AECOM

# Klamath River Renewal Project

## California Environmental Quality Act (CEQA) and California and Oregon 401 Water Quality Certifications Technical Support Document

**Submitted to:** California State Water Resource Control Board and Oregon Department of Environmental Quality

**Submitted by:** Klamath River Renewal Corporation

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**Prepared for:**

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# Table of Contents

## Figures

## Tables

## Appendices

## List of Abbreviations and Acronyms

| | |
|---|---|
| ACHP | Advisory Council on Historic Preservation |
| ACM | Asbestos Containing Material |
| ADA | Americans with Disabilities Act |
| AR | Aquatic Resources |
| ATWG | Aquatic Technical Work Group |
| BCE | before the Common Era |
| BLM | Bureau of Land Management |
| CA | California |
| Caltrans | California Department of Transportation |
| CDFW | California Department of Fish and Wildlife |
| CE | California Endangered |
| CEII | Critical Energy/Electric Infrastructure Information |
| CEQA | California Environmental Quality Act |
| cfs | cubic feet per second |
| CFM | Cubic Feet per Minute |
| CFR | Code of Federal Regulations |
| CHP | California Highway Patrol |
| CHR | Cultural and Historic Resources |
| CMP | Corrugated Metal Pipe |
| CNDDB | California Natural Diversity Database |
| COD | Chemical Oxygen Demand |
| CORP | Central Oregon and Pacific Railroad |
| CRHR | California Register of Historical Resources |
| CSSC | California Species of Special Concern |
| CT | California Threatened |
| CY | cubic yards |
| D | Diameter |
| DEM | Digital Elevation Model |
| DSOD | California Division of Safety of Dams |
| DWR | California Department of Water Resources |
| EAP | Emergency Action Plans |
| EIR | Environmental Impact Report |
| EIS/R | Environmental Impact Statement/Report |
| EM | Engineering Manual |
| EPA | Environmental Protection Agency |

| | |
|---|---|
| ESA | Endangered Species Act |
| FC | Federal Candidate Species |
| FE | Federal Endangered |
| FEMA | Federal Emergency Management Agency |
| FERC | Federal Energy Regulatory Committee |
| FP | Fully protected |
| FSC | Federal Species of Concern |
| FT | Federal Threatened |
| $ft^2$ | feet squared |
| GHG | Green House Gas |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| GW | Groundwater |
| H | Horizontal |
| HABS | Historic American Building Survey |
| HAER | Historic American Engineering Record |
| HALS | Historic American Landscape Survey |
| HEC-RAS | Hydrologic Engineering Center River Analysis System |
| hp | horsepower |
| I | Interstate |
| IEV | Invasive Exotic Vegetation |
| IGH | Iron Gate Hatchery |
| IM | Interim Measure |
| IPaC | Information for Planning and Conservation |
| JPBO | Joint Preliminary Biological Opinion |
| KBMP | Klamath Basin Monitoring Program |
| KBRA | Klamath Basin Restoration Agreement |
| KHHD | Klamath Hydroelectric Historic District |
| KHSA | Klamath Hydroelectric Settlement Agreement |
| KRRC | Klamath River Renewal Corporation |
| kV | kilovolt |
| kVA | kilovolt amperes |
| lb | pound |
| LBP | Lead Based Paint |
| LKP | Lower Klamath Project |
| MBTA | Migratory Bird Treaty Act |
| MOA | Memorandum of Agreement |
| MVA | Megavolt-amperes |
| MW | Megawatt |
| N/A | Not Applicable |
| NAGPRA | Native American Graves Protection and Repatriation Act |
| NAHC | Native American Heritage Commission |
| NAVD | North American Vertical Datum |
| NISIMS | National Invasive Species Information Management System |
| NGVD | National Geodetic Vertical Datum |
| NMFS | National Marine Fisheries Service |

| | |
|---|---|
| No. | Number |
| NRHP | National Register of Historic Places |
| NSO | Northern Spotted Owl |
| NW | Northwest |
| OC | Candidate listing by ODA |
| ODA | Oregon Department of Agriculture |
| ODEQ | Oregon Department of Environmental Quality |
| ODFW | Oregon Department of Fish and Wildlife |
| ODOT | Oregon Department of Transportation |
| OE | Listed as endangered by ODA or ODFW |
| ONHP | Oregon Natural Heritage Program |
| OR | Oregon |
| ORBIC | Oregon Biodiversity Information Center |
| ORS | Oregon Revised Statute |
| OSS | Oregon Sensitive Species |
| OT | Listed as threatened by ODFW |
| OWRD | Oregon Water Resources Department |
| PCB | Polychlorinated Biphenyls |
| PIT | Passive Integrated Transponder |
| PRO | Partial Removal Option |
| QA | Quality Assurance |
| QAP | Quality Assurance Plan |
| QC | Quality Control |
| RM | River Mile |
| RT | Round Trip |
| RWS | Reservoir Water Surface |
| RV | Recreational Vehicle |
| SAP | Sampling Analysis Plan |
| SE | Southeast |
| SDOR | Secretarial Determination of Record |
| SHPO | State Historic Preservation Office |
| sUAS | small Unmanned Aircraft System |
| SWPPP | Storm Water Pollution Prevention Plan |
| SWRCB | California State Water Resources Control Board |
| SPT | Standard Penetration Test |
| TCPs | Traditional Cultural Properties |
| TER | Terrestrial Resources |
| TMP | Transportation Management Plan |
| TSS | Total Suspended Sediments |
| U.S. | United States |
| USACE | United States Army Corps of Engineers |
| USBR | United States Bureau of Reclamation |
| USFS | United States Forest Service |
| USFWS | United States Fish and Wildlife Service |
| USGS | United States Geological Survey |
| V | Vertical |

| | |
|---|---|
| WQ | Water Quality |
| WSE | Water Surface Elevation |
| WY | Water Year |

# 1. Report Objectives & Background

## 1.1 Report Objectives

The primary objective of this Technical Support Document is to provide the California State Water Resources Control Board (SWRCB) and the Oregon Department of Environmental Quality (ODEQ) the information they require to prepare the Clean Water Act Section 401 Water Quality Certifications (401 Certifications) for the Lower Klamath Project, also referred to as the Klamath River Renewal Project (Project). The 401 Certifications are required before the Federal Energy Regulatory Committee (FERC) can issue a final surrender order for the Project.

In addition, this document provides the latest available technical and field information developed by the Klamath River Renewal Corporation and its consultants (KRRC), for SWRCB's use in preparation of an Environmental Impact Report (EIR) consistent with the California Environmental Protection Act (CEQA).

The SWRCB and ODEQ communicated their specific information needs via letters dated August 24, 2017 and July 19, 2017, respectively. Copies of the Additional Information Request letters can be found in Appendix A. Table 1.1-1 and 1.1-2 below provide summaries of the requested information and where that information can be found in this Technical Support Document.

### Table 1.1-1 SWRCB Additional Information Request Items

| SWRCB Request Number | Request Name | Technical Support Document Section | Notes |
|---|---|---|---|
| General 1 | 2017 Studies | - | Provided in transmittal letter |
| General 2 | USACE CWA 404 permit | - | Provided in transmittal letter |
| General 3 | Hot Springs at Shovel Creek | 3.8 | - |
| 1 | Iron Gate Fish Hatchery | 8.10 | Additional detail to be provided in near-future |
| 2 | Copco 1 Dam Removal Elevation | 3.6 | - |
| 3 | Reservoir Slope Stability and Drawdown Rates | 3.3, 4.5, 4.6.3 | 3.3 (stability assessments); 4.5 (monitoring); 4.6.3 (stability measures) |
| 4 | Copco 2 Dam Development | 5.4 | - |
| 5 | Mitigation Measures | 8 | Section 7 includes numerous Project components that were previously identified as mitigation measures |
| 6a | Reservoir Drawdown and Streamflow Diversion | 4 | - |
| 6b | Reservoir Area Restoration Plan | 6.1, | - |

| | | | |
|---|---|---|---|
| | | Appendix G | |
| 6c | Water Quality Monitoring Plan | 7.7.2 | - |
| 6d | Waste Disposal Plan | 5.1, 5.2, 5.3, 5.4, 5.5, 7.7.5 | Summary of specific request items in Section 5.1 |
| 6e | Groundwater Well Management Plan | 7.7.3 | - |
| 6f | City of Yreka Water Supply Plan | 7.5 | - |
| 6g | Habitat Restoration Plan Outside of Reservoir Areas | 6.2 | - |
| 6h | Road Management Plan | 5.2.2, 5.3.2, 5.4.2, 5.5.2, 7.4 | - |
| 6i | Fire Management Plan | 7.7.4 | - |
| 6j | Recreation Facilities Removal and Management | 7.6, 8.9 | - |
| 6k | Eagle and Other Migratory Bird Conservation Plan | 7.3, Appendix E | - |
| 6l | Traffic Management Plan | 7.7.1 | - |
| 6m | Hazardous Material Management Plan | 7.7.5 | - |
| 6n | Emergency Response Plan | 7.7.6 | - |
| 6o | Noise and Vibration Control Plan | 7.7.7 | - |

## Table 1.1-2 ODEQ Additional Information Request Items

| ODEQ Request Number | Request Name | Technical Support Document Section | Notes |
|---|---|---|---|
| a | Section 401 Water Quality Certification | - | - |
| b | Army Corps 404 Permit | - | Provided in transmittal letter |
| c | NPDES 1200C Construction Stormwater Permit | - | - |
| d | J.C. Boyle Emergency Spillway Restoration Plan | 5.2.3, 6.2 | - |
| e | J.C. Boyle Waste Disposal Plan | 5.2.7 | - |
| f | J.C. Boyle Removal Limits | 5.2 | - |
| g | Reservoir Drawdown Plan | 4 | - |
| h | Embankment Stability and Drawdown Rates | 3.2, 3.3 | - |
| i | Emergency Spillway during | 4.4.2 | - |

| | | | |
|---|---|---|---|
| | Drawdown | | |
| j | Sediment Estimate | 3.7 | - |
| k | Reservoir Restoration Plan | 6, Appendix G | - |
| l | Hydro-Seeding and Nutrient Control | 6, Appendix G | - |
| m | Planting Species and Soil Characteristics | 6, Appendix G | - |
| n | Hazardous Materials Management Plan | 7.7.5 | - |
| o | Water Quality Monitoring Plan | 7.7.2 | - |
| p | Mitigation Measures | 8 | Section 7 includes numerous Project components that were previously identified as mitigation measures |
| q | Aquatic Resources Mitigation Measures | 7.2, Appendix H | - |
| r | Terrestrial Resource Mitigation Measures | 7.3, Appendix E | - |
| s | Groundwater Mitigation Measure | 7.7.3 | - |
| t | Water Supply/Water Rights Mitigation Measure | 8.2 | - |

## 1.2 Background and Project Summary

The proposed Project includes the decommissioning and removal of four dam developments (Iron Gate, Copco No. 1 and No. 2, and J.C. Boyle) on the Klamath River approximately 200 miles from the Pacific Ocean in the states of Oregon and California by the KRRC (see Figure 1.2-1). The four dam developments (facilities) are currently owned by PacifiCorp, and a formal Transfer Application was submitted to the FERC jointly by PacifiCorp and the KRRC that would result in KRRC ownership of the license and facilities if approved by FERC. Up until the time of the Transfer Application, the facilities were part of FERC Project 2082. As part of the Transfer Application, PacifiCorp and the KRRC requested and FERC approved designation of the facilities as the "Lower Klamath Project" under new Project 14803. The KRRC has submitted a separate Surrender Application to FERC for Project 14803 that, if approved, would allow the KRRC to decommission the facilities. Figure 1.2-1 provides an overview of the Klamath River watershed and the locations of the four dams. Figure 1.2-2 (C) provides an overview of the project area and the major access routes to the area.

Prior to removal of the dams and hydropower facilities, the water surface elevation in each reservoir will be drawn down as low as possible to facilitate accumulated sediment evacuation and to create a dry work are for facility removal activities.  Section 4 describes the drawdown timing and duration, as well as any infrastructure modifications necessary to facilitate drawdown.  In general, drawdown will begin on January 1 of the drawdown year, and will extend through March 15 of the same year.

After drawdown is accomplished, remaining reservoir sediments will be stabilized to the extent feasible, as described in Section 6, and dam and hydropower facility removal will begin. Section 5 details the facility removal and summarizes pertinent activities, material volumes, truck trips and other construction means and methods information.

Full reservoir area restoration will also be accomplished as described in Section 6, and will begin after drawdown, and extend throughout the year, and possibly extend into the subsequent year. Vegetation establishment could extend several years.

Other key project components include measures to reduce Project related effects to aquatic and terrestrial resources, road and bridge improvements, relocation of the City of Yreka's pipeline across Iron Gate Reservoir and associated diversion facility improvements, as well as demolition of various recreation facilities adjacent to the reservoirs. These other project components are summarized in Section 7.

The KRRC submitted a letter to the SWRCB on June 1, 2017 that referenced Sections 4, 6, 7 and 8 from the 2012 Detailed Plan (USBR 2012b), noting that the information contained in those sections constituted an accurate summary of the associated Project components. It was also noted in the letter that, as new information became available, the KRRC would assess whether the new information resulted in any changes to the Project described in the Detailed Plan. Changes or refinements to the Project description, resulting from new information or analyses, are summarized in the numbered list below, and further detailed in the referenced sections of this document.

1. Copco No. 1 Dam Modifications: The Detailed Plan (USBR 2012b) included sequential dam notching activities as part of the reservoir drawdown. Due to constructability and schedule risks associated with this activity, it is no longer included in the Project. The revised dam modification activities at Copco No. 1 include a larger new gate to be installed on the downstream end of the existing diversion tunnel, to be used as the primary mechanism for reservoir drawdown. Additional detail on the refined approach, and the risks associated with the discarded nothing option, can be found in Sections 5.2 and 4.

2. Maximum Reservoir Drawdown Rate: Based on the stability analyses and assessments summarized in Sections 3.2 and 3.3, the maximum recommended drawdown rate is 5 feet per day. Associated drawdown plans for each facility are discussed in Section 4.

3. Material Quantities: Material quantities have been refined and updated to reflect the latest understanding of the work. Material quantities are summarized in text and table format for each facility in Sections 5.2, 5.3, 5.4 and 5.5.

4. Aquatic and Terrestrial Resource Measures: Aquatic and terrestrial resource measures have been refined from the previous AR and TER mitigation measures included in the 2012 EIS/R (USBR and CDFW 2012), and these measures are now included in the Project description. The process included collaboration with state and federal fisheries and other biological resource agencies, to develop measures that have the highest potential to reduce Project related effects, using the latest science and case

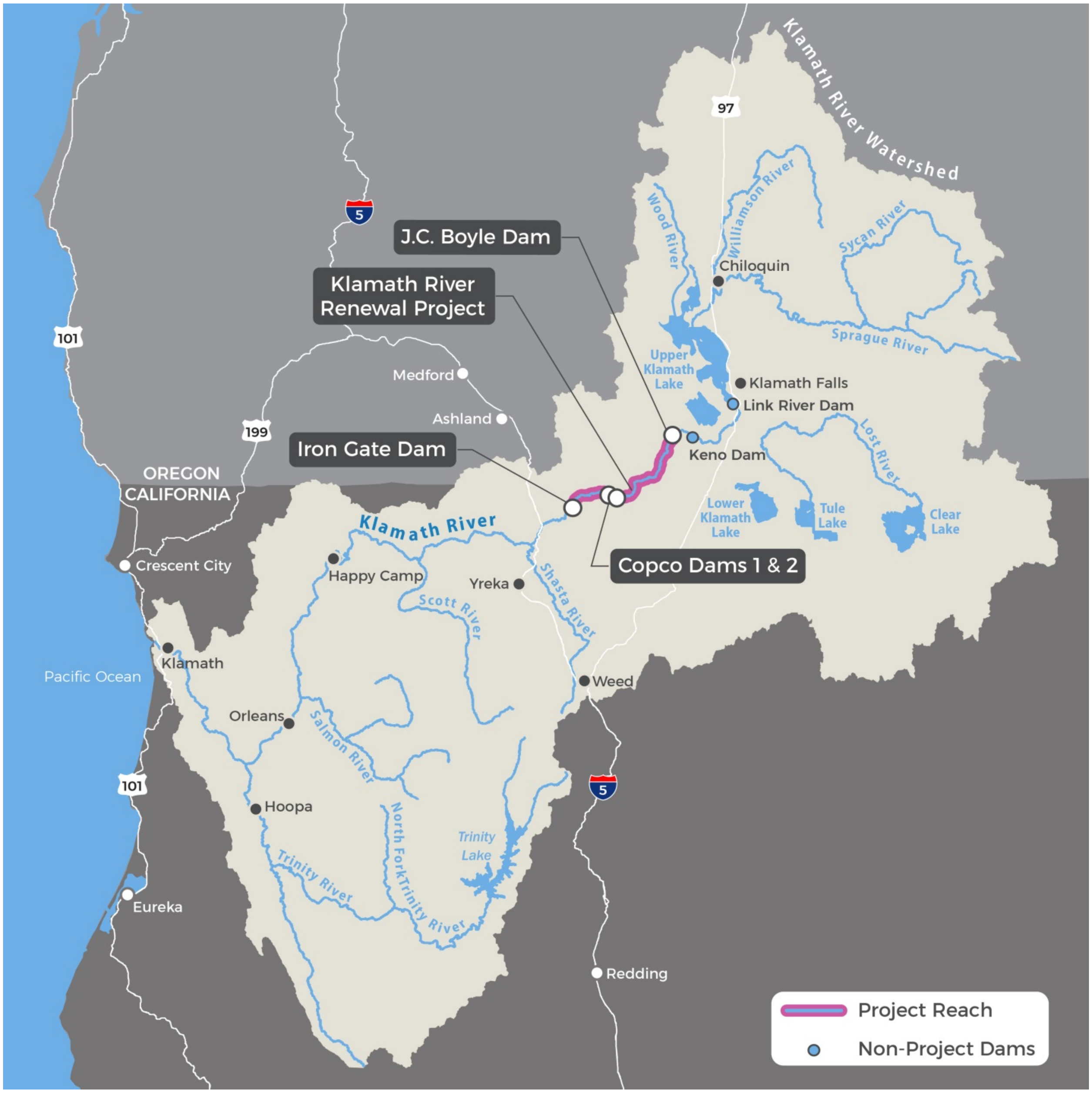
studies available. Measures are summarized in Sections 7.2 and 7.3, with further detail provided in Appendices E and H.

5. Partial Removal Options: While full removal is preferred at each facility location, an option for leaving some existing infrastructure is included. A list of these optional items to remain is included in table format at the beginning of Sections 5.2, 5.3, 5.4 and 5.5.

6. Road and Bridge Improvements: Field and technical assessments concerning road and bridge improvements required for construction access, or to address Project related effects, have updated the understanding of what is required for the Project. Refined construction access improvements are summarized in Section 5, while road improvements required to address Project related effects are summarized in Section 7.4.

7. City of Yreka Waterline Relocation: The Detailed Plan (USBR 2012b) included an overhead pipe bridge as the pipeline relocation solution for the Project. Due to ongoing technical assessments and discussions with the City of Yreka, there are three possible options for waterline relocation included in this document. Each option is described in Section 7.5 and should be analyzed in CEQA for possible implementation.

To the extent that there is conflicting information in this document relative to the 2012 Detailed Plan, the information in this document supersedes the information in the Detailed Plan.




## Figure 1.2-1 Klamath River Watershed and Facilities Locations

## Figure 1.2-2 Project Vicinity and Access (Appendix C)

## 1.3 Elevations and Measurement Corrections

Previous documents and reports prepared for the Project facilities used older datum sources and outdated measurement techniques. When applicable, numbers cited in this report have been updated. Elevations were previously noted in project datum, which is the National Geodetic Vertical Datum of 1929 (NGVD29). Elevations were converted from project datum to

North American Vertical Datum of 1988 (NAVD88) according to Table 1.3-1. In addition, some older documents provide elevations in local datum (a datum relevant to only specific locations in the Lower Klamath Project), and elevations were converted from local datum to NAVD88 according to Table 1.3-1.

River miles (the distance a river feature or location is demarked from the Pacific Ocean in river miles ((RMs)) were previously incorrectly calculated; the river mile locations noted in this report have been updated using the same river route as the previous markers but with new distance calculations. A sampling of river mile conversion from those noted in the Detailed Plan (U.S. Bureau of Reclamation (USBR) 2012) can be found in Table 1.3-2. Areas and acreages previously reported have also been updated using GIS.

### Table 1.3-1 Elevation Conversion Factors

| Location | From project datum (NGVD29) to NAVD88 | From local datum* to NAVD88 |
|---|---|---|
| J.C. Boyle | + 3.71 feet | |
| Copco No. 1 | + 3.48 feet | + 2414.48 feet |
| Copco No. 2 | + 3.48 feet | +2214.48 feet |
| Iron Gate | + 3.33 feet | |

* Local datums were used during design and construction of Copco No. 1 and No. 2

### Table 1.3-2 River Mile Comparison

| Location | River Mile in Detailed Plan | River Mile in Technical Support Document |
|---|---|---|
| Upstream end of J.C. Boyle Reservoir | 228 | 233.3 |
| J.C. Boyle Dam | 224.7 | 229.8 |
| J.C. Boyle Powerhouse | 220 | 225.2 |
| Upstream end of Copco Lake | 204 | 208.3 |
| Copco No. 1 Dam | 198 | 201.8 |
| Copco No. 2 Dam | 199 | 201.5 |
| Copco No. 2 Powerhouse | 196 | 200.0 |
| Upstream end of Iron Gate Reservoir | 197 | 200.0 |
| Iron Gate Dam | 190 | 193.1 |

## 1.4 Document Organization

The sections in the document are organized as follows:

- **Section 1 – Report Objectives & Background**: describes the objectives of the document, background on the Project, corrections to elevations and river miles from previous documents, and document organization.
- **Section 2 – Existing Feature Descriptions**: describes the existing features and facilities of the four dams and their powerhouses.
- **Section 3 – Field & Technical Assessments**: describes field data collection and analyses conducted for the preparation of this document.
- **Section 4 – Reservoir Drawdown & Diversion Plan**: describes the drawdown facilities, process, flows and sediment releases, monitoring, adaptive management measures, and inadvertent discovery plan.
- **Section 5 – Dam Removal Plans**: describes the removal limits, construction access, staging and disposal areas, removal process, demolition methods and equipment, imported materials, and waste disposal for the four dams and powerhouses.
- **Section 6 – Reservoir and Other Restoration**: describes the restoration plan for the former reservoir areas and other areas disturbed by the Project.
- **Section 7 – Other Project Components**: describes other features of the Project including aquatic and terrestrial resources measures, long-term road improvements, Yreka water supply improvements, recreation facilities demolition/restoration, and other resource management plans.
- **Section 8 – Mitigation Measures**: provides a summary of proposed mitigation measures for the various resource areas
- **Section 9 – References**: provides citations for references used in the document.
- **Figures**: figures are provided throughout the document text as well as in two appendices. Figures throughout the document are numbered according to their respective subsection and then sequentially. Figures that can be found in an appendix are noted after the figure number with a letter in parentheses. For example, Figure 2.1-2 is associated with the text of Section 2.1 and would be found in the text; whereas, Figure 2.1-3 (B) would be found in Appendix B.
  - Appendix B includes figures designated as Critical Energy Infrastructure Information (CEII) and thus cannot be shared generally. Appendix B will only be provided to specific agencies and individuals according to FERC rules and regulations.
  - Appendix C contains non-CEII figures referred to in the text.

# 2. Existing Feature Descriptions

The following feature descriptions are based on information and drawings provided by PacifiCorp for this study.

## 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 gravity dam, gated spillway, diversion culvert, water conveyance system, and powerhouse located on the Klamath River between RM 233.3 and RM 225.2, in Klamath County, Oregon. Refer to Figure 2.1-1 (C) for plan views of these features.

**Figure 2.1-1 J.C. Boyle Dam Existing Features (Appendix C)**

J.C. Boyle Dam was completed in 1958 at RM 229.8, and is downstream of Keno Dam and upstream of Copco No. 1 Dam. The primary purpose of the facility is to generate hydroelectric power. Structures at the site include an office building (known as the Red Barn), maintenance shop, fire protection building, communications building, two occupied residences near the dam, and a large warehouse near the powerhouse.

### 2.1.1 Reservoir

J.C. Boyle Dam impounds a narrow reservoir of 350 acres (J.C. Boyle Reservoir) and according to a 2003 bathymetric survey (Eilers and Gubala 2003), provides approximately 2,267 acre-feet of total storage capacity at reservoir water surface (RWS) elevation 3797.2[1]. The maximum and minimum operating levels are between RWS elevations 3796.7 and 3791.7, a vertical operating range of 5 feet, although the reservoir is normally maintained at RWS elevation 3796.7, or 0.5 feet below the top of the spillway gates.

### 2.1.2 Dam, Spillway, and Diversion Culverts

The dam is composed of an earthen embankment section, fish ladder, spillway and diversion culverts, intake to the powerhouse, and concrete gravity section (from right abutment to left abutment, looking downstream). The dam is shown in Figure 2.1-2.

[1] All elevations in this Technical Support Document are in NAVD88 vertical datum. Previously reported elevations were in project datum. See Table 1.3-1 for conversion factors.

*Credit: River Design Group*

**Figure 2.1-2 J.C. Boyle Dam**

The earthfill embankment portion is 68 feet tall (on the dam axis at its maximum height above the original streambed elevation 3735.7) with a 15-foot-wide crest and a crest length of 430 feet at elevation 3803.7 (Figure 2.1-3 (B)). 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 above elevation 3783.7 has a 2½H:1V slope with a 3-foot-thick riprap layer, and a 3H:1V slope below elevation 3783.7. The downstream face has a 2½H:1V slope, with a 2-foot-thick riprap layer below approximately elevation 3771.7. A 3-foot-high concrete cutoff wall is provided along the bedrock foundation about 7 feet upstream of the dam axis.

**Figure 2.1-3 Cross Section of J.C. Boyle Dam (Appendix B)**

The concrete portion of the dam is 279 feet long and from right to left (looking downstream) 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 (Figure 2.1-4 (B)).

