam removal. Freshwater mussels cannot move to avoid these impacts, and some species are very long lived, and may not reproduce successfully (or at all) each year. An action to mitigate this effect is to relocate freshwater mussels prior to drawdown. Freshwater mussels could be relocated to tributary streams or upstream of Keno Dam, then moved back to their approximate location or to other suitable habitat in the river after dam removal has been completed.

Freshwater mussel relocation success depends on a variety of factors including the availability of suitable habitat (for juveniles, adults, reproduction, feeding, growth, and host fish), population density at the relocation site, and handling during relocation. While many (and still unknown) factors influence the survival and reproduction of freshwater mussels in their natural environment, relocation adds an additional stress. Thus, the variables associated with the characteristics of freshwater mussel habitat at the source and destination sites as well as with the relocation methods should be as similar as possible for all life stages. Previous studies indicate varied success of freshwater mussel relocation projects, with most mortality observed within one year. Habitat selection is important for success, as changes in habitat (e.g., substrate size) from the original site appear to influence mortality. As such, the presence of existing freshwater mussel populations should guide site selection. Proper handling, transport, and selection of suitable habitat improved survivorship of relocated freshwater mussels.

General guidelines for freshwater mussel relocation projects include 1) an initial evaluation of freshwater mussel populations to identify species, estimate abundance, and sex ratio and age distribution (if possible), 2) site evaluation for relocation to determine (among other factors) habitat quality and presence of appropriate fish hosts, 3) careful and quick transport to minimize stress, and 4) monitoring relocated populations to determine initial survival, recruitment, and persistence through the range of environmental conditions at the site. Following these guidelines, prior to drawdown (e.g., fall 2019 or before) surveys would be conducted to evaluate current freshwater mussel species and habitat below Iron Gate Dam and to identify potential sites for relocation. Freshwater mussels would be relocated to suitable habitats and monitored over the duration of high suspended sediment concentrations. After dissipation of effects, original locations could be resurveyed to determine habitat suitability. If suitable, then the relocated freshwater mussels could be returned to their source location. Most relocation projects are conducted during warm periods when reproductive stress is presumably low for most species, and their metabolic rates are sufficient for burrowing in the substrate.

If suitable in-stream habitat cannot be found for the time period of increased suspended sediment concentrations, it may be possible to temporarily house relocated freshwater mussels in fish hatchery raceways at facilities near the removal sites; however, many freshwater mussels need to burrow to reduce the energy needs of holding their valves closed for extended periods. Thus, such artificial holding areas should not be used for long periods. Aquaculture ponds have sometimes been used as well.

This mitigation measure would benefit from a pilot program prior to initiation, to assess the success and potential levels of mortality associated with relocation. Relocation should also consider the potential for transmission of disease or interbreeding between genetically distinct populations.

A detailed plan describing freshwater mussel rescue and relocation would be developed by the DRE prior to 2019. Until better information is provided, it was assumed that this effort would be more costly than the proposed sucker rescue operation, since the mussels must be returned following dam removal; however, it is still seen to be a relatively minor cost. A preliminary cost estimate was prepared for this mitigation measure. A range of + 50 percent and – 30 percent was used for the MPH and MPL estimates, respectively, due to the uncertainty associated with the estimate.

9.7.2 Terrestrial Resources

TER-1: Habitat restoration plan.

To restore native vegetation communities and wildlife habitat in areas disturbed by construction, a Habitat Restoration Plan will be developed once the Definite Plan is prepared and construction areas are delineated. The Habitat Restoration Plan will be separate from the Reservoir Area Management Plan, which describes restoration of the reservoir areas. The Habitat Restoration Plan will cover all areas disturbed by construction, including upland disposal sites, access and haul roads, pipeline corridors, and equipment staging areas. The Habitat Restoration Plan will include maintenance and monitoring requirements to be conducted for a minimum of three years following hydroseeding and/or planting of native species in areas disturbed by construction. Measures to remove and control noxious weeds and other invasive plants will be included. The Habitat Restoration Plan will outline the performance standards to be met, and the corrective actions to be taken if performance standards are not met. No cost estimates have been prepared for this mitigation measure; however, the potential cost is assumed to have no significant effect on the total cost of all mitigation measures assumed for the project cost estimate.

TER-2: Nesting bird surveys.

If, during preconstruction surveys, an active nest of a special-status bird species (e.g., northern spotted owl, osprey, willow flycatcher) or migratory bird is identified, a restriction buffer would be established in consultation with the resource agencies to ensure nests are not disturbed during construction. This may include evaluation of noise levels at the nesting site for special-status species such as northern spotted owl. Once the Definite Plan is prepared and construction areas are delineated, detailed plans for nesting bird surveys and measures to be implemented if active nests are found will be developed in consultation with USFWS, ODFW, and CDFG.

The EIS/EIR lists the restriction buffers for many common raptor species with potential to occur within or near construction areas. *Buffer zones* are defined as seasonal or spatial areas of inactivity in association with individual nests or nesting territories. *Spatial buffers* are defined as radii from known occupied and unoccupied nest sites. *Seasonal buffers* are restrictions on the times when human activities should be allowed to occur within the spatial buffers. All restriction buffers would be established as appropriate and in consultation with USFWS, ODFW, and CDFG.

When active raptor nests (with eggs or young) are located within the disturbance buffer for that species, and if construction is scheduled to occur in the vicinity during the nesting period, then additional considerations will include the following: line-of-sight considerations- if the nest is visually obscured from construction activities by substantial vegetation (i.e., a forest or woodlot), or by geographic relief (e.g., a ridgeline), or any other type of visual barrier, then construction may continue. However, the nest will be monitored continuously throughout the nesting season to assure that the birds are not disturbed to a level that jeopardizes or alters the outcome of the nest. Initially, the birds will be monitored for signs of disturbance, and bird behavior will be compared to pre-construction levels. Monitoring in these cases will include determining and reporting to USFWS the ultimate fate of the nest. Birds nesting in locations that are visually protected from the construction site are not automatically protected from disturbance; their level of response to disturbance will depend on the species, tolerances of individual birds, type of activity, noise level, and distance from the activity. If birds appear to be disturbed by construction, regardless of species, then the USFWS Migratory Bird Program will be contacted to seek solutions to this issue.

No cost estimates have been prepared for this mitigation measure; however, the potential cost is assumed to have no significant effect on the total cost of all mitigation measures assumed for the project cost estimate, provided there are no significant adverse impacts to construction activities.

TER-3: Bald and Golden Eagles.

If pre-construction surveys indicate part of the construction footprint or facilities slated for removal is utilized by bald or golden eagles, then the following mitigations will be employed to minimize disturbance and mortality to those birds: If active nests are present within construction areas, 1) modify the project footprint to avoid bald or golden eagle nest trees permanently wherever possible; or 2) protect the nest tree until the young have fledged by establishing a restriction buffer as described below. If active bald or golden eagle nests are present within 2 miles of construction areas, a 1 mile restriction buffer would be established in consultation with the resource agencies to ensure nests are not disturbed. If active bald eagle nests are present within 1 mile of construction areas, construction activities would be halted until approval is obtained from the resource agencies to resume. If an active nest is not within line of site of the project, meaning that trees or topographic features physically block the eagles' view of construction activities, the buffer could be reduced to 0.5 miles. Implement measures included in the Eagle Conservation Plan in coordination with USFWS.

If project activities are anticipated to result in take under the Bald and Golden Eagle Protection Act, five years of monitoring by qualified avian biologists will be conducted following completion of deconstruction activities. The mitigation will be deemed successful if there is no net loss of eagles within the project area. If this standard is not met, the DRE will consult with the USFWS and CDFG or ODFW, as appropriate, to ascertain the potential need for further mitigation. No cost estimates have been prepared for this mitigation measure; however, the potential cost is assumed to have no significant effect on the total cost of all mitigation measures assumed for the project cost estimate, provided there are no significant adverse impacts to construction activities.

TER-4: Special-status plants.

Once the Definite Plan is prepared and construction areas are delineated, detailed plans for protocol-level surveys for special-status plants will be developed in consultation with USFWS, ODFW, and CDFG. If, during preconstruction surveys, any special-status plants are found to occur within the construction areas, the size and location of all identified occurrences would be mapped on the final construction plans, and impact acreages would be quantified based on proposed limits of disturbance. Compensation measures are expected to be a combination of the relocation, propagation, and establishment of new populations in conservation areas within the project site at a 1:1 ratio or at a 2:1 ratio in approved off-site habitat preservation areas, as determined in consultation with the resource agencies. No cost estimates have been prepared for this mitigation measure; however, the potential cost is assumed to have no significant effect on the total cost of all mitigation measures assumed for the project cost estimate, provided there are no significant adverse impacts to construction activities.

TER-5: Permanent loss of wetlands at reservoirs.

Under the Proposed Action, there would be loss of wetlands from the drawdown and permanent removal of reservoirs. Based on PacifiCorp surveys, there could be unavoidable impacts on 245 acres of wetland habitat at the J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate Reservoirs. If it is determined that under the Clean Water Act (CWA) a Section 404 Permit is required, a Compensatory Wetland Mitigation Plan will be developed and implemented in accordance with the requirements of the United States Army Corps of Engineers (USACE).

If one is required, the Compensatory Wetland Mitigation Plan will include creation and/or preservation of wetlands at an off-site conservation bank or other approved mitigation site in consultation with USACE and the resource agencies. Compensation wetlands will be required to meet or exceed the functions and quality of the wetland habitat lost at the reservoirs. A monitoring plan will be required to assess whether the compensation wetlands are functioning as intended. Specific performance standards for hydrologic, floral, and faunal parameters will be proposed to determine success of the created wetlands. The monitoring plan would specify the corrective measures/modifications to be implemented in the event that monitoring indicates that the performance standards are not being met. Monitoring will occur for at least five years and until success criteria are met, and as required by USACE and the resource agencies. In addition, a maintenance plan will be required for the wetland preservation/mitigation areas describing the measures to be implemented to assure that they are maintained as wetland habitat in perpetuity. The maintenance plan will address buffering from adjacent uses, fencing, access erosion control, and weed eradication.

For cost estimating purposes, it was assumed that since most of the dam removal activities are intended to promote restoration efforts, the project would fall under one of USACE's Nationwide Permits, and consequently any mitigation requirements would focus on protecting wetlands directly impacted by construction activities. To provide an approximation of the potential mitigation cost for replacement of wetlands directly impacted by dam removal and reservoir drawdown, a remote sensing analysis was performed to assess the wetlands previously identified by PacifiCorp in the areas near the proposed construction activities, defined for this analysis as the proposed access roads, disposal areas, and facility removal areas. This analysis indicates that the wetlands directly impacted by construction activities could range from 0 to 20 acres (subject to further analysis), and would be limited to areas associated with the removal of

J.C. Boyle Dam, Canal, and Powerhouse, and the removal of Copco No. 2 Powerhouse. Generally, wetland restoration can range in cost from $11,000 to as much as $175,000 per acre depending on the type of wetlands that must be mitigated, whether on-site mitigation is proposed, and the location of the project. For this analysis, a figure of $35,000 per acre was used as this is a cost from a source in California where most of the potential mitigation would likely be from (Sacramento County Planning and Community Development Department, 1991). Therefore, a range of costs from $0 to $700,000 for mitigation related to CWA compliance might be expected. A likely mid-range value that could be utilized for planning purposes would be 10 acres of mitigation with a total cost of $350,000.

TER-6: Roosts for special status bats.

Mitigation to reduce impacts on special-status bats from loss of roosting habitat will include the following: For the two years immediately prior to construction activities, qualified bat biologists will conduct bat surveys at facilities to be removed or modified to determine bat use patterns. Surveys will be conducted during the time of year most likely to detect bat usage. If surveys indicate a facility is utilized as a bat roost, then one of two mitigations will be employed to minimize disturbance and mortality to roosting bats: 1) the facility shall be removed or modified outside the bat roosting and breeding period (November 1 to March 1); or 2) bat exclusion methods to seal-up facility entry sites (e.g., blocking and netting or installing sonic bat deterrence equipment) will occur prior to March 1 of the year the facility will be removed or modified.

Replacement habitat would be provided for bats displaced by demolition of the structures at each damsite. The primary bat requiring mitigation is Yuma myotis, which frequently uses bridges and buildings, and only sometimes uses caves and mines. The ideal locations for new roosts would have full sun, near the Klamath River, and near previous roosts. The proposed bat roosts for mitigation are assumed to consist of one free-standing structure at each site, located at least 30 feet above the ground and supported by concrete or steel piers. The bat roost itself would be of concrete with a high thermal mass, to provide a high heat-holding ability (which bats desire) and to make it relatively vandal-resistant and extremely low-maintenance. For the cost estimate, each structure is assumed to consist of several precast concrete beams supported on four concrete piers, and constructed using a crane. The concrete beams are spaced about 1 inch apart to create small chambers and are protected by a timber roof structure. The chambers can be lined with redwood, which is not assumed for this estimate. Final designs of the roost chambers would need to meet the specifications provided in “Bats in American Bridges” by Keeley and Tuttle (1999) and “California Bat Mitigation Techniques, Solutions, and Effectiveness” by H.T. Harvey and Associates (2004).

- For the Full Removal alternative at J.C. Boyle Dam, two bat roosts would be provided – one at the dam and one at the forebay. Although a 2003 bat survey describes a small amount of guano found at the J.C. Boyle pumphouse (assumed to mean the powerhouse), no bat roost is proposed for the powerhouse location. For the Partial Removal alternative, the Red Barn near the dam would be retained so that no bat roost would be needed at the dam, but one would be provided at the forebay.

- For the Full Removal alternative at Copco No. 1 Dam, one bat roost would be provided at the powerhouse, based on the results of the 2003 bat survey. Bats are also described in ceiling cracks of the gate house at Copco No. 2 Dam, which is assumed to mean the gate houses on top of Copco No. 1 Dam (since there is no gate house at Copco No. 2 Dam, and no evidence of bats). If this is the case, a second bat roost would be needed near the dam crest. For the Partial Removal alternative, both the powerhouse and gate houses at Copco No. 1 Dam are retained, so no bat roost would be needed.

- For the Full Removal alternative at Copco No. 2 Dam, one bat roost would be provided at the powerhouse. For the Partial Removal alternative, the powerhouse remains so no bat roost would be needed. There are no signs of bats at Copco No. 2 Dam.

- For the Full Removal alternative at Iron Gate Dam, one bat roost would be provided near the dam crest to replace the diversion tunnel gate house. An ultrasonic device is being used to keep bats away from the office building next to the Iron Gate powerhouse (assumed to be the "barn" referenced in the 2003 bat survey), so there is no reason to provide a roost. The Iron Gate powerhouse does not show signs of bats so no roost is needed. For the Partial Removal alternative, the diversion tunnel gate house would still be removed so one bat roost would be required.

This results in an estimate of six bat roosts for the Full Removal alternative, and two bat roosts for the Partial Removal alternative, as indicated above. Five bat roosts are assumed for the MPL estimate, with no bat roost provided near the dam crest of Copco No. 1 Dam. Cost estimates for each bat roost vary for the Most Probable, MPL, and MPH estimates. Since these cost estimates are very low relative to other mitigation measures, no distinction was made for the final overall estimate of mitigation costs between the Full and Partial Removal alternatives.

Five years of monitoring by qualified bat biologists would be conducted following installation of the bat roosts to determine the pattern and amount of use by bats. The mitigation would be deemed successful if one or more of the bat roosts are utilized by at least 600 bats (combined use at all five facilities) as either day or night roosts, or some combination, for at least two years. If this standard is not met, the DRE would consult with the USFWS and CDFG or ODFW, as appropriate, to ascertain the potential need for further mitigation. No costs for this monitoring have been included in the estimates. Special provisions can be made for bat access through any of the required concrete plugs at tunnel portals for little additional expense, if desired.

9.7.3 Surface Water Hydrology

H-1: Emergency response plan.

Prior to dam removal, the DRE will inform the National Weather Service River Forecast Center of a planned major hydraulic change (removal of four dams) to the Klamath River that could potentially affect the timing and magnitude of flooding below Iron Gate. The River Forecast

Center is the federal agency that provides official public warning of floods. As needed, the River Forecast Center would update their hydrologic model of the Klamath River to incorporate these hydraulic changes so that changes to the timing and magnitude of flood peaks would be included in their forecasts. As currently occurs, flood forecasts and flood warnings would be publicly posted by the River Forecast Center for use by federal, state, county, tribal, and local agencies, as well as the public, so timely decisions regarding evacuation or emergency response could be made.

The DRE will also inform FEMA of a planned major hydraulic change to the Klamath River that could affect the 100-year flood plain. The DRE will ensure recent hydrologic/hydraulic modeling, and updates to the land elevation mapping, will be provided to FEMA so they can update their 100-year flood plain maps downstream of Iron Gate Dam (as needed), so flood risks (real-time and long-term) can be evaluated and responded to by agencies, the private sector, and the public. At least two new stream gaging stations will be installed and operated as a mitigation measure to assist in the calibration of the model. Key gaging station locations include Jenny Creek (a large tributary to the Klamath River upstream of Iron Gate Dam) and on the mainstem near the current location of Copco No. 1 Dam.

No cost estimates have been prepared for this mitigation measure; however, the potential cost is assumed to have no significant effect on the total cost of all mitigation measures assumed for the project cost estimate.

H-2: Flood proofing structures.

This mitigation measure requires the DRE to work with willing landowners to move or relocate permanent, legally established, permitted, habitable structures in place before dam removal. The DRE will move or elevate structures where feasible that could be affected by changes to the 100-year flood inundation area as a result of the removal of the four dams.

A preliminary 100-year floodplain map was developed by Reclamation from Iron Gate Dam to Happy Camp for both the current conditions (i.e. existing conditions with dams) and for the with-project conditions (i.e. altered conditions without dams). Reach-averaged changes in water surface elevation (WSE) and depth between the with-project conditions and current conditions were calculated as indicated in Table 9.7.1 below, based on estimates of sediment deposition.

Table 9.7.1 – Changes in River Stage with Dam Removal

River Reach	**Average WSE (ft)**
Iron Gate to Bogus Creek	1.65
Bogus Creek to Willow Creek	1.51
Willow Creek to Cottonwood Creek	0.90
Cottonwood Creek to Shasta River	0.72
Shasta River to Humbug Creek	0.58
Humbug Creek to Beaver Creek	0.45
Beaver Creek to Dona Creek	0.41
Dona Creek to Horse Creek	0.43

Horse Creek to Scott River	0.36
Scott River to Indian Creek	0.28
Indian Creek to Elk Creek	0.32
Elk Creek to Clear Creek	0.34

Structures in the affected area below Iron Gate Dam have been categorized as follows: (1) within the preliminary 100- year floodplain for current conditions, as determined by Reclamation, (2) within the altered 100-year floodplain without dams, as determined by Reclamation, and (3) near but not within the altered 100-year floodplain. The structures and their appropriate categories were field checked and some of the structures were re-classified. Only the structures in the reaches between Iron Gate Dam (RM 190) and Humbug Creek (RM 172) were categorized. This is because the tributaries below Iron Gate dominate the flood discharges as one travels downstream from Iron Gate and the impact of dam removal on the 100-yr flood is not considered significant below Humbug Creek.

An estimated 6 or fewer structures would be subject to flooding following dam removal when compared to the existing floodplain, which serves as the basis for the low (or minimum) estimate. A total of 53 structures would be located within the altered 100-year floodplain between Iron Gate Dam and Humbug Creek following dam removal, which establishes the most probable estimate, with an additional 10 structures located near the altered floodplain and included in the high estimate. Final determination of the future 100-year floodplain after dam removal will be made by FEMA. The estimates used for this study were developed for estimating potential costs to mitigate the increase in flood risk.

"Engineering Principles and Practices for Retrofitting Flood-prone Residential Structures" (FEMA, 2001) was used to help generate initial cost estimates for flood-proofing homes. Rough cost estimates were developed for elevating the structures, relocating the structures, constructing a floodwall or levee around the structures, as well as dry floodproofing and wet floodproofing the structures. Initial cost estimates use information not readily available for all of the structures identified, such as construction type (wood frame / masonry) and foundation type (basement / crawl-space / slab-on-grade) which can greatly vary the cost of retrofitting the structure. Dimensions were developed by gathering data from for-sale houses in the towns of Hornbrook, Seiad Valley, and Happy Camp, and using engineering judgment to estimate quantities such as structure footprint, structure perimeter, and foundation depth. A range of costs for each retrofit alternative considered is presented in Table 9.7.2 below. These estimates do not include the cost of temporary relocation of residents during construction or following a flood. Some of the retrofits recommend or require the family to not be inside the structure either during construction or flooding.

Table 9.7.2. – Unit Costs for Floodproofing Alternatives

Type	Min	Average	Max
Elevation	$ 22,835	$ 44,400	$ 63,429
Relocation	$ 36,789	$ 56,663	$ 82,458
Floodwall		$ 30,047	
Levee Protection		$ 16,661	
Dry Floodproofing	$ 10,724	$ 11,167	$ 12,052
Wet Floodproofing	$ 1,776	$ 3,282	$ 4,694

It is assumed that structure elevation or structure relocation would be the most likely retrofits for the purpose of cost estimating. Floodwall and levee estimates were developed assuming four walls around a structure, and may be too high due to the fact that in many cases there are a row of houses where it would be more economical to protect the group of houses collectively. Dry floodproofing requires much more detailed information per structure than can be obtained at this level of analysis and this estimate is assumed to be inaccurate. Wet floodproofing basically assumes that people will move their personal items above flood elevation in the event of a flood warning, which does not seem reasonable for this estimate. Figure 9.7.1 below presents initial average cost estimates for all structures within the existing FEMA 100-year floodplain, for all structures within the altered (with project) 100-year floodplain, and for all structures that are near but not within the altered floodplain, for each type of retrofit.

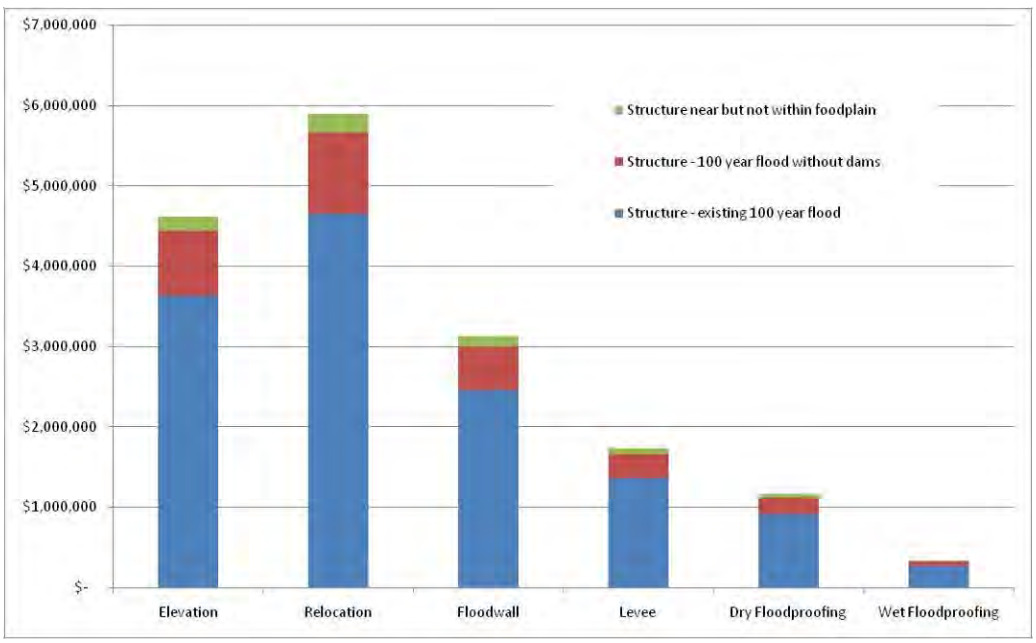


Figure 9.7.1. – Total Costs for Floodproofing Alternatives

With the range of structures identified in the floodplain, and the potential range of costs for elevating and relocating a house, the following table shows the range of probable costs (in millions of dollars) associated with retrofitting structures from Iron Gate Dam to Humbug Creek.