**Figure 2.1-4 Elevation of J.C. Boyle Spillway and Diversion Culverts (Appendix B)**

The spillway section is a concrete gravity overflow structure with three 36-foot wide by 12-foot high radial gates and upstream stoplog slots (Figure 2.1-5 (B)). The spillway crest is at elevation 3785.2, with the top of gates at elevation 3797.2 (0.5 feet above the normal operating level). A traveling gate hoist is provided for operation of the spillway gates. The spillway bays discharge 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 3796.7 with all three gates open is 15,400 cubic feet per second (cfs).

**Figure 2.1-5 Cross Section of J.C. Boyle Dam Spillway (Appendix B)**

A concrete box culvert with two 9.5- by 10-foot bays is located beneath the center and right spillway gates at invert elevation 3755.2 (30 feet below the spillway crest, as shown in Figure B2.1-4 (B)). 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.

### 2.1.3 Intake, Fish Screens, and Fish Ladder

The intake structure is located to the left of the spillway and consists of a 40-foot-high reinforced concrete tower (Figure 2.1-6). It has four approximately 11-foot by 37-foot 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 cfs to the Klamath River below the dam. A fabricated metal building was added to the intake structure in 1989. Downstream of the traveling fish 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 concrete pool and weir fish ladder located along the abutment wall between the embankment and concrete sections. The fish ladder is approximately 569 feet long with 63 pools. Reservoir releases to the fish ladder are regulated by a 24-inch slide gate, and the fishway operates over a head range of approximately 61 to 66 feet.

**Figure 2.1-6 J.C. Boyle Intake Structure**

### 2.1.4 Water Conveyance to Powerhouse

A water conveyance system connects the dam to the powerhouse and has a total length of 2.56 miles. The conveyance system from upstream to downstream consists of a steel pipeline, a headgate, a canal, a forebay, a tunnel, and 2 penstocks connecting to the powerhouse.

From the intake structure at the dam, 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 concrete-lined canal (the power canal).

The power canal is nearly 2.2 miles long and located along a bench cut in the slope of the river canyon (Figure 2.1-7). Depending on the terrain, the canal either has walls on the down-slope side only or on both the down-slope and up-slope sides. The canal is a concrete flume approximately 17-feet wide and 12-feet high, with shotcrete applied to the canyon walls where exposed. It has overflow structures at the upstream end (consisting of a siphon pipe) and at the downstream forebay (consisting of a gated overflow weir).

**Figure 2.1-7 J.C. Boyle Power Canal (left) and Klamath River Bypass Reach (right)**

The forebay is a somewhat enlarged area at the end of the power canal that connects to the tunnel, the next downstream component in the water conveyance system. The forebay has an overflow or spillway equipped with two float-operated automatic spill gates, which release water from the canal during a hydraulic surge 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 (between the dam and powerhouse) via a large eroded channel (or scour hole) in the hillside (Figure 2.1-8). A forebay sluiceway pipe has been abandoned in place.

**Figure 2.1-8 Forebay Overflow Chute and Upper Portion of Scour Hole**

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 (Figure 2.1-9) 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.

**Figure 2.1-9 J.C. Boyle Forebay and Tunnel Trash Rack (left)**

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 (Figure 2.1-10). A 108-inch-diameter butterfly valve is provided at the downstream end of each penstock.

**Figure 2.1-10 J.C. Boyle Penstocks**

### 2.1.5 Powerhouse

A conventional outdoor-type reinforced concrete powerhouse (Figure 2.1-11) is located on the right bank of the river and approximately 4.7 river miles downstream of the dam, at RM 225.2, and is the largest power generating facility in the Lower Klamath Project. The two turbines are vertical-shaft, Francis-type units with a total rated discharge capacity of 2,850 cfs. The turbines are rated at 75,700 horsepower (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.

Figure 2.1-11 J.C. Boyle Powerhouse

The generators are rated at 53 megavolt-amperes (MVA) for Unit 1, with a 0.95 power factor (50 megawatts (MW)), and 50 MVA for Unit 2, with a 0.95 power factor (48 MW). The power from the powerhouse is transmitted a very short distance to the adjoining J.C. Boyle substation. Two three-phase transformers step up the generator voltage for transmission interconnection. Line No. 58 (to Lone Pine) and Line No. 59 (to Klamath Falls) extend from the J.C. Boyle substation to a line tie. There is also a third 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, but based on field observation and aerial photos this line appears to have been removed.

### 2.1.6 Site Access

Site access is provided from Oregon Route 66 (OR66, Green Springs Highway) and from Topsy Grade Road via a network of unpaved project access roads. A small timber bridge crosses the Klamath River downstream of the dam.

#### 2.1.7 Recreation Facilities

Recreation facilities include Topsy Campground (managed by the Bureau of Land Management, BLM), Pioneer Park east and west units (managed by PacifiCorp), and numerous smaller dispersed shoreline recreation sites.

## 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 208.3 and RM 201.8, in Siskiyou County, California. Refer to Figure 2.2-1 (C) for plan views of these features.

**Figure 2.2-1 Copco No. 1 and Copco No. 2 Dams Existing Features (Appendix C)**

Copco No. 1 Dam was constructed between 1911 and 1922 at RM 201.8, 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. Numerous residences are located along the shoreline of Copco Lake. Structures at the site include an occupied residence with small garage, a vacant house, and a maintenance building.

#### 2.2.1 Reservoir

Copco No. 1 Dam impounds a reservoir of approximately 972 acres (Copco Lake) and according to a 2003 bathymetric survey (Eilers and Gubala 2003), provides approximately 33,724 acre-feet of total storage capacity at RWS elevation 2611.0[2]. The maximum and minimum reservoir operating levels are between RWS elevations 2611.0 and 2604.5, a vertical operating range of 6.5 feet, although the reservoir is normally maintained at RWS elevation 2609.5, or 1.5 feet below the top of the spillway gates.

#### 2.2.2 Dam, Spillway, and Diversion Tunnel

The dam is composed of a concrete gravity arch which also functions as a spillway, diversion culverts, and intakes to the powerhouse. The dam is shown in Figure 2.2-2.

[2] All elevations in this Technical Support Document are in NAVD88 vertical datum. Previously reported elevations were in project datum. See Table 1.3-1 for conversion factors.

Figure 2.2-2 Copco No. 1 Dam (right) and Powerhouse (left)

The dam is a concrete gravity arch structure approximately 133 feet tall to the top of the spillway deck, with a 492-foot radius at the upstream face. The crest length between the rock abutments is approximately 410 feet at elevation 2616.5. 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 2597.0 (Figure 2.2-3 (B)). Three traveling gate hoists are provided for operating the spillway gates, and stoplog slots are provided upstream of each opening.

Figure 2.2-3 Cross Section of Copco No. 1 Spillway (Appendix B)

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 (Figure2.2-4 (B)). The estimated spillway discharge capacity at RWS elevation 2611.0 with all 13 gates fully open is 35,000 cfs.

**Figure 2.2-4 Cross Section of Copco No. 1 Dam (Appendix B)**

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 (Figure 2.2-5). A gated concrete intake structure, which regulated flows during construction, is located at the upstream end of the tunnel and has three 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 using gate stems and wire ropes from hoists located on a concrete deck upstream of the left abutment of the dam. The current condition of the valves and upstream tunnel is unknown as they are submerged by reservoir sediment. The existing hoists, stems, and wire ropes were abandoned in place and are not currently operational.

**Figure 2.2-5 Copco No. 1 Diversion Tunnel Downstream Portal**

### 2.2.3 Water Conveyance to Powerhouse

The intakes for the three penstocks, two 10-foot diameter and one 14-foot diameter (Figure 2.2-6), are located at the right abutment at approximately invert elevation 2578.5[3]. Two cast-iron slide gates are provided for each penstock, with electric motor hoists located in two concrete gatehouses. The two 10-foot-diameter (reducing to 8-foot diameter) steel penstocks closest to the river feed Unit No. 1 in the powerhouse, and the 14-foot-diameter (splitting and reducing to two 8-foot diameter) steel penstock feeds Unit No. 2. Trash racks with bar spacing of 3 inches are provided in front of each intake.

A third generating unit at the powerhouse was planned, but never built. Some conveyance facilities (two slide gates and a short penstock section) were built to the right of the existing penstocks for this possible future expansion.

**Figure 2.2-6 Copco No. 1 10-ft (left and middle) and 14-ft (right) Penstocks**

[3] PacifiCorp's Supporting Technical Information Document and the Detailed Plan show the intakes having an invert of 2578.5 ft (NAVD88). 1921 as-built drawings for the 14-foot penstock show an invert of 2575.5 ft (NAVD88).

### 2.2.4 Powerhouse

The Copco No. 1 Powerhouse (Figure 2.2-7) 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 3,650 cfs. The turbines have a rated output of 21,759 hp and 18,600 hp for unit 1 and 2, respectively, with a net head of 125 feet. No bypass capacity is provided.

The generators are each rated at 12,500 kilovolt-amperes (kVA) with a 0.8 power factor (10 MW). Unit 1 has three indoor, single-phase 5,000-kVA, 2,300/72,000-volt (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 upslope of 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.

**Figure 2.2-7 Copco No. 1 Powerhouse**

### 2.2.5 Site Access

Site access is provided from Interstate 5 via Copco Road, and then by a steep and narrow access road to the dam right abutment and powerhouse. Copco Road provides access to the north side of the reservoir. Ager-Beswick Road provides access to the south side of the reservoir, and is an extension of the Topsy Grade Road in Oregon.

### 2.2.6 Recreation Facilities

Recreation facilities include Mallard Cove and Copco Cove (both managed by PacifiCorp), and smaller dispersed shoreline recreation sites.

## 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 201.8 and RM 200.0, in Siskiyou County, California. Refer to Figure 2.2-1 (C) for plan views of these features.

The dam was completed in 1925 approximately 0.3 mile downstream of Copco No. 1 Dam at RM 201.5, while the powerhouse is located at RM 200.0, just upstream of Iron Gate Reservoir. The purpose of the facility is to generate hydroelectric power.

Structures near the powerhouse include a control center building, maintenance building, and oil and gas storage building. The nearby Copco 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.

### 2.3.1 Reservoir

The reservoir created by Copco No. 2 Dam is approximately 0.3 mile long (unnamed), and has a total storage capacity of approximately 70 acre-feet at the normal operating RWS elevation 2486.5[4].

### 2.3.2 Dam and Spillway

The dam is composed of a concrete gravity section which also functions as a spillway, an earthen embankment section, a small penetration for bypass flows, and a water conveyance intake for the powerhouse. The dam is shown in Figure 2.3-1.

[4] All elevations in this Technical Support Document are in NAVD88 vertical datum. Previously reported elevations were in project datum. See Table 1.3-1 for conversion factors.

**Figure 2.3-1 Copco No. 2 Dam from Downstream Side**

The dam is a concrete gravity structure with a gated side intake to a water conveyance tunnel at the left abutment, a central 145-foot-long spillway section with five 26- by 11-foot radial (Tainter) gates, and a 100-foot-long earthen embankment with gunite cutoff wall on the right abutment (Figures 2.3-2 (B), 2.3-3 (B), and 2.3-4 (B)). The dam is 32 feet high, with an overall crest length of 305 feet and a crest width of 9 feet at elevation 2496.5.

**Figure 2.3-2 Layout of Copco No. 2 Dam Features (Appendix B)**

**Figure 2.3-3 Cross Section of Copco No. 2 Dam (Appendix B)**

**Figure 2.3-4 Elevation of Copco No. 2 Dam (Appendix B)**

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 half-pipe provides approximately 5 cfs of flow to the bypass reach below the dam. The concrete gravity spillway crest is at elevation 2476.5, with a downstream apron at elevation 2459.5, between two concrete retaining walls. The estimated spillway discharge capacity at RWS elevation 2486.5 is 13,500 cfs 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 (Figure 2.3-5).

**Figure 2.3-5 Copco No. 2 Dam from Upstream Side Showing Intake (at water level) and Crib Wall (high) on Left Abutment**

### 2.3.3 Water Conveyance to Powerhouse

Water conveyance to the powerhouse is via the intake at the dam to a first tunnel, then through a wood-stave penstock, a second tunnel, and into a pair of steel penstocks to the powerhouse.

The intake structure incorporates a large trash rack and a 20- by 20-foot roller-mounted (caterpillar) gate at invert elevation 2459.5. The trash rack is 36.5- by 48-feet with a 4-inch bar spacing.

The water conveyance system for the powerhouse includes 2,500 feet of concrete-lined tunnel (including an adit and air vent shaft), 1,330 feet of wood-stave pipeline (Figure 2.3-6), 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 feet long and one 410 feet long, range from 16 feet in diameter at the upstream ends to 8 feet in diameter at the turbine spiral casings. A 138-inch butterfly valve is provided near the downstream end of each penstock.

**Figure 2.3-6 Copco No. 2 Wood-Stave Penstock**

### 2.3.4 Powerhouse

The Copco No. 2 Powerhouse (Figure 2.3-7) is a reinforced-concrete structure located 1.6 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 2,786 cfs. Each turbine has a rated output of 26,285 hp and 20,000 for Units 1 and 2, respectively, with a net head of 145 feet and 140 feet for Units 1 and 2, respectively. 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 6.45 miles, to the Copco No. 2 switchyard. Drawings provided by PacifiCorp also note Lines 1, 2, 4, 14, 18, 19, and 67 connecting to the Copco No. 2 switchyard.

**Figure 2.3-7 Copco No. 2 Powerhouse**

### 2.3.5 Site Access

Site access is provided from Interstate 5 via Copco Road. Access to the dam is via a steep and narrow access road; the same access road as for Copco No. 1. Access to the powerhouse is via the Daggett Road crossing of the Klamath River on a single-lane bridge.

### 2.3.6 Recreation Facilities

No recreation facilities are provided.

## 2.4 Iron Gate Dam and Powerhouse

The Iron Gate Development consists of a reservoir, embankment dam, side-channel spillway, diversion tunnel, intake structures, and powerhouse located on the Klamath River between RM 200.0 and RM 193.1, about 17 miles northeast of Yreka, California, in Siskiyou County. Refer to Figure 2.4-1 (C) for plan views of these features.

**Figure 2.4-1 Iron Gate Dam Existing Features (Appendix C)**

The dam was completed in 1962 at RM 193.1. It is the farthest downstream hydroelectric facility of the Lower Klamath Project. The primary purpose of the Iron Gate facility is to generate hydroelectric power. Structures at the site include a communications building, a restroom building, a maintenance shop, two occupied residences, and a fish spawning building.

### 2.4.1 Reservoir

Iron Gate Dam impounds a reservoir of 942 acres (Iron Gate Reservoir) and according to a 2003 bathymetric survey (Eilers and Gubala 2003), provides approximately 50,941 acre-feet of total storage capacity at RWS elevation 2331.3[5]. The maximum and minimum operating levels are between RWS elevations 2331.3 and 2327.3, a vertical operating range of 4 feet.

### 2.4.2 Dam, Spillway, and Diversion Tunnel

The dam is composed of a side channel spillway, earthen embankment section, diversion tunnel, intake to Iron Gate hatchery water supply, and intake to the powerhouse (from right abutment to left abutment, looking downstream) (Figure 2.4-2). A fish ladder and trapping and holding facilities are located at the downstream base of the dam.

[5] All elevations in this Technical Support Document are in NAVD88 vertical datum. Previously reported elevations were in project datum. See Table 1.3-1 for conversion factors.

Figure 2.4-2 Iron Gate Dam, Spillway (left), and Powerhouse (right)

The dam is a zoned earthfill embankment with a current height of 189 feet from the rock foundation (elevation 2157.5) to the dam crest at elevation 2346.3. The dam crest is 20 feet wide and approximately 740 feet long (Figure 2.4-3 (B)). 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 2331.3, a 2½H:1V slope between elevations 2331.3 and 2303.3, and a 3H:1V slope below elevation 2303.3, with a 29-foot-wide bench at elevation 2278.3. A 10-foot-thick riprap layer is provided on the upstream face for slope protection (Figure 2.4-4 (B)).

Figure 2.4-3 Elevation of Iron Gate Dam (Appendix B)

Figure 2.4-4 Cross Section of Iron Gate Dam (Appendix B)

The downstream face has a 1.75H:1V slope above and a 2H:1V slope below elevation 2326.3, with a 10-foot-wide bench at elevation 2278.3. 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 2341.3 to elevation 2346.3 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 sheet pile wall is at elevation 2351.3. Additional riprap materials were placed on the upstream face of the dam to protect those areas inundated by the higher reservoir elevations during large flood events.

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 2331.5, 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. The spillway has an estimated discharge capacity of 22,350 cfs at RWS elevation 2336.3. 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 (Figure 2.4-5). The diversion tunnel intake is a reinforced concrete structure equipped with four 10- by 33-foot trash racks and is located approximately 520 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 119 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 2331.3, with a corresponding discharge capacity of 1,750 cfs; under emergency conditions, a full gate opening of 57 inches would produce a release of 2,700 cfs.[6] 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.

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

**Figure 2.4-5 Iron Gate Diversion Tunnel Outlet (center-right, in shadow)**

### 2.4.3 Water Conveyance to Powerhouse

Water conveyance to the powerhouse consists of an intake structure and penstock.
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 intake with 4-inch bar spacing.

### 2.4.4 Powerhouse

The Iron Gate Powerhouse is an outdoor-type facility located at the downstream toe of the dam on the left bank (Figure 2.4-6), and consists of a single vertical-shaft, Francis-type turbine with a rated discharge capacity of 1,735 cfs. 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 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 6.45 miles to the Copco No. 2 switchyard.

**Figure 2.4-6 Iron Gate Powerhouse**

### 2.4.5 Fish Trapping and Holding Facilities

There are fish trapping and holding facilities (Figure 2.4-7) located on “random fill”[7] at the downstream toe of the dam. The top of the random fill area is at elevation 2192.3. The fish facilities at the dam include six fish holding tanks, a spawning building, a fish ladder, and an aerator for the hatchery water supply. High- (elevation 2313.3) and low- (elevation 2253.3) level intakes for the fish facility cold water supply are incorporated in the dam on the left abutment.

[7] This is the type of material shown on the construction drawings used to fill in the area.

**Figure 2.4-7 Iron Gate Fish Holding Tanks and Spawning Building**

### 2.4.6 Iron Gate Fish Hatchery

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 cfs 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. The hatchery is operated by the California Department of Fish and Wildlife, with a large portion of the operations and maintenance costs currently funded by PacifiCorp. See Section 8.10 for a more detailed description of the existing facility and operation.

### 2.4.7 Site Access

Site access is provided from Interstate 5 via Copco Road and then by Lakeview Road to the dam crest and reservoir area, or by a project access road to the powerhouse. The single-lane Lakeview Road Bridge crosses the Klamath River downstream of the dam.

### 2.4.8 Recreation Facilities

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.

# 3. Field & Technical Assessments

Recent technical analyses completed in 2017 are summarized below. The sections below include descriptions of how each assessment was utilized in the subsequent work. Technical assessments include:

1. Geotechnical Reconnaissance
2. Dam Embankment Stability
3. Reservoir Rim Stability
4. Biological Reconnaissance Surveys – Terrestrial Resources
5. Cultural Resource Surveys
6. Copco No. 1 Foundation Removal
7. Topographic and Bathymetric Surveys
8. Data Collection at Shovel Creek

## 3.1 Geotechnical Reconnaissance

To date, geotechnical investigations by the KRRC have been limited to geologic reconnaissance site visits at Iron Gate, Copco No. 1, Copco No. 2, and J.C. Boyle dam sites and along public roadways. As discussed below, geotechnical investigations will not be required for the J.C. Boyle Dam and Iron Gate Dam embankments to support the design process, since data from previous investigations is sufficient for the embankment stability analyses described in Section 3.2.

Geotechnical investigations are planned by the KRRC in October 2017 for evaluation of reservoir rim stability for Copco Lake (see Section 3.1.2) and Iron Gate Reservoir (see Section 3.1.3). No investigations are required to evaluate reservoir rim stability at J.C. Boyle Reservoir, as explained in Section 3.1.1. Geotechnical investigations of subsurface materials at the Yreka water supply pipeline crossing of Iron Gate Reservoir, in addition to at selected bridge and roadway improvement locations will also be undertaken in October 2017 to support the preliminary design.

### 3.1.1 J.C. Boyle Dam and Reservoir

The following discussion of geologic conditions at J.C. Boyle Reservoir is excerpted from PanGEO (2008). Topography for the area around reservoir is gently sloping (less than 10%) to rolling terrain without many steep slopes other than on stratovolcanoes that are scattered around the region. Upstream and downstream of the dam, the Klamath River has cut a series of deep canyons into the volcanic rocks that mantle this part of northeastern California and southeastern Oregon. These canyons have slopes up to about 60 degrees. Bands of 30 and 40 degree slopes form NW-SE-oriented lineations in the topography; one of these bands forms the upstream boundary of the topographic bowl that the reservoir is located within.

Bedrock geology in the J.C. Boyle area is complex, being characterized by inter-fingered volcanic deposits from a variety of sources less than 5 million years old that are part of the High Cascade stratovolcanic deposits. Common lithologies include hard, resistant basalt and basaltic andesite and less resistant volcaniclastic deposits. The area is characterized by several stratovolcanoes (Mount McLoughlin, Chase, Hamaker, Buck, and Surveyor Mountains) as well as dozens of smaller vents that erupted lavas and volcaniclastic materials. Younger alluvium and colluvium (at least 18,000 years old) are present on some of the slopes and as gently sloped terraces around the margins of the reservoir. An outcrop of very light grayish tan diatomite is present along the margin of the reservoir on the north side of the river by the prominent eastward bend. The outcrop is at least 10 feet high and located at the foot of a rounded hill mapped as glacial material. The diatomite is underlain by black sand and is possibly interbedded with volcaniclastic material.

Faulting is prominent in the J.C. Boyle Reservoir area. The faulting appears to display a normal sense of offset associated with the extensional tectonics of the Basin Range province. The bowl topography of the reservoir area likely owes its configuration, in part, to being within a down-dropped basin. One prominent fault system is a fault that trends northwest through the northeast corner of the project area. The fault is down-dropped to the southwest, and the fault forms the southwest boundary of the hard rock canyon located upstream of the reservoir. To the northwest of the dam site, another fault system exists along the east side and through the middle of a prominent hill. This fault appears to mark the west side of the down-dropped block that forms the reservoir basin, as the fault is down to the northeast.

Review of topographic data and reconnaissance of the reservoir slopes indicate that no landslides are present adjacent to the reservoir. Furthermore, the land surface surrounding the J.C. Boyle Reservoir is generally low gradient and underlain by competent materials. For these reasons, the stability of the reservoir slopes will be unaffected by the reservoir lowering and no investigations will be required.

### 3.1.2 Copco No. 1 Dam and Copco Lake

Bedrock and surficial geologic units in the Copco Lake rim area have been mapped by Hammond (1983) at more detail than the mapping by Williams (1949) described in Section 3.1.3 and include:

#### 3.1.2.1 Surficial Deposits

Hammond (1983) mapped undifferentiated surficial deposits around much of Copco Lake. These deposits include talus and rockfall debris, alluvium and alluvial fans associated with tributary drainages, and alluvial and lacustrine terrace deposits. Most of the lacustrine terrace deposits are diatomaceous and are described below. One notable feature is a large alluvial fan on the north side of the lake, just west of Spannus Gulch. PanGEO (2008) states that the location of this fan between tributary drainages suggests that the feature could be colluvial (landslide related), but if this is the case, the feature is likely ancient and inactive. This feature is more likely an old alluvial or lacustrine terrace deposit with a more recent alluvial fan deposition on the surface. The feature is underlain by Spannus Ranch Andesite on the east side (Hammond 1983; this study). This feature will be further characterized during future reconnaissance and drilling by KRRC to determine if it is a landslide or a terrace deposit overlying bedrock.

No large scale landslides have been identified in either the terrestrial or submarine slopes around Copco Lake by this or previous studies. PanGEO (2008) identified two small to medium-size inactive landslides on the north shore and concluded that these are not likely to be reactivated by reservoir lowering, due to their position above reservoir rim.

#### 3.1.2.2 Diatomite Terrace Deposits

Fresh water diatomite terrace deposits surround much of the shoreline of Copco Lake, extending to approximately 40 feet above the current lake level. The terrestrial (onshore)[8] extent of these deposits has been mapped (see Figure 3.1-1(C)) by KRRC on modern topography and aerial imagery, modified from previous mapping by Williams (1949), Hammond (1983), and PanGEO (2008). This light gray to light tan colored material is low density and weak to very weak. Near vertical bluffs have formed in the diatomaceous deposits as a result of undercutting due to wave erosion and failure of the weak material. In general, it appears that the diatomite has eroded back to where little diatomite remains within the current range of reservoir levels. In some locations, the base of the diatomite is underlain by a bed of laminated black sand, roughly 3 to 4 inches thick. Below the black sand are tuffaceous volcaniclastic strata of the western Cascades (PanGEO, 2008). Where the toe of the terrestrial diatomite terrace deposit lies above the current high lake level, the response of the slope to rapid drawdown will be determined by the properties and geometry of the underlying volcanic and volcaniclastic strata. Where the toe of the terrestrial diatomite terrace deposit lies below the current high lake level, the response of the slope to rapid reservoir drawdown will be determined by the properties of the diatomite deposits as well as the underlying material. The extent and distribution of these different geometries along the shoreline is not well known, and the KRRC's proposed field investigations are designed to document these geometries. The reservoir rim stability analysis and drawdown recommendations are discussed in detail in Section 3.3.2.

**Figure 3.1-1 Copco Lake Rim Stability and Exploration Plan (Appendix C)**

Diatomite terrace deposits are also likely to exist completely below the current range of reservoir levels and may form submarine diatomite terrace deposits that appear as a prominent bench in the bathymetry. Along the south shore this bench is mostly continuous and ranges between 100 and 300 feet wide. Along the north shore, the terrace bench is wider, with large peninsulas extending to the south with very steep to near vertical side slopes.

The diatomaceous materials in the Copco Lake area are likely lacustrine deposits that were deposited behind dams formed by volcanic episodes associated with the High Cascade Volcanics units described below.

[8] The terrestrial terraces primarily extend above the reservoir water level but some lower portions may extend below the reservoir water levels. Fully submerged terraces are referred to as submarine.

#### 3.1.2.3 High Cascades Volcanics

Copco Basalt, a 0.14 million years old intracanyon flow unit (Hammond 1983), outcrops at the west end of the lake and likely underlies some of the western (downstream) submarine terrace deposits. This unit erupted from vents on both sides of the Klamath River, damming the river to form a lake that was approximately 35-40 feet higher than the modern lake (Hammond 1983). Other Quaternary basalt lava flows unconformably overlie the older volcanics of the Western Cascades Group to form the generally flat-lying rim rock at the topo of the slopes around much of Copco Lake, but more prominent to the north.

#### 3.1.2.4 Western Cascades Volcanics

Volcanic and volcaniclastic bedrock around the rim includes Spannus Ranch Andesite, undifferentiated intrusives, and several members of the Bogus Mountain volcaniclastic beds.

The Spannus Ranch Andesite consists mainly of pyroxene andesite flows with interbeds of lithic breccia (PanGEO 2008).

The Bogus Mountain Beds consist of interstratified tuff-breccia, volcaniclastic sandstone and tuffs, with thinner interbedded andesite flows. The strata tend to be greenish gray, and the tuffs and sandstones are fine to medium grained. One of the basal members of the Bogus Mountain has been dated at roughly 23 million years old (Hammond, 1983).

PanGEO (2006) suggests the slight possibility of drawdown-induced block sliding where hard strong volcanic flow rocks are underlain by saturated tuffaceous beds and bedding dips into the valley. Hammond (1983) reports several low to moderate dip angles of volcaniclastic beds into the valley, but there is no evidence of previous slope instability at these locations. PanGEO (2008) does not address this possibility, and compiled geologic map data from this and previous studies is not sufficient for a more detailed analysis. Planned field investigations, including seismic refraction surveys and geotechnical drilling as discussed below, are planned by the KRRC in October 2017 to address this potential concern.

#### 3.1.2.5 Field Investigations

Field investigations by the KRRC to date have been limited to reconnaissance along public roadways around Copco Lake during the week of June 5, 2017, and the week of July 24, 2017. During the reconnaissance, an outcrop sample of terrace diatomite was collected from the north side of the lake near Beaver Creek. Geotechnical testing by the KRRC to determine the strength and permeability of this sample is ongoing.

To investigate the subsurface geometry and geotechnical properties of rim deposits, additional reconnaissance mapping, geotechnical borings, and seismic refraction surveys (Figure 3.1-1(C)) are planned by the KRRC for October 2017. Additional reconnaissance mapping will be performed to better constrain the extent and geometry of the weak, low density diatomite terrace deposits along the shoreline. The investigation data and mapping will be used during preliminary design to confirm the stability of the reservoir rim (see Section 3.3).

Up to seven borings are planned to better characterize near shore subsurface conditions. Boring BC-01 is located within likely diatomaceous terrace deposits on shore. Boring BC-02 is located to characterize the submarine bench. Borings BC-03 to BC-06 are located within near shore submarine terrace deposits. These borings will attempt to acquire undisturbed samples of the terrace deposits and underlying weathered volcanics for strength and permeability testing. Boring BC-07 is located along the waterside margin of the feature near Spannus Gulch to determine if the feature is an ancient landslide or a terrace deposit.

Several seismic refraction profiles are planned near the south shore of the lake. The purpose of these surveys is to determine the thickness (depth) of the diatomite terrace deposit to better constrain the geometry of these deposits for stability analysis. Line SR-03 is located adjacent to a proposed on-land boring (BC-01) to better correlate survey results to actual subsurface conditions.

In addition to the planned field investigations, new bathymetric survey data that will be available January 2018, will be reviewed and analyzed to better characterize submarine landforms.

### 3.1.3 Iron Gate Dam & Reservoir

Iron Gate Dam and its reservoir lie entirely within the Western Cascades geologic province. The only geologic mapping of the area to date is that done by Williams (1949). Hammond (1983) suggests that the volcaniclastic formation that he informally named the Bogus Mountain beds extend into the Iron Gate area (PanGEO 2008). Bedrock units include tuffaceous siltstones and sandstones, bouldery volcaniclastics and volcanic breccia, tuff and tuff breccia, and pyroxene flow rocks. Preliminary geologic reconnaissance indicates generally shallow bedrock with a thin soil mantle. Surficial geologic units including landslide and alluvial deposits are not differentiated from the underlying volcanic rocks in previously published mapping.

PanGEO (2008) identified three possible landslide related features on the south rim of the reservoir (Figure 3.1-2(C)), and characterized these as "weakly suggestive of old landslides ranging from small slumps only a few meters in size up to possible slides covering several square miles". These existing features are considerations in the rim stability assessment described in Section 3.3.

**Figure 3.1-2 Iron Gate Reservoir Rim Stability (Appendix C)**

For this study, the KRRC reviewed the 2010 LiDAR-derived terrestrial digital elevation model (DEM), bathymetric survey data, and pre-dam stereoscopic aerial photographs (1944 and 1951) for the entire lake area. The bathymetric survey data is not of sufficient resolution to identify fine scale geomorphic landforms. Features previously identified by PanGEO as well as several other features with possible landslide morphology identified by the KRRC are delineated as shown on Figure 3.1-2(C). These features appear unchanged from 1944 and 1951historical aerial photographs, and do not show any indications of recent activity on the

LiDAR DEM. The morphology of the two larger features appears more consistent with differential erosion of different volcanic/volcaniclastic bedrock units or in the case of the western feature, possible volcanic flow collapse during or immediately after emplacement. Two smaller features, including the third, western feature identified by PanGEO (2008) appear more likely to be inactive slide features. Neither of these features appears to extend significantly into the submarine portion of the slope based on review of on the pre-dam aerial photographs. These areas are not likely to be affected by reservoir drawdown, considering that they were apparently unaffected by historical reservoir drawdowns, as described later in Section 3.3.3. This conclusion will be confirmed by the KRRC during preliminary design based on future site reconnaissance and evaluation of the submarine morphology of the landforms on higher resolution bathymetric data, when it becomes available.

The KRRC field investigations to date was limited to preliminary reconnaissance along public roadways around the reservoir during the week of June 5, 2017, and the week of July 24, 2017. Due to the low risk or rim stability failure, as described in Section 3.3, a subsurface investigation (borings) is not planned or considered necessary to support the preliminary design. Future field work to support preliminary design will include more detailed site reconnaissance of the entire shoreline and of the areas around the possible slide features identified on the LiDAR DEM. Subsurface investigation may be proposed if additional site reconnaissance and analysis of higher resolution bathymetric data indicates areas that would have the potential of sliding.

## 3.2 Dam Embankment Stability

The stability of the upstream slope of earthen dams during reservoir drawdown is a function of the permeability and shear strength of the embankment materials, the rate at which the reservoirs are drawn down, and the starting and ending reservoir levels during drawdown. Rapid drawdown[9] analyses were performed for the earthfill portion of J.C. Boyle Dam and for Iron Gate dam to determine a rate of reservoir drawdown that would also provide for an acceptable factor of safety against a slope failure of the upstream slope of the dams. The methodology used by the KRRC to evaluate rapid drawdown included the following steps:

1. Develop analysis sections and material properties based on available data and determine if additional data is necessary for the analyses.
2. Develop upper and lower bound factors of safety for stability of the dams during rapid drawdown by performing conventional rapid drawdown stability analysis under instantaneous drawdown:

[9] The term rapid drawdown typically refers to any drawdown that is faster than a normal operational drawdown or one that would not allow for pore pressure dissipation in an embankment.

   a. The first scenario (least conservative bound) assumes full pore pressure dissipation[10] within the pervious shell after drawdown from the steady state condition.

   b. The second scenario (most conservative bound) assumes no pore pressure dissipation [11] within the pervious shell from after drawdown from the steady state condition.

3. Perform transient drawdown analysis for various drawdown rates to arrive at most likely estimates of the factors of safety for stability of the dams during rapid drawdown:

   a. Transient seepage analysis to determine the location of the phreatic surface at different time steps during reservoir drawdown.

   b. Slope stability analysis for each corresponding phreatic surface during reservoir drawdown.

4. Additional sensitivity analyses, if needed.

Because the shells of the dams are constructed of pervious materials, rapid drawdown of the reservoir level behind the dams will result in concurrent (but slower) lowering of the phreatic surface (groundwater level) in the upstream shell of the dams. To account for this, transient seepage analyses were performed.

The computer program SEEP/W (Geo-Studio 2016), which is a two-dimensional, finite element analysis software program that has the capability to analyze both steady-state and transient seepage conditions was used for the seepage analyses. Slope/W (Geo-Studio, 2016), which makes use of the phreatic surface developed in SEEP/W, was used to perform limit equilibrium slope stability analyses.

According to the Engineering Manual (EM-110-2-1902) of United States Army Corps of Engineers (USACE 2003), the minimum factor of safety for the rapid drawdown analyses of the upstream slope of earthen dams should be no less than the range of 1.1 to 1.3.[12] Given, the importance of safety to both workers on site and the public downstream of the J.C. Boyle and Iron Gate dams, the minimum rapid drawdown factor of safety for transient seepage analyses is set to be 1.3.

The following sections summarize the KRRC's rapid drawdown analyses for J.C. Boyle and Iron Gate dams. Appendix D includes a full description of the rapid drawdown stability analyses.

[10] Full pore pressure dissipation assumes that free water within the voids between the particles in the upstream shell of the dam freely drain such that the phreatic water surface in the upstream is at the same level as the reservoir water level during drawdown.

[11] No pore pressure dissipation assumes that free water within the voids between particles in the upstream shell of the dam is unable to drain such that all of the water between the particles at the beginning of drawdown remains trapped in the upstream shell during drawdown.

[12] Factors of safety are unitless values that relate the design strength or stability to the expected force or load on the structure. The design strength is greater than the forces experienced by the structure by the factor of safety (e.g., 1.3 times higher)

### 3.2.1 J.C. Boyle Dam

Historical reservoir drawdown, material characterization, rapid drawdown analysis results, and KRRC recommendations for reservoir drawdown are discussed for J.C. Boyle Dam in the following sections.

#### 3.2.1.1 Historical Drawdown

J.C. Boyle Reservoir levels between January 1, 1979, and December 31, 2016 were reviewed by the KRRC for historical occurrences of reservoir drawdown. The reservoir appears to have operated over a narrow range of levels between a low of about elevation 3790.7 feet to a high of about elevation 3796.7 feet with daily fluctuations that appear to be as much as about 3 feet per day.

#### 3.2.1.2 Material Characterization

Material characterization was completed by the KRRC. The maximum cross section of the dam was used by the KRRC for analysis. Unit weights of the embankment materials are based on compaction test results performed by others[13] on samples from the core and shell borrow sources during borrow source evaluation prior to dam construction.

Shear strength parameters for the core material were based on direct shear tests performed by others on samples from the core borrow sources during borrow source evaluation prior to dam construction. Shear strength parameters for the shell, filter, and waste rock materials were estimated by the KRRC based on standard penetration test (SPT) blow counts from three borings drilled by Black and Veatch on the downstream slope of the dam in 1994 (Black and Veatch 1998), compaction required by the construction specifications, published literature, and experience with similar materials on other projects.

The permeability of the compacted core materials was based on falling head permeability tests that were performed by others during evaluation of the borrow sources to be used for construction before the dam was built. The permeability for the shell and filter materials used in the downstream blanket, and waste rock fill were based on laboratory results, published correlations, and data, and experience with similar materials on other projects.

Due to the variation of the shear strength test results of the core, sensitivity analyses were performed by the KRRC using the lowest values from the direct shear tests. Another set of sensitivity analysis was performed by the KRRC on the permeability of the shell, which is selected based on published typical ranges of permeability.

The available data from others, coupled with the sensitivity analyses completed by the KRRC, provides adequate information for performing rapid drawdown stability analyses without performing additional field investigations. Additional field investigations would not be anticipated to provide additional data that would significantly alter the results of the analyses.

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[13] Data by others refers to data included or attached to PacifiCorp's Standard Technical Information Documents but that did not note the entity that collected or analyzed the data.

#### 3.2.1.3 Analyses Results

The results of the analyses indicate lower and upper bound factors of safety of 1.1 and 2.1; the lower bound being less than the minimum required factor of safety of 1.3. Lower and upper bound factors of safety for sensitivity analyses assuming lower shear strength for the core zones are 1.1 and 2.0, respectively. The similar factors of safety are due to negligible influence of the narrow core on the performance of the dam during rapid drawdown conditions. Transient seepage analyses for drawdown rates of 3 feet per day, 5 feet per day, and 10 feet per day resulted in minimum factors of safety of 1.7 using for best estimate shear strength parameters and minimum factors of safety of 1.6 for sensitivity analyses. The factors of safety for the transient analyses are equal to or greater than the minimum required factor of safety of 1.3.

#### 3.2.1.4 Drawdown Recommendations

The proposed reservoir drawdown plan could result in rapid drawdowns of approximately 10 feet (between RWS elevations 3783.7 and 3773.7) and 8 feet (between RWS elevations 3773.7 and 3765.7) within less than 24 hours as each barrel of the diversion culvert under the spillway is opened (see Section 4.2.1). Based on the rapid drawdown analyses, drawdown rates of up to 10 feet per day would not impact the stability of J.C. Boyle Dam because the dam has an upstream shell that is a mixture of compacted sand and gravel with a high strength, adequate permeability, and a relatively flat slope. The KRRC recommends that a hold period of one week be implemented between removal of the stoplogs from the first culvert until the stoplogs from the second culvert are removed to allow for pore pressure dissipation. Rapid drawdown rates may result in some pore pressure development and localized shallow slope instability, which will be monitored (see Section 4.5), but is not anticipated to impact the overall integrity of the dam during the drawdown process.

### 3.2.2 Iron Gate Dam

Historical reservoir drawdown, material characterization, rapid drawdown analysis results, and recommendations for reservoir drawdown are discussed for Iron Gate Dam in the following sections.

#### 3.2.2.1 Historical Drawdown

Iron Gate reservoir levels between January 1, 1979, and December 31, 2016, were reviewed by the KRRC for historical occurrences of reservoir drawdown. The four most significant drawdown events occurred in the falls of 2004, 2014, 2015, and 2016 (see Figure 3.2-1). The magnitude of the drawdowns ranged from about 9 feet to 14.5 feet. The maximum daily drawdown rate of 2 feet per day occurred in 2014. Based on inquiries made to PacifiCorp there were no reported slope failures resulting from the drawdowns (email with Demian Ebert August 2, 2017).

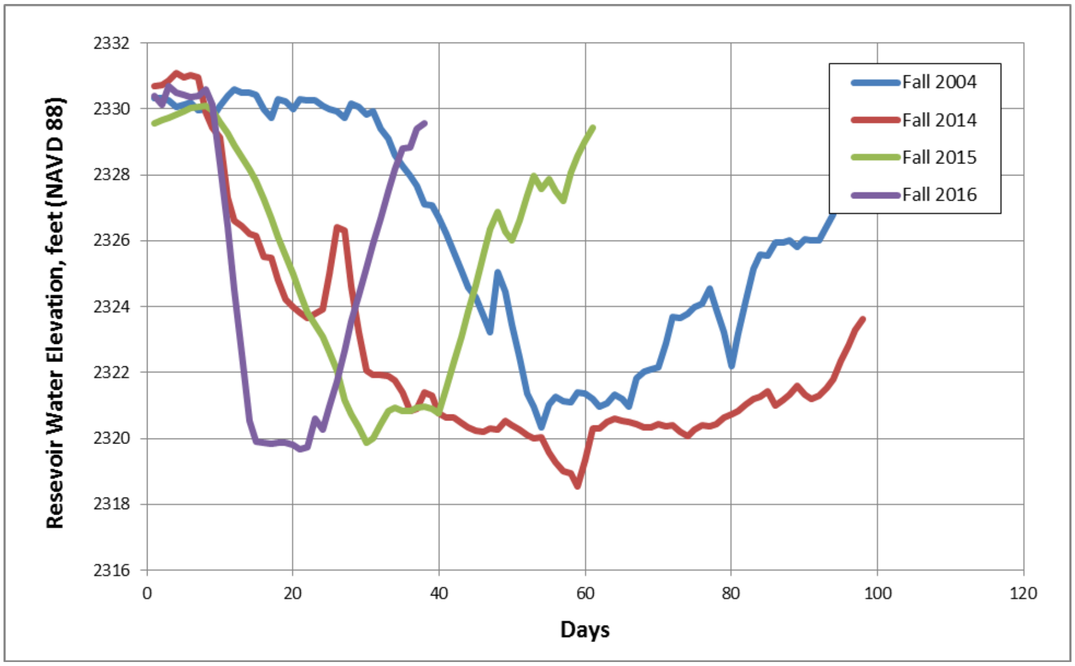


**Figure 3.2-1 Iron Gate Reservoir Maximum Historical Drawdown Events (1979 to 2016)**

### 3.2.2.2 Material Characterization

The maximum cross section of the dam was used by the KRRC for analysis. Unit weights are based on laboratory tests performed by others on borrow source samples prior to dam construction (California Oregon Power Company 1960b), compaction test results (California Oregon Power Company 1960a) during construction, and published data.

Shear strength parameters for the core material were based on isotropic consolidated undrained triaxial tests (TX-ICU) performed by others on samples from the core borrow sources during borrow source evaluation prior to dam construction (California Oregon Power Company 1960b). Shear strength data for the shell, drain, filter, and transition materials is not available. The shear strength of the shells, which are rockfill or a rocky earthfill, would not be obtainable through field investigations. Therefore, shear strength parameters for the shell, drain, filter, and transition materials are based on the type of materials used, compaction required by the construction specifications (California Oregon Power Company 1960a), published literature, and experience with similar materials on other projects.

The permeability of the compacted core and upstream shell materials were based on falling head permeability tests that were performed by others during evaluation of the borrow sources to be used for construction before the dam was built (California Oregon Power Company 1960b). The permeability for the filter and drain materials used in the chimney and downstream blanket were based on published data and experience with similar materials on other projects.

The available data provides adequate information for performing rapid drawdown stability analyses without performing additional field investigations. Additional field investigations would not be anticipated to provide additional data that would significantly alter the results of the analyses.

#### 3.2.2.3 Analyses Results

The results of the KRRC analyses indicate lower and upper bound factors of safety of 1.4 and 2.0; both being greater than the USACE minimum required factor of safety of 1.3. Transient seepage analyses for drawdown rates of 3 feet per day, 6 feet per day, and 10 feet per day resulted in minimum factors of safety of 1.5. The factors of safety for the transient analyses are equal to or greater than the minimum required factor of safety of 1.3.

#### 3.2.2.4 Drawdown Recommendations

Based on the KRRC rapid drawdown analyses, drawdown rates of up to 10 feet per day would not impact the stability of Iron Gate Dam because the dam has wide, pervious outer shells that have high strength and should drain relatively quickly as the reservoir is drawn down. High drawdown rates are desired because they provide increased reservoir sediment evacuation during the January and February period. Evaluation of the rapid drawdown stability of the reservoir rim slopes is described in Section 3.3.3. To limit the maximum flow released from Iron Gate Reservoir (for downstream channel capacity purposes) and to enable monitoring the performance of the embankment during drawdown, the KRRC recommends limiting the maximum rate of drawdown for the Iron Gate reservoir to a more conservative 5 feet per day.

## 3.3 Reservoir Rim Stability

The purpose of this section is to summarize relevant geologic background information, recent KRRC field reconnaissance, and any KRRC assessments or analyses completed to assess reservoir rim stability at J.C. Boyle, Copco No.1 and Iron Gate reservoirs. Where additional investigation or analyses are identified for completion during detailed design, they are summarized below. Based on the assessment completed by the KRRC and summarized in more detail below, rim stability is unlikely to be affected by the reservoir drawdown rate, and will therefore not be a limiting factor in recommendations for maximum reservoir drawdown rates. Monitoring associated with rim stability is discussed separately in Section4.5 and measures proposed to address rim stability are discussed separately in Section 4.6.3.

When discussing reservoir rim stability during drawdown at the various reservoir locations, it is important to differentiate between the potential for deep-seated large landslides, which could impact residences and other resources adjacent to the rim, and shallower slides of material beneath the current water surface, which would only impact resources within the local limited slide footprint. The methodology being used by the KRRC for evaluation of reservoir rim stability includes the following steps:

1. Perform a desktop geologic study of the reservoir rims including a literature review of previous geologic studies of the area and a review of available aerial photography.
2. Perform a geologic reconnaissance along the areas of the reservoir rims identified during the desktop study that appear to be susceptible to instability based on topographic and geologic conditions.

3. If areas of potential instability are identified, develop analysis cross-sections and material properties based on available data, geotechnical field investigations, and laboratory testing. Perform rapid drawdown analyses as follows:
   a. Develop upper and lower bound factors of safety for stability of the dams during rapid drawdown by performing conventional rapid drawdown stability analysis under instantaneous drawdown:
      i. The first scenario (least conservative bound) assumes full pore pressure dissipation after drawdown from the steady state condition.
      ii. The second scenario (most conservative bound) assumes no pore pressure dissipation from after drawdown from the steady state condition.
   b. Perform transient drawdown analysis for various drawdown rates to arrive at most likely estimates of the factors of safety for stability during rapid drawdown:
      i. Transient seepage analysis to determine the location of the phreatic surface at different time steps during reservoir drawdown
      ii. Slope stability analysis for each corresponding phreatic surface during reservoir drawdown.
   c. Additional sensitivity analyses, if needed.

According to the Engineering Manual (EM-110-2-1902) (USACE 2003), the minimum factor of safety for the rapid drawdown analyses of the upstream slope of earthen dams should be no less than the range of 1.1 to 1.3. Given, that the reservoir rims are not as critical as the dams, the minimum drawdown factor of safety for transient seepage analyses is set to be 1.15.

The following sections summarize KRRC evaluations of the reservoir rims behind J.C. Boyle, Copco No. 1, and Iron Gate dams for potential instability during reservoir drawdown.

### 3.3.1 J.C. Boyle Reservoir

This section provides an overview of the stability assessment completed by the KRRC along the J.C. Boyle Reservoir rim, with a focus on two structures along the reservoir rim that could be impacted by reservoir drawdown; Spencer Bridge on OR66 at milepost 43.86 and a portion of Topsy Grade Road. A discussion is also provided on whether or not the rim stability would affect the determination of maximum drawdown rates.

#### 3.3.1.1 Geologic Conditions

Geologic conditions are summarized in Section 3.1.1.

#### 3.3.1.2 Reservoir Rim Stability

The geologic reconnaissance of the J.C. Boyle Reservoir rim (described in Section 3.1.1) did not reveal obvious stability problems. Based on the results of the geologic reconnaissance, the historic performance of the slopes above the reservoir level, and the bathymetry, it is concluded that deep-seated large landslides are unlikely. Therefore, drawdown stability analyses for the rim of J.C. Boyle Reservoir are not required to support the preliminary design.

Shallower slides could occur in the surficial soil deposits around the reservoir rim and on the reservoir slopes that are currently below the reservoir surface.

#### 3.3.1.3 Evaluation of Potentially Impacted Structures

**Spencer Bridge (OR66/Green Springs Highway)**

The eastern abutment of Spencer Bridge is composed of constructed fill extending about 65 feet into the reservoir with a maximum thickness of approximately 30 feet. Based on as-constructed drawings, the lower 15 feet of fill is located below the reservoir high water level. The fill was placed as part of bridge construction in 2006. Prior to fill placement, existing fill was removed from the abutment embankment area, the foundation was prepared by compaction to 95% (compaction standard is not called out on as-built drawings), and engineered stone material placed and compacted. The engineered stone material consists of well graded, quarried basalt placed in maximum 8 inch lifts and compacted to 95% of maximum density (compaction standard is not called out on as-built drawings) to an elevation about 5 feet higher than the high pool. Moisture content at the time of compaction was specified to be within minus 4% to plus 2% of optimum moisture content. An approximately 3-foot thick layer of Class 1000 riprap ($M_{50}$>660 pounds (lb)) covers and protects the engineered stone material from erosion. The final grade of the fill ranges from 2H:1V to nearly 5H:1V.

Given the highly pervious, strong basalt material used for the engineered stone material, it is expected that the embankment would remain stable during and following the drawdown of J.C. Boyle Reservoir. The embankment would be inspected following the drawdown, and if damaged, the riprap outer layer would be repaired. The restored Klamath River channel is anticipated to locate between the 2$^{nd}$ and 3$^{rd}$ bridge bents, both of which were constructed on bedrock. Scour at the bents following dam removal is not anticipated.

**Topsy Grade Road**

Topsy Grade Road crosses an unnamed drainage, roughly 1900 feet to the east of the J.C. Boyle Dam. Where it crosses the drainage, the road is an embankment roughly 400 feet long with a crest width of 20 feet and is up to about 11 feet high above the original foundation. The slopes of the embankment are 3.3H:1V or flatter. The lower 9 feet of the embankment are below the J.C. Boyle low water operating level and previous reservoir drawdowns have lowered the water to cover only the bottom 3 feet of the embankment.

There are three 24-inch culverts through the embankment that drain a watershed of roughly 5 square miles. The fill and culverts appear to have been constructed as part of the J.C Boyle Dam and Powerhouse project. Based on topography prior to dam construction, the existing culverts do not appear to be aligned with the original creek bed. Although the engineering characteristics of the embankment fill are unknown, the amount of inundation of the base of the embankment is small and has been previously drawn down to near the toe in the past without slope instability.

The only improvement that may be required is directing of flows through the culverts to the original drainage thalweg downstream of the embankment and erosion protection along the downstream toe of the embankment after reservoir drawdown. The need for these minor improvements would be determined by the KRRC during monitoring following drawdown.

#### 3.3.1.4 Drawdown Recommendations

As discussed previously in Section 3.3.1.2, the KRRC has concluded that deep-seated large landslides are unlikely around the reservoir rim at J.C. Boyle, and that associated detailed drawdown stability analyses are not required. In addition, reservoir rim stability will not be a limiting factor in determining the drawdown rate at J.C. Boyle.

Spencer Bridge, located on OR66 at milepost 43.86, was evaluated by the KRRC for potential impacts due to drawdown of the reservoir. Specifically, the east abutment of the bridge, which was constructed on fill, was evaluated. Due to the relatively flat slopes of the abutment, the strong well-compacted engineered stone fill used to construct the abutment there is a low likelihood of slope failure during drawdown. The well compacted fill is also unlikely to undergo settlement during dewatering. Therefore, the bridge and associated embankment stability will not be a limiting factor in determining the drawdown rate at J.C. Boyle.