Table 9.7.3. – Range of Total Costs for Floodproofing

		Cost ($Millions)		
		Low	Most Likely	High
Structure Count	Low	$ 2.03	$ 3.95	$ 5.65
	Most Likely	$ 2.15	$ 4.17	$ 5.96
	High	$ 2.37	$ 4.62	$ 6.60

For purposes of the cost estimate, the low, most probable, and high estimates are $3 million, $4 million, and $6 million, with a weighted average of $4.3 million. All work is assumed to be completed in 2019, prior to dam removal.

9.7.4 Groundwater

GW-1: Replace groundwater wells.

This mitigation measure provides for the deepening (or replacement) of an existing affected domestic or irrigation groundwater well so the groundwater production rate from the well is returned to conditions prior to dam removal. As this mitigation measure is intended to mitigate for potential impacts from dam removal, a preconstruction well survey will be conducted prior to implementation. This survey will measure water levels and pumping rates in existing domestic and irrigation wells. This information will form the basis of review for potential claimed damages following construction activities. Well owners not participating in this preconstruction survey will be required to provide adequate documentation showing a decrease in production from the well before and after construction conditions. The review of pre-construction data will be considered with respect to preceding hydrologic conditions (i.e. climatic cycles, wet year vs. dry year). This mitigation measure would also provide an interim supply of potable water for health and safety prior to the completion of the modifications to the affected well. Significant impacts to wells from the temporary rise in fine sediment concentration in the river are not anticipated, since the river bed is expected to filter out most of the fine material.

For cost estimating purposes, all wells within 2.5 miles of any of the three reservoirs were identified and available well log data were collected for analysis. Table 9.7.4 below lists the 15 wells (in bold) that are most likely to be impacted by reservoir drawdown, with estimates shown for additional drilling depth to reasonably reach a reliable water supply, and for replacement well drilling if found to be necessary. For uncased and unscreened wells, deepening them is likely more cost effective than replacing them, and was assumed for the cost estimates. For screened and/or cased wells (indicated by an asterisk), if a suitable-sized well cannot be created by deepening the existing well without pulling the casing and screen, then it would likely be more cost effective to abandon the existing well in accordance with State Abandonment requirements (requiring fill material and/or concrete to seal the well) and to replace it with a deeper well. Wells which are currently screened would likely have to be screened when deepened. The 10 remaining wells shown below are included in the MPH estimate only, and are either already more than 70 feet below the Original River Channel, ORC (indicated by N/A), or are associated with PacifiCorp housing and may be abandoned following dam removal (indicated by ABN).

Table 9.7.4. – Wells Included in Groundwater Study

WELL ID	RESERVOIR			WELL		
	Reservoir	Distance to (ft)	Bottom Elev. (ft) – ORC	Bottom Elev. (ft)	Additional Drilling (ft)	Replacement Drilling (ft)
14918	Iron Gate	554.5	2165.0	2169.4	75	235
334387	Iron Gate	866.2	2165.0	2088.8	N/A	420
311078	Iron Gate	1095.9	2165.0	2219.9	130	376
333890	Iron Gate	1683.2	2165.0	2100.7	10	281
99852	Iron Gate	1735.6	2165.0	2212.9	125	625
70943	Copco	39.4	2493.0	2539.5	120*	210
555722	Copco	55.8	2493.0	2440.8	25	209
406066	Copco	85.3	2493.0	2386.4	N/A	300
512954	Copco	98.4	2493.0	2388.4	N/A	384
555712	Copco	154.2	2493.0	2522.7	80*	300
113378	Copco	160.8	2493.0	2562.3	145*	220
93347	Copco	183.7	2493.0	2545.4	100	210
406065	Copco	196.9	2493.0	2457.6	40	240
713255	Copco	196.9	2493.0	2500.9	75	199
1075453	Copco	239.5	2493.0	2490.4	70*	270
750784	Copco	242.8	2493.0	2176.3	N/A	510
406993	Copco	259.2	2493.0	2485.6	65*	237
126312	Copco	272.3	2493.0	2553.1	135	218
1075456	Copco	420.0	2493.0	2232.6	N/A	425
1089469	Copco	547.9	2493.0	2377.8	N/A	350
784332	Copco	2004.7	2493.0	2522.6	100*	250
54713	J.C. Boyle	29.5	3720.0	3712.6	ABN	N/A
54714	J.C. Boyle	62.3	3720.0	3725.9	ABN	N/A
54615	J.C. Boyle	65.6	3720.0	3656.4	ABN	N/A
54618	J.C. Boyle	278.9	3720.0	3707.8	ABN	N/A

The following assumptions were used for estimating the work:

- Down-hole hammer drill, conservatively estimated at 50 ft/day for 'hard rock' such as competent basalt and lava, and un-decomposed granite.
- Material type: basalt and/or granite.
- Drill hole diameter: 6 inch to 8 inch.

- Existing well conditions: uncased, open hole (unless otherwise indicated).
- Mobilization requires one day of rig and crew time for each well.
- Well casing and screens priced by linear foot where required, including two days to set screen.
- Drilling durations are rounded up to the next whole day.
- Air rotary drill, with or without water/foam, would be about the same as the down-hole hammer drill under the same assumptions.
- Smaller diameter boreholes would decrease the advancement rate, conservatively estimated at 30 ft/day, primarily due to the reduced weight of the drill string which reduces the impact of the hammer or the down-hole 'pressure' on the rotary drill bit.
- Cased and/or screened holes would either require the casing to be pulled, or a smaller diameter borehole below the casing/screen bottom. The bottom cap would have to be pulled or drilled through.
- Softer materials, such as sandstones, claystones, cinders, ash, clays, broken or decomposed hard rock would allow for higher advancement rates of up to 100 ft/day.

Cost estimates were based on Reclamation's current average drill crew costs (rig and crew) of $3,600 per day, which is consistent with standard industry practice. Actual costs for local drillers would vary depending upon workload, experience, and types of rigs used. Additional costs were estimated for well casing and screens, filter packs, cement seals, well development and testing, site preparation, and for removal and replacement of well pumps based on recent work, and were varied for MPL, Most Probable, and MPH estimates. Since the well logs have no indication as to what size of pump is/was installed, the type of pump, how deep it was set, and its rating curve, no specific information was available on which to base pump costs. Other factors that may influence the drilling costs include:

- The materials to be drilled through.
- Type of drill rig that is used.
- Whether the well is to be cased to some depth and then open, cased and screened to some depth and then open, or cased and screened to the bottom of the well.
- The type of casing and/or screen, size of casing and/or screen, and whether the well can be deepened through the existing casing and/or screen or not.
- Whether or not the deepened well would require casing and/or screen where the original well was open.

Cost estimates were developed for 11 wells, resulting in average costs per well of approximately $54,000, $61,500, and $69,000 for the MPL, Most Probable, and MPH cost estimates. These average costs per well were used to determine the total costs for 15 wells identified for the MPL and Most Probable estimates, and for the 25 wells identified for the MPH estimate. This work is assumed to occur in 2019 prior to reservoir drawdown. A potable water supply provided to homeowners while the wells are being drilled would require a nominal additional cost.

9.7.5 <u>Water Supply/Water Rights</u>

WRWS-1: Protection for downstream water intakes.

This mitigation measure would provide protection for downstream water intakes during passage of the eroded sediment within the Klamath River. The DRE would assess each pump location at legitimate points of diversion. Following dam removal, legitimate intake and pump sites would be investigated at the request of the water user. If effects on water supply intakes occur as a result of dam removal, the DRE would complete modifications to intake points as necessary to reduce effects to less than significant. The EIS/EIR identifies downstream water users, including one private domestic intake and all others indicated as used for irrigation and/or livestock. For cost estimating purposes, a crude estimate of $10,000 was included for excavation to clear each intake from aggraded sediment materials, and an additional $20,000 was assumed to provide replacement water during the reservoir drawdown period for livestock or other small volume uses, for the Most Probable estimate. The number of intakes assumed to be impacted varied from 7 to 18, with a Most Probable estimate of 12. The average costs for each intake ranged from $20,000 to $40,000. This work is assumed to occur in 2020 during the sediment release, on an as-needed basis.

9.7.6 <u>Air Quality</u>

The following mitigation measures are assumed for cost estimating purposes to represent a minor additional cost to the project and cost estimates have not been prepared. It is expected that the contract costs for the construction work would already include allowances for these costs.

AQ-1 – Any off-road construction equipment (e.g., loaders, excavators, etc.) must be equipped with engines that meet the model year (MY) 2015 emission standards for off-road compression-ignition (diesel) engines (13 CCR 2420-2425.1). Older model year engines may also be used if they are retrofit with control devices to reduce emissions to the applicable emission standards.

AQ-2 – Any on-road construction equipment (e.g., pick-up trucks at the construction sites) must be equipped with engines that meet the MY 2000 or on-road emission standards.

AQ-3 – Any trucks used to transport materials to or from the construction sites must be equipped with engines that meet the MY 2010 or later emission standards for on-road heavy-duty engines and vehicles (13 CCR 1956.8). Older model engines may also be used if they are retrofit with control devices to reduce emissions to the applicable emission standards.

AQ-4 – Dust control measures will be incorporated to the maximum extent feasible during blasting operations at Copco No. 1 Dam. The following control measures will be used during blasting activities: conduct blasting on calm days to the extent feasible (wind direction with respect to nearby residences must be considered); design blast stemming to minimize dust and to control fly rock; install wind fence for control of windblown dust.

9.7.7 Greenhouse Gases/Global Climate Change

Although cost estimates have not been prepared, the following mitigation measures are assumed to represent a total nominal project cost of $1 million for all estimates, to be split evenly between Oregon and California.

CC-1 – Use the market mechanism under development as part of AB 32 development when feasible to mitigate greenhouse gas emissions impacts. The market mechanism program under AB 32 is targeted for implementation in 2012.

CC-2 – Establish an energy audit program to enable local residences and businesses to determine how much energy they currently consume and to identify measures that would reduce energy consumption.

CC-3 – Establish an energy conservation plan to reduce the region's reliance on purchased electricity.

9.7.8 Geology, Soils, and Geologic Hazards

The following mitigation measure is assumed to represent a minor additional cost to the project and a cost estimate has not been prepared. Sediment deposits, where encountered for the construction of new recreation facilities and access roads, should not be very thick and could be excavated if necessary at little additional cost.

GEO-1 – Prior to commencing construction of new recreation facilities or access roads in the former reservoir areas, geotechnical analysis of the proposed sites should be conducted by a qualified geologist to determine the limitations of construction on the sediment. If geotechnical tests indicate that the sediment is not suitable to accommodate the proposed activities, the site should be avoided or a sediment removal or treatment plan should be developed prior to beginning construction activities.

9.7.9 Cultural and Historic Resources

The following four mitigation measures were used to develop a single cost estimate for the cultural resources/historic properties mitigation, which is provided below.

CHR-1 – This mitigation measure identifies steps to resolve the adverse effects/significant impacts of dam removal on the four Hydroelectric Facilities and on the Klamath Hydroelectric Historic District (KHHD), and includes:

- Update 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 KHHD.
- Continue consultations under Section 106 of the National Historic Preservation Act (NHPA) with the Advisory Council on Historic Preservation (ACHP), State Historic Preservation Officers (SHPOs), and other interested parties to reach a consensus on the eligibility determination.

- Enter into an agreement document (Memorandum of Agreement or Programmatic Agreement) under Section 106 of the NHPA with ACHP, SHPOs, and other consulting parties for the resolution of adverse effects.
- Document the four dams to Historic American Buildings Survey (HABS), Historic American Engineering Record (HAER), and Historic American Landscapes Survey (HALS) standards or equivalent.
- Identify additional mitigation measures in the agreement document, including a public outreach or education component.