A portion of Topsy Grade Road where it crosses a shallow portion of the J.C. Boyle Reservoir was also evaluated and determined to have a little likelihood of slope failure given that the reservoir level, which is against the embankment, has already been nearly fully drawdown during normal operations of the reservoir. Therefore, road embankment stability will not be a limiting factor in determining the drawdown rate at J.C. Boyle.

For the reasons discussed above, the drawdown of J.C. Boyle Reservoir would be controlled by the rate that would be safe for the embankment dam, which is discussed in Section 3.2.1.

### 3.3.2 Copco No. 1 Reservoir (Copco Lake)

This section provides an overview of the stability assessment completed to date by the KRRC along the Copco Lake rim. A discussion is also provided on whether or not the rim stability would affect the determination of maximum drawdown rates.

KRRC studies undertaken to evaluate the potential for slope instability of the Copco Lake rim during reservoir drawdown include review of previous reservoir drawdowns, geologic reconnaissance, review of previous drilling (water wells), field investigations including geologic mapping, drilling, and geophysical surveys, and laboratory testing. The purpose of the field investigations (scheduled for October 2017) is to develop a better understanding of the geologic section that will be subjected to the reservoir drawdown, particularly the thickness of the weak diatomaceous material exposed along portions of the reservoir rim. The laboratory testing will focus on evaluating the strength of the diatomaceous material and underlying bedrock materials. The thickness and material strength would be used during preliminary design to finalize the stability analysis and incorporate the results, as necessary, into the Project design.

#### 3.3.2.1 Historical Drawdown

Copco Lake levels between November 1, 1978, and December 31, 2016, were reviewed by the KRRC for historical occurrences of reservoir drawdown. The three most significant drawdown events occurred in 1982, 2014, and 2015 (see Figure 3.3-2). The magnitude of the drawdowns ranged from about 9 feet to 14.5 feet. The maximum daily drawdown rate of 2 feet per day occurred in 2014. Based on inquiries made to PacifiCorp there were no reported slope failures resulting from the drawdowns (email with Demian Ebert August 2, 2017).

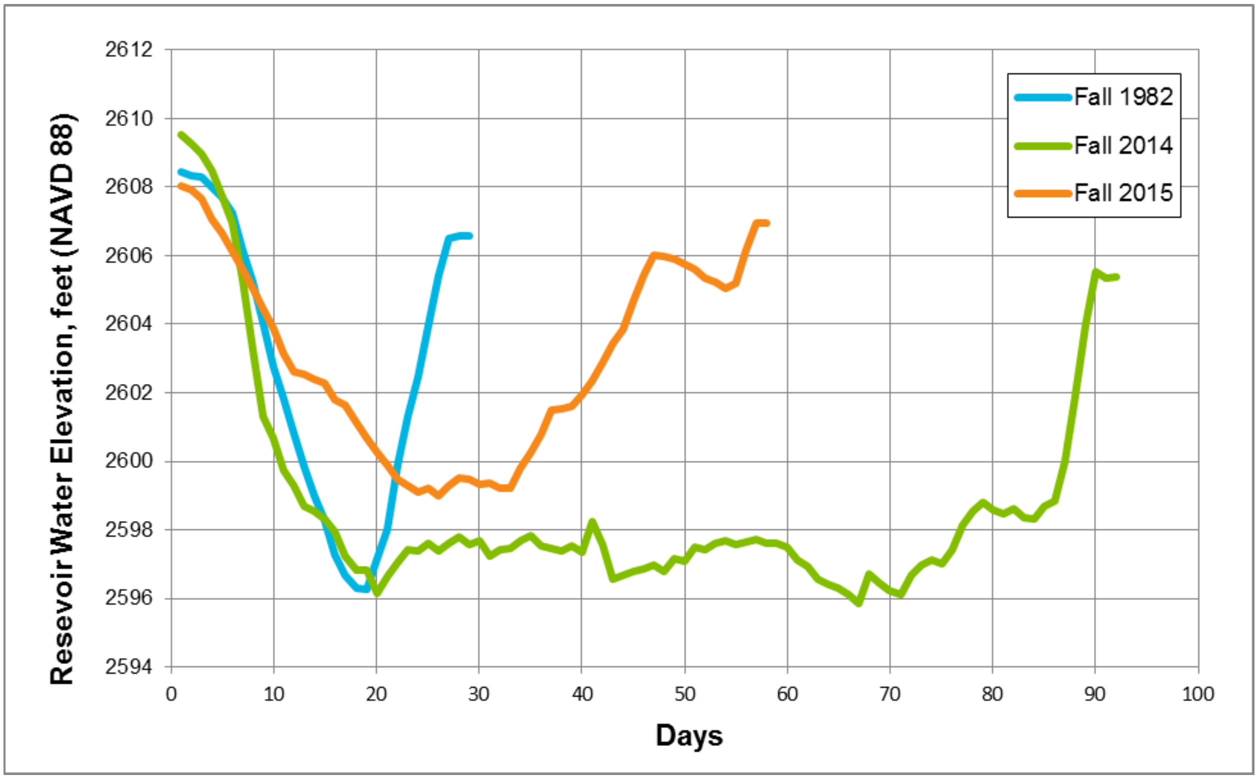


**Figure 3.3-1 Copco Lake Maximum Historical Drawdown Events (1978 to 2016)**

### 3.3.2.2 Geologic Conditions

Geologic conditions are summarized in Section 3.1.2.

### 3.3.2.3 Reservoir Rim Stability

The KRRC's geologic reconnaissance of the reservoir rim at Copco Lake indicates that the diatomaceous terrace deposits along the rim and below the reservoir level present the greatest potential for slope stability problems. Where the toe of the diatomaceous terrace deposits lie above the current high lake level, the response of the slope to rapid drawdown will be controlled by the underlying volcanic and volcaniclastic strata that are likely to be strong enough and pervious enough to not be susceptible to rapid drawdown failure. Therefore, based on our current understanding, the potential for deep-seated large landslides through the underlying volcanic and volcaniclastic strata along the rim that might impact structures or cultural sites along reservoir rim during drawdown is low, and would likely not be a limiting factor when determining maximum drawdown rates.

Locations may exist where the diatomaceous deposits exposed along the rim extend into the reservoir body. Such locations could be susceptible to slope instability during drawdown with the size of the slide being dependent on the thickness of the diatomaceous deposits. The potential for reservoir rim instability where the diatomaceous deposits may extend from the rim into the reservoir body will be confirmed when the field investigations and rapid drawdown analyses have been completed. Drawdown stability analyses will be performed by the KRRC after October 2017, based on the results of the field investigations described in Section 3.1.2.5 and laboratory tests that would performed on samples from the investigations.

Monitoring associated with rim stability at Copco Lake is discussed in Section 4.5 and measures associated with rim stability are discussed in Section 4.6.3.

It is the KRRC's opinion that the diatomaceous terrace deposits located below the current reservoir surface will exhibit low shear strength. We believe that diatomaceous terrace deposits are also likely to have low permeability that will not drain substantially, even at reservoir drawdown rates as low as 1 foot per day. Thus, inundated terraces or slopes (which could be locations of cultural resources) that include diatomite material will likely be unstable as the reservoir is drawn down and could result in shallow slides. Measures associated with monitoring and adaptive management of exposed cultural resources associated with shallow slides are discussed in Section 4.8.

#### 3.3.2.4 Drawdown Recommendations

The extent of diatomite deposits below the current reservoir surface is unknown. Because the stability of the submerged diatomite materials are likely to be independent of reservoir drawdown rate, it is recommended that drawdown rates for reservoir lowering be set at 5 feet per day to maximize the likelihood of completing reservoir drawdown within the months of January and February and minimize water quality impacts after February.

### 3.3.3 Iron Gate Reservoir

This section provides an overview of the stability assessment completed to date by the KRRC along the Iron Gate Reservoir rim. A discussion is also provided on whether or not the rim stability would affect the determination of maximum drawdown rates.

KRRC studies undertaken to evaluate the potential for slope instability of the Iron Gate Reservoir rim during reservoir drawdown include review of previous reservoir drawdowns, geologic reconnaissance, and field reconnaissance that include additional geologic mapping. The purpose of the field reconnaissance described in Section 3.1.3 (scheduled for October 2017) is to develop an understanding of the geologic section that will be subjected to the reservoir drawdown. KRRC's review of the Iron Gate reservoir rim found that there are no structures that could be damaged by potential slope failures. Portions of Copco Road along the right bank of the reservoir that are close to the reservoir could be damaged by potential slope failures.

#### 3.3.3.1 Historical Drawdown

Historical reservoir drawdown for Iron Gate reservoir is discussed in Section 3.2.2.1.

#### 3.3.3.2 Geologic Conditions

Geologic conditions are summarized in Section 3.1.3.

#### 3.3.3.3 Reservoir Rim Stability

Much of the bedrock mapped around the rim of Iron Gate Reservoir consists of volcanic flow rock, rhyolite tuff and tuff breccia. The extent and morphology of these outcrops and general lack of surficial deposits suggest a shallow weathering profile that is interpreted to form generally stable reservoir slopes under drawdown conditions. Where bedrock lithologies include more thinly bedded volcaniclastic units such as the Bogus Mountain beds, there is a possibility that large scale block sliding of more massive flow or tuff breccia over weaker, more deeply weathered volcaniclastic beds could be induced by rapid drawdown, as suggested by PanGEO (2008). In particular this would be possible where the structure of the volcaniclastic beds dips moderately to steeply downslope toward and below the reservoir rim.

Existing structural data (PanGEO 2008) and reconnaissance performed by the KRRC to date has not identified this condition anywhere around Iron Gate reservoir. Bogus Mountain beds are mapped at the very upstream end of the reservoir, but the outcrop pattern and structural measurements indicate the beds strike normal to the slope and dip gently to the east. PanGEO (2008) mapped volcaniclastic beds on the northwest arm of the reservoir, to the north and east of Juniper Point, dipping gently to the west. On the west facing, eastern slope of the reservoir, this orientation has the potential for structural block slide slope failure. The lower slope near the reservoir rim is also relatively gentle with smooth, planar morphology and very little rock outcrop. This suggests that the likelihood of large scale block sliding of this slope due to drawdown is very low.

Shallower slides are likely to occur in the soil deposits around the reservoir rim and on the reservoir slopes that are currently below the reservoir surface. Small, shallow soil failures in the more deeply weathered volcaniclastic beds present a minor hazard to Copco Road where the road is immediately adjacent to the shore. These slope failures are likely to be shallow and local, but may possibly require minor repair to maintain full use of the roadway. Monitoring associated with rim stability at Iron Gate Reservoir is discussed in Section 4.5 and measures associated with rim stability are discussed in Section 4.6.3.

#### 3.3.3.4 Drawdown Recommendations

The KRRC's geologic reconnaissance 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 deep-seated rapid drawdown slope failures. Based on the results of the KRRC's geologic reconnaissance, it is concluded that drawdown stability analyses for the rim of Iron Gate Dam are not needed, and rim stability would not be a limiting factor when determining maximum drawdown rates. The drawdown of Iron Gate Reservoir would therefore be controlled by the rate that would be safe for the embankment dam, which is discussed in Section 3.2.2. If future geologic mapping by KRRC or evaluation of better bathymetric data by KRRC identifies areas with potential stability concerns, subsurface investigation and stability analyses will be performed by the KRRC.

## 3.4 Biological Reconnaissance Surveys - Terrestrial Resources

### 3.4.1 Introduction

This section provides the existing conditions information related to terrestrial resources in the Project area.

### 3.4.2 Methods

#### 3.4.2.1 Literature Review

A review of existing information on terrestrial resources in the Project area was conducted by the KRRC. Key documents reviewed included the 2004 PacifiCorp Terrestrial Resources report and the 2012 EIS/R and associated technical appendices. Some additional information on special status species was provided by federal and state agencies and other entities as discussed in Section 3.4.5 below. Known occurrences for special status species were obtained from the Oregon Biodiversity Information Center (ORBIC), the California Natural Diversity Database (CNDDB), and the U.S, Fish and Wildlife Service (USFWS) Information for Planning and Conservation (IPaC) database.

#### 3.4.2.2 Agency Coordination

The KRRC has close coordination with federal and state resource agencies including USFWS, California Department of Fish and Wildlife (CDFW), Oregon Department of Fish and Wildlife (ODFW), BLM, and U.S. Forest Service (USFS) during development of the understanding of existing terrestrial resources documented herein. Other entities that have provided or will provide information on existing conditions and that will assist with survey planning include the Klamath Bird Observatory and the National Council for Air and Stream Improvement, Inc.

#### 3.4.2.3 Site Reconnaissance

A field reconnaissance was conducted by the KRRC in July 2017. During the field reconnaissance, KRRC biologists visited proposed disturbance areas, including the dams, powerhouses and associated structures, recreation areas, roads, and proposed disposal sites to gather qualitative information on habitats present and the potential for special status species, wetlands, and rare natural communities to be present within the limits of work. Changes to existing conditions that may have occurred since previously documented surveys were noted. KRRC biologists also gathered information to aid in planning for 2018 KRRC surveys, including development of the survey work plans provided in Appendix E. The purpose of the 2018 surveys are to obtain additional input concerning existing biological conditions, which will feed into both the preliminary design process and the regulatory permit application development.

### 3.4.3 Vegetation Communities and Habitats

Eight vegetation cover types were mapped by PacifiCorp (2004), and each cover type was further sub-classified. The results of the 2004 mapping are available in the PacifiCorp Terrestrial Resources report. In some locations, differences between the 2004 PacifiCorp mapping data and current conditions were noted during the recent KRRC field reconnaissance survey. Vegetation community maps will be updated by the KRRC as appropriate to reflect existing conditions based on surveys to be conducted in 2018.

The following sections describe the vegetation communities observed by the KRRC within the proposed limits of work and adjacent areas during the July 2017 site reconnaissance.

#### 3.4.3.1 Vegetation Communities

**J.C. Boyle**

J.C. Boyle Reservoir consists of approximately 420 acres of open water situated within Klamath mixed conifer forest, dominated by ponderosa pine (*Pinus ponderosa*) with Douglas-fir (*Pseudotsuga menziesii*) also common (Figure 3.4-1). North of OR66, the reservoir supports a broad, shallow emergent marsh along both edges supporting a large community of bulrush (*Schoenoplectus*) and aquatic vegetation including pondweeds (*Potamogeton* sp.) and coontail (*Ceratophyllum demersum*) along the eastern shoreline. Sportsmen's Park is located just east of this marsh and provides limited access. South of OR66, the reservoir is relatively narrow with forested slopes and some flatter areas supporting patches of bulrush, cattail (*Typha* sp.), and rushes (*Juncus* sp.) along the shoreline.

**Figure 3.4-1 J.C. Boyle Reservoir Downstream of OR66**

Developed areas associated with the dam and hydropower facilities consist of annual grasses dominated by cheatgrass (*Bromus tectorum*) and other non-native species. Recreational sites around the reservoir include day use facilities with unpaved parking lots and the developed Topsy Campground with paved roads and parking areas, a boat dock, and small structures. These areas consist primarily of scattered ponderosa pine and Douglas-fir. Downstream of J.C. Boyle powerhouse, an undeveloped campground is situated among mature ponderosa pine, Douglas fir, and black oak (*Quercus kelloggii*).

The proposed J.C. Boyle disposal site is located adjacent to a high-power transmission line corridor (Figure 3.4-2). A portion of the site was likely used as a borrow site during dam construction. The majority of the area is heavily disturbed and consists of bare ground. Evidence of cattle grazing was also observed. Several depressions support dense stands of coyote willow (*Salix exigua*) in some areas, while others are sparsely vegetated with herbaceous vegetation including cudweed (*Gnaphalium palustre*), Bach's calicoflower (*Downingia bacigalupii*), and Bermuda grass (*Cynodon dactylon*).

**Figure 3.4-2 Power Line Corridor Adjacent to J.C. Boyle Disposal Site**

A portion of the proposed disposal site is located within a deep ravine that supports a dispersed mixed chaparral/sagebrush scrub community consisting of antelope bitterbrush (*Purshia tridentata*), deerbrush (*Ceanothus integerrimus*), big sagebrush (*Artemisia tridentata*), gray rabbitbrush (*Chrysothamnus nauseosus*), greenleaf manzanita (*Arctostaphylos patula*), and serviceberry (*Amelanchier alnifolia*). Herbaceous species observed in this area include nettleleaf horsemint (*Agastache urticifolia*), parched willowherb (*Epilobium brachycarpum*), needle navarretia (*Navarretia intertexta*), lupine (*Lupinus argenteus*), yarrow (*Achillea millefolium*), bull thistle (*Cirsium vulgare*), cheatgrass, and other non-native grasses. A narrow drainage channel was noted at the bottom of the ravine. The channel was dry during the July 2017 site reconnaissance.

Downstream of the dam, the Klamath River runs through a narrow canyon with steep, forested slopes and exposed rock cliffs and talus slopes in many areas. Reed canarygrass (*Phalaris arundinacea*) dominates the Klamath River shoreline downstream of the dam. Water from the reservoir is conveyed through an approximately 2.2-mile long power canal located along a bench cut in the face of the river canyon. The canal is a concrete flume approximately 17-feet wide and 12-feet high and single-walled in places, supporting patches of arroyo willow (*Salix lasiolepis*) riparian vegetation on the uphill side in some areas along its route to the forebay.

Vegetation on the slopes surrounding the J.C. Boyle powerhouse, including the former access roads to the penstocks, consists of an open forest of Oregon oak and conifers with mixed chaparral/sagebrush vegetation (Figure 3.4-3).

**Figure 3.4-3 Oak-Conifer Woodland around J.C. Boyle Penstocks**

### Copco No. 1 and No. 2

Copco No. 1 Dam is situated in a narrow canyon adjacent to exposed rock faces. The dam impounds an approximately 1,000-acre reservoir. Much of the reservoir shoreline is steeply sloped and consists of open Oregon oak (*Quercus garryana*) and western juniper (*Juniperus occidentalis*) woodland, with large expanses of annual and perennial grassland on the slopes north of the reservoir dominated by invasive yellow starthistle (*Centaurea solstitialis*) and medusahead (*Taeniatherum caput-medusae*) (Figure 3.4-4). Denser mixed oak-conifer forests are found along the slopes south of the reservoir. There is evidence of cattle grazing around the reservoir, and feral horses were noted during the July 2017 reconnaissance.

Riparian habitat dominated by coyote willow and shining willow (*Salix lucida*) is primarily found where stream channels enter the reservoir. An area of seeps and springs supports a dense willow and hardwood forest along the slope on the northwest shore of the reservoir. Patches of emergent vegetation, including bulrush, cattail, and rushes, exist in areas where the shoreline topography supports areas of shallow water.

**Figure 3.4-4 Copco Lake**

Two recreational sites are located along Copco Lake and provide day use facilities and boat launches. Numerous residences are located along the reservoir shoreline and in some places form small villages, such as near the upstream end.

Copco No. 2 Dam is situated approximately 0.3 mile downstream of Copco No. 1 Dam, creating a narrow reservoir with steep sides. The north slope of this reach is developed with access roads to Copco No. 1 Dam, the powerhouse at the base of Copco No. 1 Dam, and to Copco No. 2 Dam. The northern slope is vegetated with yellow starthistle, non-native grasses, and scattered native forbs including giant blazing-star (*Mentzelia laevicaulis*). Exposed basalt outcrops form cliff faces on the northern slope. The southern slope is forested with willows, oaks, and conifers.

The proposed Copco disposal site is located on the slope north of Copco No. 2 Reservoir. The site is developed with a house and other structures. The topography of the site suggests it was used as a borrow site for dam construction. Vegetation at the site consists of yellow starthistle, medusahead and other non-native grasses, weedy species such as mullein

(*Verbascum thapsus*), and scattered sagebrush shrubs such as rabbitbrush (Figure 3.4-5). Two mature eastern arborvitae (*Thuja occidentalis*) trees and irrigated lawn surround the house.

**Figure 3.4-5 Copco Disposal Site**

Downstream of Copco No. 2 Dam, the river winds through a horseshoe-shaped canyon with steep exposed cliff faces along the northern slope. The large wooden Copco No. 2 penstock is located on a terrace above the south shore of the river. Vegetation along the southern bank is dominated by willows and white alder (*Alnus rhombifolia*). Himalayan blackberry (*Rubus armeniacus*), and poison oak (*Toxicodendron diversilobum*) were observed in the understory.

Water leaking from the Copco No. 2 penstock supports wetland vegetation in several locations, including broadleaf cattail (*Typha latifolia*), water smartweed (*Polygonum amphibium*), and beggarstick (*Bidens frondosa*) (Figure 3.4-6). Culverts drain these ponded areas down to the river. Open disturbed sites dominated by invasive yellow starthistle are located along the penstock, including a large flat area at the eastern end that was likely created during the penstock construction.

Copco No. 2 powerhouse is situated along the southern bank of the river upstream of the Daggett Road crossing. Several residences and other structures are also located in this area, known as Copco Village. Vegetation is disturbed with irrigated lawns surrounding the structures.

**Figure 3.4-6 Copco No. 2 Penstock**

The confluence of Fall Creek and the Klamath River is located just downstream of Copco Village and supports a willow riparian and emergent wetland vegetation community. The City of Yreka water supply line is located in this vicinity. Wetland vegetation includes hardstem bulrush and reed canarygrass. Several weedy species including teasel (*Dipsacus fullonum*), curly dock (*Rumex crispus*), lambsquarters (*Chenopodium album*), and oxeye daisy (*Leucanthemum vulgare*) were noted on the southern bank of the Klamath River in the vicinity of the City of Yreka water supply line.

### Iron Gate

Iron Gate Reservoir consists of approximately 944 acres situated within open oak and juniper woodlands similar to those found at Copco Lake (Figure 3.4-7). The reservoir shorelines are less steep than those of Copco Lake. Annual grasslands are dominated by invasive yellow starthistle and medusahead and there is evidence of cattle grazing in many areas. A single-lane bridge crosses the Klamath River downstream of the dam and provides access to the powerhouse and fish hatchery. Several structures including two residences are located on the north side of the river and are surrounded by irrigated lawns.

**Figure 3.4-7 Iron Gate Reservoir**

Several day use sites and campgrounds are located around the reservoir (Figure 3.4-8). Vegetation within these areas consists primarily of Oregon oak, western juniper, willows, and chaparral/sagebrush scrub. A few mature black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) and weeping willow (*Salix babylonica*) were observed. Dense willow riparian communities consisting of coyote and shining willow are associated with the mouths of Jenny, Scotch, and Camp creeks (Figure 3.4-9). Emergent wetland vegetation in these areas consists of hardstem bulrush, cattails, rushes, and other species.

The proposed Iron Gate disposal site consists of annual grassland dominated by yellow starthistle, medusahead, with scattered forbs including barestem buckwheat (*Eriogonum nudum*), sunflower (Helianthus sp.), turkey mullein (*Eremocarpus setigerus*), and wild onion (Allium sp.) (Figure 3.4-10). The site also supports open Oregon oak and western juniper woodlands, and chaparral communities dominated by wedgeleaf ceanothus (*Ceanothus cuneatus*) with three-leaf sumac (*Rhus trilobata*) also observed. The site appears to be used for target shooting and there is evidence of cattle grazing. The site may have been used as a borrow area during construction of the dam. A shallow drainage swale that runs south toward Bogus Creek was dry during the July 2017 site reconnaissance.

**Figure 3.4-8 Recreation Site at Iron Gate Reservoir**

**Figure 3.4-9 Willow Riparian Habitat at Iron Gate Reservoir**

**Figure 3.4-10 Iron Gate Disposal Site**

#### 3.4.3.2 Rare and Natural Communities

There are no rare natural communities identified in the CNNDB database. During the July 2017 site reconnaissance, areas of willow riparian and wetland habitats were observed (as described in Section 3.4.6). Although no other rare natural communities were observed within the limits of work or surrounding areas during the July 2017 site reconnaissance, a more thorough investigation will be completed as part of the special status plant surveys to be conducted as described in Section 3.4.5.2.

#### 3.4.3.3 Invasive Species

As noted above, large infestations of invasive yellow starthistle and medusahead were observed adjacent to Copco Lake and Iron Gate Reservoir and other disturbed areas. Himalayan blackberry was also observed in localized areas, including along the Klamath River near the Copco penstock. Reed canarygrass was dominant along most reaches of the Klamath River within the Project area.

Additional information on invasive species in the J.C. Boyle Project area was obtained from the BLM National Invasive Species Information Management System (NISIMS) database. Spatial data show large infestations of medusahead around the J.C. Boyle Reservoir, yellow starthistle in the vicinity of the J.C. Boyle powerhouse, Scotch thistle (*Onopordum acanthium*) around the J.C. Boyle Dam, and common St. John's wort (*Hypericum perforatum*) along the Klamath River canyon between the J.C. Boyle Dam and powerhouse. Other invasive species mapped in the J.C. Boyle area include diffuse knapweed (*Centaurea diffusa*), bull thistle, Canada thistle (*Cirsium arvense*), Scotch broom (*Cytisus scoparius* var. *scoparius*), Dyer's woad (*Isatis tinctorial*), and smallflower tamarisk (*Tamarix parviflora*).

### 3.4.4 Wildlife

Since the 2012 EIS/R was published, there have not been any significant changes in habitats within the Project limits of work. Based on a review of historical aerial photography conducted by the KRRC, timber harvest has been conducted in several locations within 0.5 miles of the limits of work near the J.C. Boyle Dam and powerhouse. These timber harvests have occurred since the PacifiCorp habitat and species surveys were conducted in 2001-2003. The analysis of historical imagery noted that logging and forest thinning occurred in late summer/fall of 2003 and between 2003 and 2005 in the vicinity of the J.C. Boyle Reservoir and east of the Klamath River canyon between the J.C. Boyle Dam and the powerhouse. Although, these habitat alterations have the potential to reduce habitat suitability for some species, they are located outside of the Project limits of work and are not on PacifiCorp property. No major wildfires or other significant habitat alterations were identified in the Project area since the PacifiCorp surveys. The summary and discussion of common wildlife found in the 2012 EIS/R is still valid for current analyses.

During the field reconnaissance in July 2017, a number of wildlife species were noted by the field biologists. A list of observed species has been compiled and is included in Table 3.4-1.