CHR-2 – This mitigation measure identifies steps to resolve the adverse effects/significant impacts of the Proposed Action on prehistoric and historic archaeological historic properties and historical resources, and includes:

- Continue consultations under Section 106 of the NHPA with ACHP, SHPOs, Indian tribes and other interested parties to identify and evaluate cultural resources for eligibility for listing on the National Register and/or California Register.
- Continue identification and evaluation of historic properties and historical resources for unevaluated cultural resources, unsurveyed areas, and inundated zones.
- Continue consultations under Section 106 of the NHPA with ACHP, SHPOs, Indian tribes and other interested parties to identify alternatives to avoid, minimize, or mitigate adverse effects to historic properties.
- Enter into an agreement document (Memorandum of Agreement or Programmatic Agreement) under Section 106 of the NHPA with ACHP, SHPOs, and other consulting parties for the avoidance, minimization, and mitigation of adverse effects, and the resolution of adverse effects (including excavation as appropriate and a public outreach component).
- Prepare a Monitoring Plan to identify historic properties and historical resources exposed during implementation of the selected alternative.
- Prepare and implement an Inadvertent Discovery Plan for unanticipated discoveries of historic properties/historical resources and Native American burials.
- Prepare and implement a Cultural Resources Management Plan to address the management and protection of historic properties and historical resources, and significant cultural resources.
- Respect and maintain the confidentiality of sensitive information following 36 CFR § 800.11(c) and the Archaeological Resources Protection Act of 1979 (16 USC 470hh).

CHR-3 – This mitigation measure identifies steps to resolve the adverse effects and significant impacts of dam removal on Traditional Cultural Places (TCPs) and cultural landscapes, and includes:

- Continue consultations under Section 106 of the NHPA with ACHP, SHPOs, Indian tribes and other interested parties to identify and evaluate TCPs and cultural landscapes for eligibility for listing on the National Register and/or California Register.
- Follow the steps in CHR-2 for identification and evaluation, alternatives to avoid, minimize, or mitigate, and resolution of adverse effects.

- Respect and maintain the confidentiality of sensitive information following 36 CFR § 800.11(c) and the Archaeological Resources Protection Act of 1979 (16 USC § 470hh).

CHR-4 – This mitigation measure identifies steps to resolve the impacts of dam removal on Native American burials, and includes:

- Consult with Indian Tribes and other Native American organizations on identification, treatment, disposition, and management of Native American burials exposed and/or impacted by the selected alternative.
- Prepare and implement a Plan of Action to manage and treat Native American burials, in accordance with the Native American Graves Protection and Repatriation Act (NAGPRA) on federal and Indian tribal lands, and with California and Oregon state burial laws as appropriate on state lands.
- Prepare and implement an Inadvertent Discovery Plan for unanticipated discoveries of historic properties and historical resources, and Native American burials.
- Consult on discoveries of historic properties and historical resources in association with Native American burials as identified in Mitigation Measure CHR-2.

Preliminary cultural resources mitigation costs were developed based on the general mitigation plans provided below.

- Prior to implementation, cultural resources surveys would be conducted in potential impact areas to identify historic and significant properties.

- After removal of the dams, cultural resources surveys would be conducted in the drawdown zones to identify historic and significant properties.

Steps must be taken to avoid, minimize, or mitigate effects on these resources through either the Federal or State processes, depending on the status of the DRE. Long-term management of the exposed cultural resources has not been included in the cost estimate. The responsibility and funding for any long-term commitments must be determined.

The following assumptions were used to develop the estimated mitigation cost:

Survey Acreage	
Drawdown Zone-JC Boyle	250
Drawdown Zone-Copco 1 & 2	800
Drawdown Zone-Iron Gate	825
Raised River Corridors	100
Haul Roads and Disposal Sites	275

Cultural Resources	
Sites	400
Eligible sites (Historic Properties)	80

Historic structures (buildings, bridges, etc.)	50
Dam Districts (dam, powerhouses, all facilities)	4
Burials	150

The estimated costs for cultural resource protection (in dollars) are as follows:

Mitigate Historic Properties		
Mitigation Research Design	75,000	
Archaeological Data Recovery	2,560,000	
Archaeological Data Recovery Analysis and Report	960,000	
Historic Structures Documentation	100,000	
HABS/HAER Documentation	1,250,000	
Curation Fees	5,200,000	
		$10,145,000
Traditional Cultural Properties		
Update Riverscape TCP and Nomination	200,000	
TCP Mitigation	2,000,000	
		$2,200,000
Recovery of Human Remains	750,000	
		$750,000
Cultural Resources Mitigation Total		$19,270,000

The cost estimates provided above are based on Federal requirements and may vary if the final project has no federal tie. State requirements are similar to those assumed. An additional allowance of 35 percent is included in the Most Probable estimate for Federal agency consultations and oversight, for a total of $26 million. A range of $20 million to $30 million was assumed for the MPL and MPH estimates to account for uncertainty. Costs for long-term cultural resources management and monitoring are not included in these estimates.

9.7.10 Public Health and Safety

Unless otherwise indicated, the following mitigation measures are assumed for cost estimating purposes to represent a minor additional cost to the project and cost estimates have not been prepared. It is expected that the contract costs for the construction work would already include these costs.

PHS-1: A Public Safety Management plan would be prepared and implemented to maintain public safety during all phases of construction and demolition. Components of the plan would include the following: public notification of the location and duration of construction and demolition activities, pedestrian/bicycle path/trail closures, and restrictions on reservoir use (i.e., boating, water skiing, fishing, swimming); verification with local jurisdictions that construction blockage of existing roadways would not interfere with existing emergency evacuation plans; verification with local jurisdictions that construction use of existing roadways for truck hauling of materials would not substantially interfere with response times of emergency vehicles; adequate signage would be installed regarding the location of construction and demolition sites and warning of the presence of construction equipment; fencing of construction staging areas and of construction and demolition areas if dangerous conditions exist when construction and demolition are not occurring; temporary walkways (with appropriate markings, barriers, and signs to safely separate pedestrians from vehicular traffic) and detour signage where an existing sidewalk or pedestrian/bicycle path/trail would be closed during construction and demolition.

PHS-2: Prior to initiating construction and demolition activities, the DRE, in consultation with the appropriate city, county, and state fire suppression agencies, would prepare and implement a Fire Management Plan. The plan would include fire prevention and response methods including fire precaution, presuppression, and suppression measures consistent with the policies and standards in the affected jurisdictions. Additionally, fire suppression equipment would be required on-site at all times and emergency contact numbers would be posted in case of a fire. This plan would include provisions that areas of construction and deconstruction work involving welding, grinding, torch-cutting, gas and diesel generators and other construction activities that could result in open sparks or flame be cleared of dried vegetation or wetted-down to prevent wildfires.

PH-3: This mitigation measure would provide cattle exclusion fencing at the reservoir sites to replace the function of the former reservoirs to serve as a natural barrier to livestock, and for the protection of revegetation efforts against damage due to any cause. Given the terrain and configuration of the restoration sites, an estimate of 100 miles of fence was originally assumed. This estimate is believed to be conservative, and should account for potential cost increases and the uncertainty of where and how many miles of fencing would be warranted, and future repair or replacement of fencing. Any future estimates should include GIS analysis to locate and confirm the extent of potential livestock issues with respect to property boundaries. Existing fencing, and future maintenance of all required fencing, should also be considered in future estimates. (Actual fencing requirements may be much lower, in the 40 to 60 mile range, based on further studies recently performed.)

The fencing is assumed to consist of four wire strands total, with 3 strands of 12.5 gauge barbed wire and a bottom strand of 12.5 gauge smooth wire. Metal T posts would be spaced 12 feet apart, with a wood or steel stretch post every 100 feet, and a wood or steel H brace every 1000 feet. A unit price based on using steel for H braces and stretch posts, installed with concrete (as used at Horseshoe Ranch) is $10/foot, which was used for the MPH estimates. If wooden posts are used in place of metal T posts, the unit price would drop to around $7.50/ft, which was used for the Most Probable and MPL estimates.

9.7.11 <u>Scenic Quality</u>

The following mitigation measures are assumed to represent a minor additional cost to the project and cost estimates have not been prepared. It is expected that the contract costs for the construction work would already largely include these costs.

SQ-1: When practical, scenic quality enhancement measures should be included for all permanent structural, landform and vegetation-altering components of the Project Alternatives. These measures would include one or more of the following: 1) determining the most aesthetically beneficial location and configuration of constructed facilities to reduce visual disturbance; 2) development of scenically harmonious design components into constructed facilities such as edges, borders, and surface textures that blend with surrounding topography and landscape; 3) coloration of constructed facilities, such as colored concrete that mimics as closely as practical the adjacent native soil, bedrock, or vegetation; and 4) screening of constructed facilities, or portions thereof, from sensitive viewpoints through the planting of native riparian or upland vegetation. The application of one or more of these measures, where feasible, will minimize scenery disturbances as needed to either achieve the Project's Visual Resource Management (VRM) classes, or achieve the most natural appearing scenic quality possible while meeting other Project objectives.

SQ-2: To reduce nighttime light and glare on surrounding residences during construction, the DRE would require the use of reflectors, shields, directional lighting, or other appropriate methods to reduce glare. All lighting would be turned off when not in use and/or motion-controlled lighting would be used, where feasible. Permanent lighting needed for security would be selected to be "dark sky friendly" to reduce glare to the surrounding area. "Dark sky friendly" lighting accessories or alternatives to typical lighting systems would be used, where feasible.

9.7.12 Recreation

REC-1: Recreation facilities.

At least 1 year before starting dam removal activities, the DRE would prepare a plan to develop new recreational facilities and river access points along the newly formed river channel between J.C. Boyle Reservoir and Iron Gate Dam. The plan would be developed in consultation with appropriate state and federal agencies (e.g., BLM and CDFG) and stakeholder groups, and would include an implementation schedule for construction of recreational facilities and river access areas. For cost estimating purposes, new recreation facilities would be provided for the river channel to replace the function of the existing facilities to be removed or modified due to reservoir drawdown. The following features have been assumed for cost estimating purposes. Most Probable estimates were selected from within the ranges provided.

a. New non-motorized trail to provide fisherman access along the river bank from J.C. Boyle damsite to Iron Gate fish hatchery. Cost estimates based on other trail construction are $20,000 to $30,000/mile for a total of 30-40 miles, at a cost between $600,000 and $1,200,000.

b. Expansion and upgrade of Jenny Creek Campgound to accommodate 5 to 10 camping sites with parking, shade structures, picnic tables, fire grates and restrooms. Cost is based on other similar construction and would vary based on final design specifications and access road surfacing, pending coordination with other agencies and recreation groups. Estimated cost would be between $400,000 and $600,000.

c. Upgrade of the day use facility and trailhead at Fall Creek to provide more durable facilities, including restrooms, picnic tables, shade structures, fire pits and trailhead parking. Additionally, the trail leading to Fall Creek waterfall and the Devil's Woodpile would be reconstructed. Cost is based on other similar construction and would vary based on final design specifications and access surfacing pending coordination with agencies and recreation groups. Estimated cost would be between $150,000 and $225,000. Additional security fencing for the City of Yreka's water supply facilities located in the vicinity of the Fall Creek trail may be required.

d. Redesign and reorientation of Topsy Campground to accommodate a river versus reservoir environment. This would include either replacement or redesign of the existing boat ramp. More extensive revegetation efforts in the vicinity of the campground would be needed to hasten stabilization of the newly exposed riverbank in areas of concentrated human activity. Depending upon the final design, costs would vary between $300,000 and $500,000.

e. Working with the reservoir restoration team and appropriate federal, state, and county agencies and public groups, two routes would be provided on each side of the river that could be retained permanently to provide public recreation access to the river. Costs would be based on location and length after exact location(s) and design were determined. Cost is based on 2 to 5 miles of road at $30,000 to $35,000/mile.

f. Reconstruct the day use site at Iron Gate hatchery to provide shade structures, picnic tables, parking, fire grates, and restrooms, and to construct a new boat ramp. Costs would be dependent upon final design and materials used, and would range between $300,000 and $450,000.

g. Construction of up to 2 new small to medium campgrounds accommodating a total of 20 campsites to provide river access, parking, boat launch, and day use facilities. The exact location(s) and design would be determined after consulting with appropriate federal, state and county agencies and public groups, and would be based on available sites and suitable access to the river. Cost is based on similar construction and would vary based on final design specifications and access surfacing pending coordination with agencies and recreation groups. The cost is estimated at between $800,000 and $1,500,000.

9.7.13 Transportation

TR-1: Bridge and culvert relocations.

This mitigation measure would relocate or modify infrastructure directly impacted by reservoir drawdown and not otherwise addressed by either the dam removal activities or Yreka City water supply pipeline modifications. These features currently include one bridge and four culvert crossings along Copco Road, and one culvert crossing on Topsy Grade Road, as described below, which are each assumed to require modifications to prevent significant scour damage and headcutting possibly leading to failure. There may be a few other culvert crossings identified by Siskiyou County that may be impacted, but to a lesser extent. The smaller tributaries should not be affected as they have not created a delta that would be eroded after dam removal. In addition, the Highway 66 bridge across J.C. Boyle Reservoir may require the placement of additional riprap on the left bridge abutment for slope protection, but this was considered to be a minor cost for this level of study.

Jenny Creek Bridge is located on Copco Road at Iron Gate Reservoir (Figure 9.7-2). Philip Williams and Associates (PWA, 2008) identified this bridge as one that may be impacted by dam removal. The approach road and bridge abutments are built on material deposited since the construction of Iron Gate Dam. After dam removal, the channel would incise through the deposits and potentially undermine the abutments of the bridge. To prevent this potential damage, a new bridge would be constructed upstream of the current bridge, above the delta and at the location of a previous temporary water crossing. The cost estimate was based on the original contract cost of the existing bridge, which was constructed in 2008, with a potential range of 15 +/- percent for the MPH and MPL estimates.

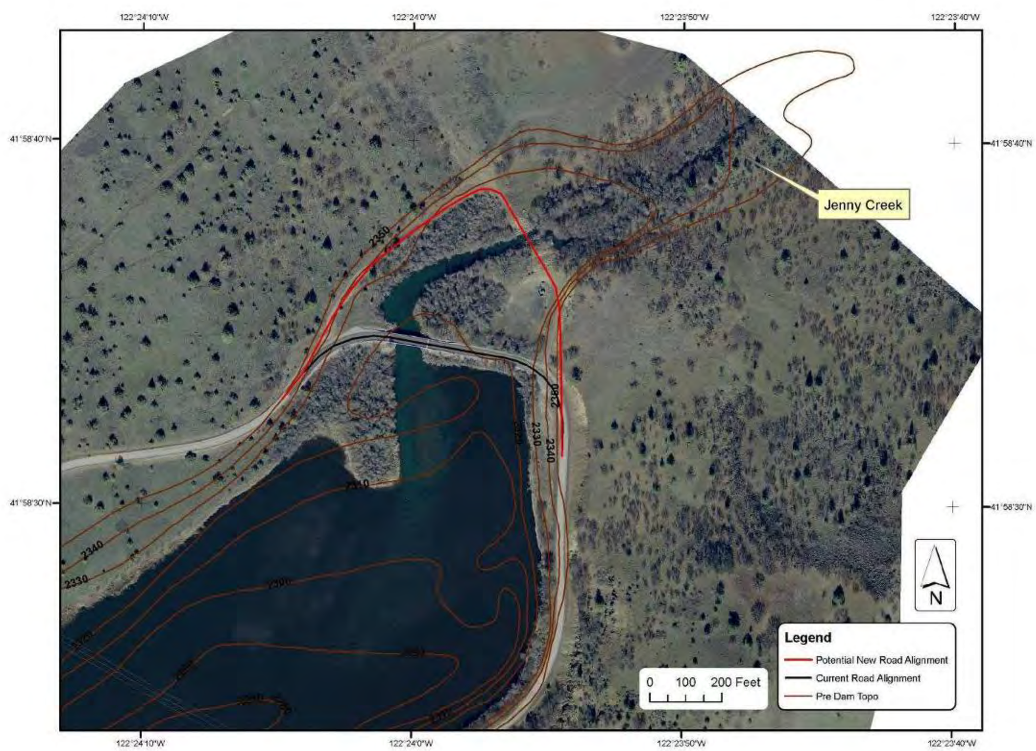


Figure 9.7-2. Location of Jenny Creek Bridge on delta deposits.

Culverts are used to pass low flows under roads from several smaller tributaries into Iron Gate and Copco Reservoirs. In some cases, these tributaries have created deltas perched above the pre-dam river channel. After the reservoirs are emptied, the tributary channels would return to their pre-dam elevations and potentially undermine the existing road crossings at these tributaries. There would be two options to ensure road access at these locations: (1) prior to dam removal, move the road crossing further upstream on the tributary, requiring a roadway realignment, or (2) immediately after reservoir drawdown, grade a new road down to the elevation of the pre-dam channel, or lower the culvert, while maintaining the current roadway alignment (possibly requiring a temporary road closure). The following culvert locations were identified for this study (all elevations in NAVD88). The estimate assumes an average cost of $20,000 for replacement of each culvert.

- Scotch and Camp Creek at Iron Gate Reservoir

Copco Road crosses Scotch Creek and Camp Creek along the north side of Iron Gate Reservoir. The current road elevation of the crossing at Scotch Creek is at 2346 feet and the stream bed is currently at 2336 feet, based upon the 2010 LiDAR survey. The pre-dam elevation of the bed at this location was approximately 2334 feet. Therefore, the bed should only incise a couple of feet at this location. The current road alignment should be sufficient and the road could be regraded and a larger culvert installed to account for the potential drop in bed elevation. At Camp Creek, the current road elevation is at 2340 feet and the water surface elevation is at 2329.5 feet. The pre-dam bed elevation was at approximately 2310 feet and therefore substantial erosion (over 10 feet) would be expected at this location.

- Fall Creek at Iron Gate Reservoir

  The access road between Copco Road and the Copco No. 2 powerhouse crosses Fall Creek at Iron Gate Reservoir. The current road elevation at this crossing is 2348 feet and the water surface elevation is at 2333 feet. The pre-dam elevation is estimated to be at approximately a normal pool elevation of 2331 feet. Therefore, the incision expected at this site should be a couple of feet.

- Beaver Creek at Copco Reservoir

  Copco Road crosses Beaver Creek and East Fork Beaver Creek along the north side of Copco Reservoir. The road elevation is at approximately 2623 feet and the gulch is at an elevation of 2616 feet just downstream of the crossing. The normal pool elevation is at about 2606 feet and is about 430 feet from the road crossing. There is evidence of a substantial delta at this location and several feet of incision at the road crossing is possible.

- Raymond Gulch at Copco Reservoir

  Copco Road crosses Raymond Gulch along the north side of Copco Reservoir. The road elevation is at approximately 2631 feet and the gulch is at an elevation of 2625 feet. The normal pool elevation is at an elevation of 2606 feet and is about 450 feet from the road crossing. This crossing is likely sufficiently elevated above the reservoir so that only a few feet of incision is likely at this crossing.

- Tributary crossing Topsy Grade Road near J.C. Boyle Dam

  Topsy Grade Road crosses an un-named tributary near J.C Boyle Dam, with an estimated watershed area of approximately 5 square miles. The elevation contour of 3793 feet is the normal maximum pool elevation and defines the extent of the reservoir. A small delta has formed upstream of the road crossing, but this delta has not reached the road. According to the Pre-Dam topographic map from PacifiCorp, there are three 24-inch culverts that pass flow beneath the road. The culverts are not aligned with the historical river channel and the road would act as a dam when high flows occur. The road would have to be armored with riprap on the downstream face so that it does not erode away when overtopped. Also, the culverts should be realigned with the historical stream channel. The same number and size of culverts would be sufficient to maintain the same level of flood protection for the road.

A HEC-RAS model was used to evaluate the potential impact of dam removal on the hydraulic capacity of several bridges downstream of Iron Gate Dam, as indicated in Table 9.7.5 below. These bridges were surveyed in early Spring 2010. Two conditions were evaluated in the hydraulic model:

Current Condition: This is the condition defined by the 2010 surveys of the local topography, bathymetry, and bridge structures. The 100-year flood peak was assumed to be 31,460 ft^3/s.

Future Dams Out Condition: This is the condition defined by assuming the dams are removed and sediment deposition has occurred in the downstream river channel. The attenuation effects of the upstream reservoirs are no longer present and the 100-year flood peak immediately below Iron Gate Dam is assumed to be 33,800 ft^3/s (an increase of about 7 percent).

The results of the 100-year flood analysis are provided in Table 9.7.5. Cross-section plots showing the Current and Future Dams Out Conditions are provided in Figures 9.7.3 through 9.7.10. All bridges intended for vehicle traffic are shown to have more than 3 feet of freeboard for the 100-year flood peak under the Dams Out Condition. CalTrans requires a minimum of 2 feet of clearance below the bottom chord for the 50-year flood peak and that the 100-year flood peak passes beneath the low chord. Therefore, no improvements to the existing road bridges should be necessary to convey flows after dam removal.

The two pedestrian bridges do not currently pass the 100-year flood peak beneath the low chord, and under the Dams Out Condition they will experience 1 to 2 feet higher water surfaces. It is uncertain what hydraulic requirements will be applicable to the pedestrian bridges, and whether any modifications may be required.

The scour potential at the bridge piers was also evaluated both under the Current Condition and the Future Dams Out Condition. The scour at the bridge piers will be a combination of the contraction scour and pier scour if the piers are located in the main channel, but will only be a function of the pier scour if the piers are located outside of the main channel. The net change in the scour elevation between the two conditions was computed by subtracting the scour elevation expected under the Future Dams Out Condition from the Current Condition estimate. HEC-RAS was used to estimate the scour. The contraction scour was computed using the default parameters and methods within HEC-RAS, where Laursen (1963) criteria are used to predict whether the contraction scour will be from live bed or clear water. The Laursen (1960) method is then used to compute the live bed contraction scour and the Laursen (1963) method is used to compute the clear water contraction scour. The Colorado State University equation (Richardson, 1990) is used to compute the pier scour. The measured existing bed material is used for the Current Condition and the predicted bed material (Section 9.2 of Reclamation, 2011) is used for the Future Dams Out Condition. Since bed material measurements were not performed at the exact location of the bridge crossing in most cases, the nearest sampling site was used to represent the conditions at each bridge crossing. The deposition expected under the Future Dams Out Condition was also estimated at the piers based upon the sediment transport simulations reported in Reclamation (2011). There is no information available on the current scour experienced by each bridge. Table 9.7.5 includes the change in deposition at each bridge and the net change in the scour elevation under Dams Out Condition relative to the Current Condition. In all cases except for the Rail Bridge, the scoured bed elevation will not decrease more than 0.2 feet due to the Future Dams Out Condition. This is not considered a significant change in scour elevation considering the uncertainty associated with scour computations and the conservatism used in scour computations. The largest change to the scour elevation is at the Rail Bridge where it is expected to decrease approximately 1.2 feet. Again, this change in scour elevation is not considered to significantly affect the structural integrity of the piers, considering the likely presence of bedrock near the riverbed that will limit scour at this location. Further investigations are planned to confirm the geologic conditions at this site for final design.

Table 9.7.5. – Results of HEC-RAS Analysis of Bridges Below Iron Gate Dam for Flood Capacity and Scour Potential (Elevations in NAVD88)

Bridge	**RM**	**Low Cord (ft)**	**Current 100-yr WSE (ft)**	**Future Dams Out 100-yr WSE (ft)**	**Change in Bed Elevation[1] (ft)**	**Change in Scour Elevation[1] (ft)**
Iron Gate	189.8	2191.1	2184.7	2188.0	2.7	1.3
Pedestrian Bridge #1	186.4	2134.0	2137.3	2139.2	N/A[2]	N/A[2]
Pedestrian Bridge #2	185.7	2128.7	2128.7	2129.9	N/A[2]	N/A[2]
Ager Road	184.15	2128.0	2110.3	2111.9	0	-0.2
Rail Bridge	183.3	2110.8	2098.6	2099.7	1.6	-1.2
Interstate 5	179.2	2077.5	2063.3	2064.0	0	-0.09
Anderson Grade	179.0	2065.1	2060.7	2061.4	0	-0.07
Highway 263	176.8	2064.0	2039.0	2039.5	0	-0.03

Note 1 - Change is defined as the difference between the Future Dams Out Condition and the Current Condition.
Note 2 - No piers are present for the pedestrian bridge and therefore scour is not evaluated for these structures.