**Table 3.4-1 Wildlife Species Observed During July 2017 Field Reconnaissance**

| Common Name | Scientific Name |
|---|---|
| **J.C. Boyle Project Area** | |
| American bullfrog | *Lithobates catesbeianus* |
| Western Pond Turtle | *Actinemys marmorata* |
| Sagebrush Lizard | *Sceloporus graciosus* |
| Western Fence Lizard | *Sceloporus occidentalis* |
| Mouse-eared Bats | *Myotis* sp. |
| Coyote | *Canis latrans* |
| Black Bear | *Ursus americanus* |
| Black-tailed Deer | *Odocoileus hemionus* |
| California ground squirrel | *Otospermophilus beecheyi* |
| Western Grey Squirrel | *Sciurus griseus)* |
| Chipmunk | *Tamias* sp. |
| Canada Goose | *Branta canadensis* |
| Eurasian Collared-Dove | *Streptopelia decaocto* |
| Mourning Dove | *Zenaida macroura* |

| **Common Name** | **Scientific Name** |
|---|---|
| Common Poorwill | *Phalaenoptilus nuttallii* |
| Killdeer | *Charadrius vociferus* |
| Least Sandpiper | *Calidris minutilla* |
| Western Gull | *Larus occidentalis* |
| Caspian Tern | *Hydroprogne caspia* |
| Double-crested Cormorant | *Phalacrocorax auritus* |
| American White Pelican | *Pelecanus erythrorhynchos* |
| Great Blue Heron | *Ardea herodias* |
| Turkey Vulture | *Cathartes aura* |
| Osprey | *Pandion haliaetus* |
| Bald Eagle | *Haliaeetus leucocephalus* |
| Northern Flicker | *Colaptes auratus* |
| Olive-sided Flycatcher | *Contopus cooperi* |
| Western Wood-Pewee | *Contopus sordidulus* |
| California Scrub-Jay | *Aphelocoma californica* |
| Barn Swallow | *Hirundo rustica* |
| Red-breasted Nuthatch | *Sitta canadensis* |
| White-breasted Nuthatch | *Sitta carolinensis* |
| American Robin | *Turdus migratorius* |
| Purple Finch | *Haemorhous purpureus* |
| Lesser Goldfinch | *Spinus psaltria* |
| **Copco Dam Project Area** | |
| Mouse-eared Bats | *Myotis sp.* |
| Feral Horses | *Equus caballus* |
| Wood Duck | *Aix sponsa* |
| Wild Turkey | *Meleagris gallopavo* |
| Rock Pigeon | *Columba livia* |
| Mourning Dove | *Zenaida macroura* |
| White-throated Swift | *Aeronautes saxatalis* |
| Spotted Sandpiper | *Actitis macularius* |
| Western Gull | *Larus occidentalis* |
| Caspian Tern | *Hydroprogne caspia* |
| Double-crested Cormorant | *Phalacrocorax auritus* |
| American White Pelican | *Pelecanus erythrorhynchos* |
| Great Blue Heron | *Ardea herodias* |
| Great Egret | *Ardea alba* |
| Turkey Vulture | *Cathartes aura* |
| Osprey | *Pandion haliaetus* |
| Red-tailed Hawk | *Buteo jamaicensis* |

| Common Name | Scientific Name |
|---|---|
| Acorn Woodpecker | *Melanerpes formicivorus* |
| Downy Woodpecker | *Picoides pubescens* |
| Hairy Woodpecker | *Picoides villosus* |
| Northern Flicker | *Colaptes auratus* |
| Western Wood-Pewee | *Contopus sordidulus* |
| Black Phoebe | *Sayornis nigricans* |
| Ash-throated Flycatcher | *Myiarchus cinerascens* |
| Tree Swallow | *Tachycineta bicolor* |
| Barn Swallow | *Hirundo rustica* |
| Bushtit | *Psaltriparus minimus* |
| Canyon Wren | *Catherpes mexicanus* |
| American Dipper | *Cinclus mexicanus* |
| American Robin | *Turdus migratorius* |
| House Finch | *Haemorhous mexicanus* |
| Lesser Goldfinch | *Spinus psaltria* |
| American Goldfinch | *Spinus tristis* |
| Savannah Sparrow | *Passerculus sandwichensis* |
| Western Tanager | *Piranga ludoviciana* |
| Black-headed Grosbeak | *Pheucticus melanocephalus* |
| Lazuli Bunting | *Passerina amoena* |
| **Iron Gate Dam Project Area** | |
| Minnows | Cyprinidae |
| Sagebrush Lizard | *Sceloporus graciosus* |
| Mallard | *Anas platyrhynchos* |
| Common Merganser | *Mergus merganser* |
| Rock Pigeon | *Columba livia* |
| Eurasian Collared-Dove | *Streptopelia decaocto* |
| Spotted Sandpiper | *Actitis macularius* |
| Caspian Tern | *Hydroprogne caspia* |
| American White Pelican | *Pelecanus erythrorhynchos* |
| Great Blue Heron | *Ardea herodias* |
| Osprey | *Pandion haliaetus* |
| Lewis's Woodpecker | *Melanerpes lewis* |
| Hairy Woodpecker | *Picoides villosus* |
| Western Wood-Pewee | *Contopus sordidulus* |
| Pacific-slope Flycatcher | *Empidonax difficilis* |
| Say's Phoebe | *Sayornis saya* |
| Ash-throated Flycatcher | *Myiarchus cinerascens* |
| California Scrub-Jay | *Aphelocoma californica* |

| Common Name | Scientific Name |
|---|---|
| American Crow | *Corvus brachyrhynchos* |
| Tree Swallow | *Tachycineta bicolor* |
| Violet-green Swallow | *Tachycineta thalassina* |
| Cliff Swallow | *Petrochelidon pyrrhonota* |
| White-breasted Nuthatch | *Sitta carolinensis* |
| Rock Wren | *Salpinctes obsoletus* |
| Western Bluebird | *Sialia mexicana* |
| American Robin | *Turdus migratorius* |
| Lesser Goldfinch | *Spinus psaltria* |
| Song Sparrow | *Melospiza melodia* |
| Brewer's Blackbird | *Euphagus cyanocephalus* |
| Western Tanager | *Piranga ludoviciana* |

### 3.4.5 Special Status Species

#### 3.4.5.1 Wildlife

A list of special status species that may occur in the Klamath Basin is shown in Table 3.4-2. The table includes notes on recorded sightings of each species and whether they may occur within the Project limits of work. The species or groups of species that have the potential to occur in or near the Project and may be affected by Project activities are detailed in the following sections. The following sections describe information gathered since the 2012 EIS/R was published and a summary of the survey work that will be conducted in 2018/2019 to determine where these species may currently occur within the Project limits of work. That information will be used to implement focused avoidance measures during construction.

## Table 3.4-2 Special Status Species with Potential to Occur in the Project Area (Terrestrial or Semi-Aquatic Species Only)

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| **Invertebrates** | | | | | |
| Conservancy fairy shrimp | *Branchinecta conservatio* | FE | Vernal pools | Not found during PacifiCorp surveys. Not listed on CNDDB search (2017); identified on IPaC (2017). | Vernal pools are not expected to be present. If noted during vegetation or wildlife surveys, focused surveys for vernal pool species will be conducted as appropriate based on the potential for impacts from project implementation. |
| Vernal pool fairy shrimp | *Branchinecta lynchi* | FT | Vernal pools | Not found during PacifiCorp surveys. Not listed on CNDDB search (2017); identified on IPaC (2017). | Vernal pools are not expected to be present. If noted during vegetation or wildlife surveys, focused surveys for vernal pool species will be conducted as appropriate based on the potential for impacts from project implementation. |
| Vernal pool tadpole shrimp | *Lepidurus packardi* | FE | Vernal pools | Not found during PacifiCorp surveys. Not listed on CNDDB search (2017); identified on IPaC (2017). | Vernal pools are not expected to be present. If noted during vegetation or wildlife surveys, focused surveys for vernal pool species will be conducted as appropriate based on the potential for impacts from project implementation. |
| Klamath pebblesnail | *Fluminicola sp. 5* | ONHP List 1 | Medium rivers in cold and relatively pristine hard-subhabitats with little disturbance | ORBIC occurrence at confluence of Spencer Creek and J.C. Boyle Reservoir/Klamath River and just east of powerhouse (ORBIC 2017). | Focused surveys are not proposed. |
| Klamath Rim pebblesnail | *Fluminicola sp.6* | ONHP List 1 | Small, cold, spring runs with shallow water and gravel-cobble substrate | ORBIC occurrence at Klamath River 0.3 miles east of J.C. Boyle powerhouse (ORBIC 2017). | Focused surveys are not proposed. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| Blue Mountains juga (snail) | *Juga sp. 2* | ONHP List 1 | Freshwater | ORBIC occurrence near Rock Creek (ORBIC 2017). | Focused surveys are not proposed. |
| Scale lanx (snail) | *Lanx klamathensis* | ONHP List 1 | Freshwater | ORBIC occurrence near Rock Creek (ORBIC 2017). | Focused surveys are not proposed. |
| Siskiyou (= Chase) sideband | *Monadenia chaceana* | BLM, ONHP List 1, tracked on CNDDB | Lower reaches of major drainages, in talus and rock slides, under rocks and woody debris in moist conifer forests, in caves, and in shrubby areas in riparian corridors. Rocks and large woody debris serve as refugia during the summer and late winter seasons. | Not documented during PacifiCorp surveys. Historical occurrence 0.25 miles below Copco Dam in lava rockslide (CNDDB 2017). May occur in large piles of rocks (termed "derrick pile" by KNF) (Henderson 2017). | Focused surveys are not proposed. |
| Terrestrial snail | *Monadenia fidelis leonine* | Tracked on CNDDB | Associated with dead alder leaves and trunks near streams, in relatively undisturbed forest; among leaves (deep maple and alder leaf litter); and under debris on ground forested and open talus or rocky areas. | Documented on CNDDB in the Beaver Creek drainage. Possibly extirpated (Henderson 2017). | Focused surveys are not proposed. |
| **Amphibians** | | | | | |
| Tailed frog | *Ascaphus truei* | FSC, CSSC | Perennial, cold, fast-flowing mountain streams with dense vegetation cover, or streams in steep-walled valleys in non-forested areas. | Widespread in tributary streams in the lower Klamath River (Green Diamond Resource Company 2006). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Western toad | *Anaxyrus boreas* | BLM, OSS | Breeds from February to early May in ponds, the edges of shallow lakes, and in slow-moving streams. Adults are common near marshes and small lakes but may also be found in dry forests, shrubby areas, and meadows. | Documented during PacifiCorp surveys along J.C. Boyle peaking reach, along the north shore of Iron Gate Reservoir, and along Klamath River near river mile 185 (between the confluence of Bogus and Cottonwood Creeks). One occurrence near Frain Ranch, Klamath River Canyon (ORBIC 2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| Northern red-legged frog | *Rana aurora* | FSC, USFS, OSS, CSSC | Breeds in quiet low-velocity habitats, such as wetlands, ponds, and disconnected side channel habitats in coastal areas of the Lower Klamath River. Usually breeds January through March (Lannoo 2005). | Documented by CDFW as breeding in coastal areas of the Lower Klamath River. | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Foothill yellow-legged frog | *Rana boylii* | FSC, BLM, OSS, CSSC, Request for CA candidate | Streams and rivers with cobble-size or larger substrate. Breeds generally between late April and June (Lannoo 2005). | Known to CDFW to breed in the Lower Klamath River Mainstem and major tributaries. ORBIC occurrence downstream of J.C. Boyle Reservoir (ORBIC 2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Cascades frog | *Rana cascadae* | FSC, OSS, CSSC | Montane aquatic habitats such as mountain lakes, small streams, and ponds in meadows; open coniferous forests. | Documented occurrence in Klamath National Forest (CNDDB 2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Oregon spotted frog | *Rana pretiosa* | FT, BLM, OSS, CSSC | Highly aquatic and generally avoids dry uplands. It is rarely found far from permanent quiet water. Usually occurs in vegetated shallows or among grasses or sedges along the margins of streams, lakes, ponds (including those behind beaver dams), oxbows, springs, and marshes. | Not found during PacifiCorp surveys. Not listed on CNDDB search (2017); identified on IPaC (2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Siskiyou Mountain salamander | *Plethodon stormi* | FSC, CT, OSS | Mixed conifer habitat of dense, pole-to-mature size, trees. Active above ground only during spring & fall rains. | Documented occurrences along Klamath River in Klamath National Forest (CNDDB 2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Southern torrent salamander | *Rhyacotriton variegatus* | FSC, OSS, CSSC | Uppermost portions of cold, well shaded permanent streams with a loose gravel substrate, springs, headwater seeps, waterfalls, and moss covered | Widespread in tributary streams in the lower Klamath River (Green Diamond Resource Company 2006). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| | | | rock rubble with flowing water. | | |
| Cope's giant Salamander | *Dicamptodon copei* | OSS | Streams and rivers in moist coniferous forests. Sometimes found in clear, cold mountain lakes and ponds | Not known to occur in project area. | Focused surveys are not proposed due to unlikelihood of occurrence. |
| **Reptiles** | | | | | |
| Western pond turtle | *Actinemys marmorata* | FSC, BLM, OSS, ONHP List 2, CSSC | Prefers quiet water in small lakes, marshes, and sluggish streams and rivers; requires basking sites. | Documented during PacifiCorp surveys at Keno, J.C. Boyle, Copco, and Iron Gate Reservoirs, along J.C. Boyle bypass reach, along J.C. Boyle peaking reach in California, and along Klamath River from Iron Gate Dam to Shasta River. Also documented at Iron Gate Reservoir and along Klamath River (ORBIC, CNDDB 2017). | TBD based on additional input from the resource agencies, other experts, and analysis of potential for impacts based on life history and existing conditions. Reservoir surveys may be needed to determine the size of the population, where the turtles are overwintering, and to determine what actions would minimize impacts. |
| Western painted turtle | *Chrysemys picta bellii* | OSS | Ponds, marshes, lakes, ditches, quiet streams with sandy or muddy bottoms and aquatic vegetation. | Not known to occur in project area. | Focused surveys are not proposed due to unlikelihood of occurrence. |
| Northern sagebrush lizard | *Sceloporus graciosus graciosus* | FSC, BLM, ONHP List 4 | Inhabits sagebrush, chaparral, juniper woodlands, and dry conifer forests. | Documented during PacifiCorp surveys in the rocky riparian shrub habitat of Keno reach, along J.C. Boyle peaking reach, near J.C. Boyle powerhouse intake canal, and near the edge of a forested wetland along Iron Gate Reservoir. | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Sharptail snake | *Contia tenuis* | BLM | Inhabits moist sites in chaparral, conifer forests, and deciduous forests, but primarily occurs in oaks and other deciduous tree woodlands, particularly in the forest edges. | Known to occur along upper J.C. Boyle peaking reach west of Frain Ranch in Douglas-fir habitat but not detected by PacifiCorp during its surveys. | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| California | *Lampropeltis* | FSC, BLM, | Inhabits thick vegetation along | Documented during PacifiCorp | Focused surveys are not |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| mountain kingsnake | *zonata* | OSS, ONHP List 4 | watercourses, farmland, chaparral, deciduous, and mixed-coniferous forests; specifically associated with moist river valleys and dense riparian vegetation. | surveys along Copco Road and in close proximity to J.C. Boyle powerhouse intake canal. Also known to occur along J.C. Boyle peaking reach. Documented in Klamath River Canyon and east of J.C. Boyle powerhouse (ORBIC 2017). | proposed. Observations during general wildlife surveys will be noted. |
| Common kingsnake | *Lampropeltis getula* | FSC, BLM, OSS, ONHP List 4 | Occurs in pine forests, oak woodlands, and chaparral in, under, or near rotting logs and usually near streams; associated with well-illuminated rocky riparian habitat with mixed deciduous and coniferous trees. | Documented during PacifiCorp surveys along J.C. Boyle peaking reach in oak/woodland and mixed conifer woodland and along Copco Road. | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| **Birds** | | | | | |
| Common loon | *Gavia immer* | FSC, CSSC | May over-winter on project reservoirs or occur in aquatic habitat associated with large bodies of water like the project reservoirs while migrating from sub-arctic freshwater breeding grounds to coastal and near-shore pelagic marine habitat along the Pacific coast. | Documented during PacifiCorp surveys at Iron Gate Reservoir. | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| American white pelican | *Pelecanus erythrorhynchos* | BLM, OSS, ONHP List 2, CSSC | Nests at lakes and marshes and uses almost any lake outside of the breeding season; have a restricted range in southern Oregon and along the California border, where they are found to be associated with only a few large bodies of inland water. | Documented during PacifiCorp surveys on all project reservoirs, with the highest number occurring on Keno Impoundment, and along Link River, Keno reach, J.C. Boyle bypass reach, and on Klamath River between Iron Gate Dam and Shasta River. | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Double-crested cormorant | *Phalacrocorax auritus* | Nesting colonies afforded | Colonial nester on coastal cliffs, rocks, offshore islands, and along lake margins. | Documented during PacifiCorp surveys at Keno and J.C. Boyle Dams. Documented nesting | Wildlife surveys will note presence and nesting colonies to identify potential for impacts from project |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| | | special protection by CDFW | | colonies near mouth of Klamath River (CNDDB 2017). | implementation. |
| Black-crowned night heron | *Nycticorax nycticorax* | FSC, Nesting colonies afforded special protection by CDFW | Found in riparian habitats and in wetland sites. | Documented during PacifiCorp surveys primarily along Keno reach, but also along Link River, at Keno Impoundment, and along Klamath River from Iron Gate Dam to Shasta River. Communal roost used by night herons and other heron species in a group of willow trees near the East Side powerhouse adjacent to Link River. | Wildlife surveys will note presence and nesting colonies to identify potential for impacts from project implementation. |
| Snowy egret | *Egretta thula* | BLM, OSS, ONHP List 2, Nesting colonies afforded special protection by CDFW | Inhabits emergent wetlands associated with freshwater marshes and along the periphery of large water bodies. The northern limit of the species range includes southern Oregon. | Documented during PacifiCorp surveys near Link River Dam, at Keno Dam, and along Keno reach. | Wildlife surveys will note presence and nesting colonies to identify potential for impacts from project implementation. |
| Great egret | *Casmerodius albius* | BLM, Nesting colonies afforded special protection by CDFW | Nests in willows and other trees; forages in shallow water, wetlands, and fields. Range includes Klamath basin and eastern Siskiyou County. Known to occur in the study area. | Documented during PacifiCorp surveys at J.C. Boyle and Keno Impoundments, Keno Canyon reach, J.C. Boyle bypass and peaking reaches, and Link River. | Wildlife surveys will note presence and nesting colonies to identify potential for impacts from project implementation. |
| Great blue heron | *Ardea herodias* | Nesting colonies afforded special status protection by CDFW | Forages mostly in slow-moving or calm salt, fresh, or brackish water in a variety of habitats, including rocky shores, coastal lagoons, saltwater and freshwater marshes, mudflats, bays, estuaries, along the margins of rivers, lakes, and | Documented during PacifiCorp surveys at all reservoirs and most study area reaches. Known colony documented along the south side of Copco Lake (Harris 2017). No known rookeries at J.C. Boyle (Wray 2017). Several rookeries documented along the Klamath | Wildlife surveys will note presence and nesting colonies to identify potential for impacts from project implementation. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
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| | | | irrigation canals, and in flooded fields. Nesting colonies are typically found in groves of large trees, often in mixed colonies with other herons, egrets, and cormorants. | River (CNDDB 2017). | |
| White-faced ibis | *Plegadis chihi* | FSC, BLM, ONHP List 4, CSSC | Breeds in freshwater marshes and lakes, and estuaries, and nests near the water on mats of vegetation and twigs; usually occurs in isolated con-specific flocks. Does not typically overwinter in Oregon but is a fairly common visitor in the Klamath Wildlife Area during the spring and summer. | Documented during PacifiCorp surveys along Link River and at Keno Impoundment and J.C. Boyle Reservoir. | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Bufflehead | *Bucephala albeola* | BLM, ONHP List 4 | Typically breeds around isolated mountain lakes; nesting habitat includes mixed conifer forest and ponderosa pine forests with sparse to moderate tree canopy closure close to lakes and ponds. Nests in cavities, including artificial nest boxes. May be found in open water and riverine habitat throughout southern Oregon after the breeding season. | Documented during PacifiCorp surveys primarily from January until April along the Link River, at Keno Impoundment and Copco and Iron Gate Reservoirs. | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Barrow's goldeneye | *Bucephala islandica* | ONHP List 4, CSSC | Tends to breed along high-elevation mountain lakes and winter in coastal areas. Potential nesting habitat includes forests with sparse to moderate tree canopy closure next to rivers and reservoirs. | Documented during PacifiCorp surveys along Keno Impoundment, in an inundated drainage ditch off of Copco Lake, and on Iron Gate Reservoir. Common winter migrant on the Link River and Keno Impoundment (R. Larson, USFWS). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Trumpeter swan | *Cygnus* | OSS | Relatively shallow (less than 6 | Not documented in project area. | Wildlife surveys will note presence |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
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| | *buccinator* | | feet deep), undisturbed bodies of freshwater with abundant aquatic plants. | | and nesting activity to identify potential for impacts from project implementation. |
| Osprey | *Pandion haliaetus* | CSSC | Nests in all forested vegetation types with large trees near water, as well as on platforms erected in less optimal habitat. | A minimum of 16 active osprey nests, both artificial nesting platforms and natural sites, are found along the shores of the project reservoirs and river reaches. Documented during PacifiCorp surveys along the Keno reach, along the J.C. Boyle bypass reach, along the J.C. Boyle peaking reach, at J.C. Boyle, Copco, and Iron Gate Reservoirs, along Fall Creek, and along Klamath River from Iron Gate Dam to Shasta River. Several occurrences along lower Klamath River (CNDDB 2017). | Wildlife surveys will note presence and nest sites to identify potential for impacts from project implementation. |
| Northern harrier | *Circus cyaneus* | CSSC | Nests and forages in grasslands and emergent wetlands. Permanent residents in the project vicinity and common at the Klamath Wildlife Area. | Documented during PacifiCorp surveys in the low-lying marshland and agricultural fields east of Keno Impoundment and along Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Golden eagle | *Aquila chrysaetos* | CSSC, FP | Breeds in open mountain and hill habitats, nests on cliff ledges, and forages in grasslands and open conifer forests and woodlands with sparse to open tree canopy closure. Eagles use two to three nests during a lifetime. | Historical records exist of several golden eagle nests on cliffs from J.C. Boyle bypass reach to Iron Gate Reservoir. Documented during PacifiCorp surveys at J.C. Boyle powerhouse, along the lower section of J.C. Boyle peaking reach, along Copco and Iron Gate Reservoirs, and Copco bypass reach. | Wildlife surveys will note presence and nest sites to identify potential for impacts from project implementation. See eagle survey plan. |
| Bald eagle | *Haliaeetus* | CE, OSS, | Nests in large conifers within | Documented during PacifiCorp | Wildlife surveys will note presence |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| | *leucocephalus* | ONHP List 4 | several miles of water; forages in rivers and lakes for fish and waterfowl; requires large snags for perching and conifers for night roosts. | surveys at all project reservoirs and in all project reaches throughout the project vicinity. Also documented on Upper Klamath River, on the Klamath River near OR-CA border (ORBIC 2017), and along lower Klamath River (CNDDB 2017). | and nest sites to identify potential for impacts from project implementation. See eagle survey plan. |
| Cooper's hawk | *Accipiter cooperii* | CSSC | Inhabits riparian deciduous forest, montane hardwood oak woodland, montane hardwood oak-juniper, montane hardwood oak-conifer, juniper woodland, mixed conifer forest, ponderosa pine forest, and lodgepole pine with any level of tree canopy closure. | Documented during PacifiCorp surveys along J.C. Boyle bypass and peaking reaches, and along Klamath River from the Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Northern goshawk | *Accipiter gentilis* | FSC, BLM, OSS, ONHP List 4, CSSC | Inhabits forested communities with at least 60 percent canopy cover and trees greater than 6 inches in diameter, except oak woodland, oak-conifer woodland, and oak-juniper woodland; forages over large home ranges. | Documented during PacifiCorp surveys flying over J.C. Boyle peaking reach. Documented near tributaries of lower Klamath River (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Sharp-shinned hawk | *Accipiter striatus* | CSSC | Inhabits riparian deciduous forest, montane hardwood oak woodland, montane hardwood oak juniper, montane hardwood oak-conifer, juniper woodland, mixed conifer forest, ponderosa pine forest, and lodgepole pine with any level of tree canopy closure and tree diameters ranging from 6 to 24 inches. | Documented during PacifiCorp surveys in oak habitat along J.C. Boyle bypass and peaking reaches, and along Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Swainson's hawk | *Buteo swainsoni* | CT, BLM, | Dwells in open country and | Documented during PacifiCorp | Wildlife surveys will note presence |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
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| | | OSS, ONHP List 4 | typically inhabits sagebrush, annual grassland, juniper woodland, montane hardwood oak-juniper, and riparian deciduous forest with sparse to open tree canopy closure. The species' range generally lies east of the project vicinity and includes the plains of the Great Basin in southeast Oregon and eastern northern California. | surveys flying over agricultural fields southeast of Keno Impoundment. Not listed on CNDDB for project area (CNDDB 2017). | and nesting activity to identify potential for impacts from project implementation.<br><br>Focused surveys are not proposed. |
| Merlin | *Falco columbarius* | BLM, ONHP List 2, CSSC | Uses a variety of forested and open habitats. Ranges throughout North America and travels great distances during migration from breeding grounds in northern Canada and Alaska to wintering habitat through the contiguous United States south to Central America. | Documented during PacifiCorp surveys at J.C. Boyle Reservoir and along J.C. Boyle peaking reach. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Prairie falcon | *Falco mexicanus* | CSSC | Uses cliffs for nesting and plateau grasslands for foraging. | Documented during PacifiCorp surveys near Keno campground and boat ramp, above J.C. Boyle bypass reach, near Copco Lake, and flying over Klamath Wildlife Refuge. Several occurrences listed as sensitive (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| American peregrine falcon | *Falco peregrinus anatum* | BLM, OSS, ONHP List 2, FP | Breeds at suitable nest sites on cliffs and rocky outcroppings. Uses a variety of habitats, including open grassland areas, forest stands, and reservoirs throughout the project vicinity. | The project vicinity is in a management area designated for peregrine falcon recovery. Known to occur along Keno Impoundment and the J.C. Boyle bypass reach but not documented during PacifiCorp surveys. Several occurrences listed as sensitive (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Long-billed | *Numenius* | OSS | Sparse, short grasses, including | Not documented in project area. | Wildlife surveys will note any |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
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| curlew | *americanus* | | shortgrass and mixed-grass prairies as well as agricultural fields. | | nesting activity to identify potential for impacts from project implementation. |
| Yellow rail | *Coturnicops noveboracensis noveboracensis* | OSS | Shallow marshes, and wet meadows; in winter, drier fresh-water and brackish marshes, as well as dense, deep grass, and rice fields. | Not documented in project area. | Wildlife surveys will note any nesting activity to identify potential for impacts from project implementation. |
| Mountain quail | *Oreortyx pictus* | FSC, BLM, ONHP List 4 | Inhabits open forests, chaparral, and juniper woodlands with dense undergrowth offering suitable refuge; breeds in higher elevation areas; migrates on foot up to 40 miles to lower elevation winter grounds. | Documented during PacifiCorp surveys at J.C. Boyle reservoir, along the J.C. Boyle bypass reach and peaking reaches, along Fall Creek, and along Klamath River from the Iron Gate Dam to Shasta River. | Wildlife surveys will note any nesting activity to identify potential for impacts from project implementation. |
| Greater sandhill crane | *Grus canadensis tabida* | FSC, BLM, OSS, ONHP List 4, CT, FP | Nests in marshes and wet meadows, and occasionally in pastures and irrigated hayfields. A primary requirement for suitable nesting habitat is the presence of surrounding water or undisturbed habitat. | Documented during PacifiCorp surveys east of Keno Impoundment and along J.C. Boyle reservoir. PacifiCorp located an active nest with two eggs in it in the emergent wetland bordering J.C. Boyle Reservoir. Several occurrences in the Lower Klamath Lake NWR (CNDDB 2017). | Wildlife surveys will note any nesting activity to identify potential for impacts from project implementation. |
| Caspian tern | *Sterna caspia* | OSS | Nests in tightly packed colonies on undisturbed islands, levees, and shores along inland water bodies during the summer breeding season. Forages over water. | Documented during PacifiCorp surveys on all project reservoirs as well as along Link River, Keno and J.C. Boyle bypass reaches, and along the Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note any nesting activity to identify potential for impacts from project implementation. |
| Forster's tern | *Sterna forsteri* | BLM, ONHP List 4 | Breeds at lakes and marshes and on mud or sand flats near water; forages over water. | Documented during PacifiCorp surveys along Link River, along Keno and J.C. Boyle bypass and peaking reaches, and at all project | Wildlife surveys will note any nesting activity to identify potential for impacts from project implementation. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
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| | | | | reservoirs. Not listed on CNDDB for project area (CNDDB 2017). | |
| Black tern | *Chlidonias niger* | FSC, BLM, ONHP List 4, CSSC | Nests in emergent vegetation along the shoreline periphery of freshwater lakes, wetlands, and marshes along rivers and ponds; forages in wet meadows, pastures, agricultural fields, and water. | Documented during PacifiCorp surveys at Keno and J.C. Boyle Reservoirs. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note any nesting activity to identify potential for impacts from project implementation. |
| Marbled murrelet | *Brachyramphus marmoratus* | FT, OT, ONHP List 2, CE | Spends most of the time in the marine environment foraging in nearshore areas. Uses old-growth forests (coast Redwood forests in California) for nesting. | Known to occur within National Forest lands and Green Diamond Resource Company managed lands near the coast. Critical habitat has been designated near the mouth of the Klamath River. | Focused surveys are not proposed due to unlikelihood of occurrence. |
| Flammulated owl | *Otus flammeolus* | BLM, OSS, ONHP List 4 | Nests in abandoned woodpecker nest cavities in open forests with a ponderosa pine component. | Documented during PacifiCorp surveys along J.C. Boyle bypass and peaking reaches. | Wildlife surveys would note any nesting activity to identify potential for impacts from project implementation. |
| Great gray owl | *Strix nebulosa* | BLM, OSS, ONHP List 4, CE | Inhabits mixed conifer, ponderosa pine, and riparian mixed forest stands with trees greater than 11 inches in diameter providing at least 60 percent canopy cover within at least 984 feet of a natural or manmade opening greater than 10 acres. Breeds in tree cavities, typically near suitable open grassland foraging habitat. | Documented during PacifiCorp surveys east of Fall Creek near Jenny Creek. Not listed on CNDDB for project area; nearest location is 24 miles west of Iron Gate Dam (CNDDB 2017). Rarely detected south of OR66 by BLM (Godwin 2017). | Wildlife surveys will note any nesting activity to identify potential for impacts from project implementation. Focused surveys are not proposed due to unlikelihood of occurrence. |
| Northern spotted owl | *Strix occidentalis caurina* | FT, OT, ONHP List 1 | Inhabits ponderosa pine forest, mixed conifer forest, and conifer forest with trees greater than 11 inches in diameter. Prefers old-growth forests with multi-layered tree canopies. Critical | Documented during PacifiCorp surveys near J.C. Boyle Reservoir and along J.C. Boyle peaking reach. Several occurrences within the project area (CNDDB 2017, ORBIC 2017). Known to occur within | Protocol surveys are proposed (see separate northern spotted owl survey plan). |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
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| | | | habitat occurs within the project area upstream of Copco Lake and south of the Klamath River and along portions of the lower Klamath River. | National Forest lands and Green Diamond Resource Company managed lands near the coast. Critical habitat has been designated near the mouth of the Klamath River. | |
| Yellow-billed cuckoo | *Coccyzus americanus* | FT, CE, OSS, BLM | Riparian forest nester, along the broad, lower flood-bottoms of larger river systems. | Not found during PacifiCorp surveys. Not listed on CNDDB search (2017); identified on IPaC (2017). | Focused surveys are not proposed due to unlikelihood of occurrence. |
| Vaux's swift | *Chaetura vauxi* | CSSC | Found in mixed conifer, ponderosa pine, lodgepole pine, riparian deciduous, montane hardwood oak woodland, montane hardwood oak-conifer, and montane hardwood oak-juniper forests with trees greater than 11 inches in diameter. | Documented during PacifiCorp surveys at J.C. Boyle, Copco, and Iron Gate Reservoirs, along the J.C. Boyle bypass and peaking reaches, along Fall Creek, and along Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Black swift | *Cypseloides niger* | OSS, ONHP List 2, CSSC | Suitable nesting habitat is limited to cliffs near water courses. Breeding sites are widely distributed in Oregon and California; none known in Klamath or northern Siskiyou Counties. | Not documented during PacifiCorp surveys. Documented along Klamath River near Orleans (CNDDB 2017). | Observations during general wildlife surveys will be noted. |
| Pileated woodpecker | *Drycopus pileatus* | BLM, OSS, ONHP List 4 | Occurs in all forest and woodland cover types with moderate to dense tree canopy closure. Requires large snags 25 inches or more in diameter for excavating suitable nest cavities. | Documented during PacifiCorp surveys along Keno reach, at J.C. Boyle Reservoir, along J.C. Boyle bypass and peaking reaches, and along Fall Creek. | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Acorn woodpecker | *Melanerpes formicivorus* | FSC, BLM, OSS, ONHP | Nests in cavities in snags of deciduous tree species, | Several nesting colonies documented during PacifiCorp | Wildlife surveys will note presence, nesting activity, and |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
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| | | List 4 | particularly oak snags at least 17 inches in diameter. | surveys in oak, oak-juniper, and oak/conifer habitats, primarily at Copco Lake. Also documented during PacifiCorp surveys at J.C. Boyle and Iron Gate Reservoirs, along J.C. Boyle peaking reach, along Copco bypass reach, along Fall Creek, and along Klamath River from Iron Gate Dam to Shasta River. | granary trees to identify potential for impacts from project implementation. |
| Lewis' woodpecker | *Melanerpes lewis* | FSC, BLM, OSS, ONHP List 2 | Associated with oak woodlands and mixed oak conifer habitat, but also can be found in a variety of open forest stands including ponderosa pine and cottonwood-dominated riparian areas. | Documented during PacifiCorp surveys in upland habitats along J.C. Boyle peaking reach, in riparian habitats at Iron Gate Reservoir, and along Klamath River from Iron Gate Dam to Shasta River. Documented in Klamath River Canyon (ORBIC 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| White-headed woodpecker | *Picoides albolarvatus* | FSC, BLM, OSS, ONHP List 2 | Nests in cavities typically in ponderosa pine at least 18 inches in diameter. Occurs in lodgepole pine, ponderosa pine, and Klamath mixed conifer forests with trees greater than 11 inches in diameter. | Documented during PacifiCorp surveys along J.C. Boyle bypass reach. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Black-backed woodpecker | *Picoides arcticus* | BLM, OSS, Petitioned for listing under CESA | Recently burned coniferous forest in the Sierra Nevada and Cascades to the Siskiyou Mtns; areas with dense standing dead trees, and less commonly in unburned forests. | Not documented during PacifiCorp surveys or listed on CNDDB or ORBIC for the project area. May occur based on information from USFWS Yreka office (May 23, 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Olive-sided flycatcher | *Contopus cooperi* | FSC, BLM, OSS, ONHP List 4 | Typically found in coniferous forests with tall trees providing suitable perch sites. | Documented during PacifiCorp surveys along Link River, at Keno, J.C. Boyle and Iron Gate Reservoirs, and along Keno and J.C. Boyle peaking reaches. Not listed on CNDDB for project area (CNDDB | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| | | | | 2017). | |
| Willow flycatcher | *Empidonax traillii* | FSC, CE BLM, OSS | Associated with dense riparian willow thickets. | Documented during PacifiCorp surveys in some of the denser willow patches along Link River, at J.C. Boyle, Copco, and Iron Gate Reservoirs, along the J.C. Boyle peaking reach, and along Klamath River from Iron Gate Dam to Shasta River. Also documented at Iron Gate Reservoir at Jenny Creek (CNDDB 2017). | In addition to noting presence and nesting activity, surveys will be conducted in suitable habitat to quantify and map potential habitat and identify potential for impacts from project implementation. |
| Purple martin | *Progne subis* | FSC, BLM, OSS, ONHP List 2, CSSC | Riparian and wetland forests, as well as Klamath mixed conifer forest, ponderosa pine forest, montane hardwood oak woodland, montane hardwood oak-conifer, and montane hardwood oak-juniper with sparse to moderate tree canopy closure (<60 percent). Range is patchy and may include portions of the study area. | Documented during PacifiCorp surveys above the upper falls at Fall Creek. | Wildlife surveys will note presence and nesting activity/colonies to identify potential for impacts from project implementation. |
| Red-necked grebe | *Podiceps grisegena* | OSS | Breeds on shallow freshwater lakes, bays of larger lakes, marshes, and other inland bodies of water. Winters on open ocean or on large lakes. | Not documented in project area. | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Black-capped chickadee | *Parus atricapillus* | CSSC | Nests in a variety of woodland habitats wherever suitable, small nest cavities can be found. | Documented during PacifiCorp surveys along Link River and at Copco and Iron Gate Reservoirs. | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Pygmy nuthatch | *Sitta pygmea* | BLM, OSS | Typically found in ponderosa pine forests with less than 70 percent canopy closure. | Documented during PacifiCorp surveys at Keno Impoundment and J.C. Boyle Reservoir. | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Yellow warbler | *Dendroica* | CSSC | Found in riparian deciduous | Documented during PacifiCorp | Wildlife surveys will note presence |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| | *petechia* | | forest, riparian shrub, scrub-shrub wetland, and forested wetland. Breeds in riparian habitat throughout North America and winters south from Mexico through South America. | surveys throughout the project vicinity at all project reservoirs and in all project reaches. Incidental occurrence documented with Willow flycatcher at Copco/Iron Gate Reservoirs (CNDDB 2017). | and nesting activity to identify potential for impacts from project implementation. |
| Yellow-breasted chat | *Icteria virens* | FSC, BLM, OSS, CSSC | Found in the brushy understory of deciduous and mixed woodlands; breeds in brushy vegetation, typically willow thickets, along rivers and streams. | Documented during PacifiCorp surveys primarily in wetland and riparian habitats along J.C. Boyle peaking reach, at Copco Lake, along Fall Creek, and along Klamath River from Iron Gate Dam to Shasta River. Incidental occurrence documented with Willow flycatcher at Copco/Iron Gate Reservoirs (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Northern waterthrush | *Parkesia noveboracensis* | ONHP List 2 | Nests in dense riparian willow thickets. | ORBIC occurrence at Grizzly Butte along Klamath River (ORBIC 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Tricolored blackbird | *Agelaius tricolor* | BLM, CSSC, Candidate for listing under CESA as endangered | Highly colonial species; requires open water, protected nesting substrate, and foraging area with insect prey within a few km of the colony. | Not documented during PacifiCorp surveys or listed on CNDDB or ORBIC for the project area. Nearest occurrences just north of Keno (Wray 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| **Mammals** | | | | | |
| Townsend's big-eared bat | *Corynorhinus townsendii* | FSC, BLM, OSS, ONHP List 2, CSSC | Generally found in open forests and a variety of habitats; the availability of suitable roost sites (rock crevices, cliff ledges, and human-made structures) limits distribution and occurrence. | Known from J.C. Boyle peaking reach but not documented during PacifiCorp surveys. One occurrence in project area listed as sensitive by ORBIC (2017). Documented occurrences along Klamath River near Somes Bar (CNDDB 2017). | See bat survey plan. |
| Yuma myotis | *Myotis* | FSC, BLM, | Generally found in open forests | Documented during PacifiCorp | See bat survey plan. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| | *yumanensis* | ONHP List 4 | and a variety of habitats; the availability of suitable roost sites (rock crevices, cliff ledges, and human-made structures) limits distribution and occurrence. | surveys roosting in J.C. Boyle forebay spillway house, in transformer bays at Copco No. 1 powerhouse, and in rafters at Iron Gate south gatehouse. Also known from J.C. Boyle peaking reach. One occurrence outside project area (CNDDB 2017). | |
| California myotis | *Myotis californicus* | OSS | Wide tolerance of habitat including forested regions of the Pacific Northwest, humid coastal forests and montane forests. | Not documented in project area. Range overlaps with project area. | See bat survey plan. |
| Fringed myotis | *Myotis thysanodes* | BLM, FSC, OSS | Oak and pinyon woodlands appear to be the most commonly used vegetative associations. Roost sites may be in caves, mines, and buildings. | Not documented in project area. Range overlaps with project area. | See bat survey plan. |
| Hoary bat | *Lasiurus cinereus* | OSS | May prefer trees at the edge of clearings, but have also been found in trees in heavy forests, open wooded glades, and shade trees along urban streets and in city parks. | Not documented in project area. Range overlaps with project area. | See bat survey plan. |
| Long-legged myotis | *Myotis volans* | OSS | Roosts in trees, rock crevices, fissures in stream banks, and buildings. Caves and mines are used at night. | Not documented in project area. Range overlaps with project area. | See bat survey plan. |
| Pallid bat | *Antrozous pallidus* | BLM, CSSC, FSC, OSS | Variety of structures for day and night roosting, including live trees and snags, a rock crevice, and buildings. | Not documented in project area. Range overlaps with project area. | See bat survey plan. |
| Silver-haired bat | *Lasionycteris noctivagans* | OSS | Prefer temperate, northern hardwoods with ponds or streams nearby. The typical day | Not documented in project area. Range overlaps with project area. | See bat survey plan. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| | | | roost for the bat is behind loose tree bark. | | |
| Western gray squirrel | *Sciurus griseus* | BLM, ONHP List 4 | Found in a variety of forested habitat types including mixed conifer forest, ponderosa pine forest, lodgepole pine, montane hardwood oak woodland, montane hardwood oak-conifer, and montane hardwood oak juniper with trees greater than 6 inches in diameter. | Documented during PacifiCorp surveys at J.C. Boyle Reservoir and Copco Lake, along J.C. Boyle peaking reach, and along Copco bypass reach. | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Ringtail | *Bassariscus astutus* | BLM, OSS, ONHP List 4, FP | Uses a mixture of forest and shrublands or other habitats that provide vertical structure near rocky or riparian areas. Range overlaps the study area. The species is known to occur in the study area. | Not documented during PacifiCorp surveys. Documented in Klamath River Canyon (ORBIC 2017). Not listed on CNDDB for project area (CNDDB 2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Fisher- West Coast DPS | *Martes pennanti (Pekania pennanti)* | FC, BLM, OSS, ONHP List 2, CSSC | Mature, closed canopy forests with some deciduous trees; intermediate to large tree stages of conifer forests and riparian deciduous forests both with high tree canopy closure. Habitats in the study area include lodgepole pine, Klamath mixed conifer forest, ponderosa pine forest, riparian deciduous forest, montane hardwood oak-conifer with trees >11 inches dbh. Range overlaps the study area. | Not documented during PacifiCorp surveys. ORBIC occurrences along Klamath River near Rock Creek (ORBIC 2017). Documented along lower Klamath River (CNDDB 2017). Has been documented in the Upper Klamath Basin within the last two years (T. Collom, ODFW, personal communication, April 29, 2011). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Wolverine | *Gulo gulo* | FPT, CT, OT, FP | Found in the north coast mountains and the Sierra Nevada. Found in a wide variety of high elevation habitats. | Documented occurrence outside of project area (CNDDB 2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| American badger | *Taxidea taxus* | CSSC | Most abundant in drier open stages of most shrub, forest, and herbaceous habitats, with friable soils. | Documented occurrences outside of project area (CNDDB 2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Canada lynx | *Lynx canadensis* | FT, ONHP List 2 | Generally occurs in boreal and montane regions dominated by coniferous or mixed forest with thick undergrowth, but also sometimes enters open forest, rocky areas, and tundra to forage for abundant prey. | Not found during PacifiCorp surveys. Not listed on CNDDB search (2017); identified on IPaC (2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Gray wolf | *Canis lupus* | FE, CE, ONHP List 2 | Habitat generalists, historically occupying diverse habitats including tundra, forests, grasslands, and deserts. Primary habitat requirements are the presence of adequate ungulate prey, water, and low human contact. | Not found during PacifiCorp surveys. Not listed on CNDDB search (2017); identified on IPaC (2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |

Notes:
Shaded rows indicate the species has been documented to occur in the project area.
*Information on occurrence in the project area is based on PacifiCorp surveys (PacifiCorp 2004) and information obtained from Oregon Biodiversity Information Center (ORBIC), California Natural Diversity Database (CNDDB), USFWS Information for Planning and Conservation (IPaC) databases (2017), and input for federal and state resource agencies. Please see Table 3.4-1 for a list of species observed during the July 2017 site reconnaissance.

Key:

| | |
|---|---|
| BLM | Bureau of Land Management sensitive species -species that could easily become endangered or extinct; and/or Survey and Manage Species |
| CDFW | California Department of Fish and Wildlife |
| CE | California Endangered |
| CSSC | California Department of Fish and Wildlife Species of Special Concern -not listed under the Federal or California Endangered Species Act but are believed to: 1) be declining at a rate that could result in listing, or 2) historically occurring in low numbers and having current known threats to their persistence |
| CT | California Threatened |
| FC | Federal Candidate Species |
| FE | Federal Endangered |
| FP | Fully protected under the California Fish and Game Code |
| FSC | Federal Species of Concern |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|

| | |
|---|---|
| FT | Federal Threatened |
| OC | Candidate listing by Oregon Department of Agriculture (ODA) or ODFW |
| OE | Listed as endangered by ODA or ODFW |
| ONHP List 1 | Oregon Natural Heritage Program (ONHP) threatened with extinction or presumed to be extinct throughout their entire range |
| ONHP List 2 | threatened with extirpation or presumed to be extirpated from the State of Oregon |
| ONHP List 3 | more information is needed before status can be determined, but may be threatened or endangered in Oregon or throughout their range |
| OHNP List 4 | of conservation concern but not currently threatened or endangered |
| OT | Listed as threatened by ODFW |
| OSS | Oregon Sensitive or Sensitive- Critical Species, East Cascades, West Cascades, and Klamath Mountains Ecoregions |
| USFS | U.S. Forest Service sensitive species |
| USFWS | United States Fish and Wildlife Service |

### Northern Spotted Owl

During the PacifiCorp surveys in 2002 and 2003, Northern spotted owl (NSO) presence was documented near J.C. Boyle Reservoir and along the J.C. Boyle peaking reach (the reach of the Klamath River that begins at the J.C. Boyle powerhouse and extends downstream to the mouth of Shovel Creek). A desktop evaluation was conducted to update the existing conditions information on the potential for NSO to be nesting within the Project area.

The desktop evaluation included a review of existing databases (CNDDB and ORBIC) to identify known NSO detections and activity centers in the Project area. Information was obtained from USFWS, BLM, and USFS biologists, and the National Council for Air and Stream Improvement, Inc., which is a nonprofit research institute focusing on issues of concern to timber and other forest products companies.

Based on the desktop evaluation, no NSO activity centers have been documented within the disturbance distances established in the Biological Assessment (BA) (USBR 2011a) for the anticipated construction activities. One NSO nest site is known to occur over 1.3 miles southeast of the eastern end of Copco Lake.

Suitable NSO nesting/roosting habitat includes mature or old-growth forests containing large diameter trees with multiple canopy layers in areas with high canopy closure and complex structure. USFWS and BLM provided spatial data on habitat suitability for NSO in the Project area. The USFWS Relative Habitat Suitability (RHS) model covers the entire Project area, while the BLM data cover only the J.C. Boyle Project area. Based on this habitat suitability information, “highly” suitable habitat for NSO occurs adjacent to the J.C. Boyle powerhouse and within 1 mile of the J.C. Boyle Reservoir. Suitable NSO habitat is not present within 1 mile of the Copco or Iron Gate Dams and hydropower facilities. Based on the USFWS RHS, the nearest suitable habitat is approximately 3 miles southeast of Copco No. 1 Dam and over 5 miles from Iron Gate Dam.

As noted under Section 3.4.5.1, Wildlife, a review of historical aerial photography identified some areas of timber harvest within 0.5 miles of the construction limits of work in the J.C. Boyle portion of the Project area since 2003. These forestry practices have altered the existing habitats and have the potential to reduce habitat suitability for NSO. No major wildfires or other significant habitat alterations were identified in the Project area since the PacifiCorp surveys.

The J.C. Boyle Powerhouse is located within designated critical habitat for NSO. Effects on designated critical habitat at the J.C. Boyle facilities are not anticipated because removal of the facilities would not involve the removal of forest cover and would provide opportunities for habitat restoration. Removal of mature trees would occur at the proposed disposal site at J.C. Boyle, which does not support suitable habitat for NSO. The proposed disposal site is not located within designated critical habitat for NSO.

In accordance with the Joint Preliminary Biological Opinion (BO) (USFWS-NMFS 2012), protocol-level surveys for NSO will be conducted within suitable nesting and roosting habitat in the noise disturbance areas defined for the proposed construction activities. These noise disturbance areas include 1 mile around potential blasting at the dams, and 0.25 miles around all other construction limits, including the use of heavy equipment and hauling on open roads. Protocol surveys will follow the 2012 USFWS NSO Survey Protocol. The NSO survey work plan is provided in Appendix E.

### Bald and Golden Eagle

Bald eagle nest surveys were conducted by the Oregon Cooperative Fish and Wildlife Research Unit in the Klamath River area on March 27, 2002, and May 29, 2002 (PacifiCorp 2004). Several nests were recorded in the vicinity of the Project area. PacifiCorp has documented additional bald eagle observations at Iron Gate, Copco, and J.C. Boyle Reservoirs, and at other locations along the middle and lower Klamath River (PacifiCorp 2004). These observation data are useful in establishing that nesting and foraging habitat are present within the vicinity of the Project area. By agency request, exact nesting locations were not published in the PacifiCorp 2004 report. To continue to protect eagle nests, exact locations will not be provided in this report.

This year, the USFWS and the BLM provided an updated dataset of bald and golden eagle nests and territories that have been monitored in the region (Willy 2017 and Hayner 2017). Based on these data, there are four bald eagle nests within 0.5 miles of J.C Boyle Reservoir and one bald eagle nest within 0.5 miles of Copco Lake. A summary of all nests in the database within 2 miles of the project limits of work is provided in Table 3.4-3.

Golden eagles are known to have historically nested on cliffs in the vicinity of the Project area (USBR and CDFW 2012). Golden eagles also nest within pine, juniper and oak trees and suitable habitat is present in the Project area. Golden eagles have historically nested on cliffs from J.C. Boyle bypass reach to Iron Gate Reservoir. During PacifiCorp surveys, golden eagles were observed in several locations, including Copco and Iron Gate Reservoirs and J.C. Boyle Powerhouse, but no nests were found (PacifiCorp 2004). Natural densities for this species in southern Oregon and northern California are low.

Bald and golden eagle surveys will be conducted concurrently by qualified avian biologists. To meet the project schedule, all eagle surveys will be completed by the end of 2018. The surveys will focus on areas with suitable nesting, roosting, or foraging habitat for bald and golden eagles. The main goal of the surveys is to determine where nest sites are distributed within the survey area and to determine baseline eagle use and behavior at nests and other key habitat features so that any disturbances that may occur during construction can be recognized and corrective actions can be taken. The bald and golden eagle survey work plan is provided in Appendix E.

### Osprey

Ospreys are a California species of special concern and are known to nest throughout the Project area. During the field reconnaissance, several active osprey nests were observed on artificial nesting platforms and transmission line towers. Ospreys may return to the same sites in subsequent years, or they may build new nests.

Nest site surveys will be conducted to identify and map any osprey nests that may be removed or disturbed by construction activities. Biologists will survey all nest platforms, transmission line towers, and reservoir and river shorelines within 1 mile of construction limits. Nest surveys will be conducted in 2018 and 2019 to determine if osprey nest sites occur within 0.75 miles of construction limits, defined as the spatial buffer distance within which construction activities are prohibited around active nests. To the extent possible, and in coordination with the resource agencies, osprey nests within 0.75 miles of construction limits will be removed following the breeding season in 2018/2019. Nesting platforms may be removed or obstructed to prevent use during the construction years. Nesting platforms may be relocated to other areas outside of the construction zone and/or "re-opened" for use following construction.