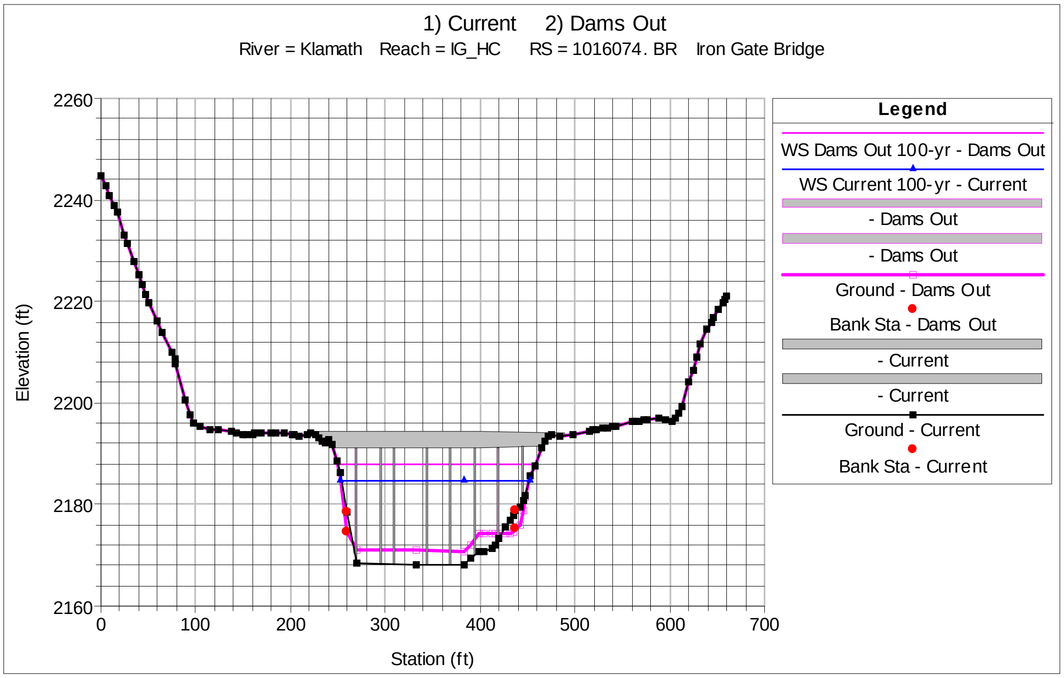


Figure 9.7.3. River bed and WSE at Iron Gate Bridge.

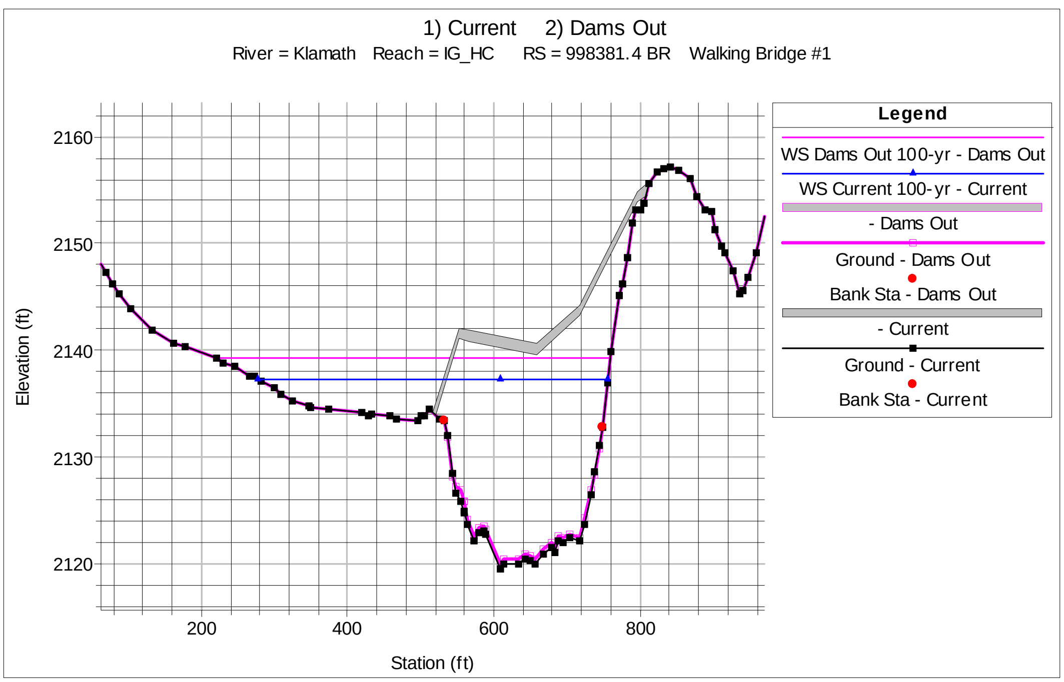


Figure 9.7.4. Riverbed and WSE at Pedestrian Bridge #1.

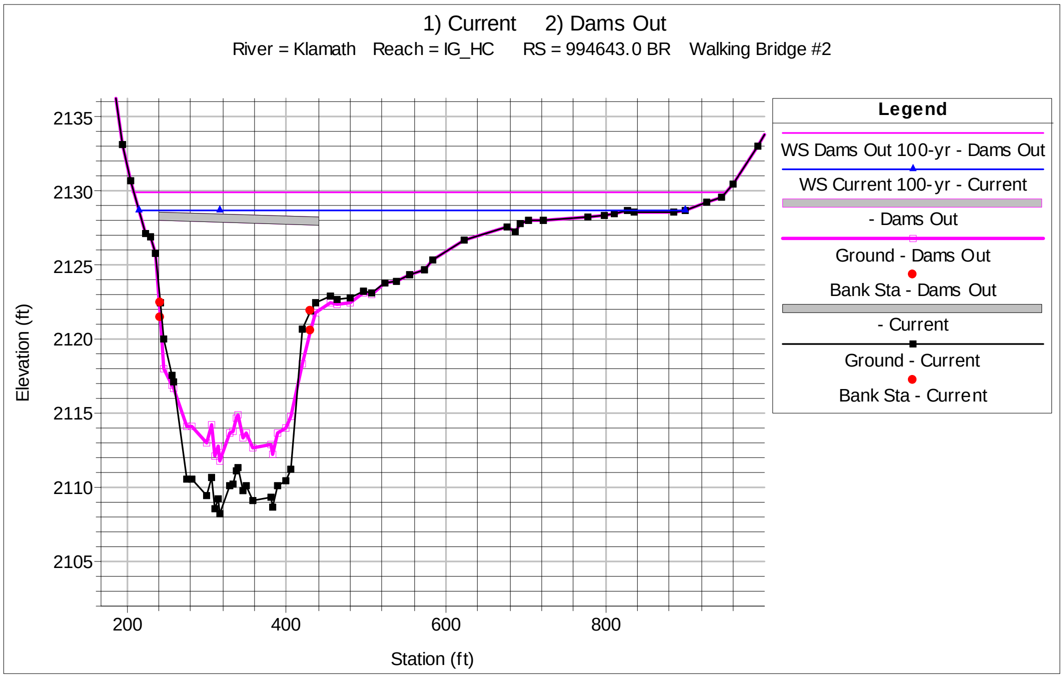


Figure 9.7.5. Riverbed and WSE at Pedestrian Bridge #2.

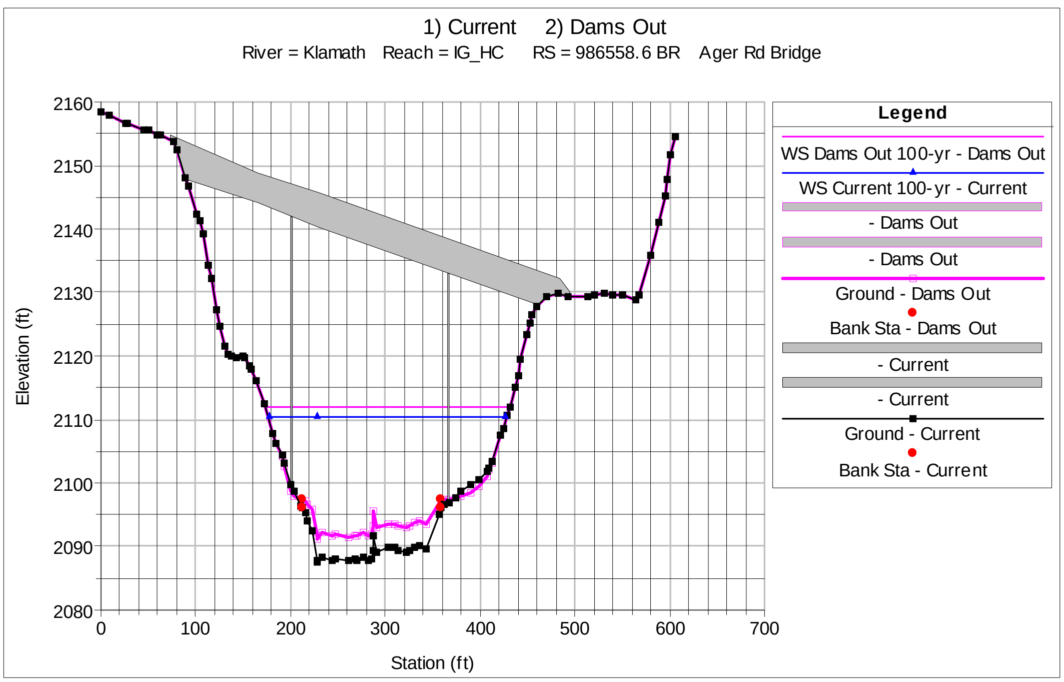


Figure 9.7.6. Riverbed and WSE at Ager Road Bridge.

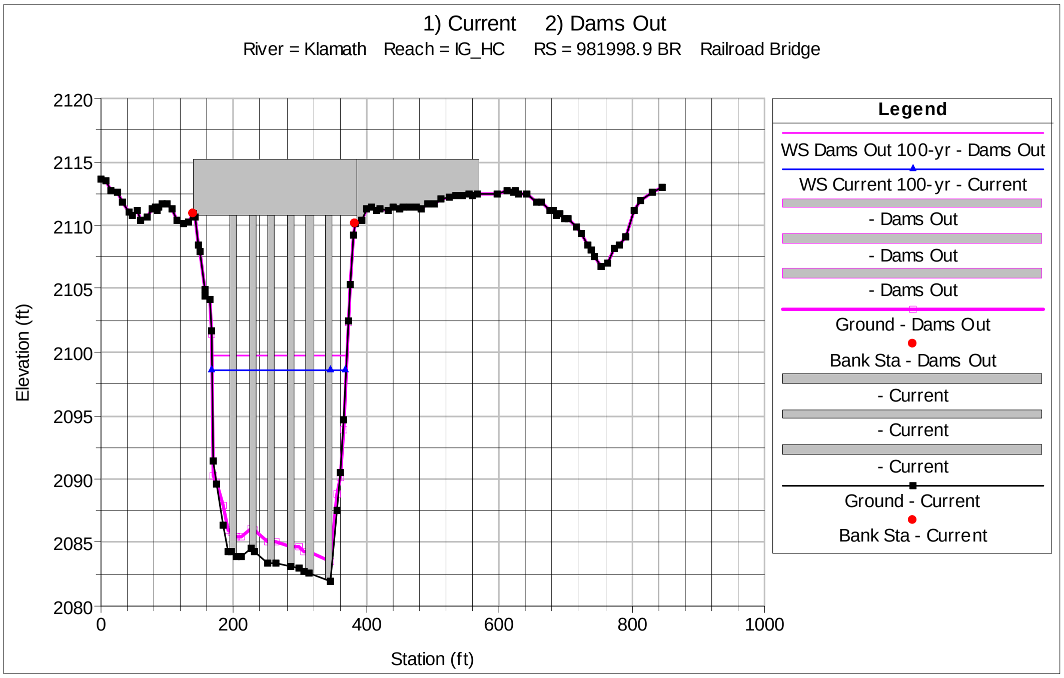


Figure 9.7.7. Riverbed and WSE at Railroad Bridge.

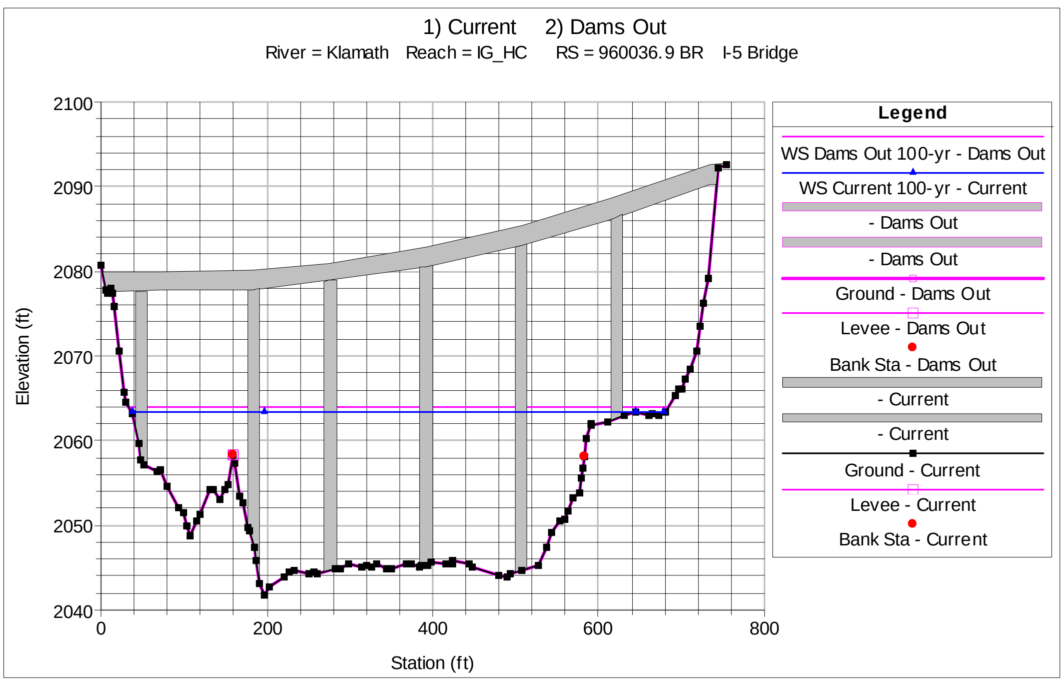


Figure 9.7.8. Riverbed and WSE at Interstate 5 Bridge.

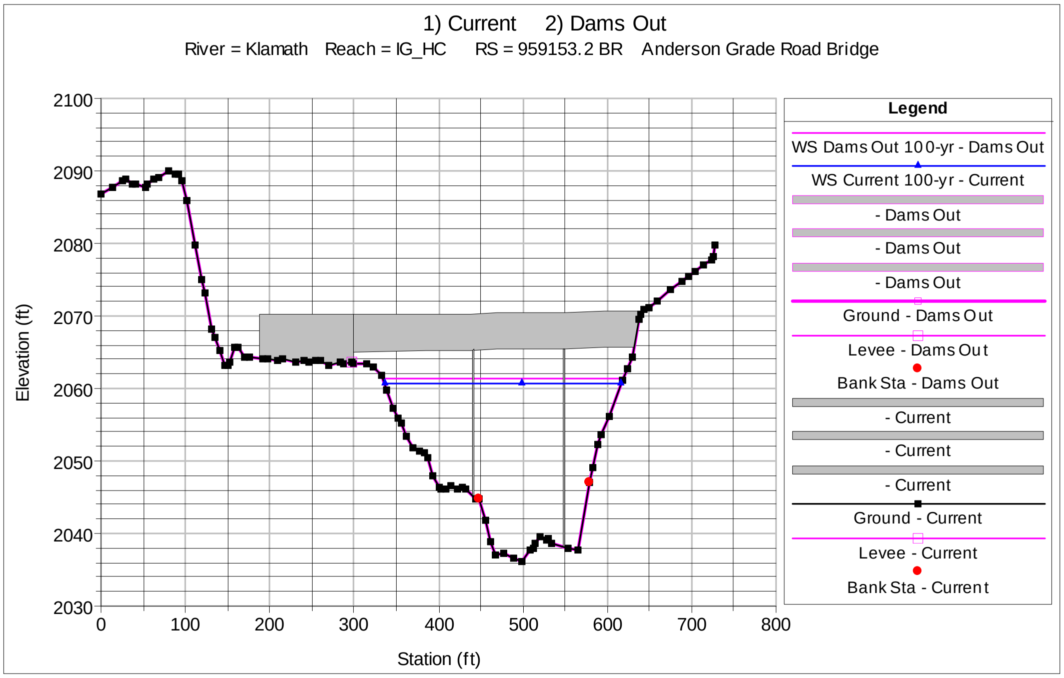


Figure 9.7.9. Riverbed and WSE at Anderson Grade Road Bridge.

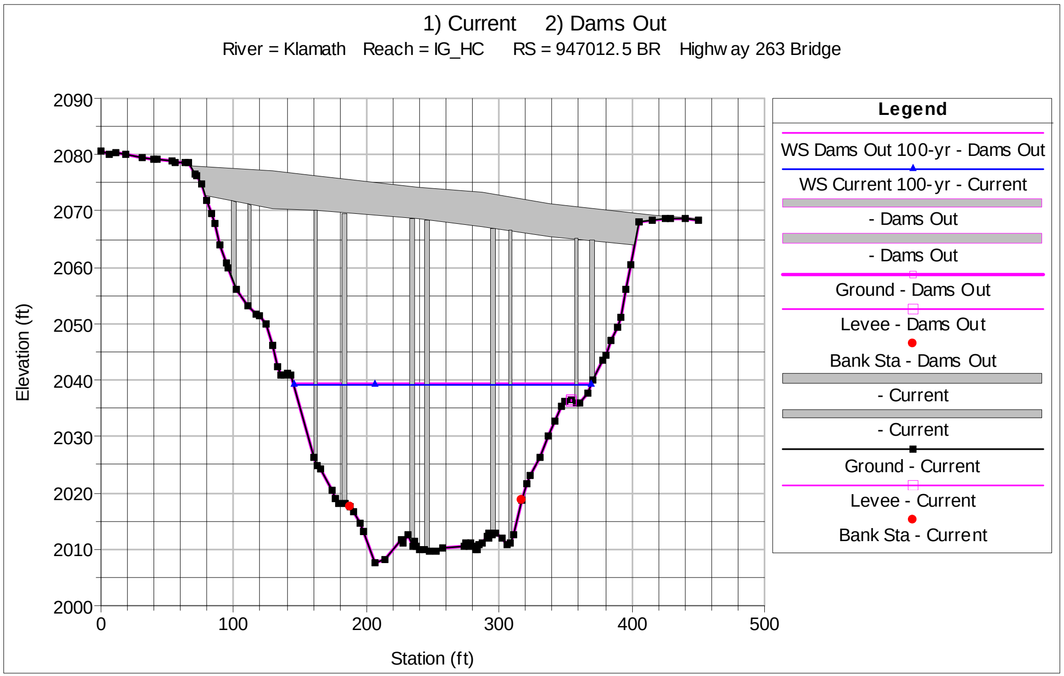


Figure 9.7.10. Riverbed and WSE at Highway 263 Bridge.

9.7.14 <u>Noise and Vibration</u>

The following mitigation measure is assumed for cost estimating purposes to represent a minor additional cost to the project and cost estimates have not been prepared. It is expected that the contract costs for the construction work would already include these costs.

NV-1 – The DRE would develop a Noise and Vibration Control Plan (NVCP) to address increased day and night time noise levels as a result of the proposed project. The NVCP would identify the procedures for predicting construction noise levels at sensitive receptors prior to performing construction activities and would describe the reduction measures required to meet the target noise level. The NVCP would be based on planned construction activities. Noise and vibration mitigation measures would include, but would not be limited to the following: the DRE would ensure that the Construction Contractor is maintaining equipment to comply with noise standards (e.g., exhaust mufflers, acoustically attenuating shields, shrouds, or enclosures); for nighttime or after-hour construction, the DRE would coordinate with the local jurisdictions to minimize noise impacts; nearby residents would be notified of hours and duration of construction activities; schedule truck loading, unloading, and hauling operations so as to reduce daytime and nighttime noise impacts to less than noticeable levels; blasting schedules would be coordinated with local jurisdictions to minimize noise impacts; nearby residents would be notified of blasting schedules; appropriate blasting techniques would be employed to minimize noise and vibration; noise and vibration complaints would be addressed promptly and high impact activities would be rescheduled or alternate means of demolition and construction would be implemented, when feasible.

9.7.15 Summary of Estimated Mitigation Costs

Each mitigation measure identified in the EIS/EIR was evaluated as to the potential cost (as described in the preceding subsections) for determination of the total construction cost for each dam removal alternative. The costs used to develop the mitigation cost allowance for the Most Probable estimate for each alternative are summarized in Table 9.7.6 below, and are considered to be at an appraisal-level. Potential monitoring costs described in section 9.8 are also included. Variations of these estimates were included in the Monte Carlo analysis for development of the forecast range of total costs. There is no significant difference in total mitigation and monitoring costs between the two dam removal alternatives (Full and Partial Removal).

Table 9.7.6. – Summary of Potential Mitigation Measure Costs (2010 Dollars)

Mitigation Measure	Most Probable Cost	Low Estimate	High Estimate
AR-1	-	-	-
AR-2	4,000,000	3,600,000	4,400,000
AR-3	0	0	0
AR-4	-	-	-
AR-5	-	-	-
AR-6	170,000	120,000	255,000
AR-7	300,000	200,000	500,000
TER-1	-	-	-
TER-2	-	-	-
TER-3	-	-	-
TER-4	-	-	-
TER-5	350,000	0	700,000
TER-6	120,000	50,000	150,000

H-1	-	-	-
H-2	4,000,000	3,000,000	6,000,000
GW-1	922,500	810,000	1,737,500
WRWS-1	366,000	244,000	488,000
AQ-1	-	-	-
AQ-2	-	-	-
AQ-3	-	-	-
AQ-4	-	-	-
CC-1, -2, -3	1,000,000	1,000,000	1,000,000
GEO-1	-	-	-
CHR-1, -2, -3, -4	26,000,000	20,000,000	30,000,000
PHS-1	-	-	-
PHS-2	-	-	-
PHS-3	4,000,000	4,000,000	5,000,000
SQ-1	-	-	-
SQ-2	-	-	-
REC-1	3,790,000	2,970,000	4,595,000
TR-1	1,620,000	1,390,000	1,850,000
NV-1	-	-	-
Subtotal - Mitigation	46,638,500	37,384,000	56,675,500
Monitoring Cost (Sec 9.8)	10,400,000	8,300,000	12,500,000
Contingency @ 10 percent	5,961,500	4,316,000	6,824,500
Total – Mitigation/Monitoring	63,000,000	50,000,000	76,000,000

9.8 Costs for Mitigation Monitoring Plans

Various monitoring plans are anticipated to be required to help ensure the proper performance of the mitigation measures and other environmental compliance measures, which are considered to be costs incurred due to the removal of the dams and reservoirs.

9.8.1 Sediment and Water Quality Monitoring

The Water Quality Subteam developed the framework for a monitoring plan for water quality changes resulting from dam removal, including the provision of approximate monitoring costs. The Engineering, Geomorphology and Construction Subteam provided estimates of costs associated with sediment monitoring, including both suspended and bed loads as well as deposition and erosion. The following describes the broad outlines for a suggested sediment and water quality monitoring plan, recognizing that final details and costs cannot be fully anticipated prior to the final Determination and associated decisions by permitting and regulatory agencies. The following also provides objectives for monitoring and assumptions upon which the monitoring framework are based. Approximate costs and the rationales for the individual components of the monitoring program are provided. However, this does not establish policy or funding decisions about what should or would be monitored, which entities would provide funding, or which entities would receive funding. Such decisions would necessarily be made following a positive Determination, if it was to occur, and would rest in the hands of the regulatory, scientific, and management structure that is put in place to carry out the terms of the

KHSA. Costs are provided in MPL, Most Probable, and MPH estimates as described below. Ongoing water quality monitoring networks already include measurement of Total Suspended Solids (TSS) as part of their routine monitoring, and it is assumed that this work would continue. Future coordination between ongoing monitoring and that outlined below is assumed if there is a positive Determination.