During the 2017 reconnaissance surveys, active osprey nests were observed on artificial platforms on power poles at the J.C. Boyle Dam, J.C. Boyle disposal area, Copco No. 1 Powerhouse, Copco disposal area, Iron Gate fish hatchery, and along Iron Gate Reservoir, Copco Lake, and the Klamath River downstream of Iron Gate Dam.

**Table 3.4-3 Summary of Bald and Golden Eagle Nests within 2 Miles of the Project Construction Limits**

| Reservoir | Name | Species | Distance | History | July 2017 Reconnaissance[3] |
|---|---|---|---|---|---|
| J.C. Boyle | BE1-31 | Bald Eagle | Within 0.5-mile | Active between 2004-2007. 1 nestling observed in 2013. Active but failed in 2014.[1] | Nest located, no activity or sign of recent activity observed. |
| J.C. Boyle | BE1-32 | Bald Eagle | Within 0.5-mile | Active between 2006-2010; one fledged in 2010; unoccupied in 2011; active 2012; nest down in 2013. [1] | Nest appears to have been rebuilt since the last survey, nest located, no activity or sign of recent activity observed. |
| J.C. Boyle | BE1-36 | Bald Eagle | Within 0.5-mile | Active between 1998-2010, 2 fledged chicks in 2013, occupied in 2014. [1] | Nest located, bald eagle juvenile observed nearby, abundant whitewash and prey remains at base of nest; presumed active this year. |
| J.C. Boyle | BE3-1 | Bald Eagle | Within 0.5-mile | Nest observed in 1995, no additional data.[2] | Nest location data received after reconnaissance, nest was not surveyed. |
| J.C. Boyle | BE1-30 | Bald Eagle | Within 2-miles | Potentially occupied in 1982, nest down in 1990.[1] | Not surveyed. |
| J.C. Boyle | BE1-33 | Bald Eagle | Within 2-miles | Active 1983-1986, nest down 2005. [1] | Not surveyed. |
| J.C. Boyle | BE1-34 | Bald Eagle | Within 2-miles | Active intermittently between 1987-2002, unoccupied 2011-2014. [1] | Not surveyed. |
| J.C. Boyle | BE1-35 | Bald Eagle | Within 2-miles | 1997-1999, nest down in 2005.[1] | Not surveyed. |
| J.C. Boyle | GE1-6 | Golden Eagle | Within 2-miles | No data, unverified nest.[1] | Not surveyed. |
| J.C. Boyle | GE3-1 | Golden Eagle | Within 2-miles | Active 2011 and 2012, no verified nesting.[2] | Not surveyed. |
| Iron Gate | BE2-1 | Bald Eagle | Within 2-miles | Active between 1986-1997.[1] | Not surveyed. |
| Copco | BE2-3 | Bald Eagle | Within 0.5-mile | 2002 - new nest.[1] | Searched for nest, but access was limited. Nest was not found. |
| Copco | BE2-0 | Bald Eagle | Within 2-miles | Active between 1993-1997.[1] | Not surveyed. |

[1] Nest location and history sourced from Willy 2017.

[2] Nest location and history sourced from Heyner 2017.

[3] Data collected during reconnaissance surveys in July 24-26, 2017. Methodology described in Appendix E.

## Willow Flycatcher

Willow flycatcher is a California endangered species that is known to occur in riparian habitat within the Project area. Surveys will be conducted in willow-dominated riparian/meadow communities to identify potential habitat for willow flycatcher. Willow flycatchers have been documented in willow riparian habitat associated with tributary streams entering Iron Gate reservoir. Based on a site visit and discussions with the state resource agencies, it appears unlikely that drawdown would affect these habitats to the extent that it would be considered a negative impact on willow flycatcher. The Copco Road bridge over Jenny Creek will need to be replaced and it is located in an area of known willow flycatcher use. This work would be timed to avoid the breeding season and impacts to willow habitat would be minimized.

## Other Special Status and Migratory Birds

Other special status bird species that may occur in the Project area include peregrine falcon and greater sandhill crane. A great blue heron colony has been documented but was not found during a cursory survey during the July 2017 site reconnaissance. A turkey vulture roost was observed during the July 2017 site reconnaissance in the canyon below Copco No. 2 Dam. Nest site surveys will be conducted within the appropriate spatial buffer distance from construction limits, focusing on suitable habitat for these species, as outlined in the Special Status Wildlife Species survey work plan (Appendix E), to identify areas that would need to be avoided during the breeding season.

If construction activities that involve clearing of vegetation must occur during the breeding season, targeted, pre-construction bird surveys would be conducted for all birds protected by the MBTA to avoid or minimize nesting disturbance. Nesting surveys would be conducted within 2 weeks before the start of construction activities that occur during nesting bird season (February through July). Biologists will search for nests in potential bird nesting habitat within 300 feet of construction limits. Active nests will be mapped and an activity restriction buffer will be established in coordination with the resource agencies to ensure nests are not disturbed by construction activities. Construction planning will include efforts to limit activities that would disturb vegetation to the non-breeding season. Efforts to exclude nesting on structures by cliff swallows and other birds will also be implemented.

## Western Pond Turtle

Western pond turtles are known to occur at Project reservoirs. U.S. Geological Survey (USGS) conducted visual surveys of basking turtles at J.C. Boyle Reservoir in the mid- to late-1990s and noted over 200 turtles (Wray 2017). The 2001-2003 PacifiCorp surveys also noted the presence of western pond turtles at J.C. Boyle, Copco, and Iron Gate Reservoirs. The PacifiCorp surveys identified suitable basking and nesting habitat along the shoreline of the reservoirs and the river as well as stretches that were not suitable habitat. During the 2017 site reconnaissance, pond turtles were observed basking at the J.C. Boyle Reservoir. As described in Appendix E, the next steps include a desktop analysis of western pond turtle habitat and overwintering requirements and the potential for impacts to pond turtles during drawdown. Following review and input from the resource agencies and other experts on the results of the analysis, additional pond turtle surveys may be conducted if warranted.

### Bats

Based on a review of California and Oregon occurrence records, presence of suitable habitat, species range overlap, and previous survey results, eight bat species have potential to occur in the Project vicinity. These species are listed in Table 3.4-4.

#### Table 3.4-4 Bat species with potential to occur in the project area

| Common Name | Scientific Name | Status[1] | Suitable Habitat[2] | Known Occurrences within Project Area | Range Overlap? |
|---|---|---|---|---|---|
| Pallid bat | *Antrozous pallidus* | BLM, CSSC, OSS, USFS, WBWG-H | 1) Buildings, bridges, and tree bark/hollows. 2) Caves, mines and cliffs/rock crevices. | None | Yes |
| Townsend's big-eared bat[3] | *Corynorhinus townsendii* | BLM, CSSC, OSS, USFS, WBWG-H | 1) Caves, mines. 2) Buildings, bridges. 3) Tree bark/hollows. | Known from J.C. Boyle peaking reach. Not documented during PacifiCorp surveys (PacifiCorp 2004). Multiple observations in Rock Creek-Klamath River watershed (exact location not given; ORBIC 2017). Occurrences along Klamath River near Somes Bar (CNDDB 2017). | Yes |
| Silver-haired bat | *Lasionycteris noctivagans* | OSS, WBWG-M | 1) Tree bark/hollows. 3) Bridges. | None | Yes |
| California myotis | *Myotis californicus* | OSS, WBWG-L | 1) Buildings, cliffs/rock crevices. 2) Bridges, caves, mines, tree bark/hollows. | None | Yes |
| Hoary bat | *Lasiurus cinereus* | OSS, WBWG-M | 1) Tree foliage. | None | Yes |
| Fringed myotis | *Myotis thysanodes* | BLM, OSS, USFS, WBWG-H | 1) Caves, mines, tree bark/hollows. 2) Buildings, bridges, cliffs/rock crevices. | None | Yes |
| Long-legged myotis | *Myotis volans* | OSS, WBWG-H | 1) Tree bark/hollows. 2) Buildings, bridges, caves, mines. | None | Yes |
| Yuma myotis | *Myotis yumanensis* | BLM, OSS, WBWG-L | 1) Buildings, bridges. 2) Caves, mines, tree bark/hollows. 3) Cliffs/rock crevices. | Documented during PacifiCorp surveys roosting in J.C. Boyle forebay spillway house, in transformer bays at Copco No. 1 powerhouse, and in | Yes |

| | |
|---|---|
| | rafters at Iron Gate south gatehouse (PacifiCorp 2004) |

[1] USFS US Forest Service sensitive species not listed or proposed for listing under the federal Endangered Species Act for which population viability is a concern, as evidenced by significant current or predicted downward trends in population numbers or density, or significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution.

BLM Bureau of Land Management sensitive species are species that could easily become endangered or extinct.

CSSC California Department of Fish and Wildlife Species of Special Concern are species not listed under the federal or California Endangered Species Act but are believed to: 1) be declining at a rate that could result in listing, or 2) historically occur in low numbers and have current known threats to their persistence.

OSS Oregon Sensitive or Sensitive-Critical Species, East Cascades, West Cascades, and Klamath Mountains Ecoregions.

WBWG Western Bat Working Group High (H), Medium (M), or Low (L) Priority for funding, planning and conservation actions in Ecoregion 5 (http://wbwg.org/matrices/species-matrix/).

[2] 1 = used frequently; 2 = used sometimes; 3 = used rarely (Johnson et al. 2004).

[3] PacifiCorp (2004) treated this as two subspecies; however, *Corynorhinus townsendii* is currently listed as one species.

Townsend's big-eared bat and Yuma myotis have been documented at caves and structures within the Project vicinity, including mixed-species groups of over 800 bats at J.C. Boyle, aggregations at Copco Nos. 1 and 2, and maternity roosts at Hoover Ranch and Salt Caves (approximately 9 miles downstream from the J.C. Boyle powerhouse) (Cross et al. 1998; PacifiCorp 2004).

Recently-published data and literature, along with a current list of species with potential to occur obtained in coordination with ODFW, CDFW, BLM, USFS, and USFWS, have been reviewed to complement and update the information cited in the 2012 EIS/R. Coordination with local bat experts, including Joe Szewczak (Humboldt State University), Greg Tatarian (Wildlife Research Associates), Dave Johnston (H. T. Harvey and Associates), and Leila Harris (ICF International), is ongoing as of September 2017. As of August 2017, additional data requests have been submitted to state and federal agencies and are pending.

A general site reconnaissance and daytime visual inspections of most structures were conducted during the 2017 maternity season, from July 24-26, 2017 at J.C. Boyle, Copco Nos. 1 and 2, and Iron Gate. Of the 46 structures present within the Project limits of work, 24 had bats or signs of bats present. Eight of the structures were not inspected or only partially inspected. Follow up surveys for winter 2017-2018 and summer 2018 will be conducted to 1) determine which facilities need to be removed or modified outside of the bat roosting and breeding period, 2) inform the design of bat exclusion methods where needed, and 3) determine the appropriate design and placement of artificial bat roosts. Appendix E contains additional details regarding future survey, planning, and design efforts.

### 3.4.5.2 Plants

Several special status plant species were noted by PacifiCorp (2004). Additional information on the occurrences of special status plant species in the Project area was obtained from the ORBIC, CNDDB, and IPaC databases. The occurrence of special status plants in the Project area was also obtained from USFWS, BLM, and USFS.

Based on this information, Table 3.4-5 presents the special status plant species with potential to occur within or near the construction limits of work. Surveys will be conducted within construction limits in suitable habitat for these species as outlined in the Special Status Plant Species survey work plan (Appendix E).

**Table 3.4-5 Preliminary List of Special Status Plants with Potential to Occur in or near Construction Limits of Work**

| Species | Status | Habitat | Location of Documented Occurrence(s) | Bloom Time | Proposed Survey Effort |
|---|---|---|---|---|---|
| Greene's mariposa-lily *Calochortus greenei* | FSC, BLM, OC, ONHP List 1, CNPS List 1B | Occurs primarily in annual grassland, wedgeleaf ceanothus chaparral, and oak and oak-juniper woodlands. | Several locations around Iron Gate Reservoir | May through July | Within construction limits in suitable habitat |
| Bristly sedge *Carex comosa* | ONHP List 2 | Marshes, lake shores, and wet meadows. | East shore of J.C. Boyle Reservoir in 2 locations (east of Dam and south of OR66); also west of Dam | May-September | Along reservoir margins and within construction limits in suitable habitat |
| Mountain Lady's Slipper *Cypripedium montanum* | ONHP List 4, CNPS List 4 | Dry, open conifer forests, more often in moist riparian habitats | J.C. Boyle peaking reach (location details unknown) | March-August | Within construction limits in suitable habitat |
| Gentner's fritillary *Fritillaria gentneri* | FE, CNPS List 1B | Cismontane woodland, chaparral. Mixed hardwood-conifer vegetation dominated by Oregon oak. | Habitat present in the reach along Copco and Iron Gate Reservoirs. No known locations. | Late March to early April; April-May at higher elevations | Within construction limits in suitable habitat |
| Bolander's sunflower *Helianthus bolanderi* | BLM, ONHP List 3 | Occurs in yellow pine forest, foothill oak woodland, chaparral, and occasionally in serpentine substrates or wet habitats. | South of Iron Gate Reservoir near proposed disposal site, J.C. Boyle peaking reach (location details unknown) | June-October | Within construction limits in suitable habitat |
| Bellinger's meadow-foam *Limnanthes floccosa ssp. bellingerana* | FSC, BLM, OC, ONHP List 1, CNPS List 1B | High elevation vernal pools located in shallow soiled rocky meadows in spots that are at least partially shaded in the spring. | J.C. Boyle peaking reach (location details unknown) | April-June | Within construction limits in suitable habitat |
| Detling's | CNPS List | Chaparral and grassy | One location on west | May-June | Within |

| Species | Status | Habitat | Location of Documented Occurrence(s) | Bloom Time | Proposed Survey Effort |
|---|---|---|---|---|---|
| silverpuffs *Microseris laciniata* ssp. *detlingii* | 2 | openings among Oregon white oak trees. | side of Iron Gate Reservoir | | construction limits in suitable habitat |
| Egg Lake monkeyflower *Mimulus pygmaeus* | FSC, CNPS List 4 | Occurs in damp areas or vernally moist conditions in meadows and open woods. | East of J.C. Boyle Reservoir in 2 locations (north of OR66 and southeast of Dam); west of Dam in two locations in damp mudflats; also west of canal near access road in one location | May-August | Along reservoir margins and within construction limits in suitable habitat |
| Holzinger's orthotrichum moss *Orthotrichum holzingeri* | CNPS List 1B.3 | Found on vertical calcareous rock surfaces and at the bases of Salix bushes just above rock that is frequently inundated by seasonally high water in dry coniferous forests. | Just upstream of Iron Gate Reservoir on Jenny Creek. | | Where in-stream work could occur at Jenny Creek at bridge |
| Red-root yampah *Perideridia erythrorhiza* | FSC, BLM, OC, ONHP List 1 | Occurs in moist prairies, pastureland, seasonally wet meadows, and oak or pine woodlands, often in dark wetland soils and clay depressions. | Along 3 drainages into west side of J.C. Boyle Reservoir and in 2 locations west of canal near access road | Mid July - August | Along reservoir margins and within construction limits in suitable habitat |
| Howell's yampah (Howell's false caraway) *Perideridia howelii* | ONHP List 4 | Moist meadows, stream banks. | One location along drainage southeast of J.C. Boyle Reservoir; one location along north side of Copco Lake north of road | July-August | Along reservoir margins and within construction limits in suitable habitat |
| Yreka phlox *Phlox hirsuta* | FE, CE, CNPS List 1B | Open areas on dry serpentine soils and is found at elevations ranging from 2,500 to 4,400 feet. | Not known to occur near construction limits. No suitable ultramafic soils occur within 0.5 miles of construction limits (NRCS 2017). | March-April | None- suitable soils not present within construction limits |
| Strapleaf willow *Salix ligulifolia* | ONHP List 3 | Riverbanks, wetlands, floodplains | One location west of J.C. Boyle Dam in a boulder flood channel in dam release zone | March-June | Along reservoir margins and within construction limits in suitable habitat |
| Fleshy sage *Salvia dorrii* var. *incana* | CNPS List 3 | Occurs in silty to rocky soils in great basin scrub, pinyon, and juniper woodland. | 3 locations around Iron Gate Reservoir | May- July | Within construction limits in suitable habitat |

| Species | Status | Habitat | Location of Documented Occurrence(s) | Bloom Time | Proposed Survey Effort |
|---|---|---|---|---|---|
| Pendulous bulrush *Scirpus pendulus* | BLM, ONHP List 2, CNPS List 2 | Occurs along streambanks and in wet meadows. | One location along Fall Creek | June-August | Along reservoir margins and within construction limits in suitable habitat |
| Lemmon's silene *Silene lemmonii* | ONHP List 3 | Open pine woodlands | J.C. Boyle peaking reach to J.C. Boyle Reservoir (location details unknown) | Spring-Summer | Within construction limits in suitable habitat |
| Western yellow cedar *Callitropsis nootkatensis* | Petitioned for federal listing, CNPS List 4.3 | Wet to moist sites, from the coastal rainforests to rocky ridgetops near the timberline in the mountains. | Not documented during PacifiCorp surveys or listed on CNDDB or ORBIC for the project area. May occur based on information from USFWS Yreka office (May 23, 2017). | | Within construction limits in suitable habitat |

Key:

| | |
|---|---|
| BLM | Bureau of Land Management sensitive species -species that could easily become endangered or extinct. |
| CE | California Endangered |
| CNPS List 1A | California Native Plant Society (CNPS)-Presumed extinct in California. |
| CNPS List 1B | rare, threatened, or endangered in California and elsewhere. |
| CNPS List 2 | rare, threatened, or endangered in California, but more common elsewhere. |
| CNPS List 3 | on the review list -more information needed |
| CNPS List 4 | on the watch list -limited distribution |
| FE | Federal Endangered |
| FSC | Federal Species of Concern |
| OC | Candidate listing by Oregon Department of Agriculture (ODA) |
| ONHP List 1 | Oregon Natural Heritage Program (ONHP) threatened with extinction or presumed to be extinct throughout their entire range |
| ONHP List 2 | threatened with extirpation or presumed to be extirpated from the State of Oregon |
| ONHP List 3 | more information is needed before status can be determined, but may be threatened or endangered in Oregon or throughout their range |
| ONHP List 4 | of conservation concern but not currently threatened or endangered |

### 3.4.6 Wetlands and Other Waters

Wetland surveys and focused delineations were not conducted during the July 2017 site reconnaissance. Willow riparian habitat was observed primarily associated with streams and drainages tributary to the reservoirs. Road crossings of some of these riparian areas are within the construction limits of work. Narrow patches of emergent wetland vegetation were also observed along reservoir margins. At the J.C. Boyle disposal site, several depressions were observed to support willows, sedges, and rushes, indicating the potential presence of wetlands in some areas.

PacifiCorp evaluated pre-construction and post-dam construction wetland and riparian conditions (PacifiCorp 2004). The study concluded that in general, the distribution of wetland and riparian habitat consisted of long, thin bands running along the historical Klamath River channel. In comparison, somewhat wider, but more widely scattered patches of these vegetation types exist along the present-day Project reservoir shorelines. The analysis concluded that the simple area of wetland and riparian habitat is somewhat greater along the J.C. Boyle Reservoir under existing conditions and that there is less area along Copco Lake and Iron Gate Reservoir as compared to historical conditions. It is anticipated that wetland and riparian areas similar to those that previously existed will become re-established along the restored Klamath River following dam removal and restoration. In addition, the tributary riparian habitats would be expected to extend as the currently drowned stream channels are restored. In addition to simple area considerations, the ecological functions of wetlands and riparian areas along the river would be different from those on the fringes of a reservoir. As part of the permitting process, the KRRC will be conducting a functional assessment of wetlands affected by the Project and those expected to be restored within the Project area.

## 3.5 Cultural Resource Surveys

### 3.5.1 Records Search Update – California only

As part of the Klamath Hydroelectric Relicensing (FERC 2007) and Klamath River Dam Removal (BOR 2012) studies, PacifiCorp (2004) and Cardno ENTRIX (2012) completed cultural resources records searches to collect information of previous archaeological research and historical information. These previous record searches provide baseline resource data for the Project site through 2012. The KRRC has recently completed an updated records search and literature review for the Project to add information for the intervening 5-year period, or through 2017.

Within the State of California, the KRRC records search area includes the length of the Klamath River from the Oregon/California Stateline (RM 214), downstream to Humbug Creek (RM 174), for a total length of roughly 40 river miles. The section of river below Iron Gate Dam (the most downstream Project dam) was included in the records search since this 18-mile-long area lies within the altered 100-year floodplain following dam removal, where cultural resources have the potential to be affected. The KRRC records search area includes a 0.5-mile wide zone, extending on either side of the shorelines of Copco Lake and Iron Gate Reservoir, or from the center point of the Klamath River in areas where the river remains free flowing.

The KRRC has completed two records searches for the Project area in California. In April 2017, the KRRC conducted a review of the records housed at the Northeast Information Center at California State University, Chico. Research included gathering archaeological site forms, survey and excavation reports, maps, and other records. Survey and site locations were hand-plotted onto United States Geologic Survey (USGS) topographic maps at the Northeast Information Center. Archival research of historic registers included the California Historic Landmarks, National Register of Historic Places (NRHP), California Register of Historical Resources (CRHR), California Points of Historical Interest, California Inventory of Historic Resources, and the California State Historic Resources Inventory. Also in April 2017, a visit was made to the Klamath National Forest office and the Siskiyou County Museum, both in Yreka, California. Klamath National Forest Heritage Program Manager Jeanne Goetz conducted a search of records for Forest Service lands within or near the KRRC records search area and provided appropriate archaeological site record forms.

In addition to these office visits, online newspaper archives were searched, including the National Digital Newspaper Program archives provided by the Library of Congress and National Endowment for the Humanities (chroniclingamerica.loc.gov); GeneaologyBank newspaper archives provided by NewsBank, Inc. (geneaologybank.com); the California Digital Newspaper Collection repository provided by University of California, Riverside (cdnc.ucr.edu); and newspaper archives provided by Ancestry.com.

In May 2017, the KRRC requested and received cultural sources data from PacifiCorp, including GIS shapefiles with previous survey and resource locations, as well as a copy of the final cultural resources technical report for Klamath Hydroelectric Relicensing Project (PacifiCorp 2004). In addition, the KRRC contacted Dr. Joanne Mack, professor emeritus at Notre Dame University, a primary researcher in the upper Klamath River area, to discuss the Project and to learn of her on-going research in the area that might not be reflected in published or unpublished literature. The KRRC also consulted with Dr. Brian Daniels, director of research and programs for the Penn Cultural Heritage Center at the University of Pennsylvania Museum, regarding ethnographic information, archival documents, and oral histories pertaining to tribal cultural resources within the California records search area.

The KRRC contacted the Native American Heritage Commission (NAHC) in June 2017, to secure a review of the Sacred Lands file for a 0.5-mile wide area on either side of the Klamath River corridor, extending from the California-Oregon state line downstream to the Pacific Ocean. In a June 14, 2017 letter, the NAHC stated that there was a positive result, with the recommendation to contact the Karuk Tribe, the Yurok Tribe, and Shasta Nation. THE NAHC also provided a consultation list of 29 tribes with traditional lands or cultural places located within the boundaries of Del Norte, Humboldt, and Siskiyou counties.

#### 3.5.1.1 Previous Cultural Resources Studies

The KRRC records search and literature review identified that 55 previous cultural resources investigations have been conducted within the records search area, with 5 of these studies (Kramer 2003a, 2003b; Cardno ENTRIX 2012; Durio 2003; PacifiCorp 2004) completed specifically for the Lower Klamath Project (Table 3.5-1). Thirteen of these studies are archaeological, ethnographic, or historical overviews, while five reports describe archaeological excavations. Two studies involved cultural resources monitoring, while the remaining 34 projects involved archaeological survey or inventory. Overall, an estimated 8,189 acres of federal, state, and/or private land have been surveyed within the records search area.