It is recognized that specific objectives may be developed following a positive Determination, if one occurs. In the interim, and for the purposes of developing cost estimates, general objectives for a framework for sediment and water quality monitoring in the Klamath Basin include the following:

- Provide objective, unbiased, accurate, and internally consistent data for evaluation of short term (1-2 year) and long term (2-5 years) effects of dam removal on water quality in the reservoir reaches and downstream river channel.
- Meet potential requirements for mandatory monitoring and data collection from State or Federal regulatory agencies.
- Identify critical data gaps and/or targeted, special studies needed to address pressing questions and/or refine methods.
- Provide opportunities for leveraging of additional funds from outside sources in order to enhance the monitoring program and associated questions and/or analysis.

This monitoring framework is based on a series of assumptions about related activities in the Klamath Basin, and about requirements for monitoring that might be promulgated by regulatory agencies. Where these assumptions are not met, changes in the scope, duration, and cost of monitoring could result. Some of these assumptions and their rationales are described below.

1. Monitoring would start approximately 1-2 years before dam removal, to provide adequate information on baseline conditions.

   The Klamath Basin is rich in existing data for many water quality constituents, although some topics remain somewhat understudied. Nonetheless, with the prospects of climate change and because of operational changes in river management that would be prescribed under KBRA or by the KHSA Interim Measures, it is prudent to ensure that data collection occurs immediately preceding dam removal so that any changes that are evaluated can be compared with appropriate baseline conditions. However, it is recognized that different constituents may require monitoring for different time periods to establish baseline conditions. For this exercise, most monitoring is assumed to require 2 years worth of data. Modifications to this assumption for specific monitoring components may be incorporated into the final monitoring plan.

2. Monitoring estimates for the MPL, Most Probable, and MPH costs include 1, 3, and 5 years following dam removal, respectively.

   A range of costs were desired for this exercise. The duration of monitoring post dam removal is a critical question in determining both the effectiveness and the costs of the monitoring plan. For the purposes of this document, various durations are assumed based on a-priori estimates of the amount of time needed to establish that changes related to dam removal have occurred. However, an alternative would be to base monitoring duration on a set of process-based endpoints such as the geomorphic stability of the channel in the current reservoir or downstream river reaches, the erosion of reservoir sediment, or reaching a required benchmark condition for water quality, periphytic or planktonic algal abundance. At this time, it is not possible to anticipate the final endpoints that could be specified in permits or by regulatory agencies following the Determination; therefore, it is most straightforward to use predetermined time periods for monitoring for the purposes of developing initial cost estimates.

3. Costs are approximate, in July 2010 dollars. Costs would be adjusted to 2020 dollars, including incorporation of contingencies, by Reclamation.

   Reclamation has been charged with developing overall cost estimates for KHSA, and has established procedures for adjusting cost estimates to 2020 dollars. It is important that such adjustments are done consistently for all estimated costs. It is therefore reasonable for Reclamation to take responsibility for the final adjustments to this monitoring estimate.

4. Existing networks would still be operational and funded from ongoing sources, and are not included in this list.

   Considerable related hydrologic and/or water quality work is currently being done or is proposed for the Klamath River Basin. This work is important as complimentary information for the proposed monitoring plan. However, this plan is solely focused on the dam removal and should not be the structure or funding source for maintaining the monitoring networks that are already in place. Chief among these are the existing stream gaging network, tribal monitoring program, and water quality/temperature monitoring programs by Reclamation and U. S. Forest Service (USFS).

5. Existing monitoring networks, with previously agreed upon methods, locations, protocols, and laboratories, would be used wherever possible or needed, in order to facilitate data comparison.

   It is important to maintain consistency with existing data collection efforts to ensure that data and products are compatible.

6. Biological monitoring for fish, invertebrates, and disease agents are covered separately and are not included in this plan. Algal monitoring, however, including periphyton, are covered as it is closely tied to nutrient dynamics and regulated water quality parameters.

   In the Klamath River Basin, algal issues are of primary importance and are intertwined with water quality. Reservoir blooms of cyanobacteria as well as periphyton effects on riverine dissolved oxygen (DO) and pH that have spurred development of Total Maximum Daily Loads (TMDLs) require algal monitoring to be coordinated if not incorporated into water quality monitoring networks. But there are obvious ties to fisheries-related disease work that may necessitate additional monitoring, and the two efforts should be coordinated.

7. Upstream and boundary condition data (including tributaries) are needed in order to evaluate longitudinal patterns and overall mass balancing of constituent loads.

Some locations that would not be directly affected by dam removal would nonetheless be important to include in a monitoring plan as they provide information on incoming constituent concentrations and loads that would be needed to understand changes resulting from dam removal. In particular, these locations include the Klamath River at Keno Reservoir and numerous tributary mouths between Keno and the Estuary.

8. Monitoring is solely directed at KHSA-related dam removal activities. If additional monitoring is needed for KBRA-related activities, it would be funded separately. Monitoring under KBRA Phase I is not explicitly considered or included here but is expected to be coordinated with KHSA-related monitoring.

   The monitoring framework and costs presented here are done for the purposes of anticipating costs associated with dam removal (i.e. KHSA). Restoration monitoring associated with KBRA is not included.

9. KBMP (Klamath Basin Monitoring Program) would continue from current funding sources as is currently being done, with no funding from the Secretarial Determination process.

   Coordination of monitoring in the basin is currently being accomplished through KBMP, which also serves to help standardize data collection protocols, data storage, and improve efficiency of data analysis efforts. While this is a valuable structure which could be used in conjunction with KHSA-related monitoring, future funding for KBMP is not included in the costs presented here.

10. Analysis of monitoring data is an important step in adaptive management and understanding the effects of dam removal. Costs are included here for analysis and reporting, on an annual basis.

    Data collection is important, and many agencies are able to muster the resources to collect data, particularly if it is legally mandated. However, reporting, analysis, and understanding of the data and their implications are often not accomplished because funds are not reserved for these efforts, thus limiting the utility and efficacy of the data collection efforts themselves. For the purposes of this KHSA-related monitoring program, an emphasis has been placed on annual or periodic reporting of data and technical data analysis. Reporting efforts differ by monitoring component because of their different needs and time scales.

The following components were assumed for the development of total costs for sediment and water quality monitoring:

1. Continuous Monitoring on Mainstem – Monitoring for water temperature, DO, pH, specific conductance, and turbidity; including data management, real time data display, shifting of unit values, and publication of results. Includes equipment, operation, and maintenance for 5 sites for up to 7 years.

2. Water Column Sampling – Monitoring for conventional constituents including nutrients, DOC, particulate organic carbon, TSS/VSS, alkalinity, BOD/CBOD, field parameters, QA/QC, and summer/fall sampling for algal toxins, beginning in 2020. Requires both monthly and event-based sampling at an estimated 24 sites, for up to 5 years.

3. Water Temperature Monitoring – Additional monitoring for water temperature in the mainstem and tributaries at approximately 30 sites, using two probes per site, for up to 7 years.

4. Contaminants – Monitoring for contaminants in water, suspended sediment, bed load, and fish on a quarterly basis and following special events, at approximately 5 sites, for up to 5 years.

5. Algae – Monitoring for periphyton before and after dam removal at approximately 10 sites, for up to 3 years.

6. Suspended Sediment Monitoring – Monitoring for suspended sediment on a quarterly basis and following special flow events, at approximately 5 sites in the river channel, for up to 10 years.

7. Bed Material – Monitoring of bed load materials on an annual basis, at approximately 15 sites, for up to 4 years.

8. Bed Profile Surveys – Boat surveys from Iron Gate damsite to Shasta River on an annual basis, for up to 4 years.

9. Reservoir Site Surveys – Topographic surveys of three reservoir sites to monitor changes and for vegetation monitoring, for 3 to 6 years.

10. Aerial Photography – Aerial photography from J.C. Boyle site to Scott River on an annual basis for up to 5 years.

11. Water Surface Profile Measurements – Monitoring water surface elevations at approximately 10 locations on an annual basis, for up to 7 years (correlated with flow measurements).

The total estimated cost for the sediment and water quality monitoring plan is provided in Attachment D. A range of 20 +/- percent was assumed for the MPL and MPH estimates.

9.8.2 Biological Monitoring for Fish and Invertebrates

No biological monitoring plans have been developed and no cost estimates have been prepared for this study. Biological monitoring for fish and invertebrates is assumed to be included under KBRA.

9.9 Cost Risk and Uncertainty

Some degree of cost risk and uncertainty is associated with each component in the cost estimates prepared for this study. Volumetric estimates for all features to be demolished and removed were based on design drawings provided by PacifiCorp, which are believed to represent current, as-built conditions. Although each damsite was inspected by members of the Engineering Subteam to confirm the existence of project features for which quantities have been prepared, no independent surveys or measurements have been taken. Production rates for demolition activities have been estimated based on assumed means and methods, which may be adversely impacted by future regulatory requirements, environmental constraints, or discovery of better construction techniques. Unusual weather conditions or labor shortages may also impact production rates and costs. Unit prices may be impacted by higher fuel prices, material costs, labor rates, and equipment costs than those assumed. Changes in both regional and/or the overall country's economic conditions may impact the bidding environment and the overall price magnitude. Because of these uncertainties, cost risk modeling methods were used to help quantify these uncertainties and their potential impacts on the total project costs.

Potential risks and the associated costs were identified and evaluated using a Monte Carlo-based simulation process. Monte Carlo simulation is a problem-solving technique used to approximate the probability of certain outcomes by running multiple trials using random variables, called simulations. It is based on a computerized mathematical technique that accounts for risk in quantitative analysis and decision making. Monte Carlo simulations furnish the decision maker with a range of possible outcomes and the probabilities with which they would occur. For each uncertain variable in a simulation, the possible values are defined using probability distributions. The type of distribution selected depends on the factors surrounding the variable. Some of the commonly used distributions in the cost risk models are normal, triangular, and beta-pert.

Monte Carlo simulation performs risk analysis by building models of possible results by substituting a range of values (probability distributions) for any factor that has inherent uncertainty. Values are sampled at random from the input probability distributions during simulation runs. Each set of samples is called an iteration, and the resulting outcome from that sample is recorded. The Monte Carlo simulation was run for 10,000 iterations to model the forecast values for Contract Cost, Field Cost, and Total Construction Cost for each feature.

For this project, the Monte Carlo simulation and risk analysis was performed using Oracle Crystal Ball software. The software uses inputs, or assumptions, to define the range of uncertainties associated with variables and outputs, or forecasts, to calculate results based on simulations. Triangular distributions were typically selected to model risks and assumptions for quantities associated with individual pay items. Beta pert distributions were typically used to model risks and assumptions assigned for unit prices. Deterministic methods were used to estimate the range of possible values for the unit prices and quantities of each item. Input value ranges were modeled in the Crystal Ball tool and categorized in ranges as follows:

Most Probable Estimate (MP). A compilation of pay items, quantities, and unit prices representing the Designer's and Cost Estimator's best opinion and assessment of the scope of work and cost for the project.

Probable Low Estimate (MPL). A compilation of pay items, quantities, and unit prices representing the Designer's and Cost Estimator's more optimistic opinion and assessment of the scope of work and cost for the project.

Probable High Estimate (MPH). A compilation of pay items, quantities, and unit prices representing the Designer's and Cost Estimator's more conservative opinion and assessment of the scope of work and cost for the project.

Allowances (e.g. contingencies, non-contract costs), computed as a percentage, were modeled within each features' Monte Carlo simulation.

For each of the forecast values, a probability curve and sensitivity chart were developed for use by management to understand the risks and probabilities of the estimated project costs for each feature. These charts and curves are included in Attachment F. The probability curves provide a tool to understand the potential range of costs possible for the project and the associated probability for each project cost to occur. Similarly, the sensitivity charts help to provide an understanding of those items (either quantity and/or cost components) in the model that introduce the greatest amount of risk for each forecast assumption. Sensitivity analyses help determine which inputs affect forecasts the most so that risk mitigation efforts can be concentrated on those factors. The sensitivity chart ranks the assumptions from the most important down to the least important in the model. For this analysis, the non-contract costs, escalation from current price level to NTP (Notice to Proceed), and other percent-based allowances (i.e. contingencies) were driving factors for variation in the Total Construction Cost forecast value.

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