## Table 3.5-1 Summary of Previous Cultural Resource Studies Conducted within the Search Area

| NEIC Report No. | Report Title and Firm | Report Reference | Study Conducted Specifically for Klamath Dams Projects | Project Type | Acres Surveyed |
|---|---|---|---|---|---|
| -- | *The Cultural Position of the Iron Gate Site*. Unpublished Master's thesis, Department of Anthropology, University of Oregon, Eugene. | Leonhardy 1961 | No | Excavation | -- |
| -- | Part Two of the Klamath Lake Railroad. *Western Railroader* 27(12). | Stephens 1964 | No | Overview | -- |
| -- | The Archaeology of a Late Prehistoric Village in Northwestern California. *University of Oregon Museum of Natural History Bulletin* 4. | Leonhardy 1967 | No | Excavation | -- |
| -- | Shasta Villages and Territory. Part 1: Shasta Villages. *University of California Archaeological Research Facility Contributions* 9(5):119-131. Berkeley. | Heizer and Hester 1970 | No | Overview | -- |
| -- | *Looking Back: The California-Oregon Stage Road from Ager, California to Topsy, Oregon*. Printers Inc., Carson City. | Hessig 1978 | No | Overview | -- |
| 13073 | *Archaeological Reconnaissance of the Proposed Meadowview Estates, Siskiyou County, California.* ARK II Anthropological Resource Management, Redding. | Dotta 1980 | No | Survey | 15 |
| 13075 | *Archaeological Reconnaissance of the Proposed Copco Shores Estates, Siskiyou County, California.* ARK II Anthropological Resource Management, Redding. | Dotta 1980 | No | Survey | 510 |
| SI-L-146 | Letter Report for Archaeological Clearance of the Copco Lake Mutual Water Company Snackenburg Spring Development, Siskiyou County. | Ritter 1983 | No | Survey | 10 |
| -- | Letter Report for Archaeological Survey of the Annie Clawson #2 / Model Ed Mining Claim near Hornbrook, California. USDI, Bureau of Land Management, Redding. | Ritter 1985 | No | Survey | 20 |
| SI-L-211 | *Cultural Resources Survey of the Klamath River Bridge (2C-39) Replacement Located Near Copco Lake, California*. Mountain Anthropological Research, Redding. | Nilsson and Greenway 1985 | No | Survey | 10 |
| 883 | *Cultural Resources Survey of the Phase III (KRCE) Realignment of the Hornbrook-Ager Road, Siskiyou County, California*. Mountain Anthropological Research, Redding. | Nilsson 1987 | No | Survey | 95 |

| NEIC Report No. | Report Title and Firm | Report Reference | Study Conducted Specifically for Klamath Dams Projects | Project Type | Acres Surveyed |
|---|---|---|---|---|---|
| 1421 | *Cultural Resources Assessment of AT&T's Medford, Oregon to Redding, California, Fiber Optic Cable*. Peak & Associates, Sacramento. | Peak & Associates 1988 | No | Survey | 64 |
| SI-L-384 | Negative Archaeological Survey Report for the US Route 96 Project, Siskiyou County, California. | Wiant and Bennett 1990 | No | Survey | 2.5 miles |
| -- | Cottonwood Henley 1851-, Hornbrook 1887-, Klamathon 1888-1909. | French 1990 | No | Overview | -- |
| -- | *Klamath River Canyon Ethnology Study*. Theodoratus Cultural Research, Inc., Fair Oaks. | Theodoratus et al. 1990 | No | Overview | -- |
| -- | Northwest Hunters and Traders Report for the Summer of 1992 Field Season. | Mack 1992 | No | Survey and Excavation | -- |
| -- | Northwest Hunters and Traders Report for the Summer of 1993 Field Season. | Mack 1994 | No | Survey and Excavation | -- |
| -- | *Archaeological Survey Report for the Proposed Jenny Creek Bridge Replacement Project (Bridge 2C-06), Siskiyou County, California.* Coyote and Fox Enterprises, Redding. | Vaughan and McGann 1995 | No | Survey | <1 |
| 4575 | Archaeological and Historical Resources Survey and Impact Assessment: A Supplemental Report for a Timber Harvesting Plan, Oregon Border THP. | Levy and Calvert 1995 | No | Survey | 194 |
| 1428 | *Archaeological Inventory and Evaluation of the Orwick BLM Copco Lake Land Exchange Parcels, Siskiyou County, California.* Heritage Research Associates Report No. 198. Heritage Research Associates, Inc., Eugene. | Oetting 1996 | No | Survey | 2,560 |
| 4578 | Confidential Archaeological Addendum for Timber Operations on Non-Federal Lands in California, Edge Flat THP, Siskiyou County. | Osterhoudt 1997 | No | Survey | 141 |
| 3310 | Confidential Archaeological Addendum for Timber Operations on Non-Federal Lands in California. | Caster 1999 | No | Survey | 120 |
| 2657 | Tree of Heaven Archaeological Survey Report with Test Excavations. | Cook-Slette 1999 | No | Excavation | <5 |
| 2960 | Archaeological Resource Management Report for NEWCOM Wireless Communication Hilt, Collier, South Yreka, and Gazelle Antenna Structures, Siskiyou County. | Rock 2000a | No | Survey | <1 |

| NEIC Report No. | Report Title and Firm | Report Reference | Study Conducted Specifically for Klamath Dams Projects | Project Type | Acres Surveyed |
|---|---|---|---|---|---|
| 2971 | Archaeological Resource Management Report for NEWCOM Wireless Communication Klamath/Shasta, Vista, Hornbrook, and Black Butte Antenna Structures, Siskiyou County. | Rock 2000b | No | Survey | <1 |
| 3266 | Archaeological Inventory Survey, Proposed Osburger Cell Tower, West of I-5 at Hornbrook Off-Ramp, Siskiyou County, California. Jensen & Associates, Chico. | Jensen 2001 | No | Survey | <1 |
| 3923 | *Survey Report for Dunsmuir to Hilt California on Behalf of Qwest Communications*. QWEST, Durham, California. | Brown 2001 | No | Survey | 1,080 |
| 4150 | *Toilet Project (CIP 2001), Salmon, Scott, Oak Knoll, and Happy Camp Ranger Districts, ARR05-05-1529.* USDA, Klamath National Forest, Yreka. | Cook-Slette 2001 | No | Survey | <1 |
| 4608 | *Archaeological Investigations for A-'chit'-ter-rah'kah – a Portion of CA-SIS-329 Along the Klamath River in Siskiyou County, California.* CALTRANS District 2, Redding. | Hamusek and Haney 2001 | No | Excavation | 20 |
| 5056 | Memorandum: Martin Right-of-Way and Adjoining Land Archaeological Inventory, Henley, Siskiyou County, California. USDI, Bureau of Land Management, Redding. | Ritter 2001 | No | Survey | 41 |
| 5061 | Memorandum: Edge Wireless Right-of-Way CA 41795. USDI, Bureau of Land Management, Redding. | Molter 2001 | No | Survey | 4 |
| 4604 | Confidential Archaeological Addendum for Timber Operations on Non-Federal Lands in California, Badger Mt. THP, Siskiyou County. | Wuerfel 2002 | No | Survey | 58 |
| 4737 | Monitoring Report, Randolph E. Collier Safety Roadside Rest Area, Siskiyou County, California. | Ross 2002 | No | Monitoring | 20 |
| 4765 | Archaeological Resource Management Report for the Zastoupil Proposed Parcel Split, Siskiyou County. | Rock 2002 | No | Survey | 33.1 |
| 6447 | *Test Excavation at Paradise Craggy Village (CA-SIS-1066H), Upper Klamath River, Northern California.* Department of Anthropology, University of Notre Dame, Northern California Resource Center. | Mack 2003 | No | Excavation | -- |
| -- | The Relationship Between Basketry and Ceramics from Northern California. *Society for California Archaeology* | Mack 2003 | No | Overview | -- |

| NEIC Report No. | Report Title and Firm | Report Reference | Study Conducted Specifically for Klamath Dams Projects | Project Type | Acres Surveyed |
|---|---|---|---|---|---|
| | *Newsletter* 37(2):24-29. | | | | |
| -- | *Klamath Hydroelectric Project, Federal Energy Regulatory Commission Project No. 2082, Historic Context Statement*. CH2M Hill, Corvallis. | Kramer 2003b | Yes | Overview | -- |
| -- | *Klamath Hydroelectric Project, Federal Energy Regulatory Commission Project No. 2082, Determination of Eligibility*. CH2M Hill, Corvallis. | Kramer 2003a | Yes | Overview | -- |
| 8626 | Klamath River Hydroelectric Project Historic District FERC Project No. 2082. | Durio 2003 | Yes | Overview | -- |
| 10483 | *Final Technical Report, Klamath Hydroelectric Project (FERC Project No. 2082), Cultural Resources.* PacifiCorp, Portland. | PacifiCorp 2004 | Yes | Survey | 2,260 |
| 6366 | Archaeological Resource Management Report for the Proposed Klamath Ranch Resort Parcel Development, Siskiyou County. | Rock 2005 | No | Survey | 562 |
| 8675 | Archaeological Reconnaissance Report for Three PacifiCorp Projects, Siskiyou County, California. USDA, Klamath National Forest, Macdoel. | Hitchcock 2005 | No | Survey | 40 |
| -- | *Historical Landscape Overview of the Upper Klamath River Canyon of Oregon and California.* Cultural Resource Series No. 13. USDI, Bureau of Land Management, Portland. | Beckham 2006 | No | Overview | -- |
| 7362 | *Cultural Resources Final Report of Monitoring and Findings for the Qwest Network Construction Project, State of California.* SWCA Environmental Consultants, Cultural Resources Report No. 06-507, Sacramento. | SWCA 2006 | No | Monitoring | 52 |
| 9506 | *Jenny Creek Bridge (No. 02C-0061) Replacement Project Addendum to Vaughan 1995 Archaeological Survey Near Copco, Siskiyou County, California, 02-SIS-9KO2, P.M. Bridge #02C-0061, E.A.02-452384. North State Resources, Inc, Redding.* | Brunmeier 2007 | No | Survey | 4.26 |
| 10768 | *A Cultural Resource Investigation of the Greco Fish Screen Project Located in Siskiyou County, California. California Department of Fish and Game Project #K-09.* Cultural | Whiteman and Ainis 2007 | No | Survey | 1 |

| NEIC Report No. | Report Title and Firm | Report Reference | Study Conducted Specifically for Klamath Dams Projects | Project Type | Acres Surveyed |
|---|---|---|---|---|---|
| | Resources Facility, Center for Indian Community Development, Humboldt State University Foundation, Arcata. | | | | |
| -- | *Klamath N.F. Humbug-Area TMP-Project Route Survey: Results of an Archaeological Survey of Roads and Trails on the West-Side of the Klamath National Forest Identified for Possible Motorized-Recreation Designation (KNF A.R.R. #2008-05-05-1709A).*USDA, Klamath National Forest, Yreka. | LaLande 2008 | No | Survey | -- |
| -- | The Destruction of Dams on the Klamath River and Some Implications for Cultural Resource Management. *Proceedings of the Society for California Archaeology* 25. | Chartkoff 2011 | No | Overview | -- |
| 12809 | *Archaeological Survey Report, Bridge Preventive Maintenance, Siskiyou County; Federal Project Number BRLO-5902(058).* U.S. Department of Transportation, Siskiyou County Public Works Department, and Caltrans District 2. Condor Country Consulting, Inc., Martinez. | Dexter 2012 | No | Survey | 20 |
| -- | *Klamath Secretarial Determination Cultural Resources Report.* Cardno ENTRIX, Sacramento. | Cardno ENTRIX 2012 | Yes | Overview | -- |
| -- | Notice of Emergency Timber Operations for the Last Tango 2014 Harvest Units. JWTR, LLC, Klamath Falls. | Howard 2014 | No | Survey | 284 |
| -- | Comparison of Two Shasta Villages' Obsidian Source Use. *Proceedings of the Society for California Archaeology* 29:33-38. | Mack 2015 | No | Overview | -- |
| -- | *Archaeological Survey Report for the Proposed Randolph C. Collier Safety Roadside Rest Area Facilities Upgrade Project, Siskiyou County, California*. Caltrans District 2, Redding. | Hamusek 2015 | No | Survey | 20 |
| -- | *Archaeological Evaluation Report for Site CA-SIS-329 for the Randolph C. Collier SRRA Water/Wastewater Project (Water/Sewer) (EA 02-4E670; EFIS 0212000031-0) and OSHA Break Room (EA-02-4G300; EFIS 0213000099-0).* Far Western Anthropological Research Group, Inc., Davis. | Waechter and Young 2015 | No | Excavation | <20 |
| -- | Remnant Home Garden Ornamentals Along the Upper | Todt and Hannon | No | Overview | -- |

| NEIC Report No. | Report Title and Firm | Report Reference | Study Conducted Specifically for Klamath Dams Projects | Project Type | Acres Surveyed |
|---|---|---|---|---|---|
| | Klamath River. *Eden 19(3):12-16.* | 2016 | | | |
| -- | *Historical Resources Evaluation Report, Klamath River Bridge Replacement Project, Yreka, Siskiyou County, California.* CALTRANS District 3, Marysville. | Miller 2016 | No | Survey | <1 |

NEIC – Northeast Information Center

### 3.5.1.2 Previously Recorded Cultural Resources

The KRRC California record searches identified 207 previously recorded cultural resources, consisting of 124 archaeological sites, 8 built environment resources, 68 isolated finds, and 7 resources of an unknown component type (Tables 3.5-2 and 3.5-3). By component type, these resources include 117 prehistoric, 59 historic-period, 22 multiple (prehistoric and historic-period), 1 ethnographic property, and 7 resources whose temporal association is unknown.

**Table 3.5-2 Previously Recorded Resources by Resource Type and Component**

| Resource Type | Component Type | | | | | Total |
|---|---|---|---|---|---|---|
| | Prehistoric | Historic | Multiple | Ethnographic Only | Unknown | |
| Archaeological Site | 52 | 49 | 22 | 1 | -- | 124 |
| Built Environment | -- | 8 | -- | -- | -- | 8 |
| Isolate | 65 | 2 | -- | -- | 1 | 68 |
| Undetermined | -- | -- | -- | -- | 7 | 7 |
| Total | 117 | 59 | 22 | 1 | 8 | 207 |

#### Archaeological Sites

Archaeological sites represent roughly 60 percent of the previously recorded resources. The sites consist of 52 prehistoric, 49 historic-period, 22 multiple component, and 1 ethnographic property. Identified prehistoric period sites include housepit villages; campsites; lithic scatters; lithic scatters with associated cultural features; toolstone quarries; a possible vision quest site with multiple features; and a site containing an exposed, isolated human burial. One lithic scatter with features reportedly includes human burials.

The historic-period archaeological sites consist of late-nineteenth or early-twentieth century properties associated with the development of agriculture, including settlements or features such as homesteads; logging; mining; commercial; public works (hydroelectric); and transportation. Agricultural-related sites include settlements (homesteads) with or without features, irrigation ditches, rock walls, piled rock in agricultural fields, and artifact scatters.

Logging-related sites focus on elements of the former Klamathon townsite, including the town and lumber mill and the associated Pokegama log chute and ditch flume. Mining related sites, located in the Klamath River area below Hornbrook, include two quartz mines and four placer mines with ditches and/or tailings. The Beswick Hotel, ranch, and Klamath Hot Springs area represents the single commercial property. An extensive refuse scatter associated with the Copco No. 1 Village is the sole public works site. Finally, transportation-related sites consist of an abandoned segment of the Klamath Lake Railroad, a collapsed trestle and segment of railroad grade, a segment of Topsy Road, a road leading to Horseshoe Ranch, and a segment of the California-Oregon Stage Road.

The multiple component sites include both prehistoric and historic-period components. Prehistoric components associated with these sites include housepit villages, a housepit village with a documented historic-period cemetery, lithic scatters, a toolstone quarry, and a rockshelter. Historic-period components comprise mining camps and/or tailing, agricultural-related resources such as historic ranches and artifact scatters, and a possible commercial property associated with a former saloon.

The site recorded solely as an ethnographic property consists of a natural rock landform in the Iron Gate area that features prominently in the stories and folklore of Shasta groups.

A group of seven sites, termed the Pollock Sites, represents undetermined site components. Currently, the only information available for these sites relates to their location, which is noted along the Klamath River between Klamathon and Humbug Creek.

Information provided in Table 3.5-3 regarding the National Register eligibility of the archaeological sites is based on recommendations provided by Cardno ENTRIX (2012), or by eligibility information noted on site records that were not part of the Cardno ENTRIX study. Overall, one site is listed in the National Register as a contributor to a district, four sites are determined eligible, 31 sites appear eligible for listing, two sites might become eligible for listing when more historical research is performed for those sites; four sites have been found ineligible, and the remaining 97 sites have not been evaluated for NRHP eligibility.

### Built Environment Resources

The KRRC records search identified eight historic-period built environment resources associated with the historic themes of commerce, settlement, transportation, and public works. The single commerce-themed resource includes a former service station converted to residence (Klamath Kamp). A duplex residence with associated structures represents the single settlement-related site. Transportation-related sites consist of a one-lane, wooden and steel beam truss bridge over the Klamath River (Ash Creek Bridge), and a two-lane, concrete, T-beam bridge over the Klamath River (Bridge 02-0015). Public works sites include four recorded elements of the Klamath Hydroelectric Project, including Copco No. 1 hydroelectric powerhouse and dam; Copco No. 2 hydroelectric powerhouse; Fall Creek hydroelectric powerhouse; and the Copco No. 2 wooden stave penstock. The Fall Creek Powerhouse coincides with the reported location of an ethnographic Shasta Indian village; however, the presence of a village at this location has not yet been confirmed. Presence will be confirmed during future KRRC field surveys.

National Register eligibility information for these eight sites indicates that the two Klamath River bridges have been determined eligible for listing in the NRHP. The four hydroelectric-related sites were noted by Cardno ENTRIX (2012) as appearing eligible for separate listing, but these sites have also been documented as contributing elements to the Klamath Hydroelectric historic district (Kramer 2003a) which has yet to be concurred upon by the California and Oregon State Historic Preservation Officers (SHPOs). The final two resources, composed of a residence and a former service station, have been found ineligible for the National Register.

## Table 3.5-3 Previously Recorded Archaeological Sites and Built Environment Resources

| Primary No. | State Trinomial | Component Age | Site Type | Year(s) Recorded or Updated | NRHP Eligibility* |
|---|---|---|---|---|---|
| P-47-000016 | CA-SIS-16/H | Multiple | Prehistoric Village/Rockshelter with Historic Artifact Scatter | 1953, 1995, 2002 | 3B |
| P-47-000017 | CA-SIS-17/H | Multiple | Prehistoric Village, Cemetery, and Historic Ranch | 1953, 1988 | 7 |
| P-47-000155 | CA-SIS-155 | Prehistoric | Village | 1952 | 7 |
| P-47-000156 | CA-SIS-156 | Prehistoric | Campsite | 1952 | 7 |
| P-47-000157 | CA-SIS-157 | Prehistoric | Lithic Scatter and Features | 1952 | 7 |
| P-47-000158 | CA-SIS-158 | Prehistoric | Lithic Scatter | 1952, 2007 | 7 |
| P-47-000159 | CA-SIS-159 | Prehistoric | Lithic Scatter | 1952 | 7 |
| P-47-000161 | CA-SIS-161 | Prehistoric | Village | 1952 | 7 |
| P-47-000264 | CA-SIS-264 | Prehistoric | Burial | 1957 | 7 |
| P-47-000326 | CA-SIS-326 | Prehistoric | Village | 1960, 1961, 1969, 1973 | 7 |
| P-47-000328 | CA-SIS-328 | Prehistoric | Lithic Scatter | 1965, 2007 | 7 |
| P-47-000329 | CA-SIS-329/H | Multiple | Prehistoric Lithic Scatter, Burial, and Historic Artifact Scatter | 1965, 2000 | 7 |
| P-47-000498 | CA-SIS-498-H | Historic | Pokegama Log Chute | 1970s, 1997, 2002, 2003 | 1B |
| P-47-000513 | CA-SIS-513-H | Historic | Klamath Hot Springs/Beswick | 1970s, 2004 | 7 |
| P-47-000522 | CA-SIS-522-H | Historic | Empire Quartz Mine | 1976 | 7 |
| P-47-000536 | CA-SIS-536-H/ CA-SIS-1315-H | Historic | Klamathon Town Site and Lumber Mill | 1970s, 1986, 1987, 2011 | 7 |
| P-47-000630 | CA-SIS-630 | Prehistoric | Village | 1977 | 7 |
| P-47-000632 | CA-SIS-632/H | Multiple | Prehistoric Village; Mine and Historic Artifact Scatter | 1977, 2004 | 7 |
| P-47-000873 | CA-SIS-873 | Prehistoric | Lithic Scatter | 1982 | 7 |
| P-47-001066 | CA-SIS-1066/H | Multiple | Midden with Lithic Scatter and Features; Mine with | 1981, 1983, 1999 | 2 |

| Primary No. | State Trinomial | Component Age | Site Type | Year(s) Recorded or Updated | NRHP Eligibility* |
|---|---|---|---|---|---|
| | | | Features | | |
| P-47-001198 | CA-SIS-1198/H | Multiple | Prehistoric Village; Historic Feature with Artifact Scatter | 1984, 1992, 1993, 1995 | 2D1 |
| P-47-001314 | CA-SIS-1314-H | Historic | Dump | 1987 | 7 |
| P-47-001670 | CA-SIS-1670 | Prehistoric | Lithic Scatter and Features | 1993, 1996, 2000 | 3S |
| P-47-001671 | CA-SIS-1671-H | Historic | Klamath Lake Railroad Grade | 1993, 2004 | 7 |
| P-47-001672 | CA-SIS-1672-H | Historic | Structures, Ditch, and Artifact Scatter | 1992 | 7 |
| P-47-001721 | CA-SIS-1721 | Prehistoric | Village | 1996 | 2D1 |
| P-47-001776 | N/A | Prehistoric | Lithic Scatter | 1995 | 7 |
| P-47-001838 | CA-SIS-1838/H | Multiple | Prehistoric Village; Historic Ranch with Structures | 1994, 1999 | 3S |
| P-47-001839 | CA-SIS-1839/H | Multiple | Prehistoric Lithic Scatter; James Whalen Saloon | 1994, 2002 | 7 |
| P-47-001840 | CA-SIS-1840 | Prehistoric | Village | 1994, 2002 | 3S |
| P-47-002117 | CA-SIS-2117-H | Historic | Features | 1996 | 6Z |
| P-47-002126 | CA-SIS-2126-H | Historic | Large Refuse Dump | 1996 | 7 |
| P-47-002127 | CA-SIS-2127-H | Historic | Habitation with Artifact Scatter | 1996 | 7 |
| P-47-002128 | N/A | Ethnographic | Traditional Cultural Property (TCP) | 1996 | 3 |
| P-47-002129 | CA-SIS-2129-H | Historic | Grieve-Miller-DeSoza Ditch | 1996 | 3 |
| P-47-002130 | N/A | Historic | Rock Wall | 1996 | 6Z |
| P-47-002131 | CA-SIS-2131 | Prehistoric | Features | 1996 | 7 |
| P-47-002132 | CA-SIS-2132 | Prehistoric | Lithic Scatter | 1996 | 7 |
| P-47-002237 | CA-SIS-2237-H | Historic | Copco Mutual Flume | 1995 | 3S |
| P-47-002238 | CA-SIS-2238-H | Historic | Greek Ovens | 1995 | 3S |
| P-47-002239 | CA-SIS-2239- | Historic | COPCO II Ranch | 1996 | 4S2 |

| Primary No. | State Trinomial | Component Age | Site Type | Year(s) Recorded or Updated | NRHP Eligibility* |
|---|---|---|---|---|---|
| | H | | Features | | |
| P-47-002241 | CA-SIS-2241/H | Multiple | Prehistoric Village and Features; Historic Irrigation Ditch | 1980, 1995, 2002 | 3S |
| P-47-002263 | CA-SIS-2263 | Prehistoric | Lithic Scatter and Features | 1997, 2000, 2002 | 7 |
| P-47-002264 | CA-SIS-2264 | Prehistoric | Village | 1997 | 3S |
| P-47-002266 | N/A | Historic | COPCO II Powerhouse | 1997 | 3S |
| P-47-002267 | N/A | Historic | COPCO I Powerhouse | 1997, 2003 | 3S |
| P-47-002268 | N/A | Historic | Fall Creek Powerhouse | 1997 | 3S |
| P-47-002400 | CA-SIS-2400/H | Multiple | Prehistoric Village; Historic Cabin and Artifact Scatter | 1997, 2002 | 3S |
| P-47-002401 | CA-SIS-2401 | Prehistoric | Lithic Scatter | 1997, 2002 | 3S |
| P-47-002402 | CA-SIS-2402/H | Multiple | Lithic Scatter and Features; Historic Foundation | 1997, 2002 | 7 |
| P-47-002403 | CA-SIS-2403/H | Multiple | Prehistoric Village; Historic Rock Wall and Artifact Scatter | 1997, 2003 | 3S |
| P-47-002566 | CA-SIS-2566 | Prehistoric | Lithic Scatter and Features | 1999, 2004 | 3S |
| P-47-002567 | CA-SIS-2567/H | Multiple | Prehistoric Village; Historic Refuse | 1999, 2001, 2004 | 3S |
| P-47-002568 | CA-SIS-2568 | Prehistoric | Lithic Scatter, Features, and Burial Site | 1999 | 3S |
| P-47-002569 | CA-SIS-2569 | Prehistoric | Village and Features | 1999, 2002 | 3S |
| P-47-002570 | CA-SIS-2570 | Prehistoric | Village | 1999, 2002 | 3S |
| P-47-002571 | CA-SIS-2571-H | Historic | Burial Cairns | 1999 | 4S2 |
| P-47-002572 | CA-SIS-2572 | Prehistoric | Lithic Scatter and Features | 1998, 2002 | 3S |
| P-47-002573 | CA-SIS-2573 | Prehistoric | Lithic Scatter and Features | 1998, 2003 | 7 |
| P-47-002574 | CA-SIS-2574 | Prehistoric | Lithic Scatter | 1998, 2002 | 3S |

| Primary No. | State Trinomial | Component Age | Site Type | Year(s) Recorded or Updated | NRHP Eligibility* |
|---|---|---|---|---|---|
| P-47-002575 | CA-SIS-2575/H | Multiple | Prehistoric Lithic Scatter; Historic Feature | 1998, 2002 | 3S |
| P-47-002276 | CA-SIS-2576 | Prehistoric | Village | 1998, 2002 | 3S |
| P-47-002577 | CA-SIS-2577/H | Multiple | Village; Ranch Complex | 1998, 2002, 2004 | 3S |
| P-47-002578 | CA-SIS-2578/H Locus 1 | Multiple | Prehistoric Village and TCP; Historic Barn | 1998, 1999, 2002, 2004 | 3S |
| P-47-002579 | CA-SIS-2579 | Prehistoric | Lithic Scatter and Feature | 1998 | 3S |
| P-47-002591 | CA-SIS-2591/H | Multiple | Prehistoric Lithic Scatter and Rock Art; Historic Feature | 1999 | 7 |
| P-47-002646 | CA-SIS-2646 | Prehistoric | Habitation and Features | 1999, 2001 | 2D1 |
| P-47-002823 | CA-SIS-2823-H | Historic | COPCO II Wooden Stave Penstock | 2000 | 3S |
| P-47-002824 | CA-SIS-2824-H | Historic | COPCO Guest House | 2000 | 3S |
| P-47-002825 | CA-SIS-2825/H | Multiple | Lithic Scatter; Historic Dam Vista Homestead | 2003 | 7 |
| P-47-002826 | N/A | Historic | Frank Wood Cabin | 2000 | 3S |
| P-47-002827 | CA-SIS-2827 | Prehistoric | Village | 2000, 2002 | 3S |
| P-47-002990 | CA-SIS-2990-H | Historic | Irrigation Ditch | 1996 | 6Z |
| P-47-003192 | N/A | Historic | Artifact Scatter | 2002 | 7 |
| P-47-003913 | CA-SIS-3913 | Prehistoric | Lithic Scatter and Features | 2003 | 7 |
| P-47-003914 | CA-SIS-3914 | Prehistoric | Lithic Scatter | 2003 | 7 |
| P-47-003915 | CA-SIS-3915 | Prehistoric | Lithic Scatter | 2003 | 7 |
| P-47-003916 | CA-SIS-3916-H | Historic | Wooden Trestle | 2003 | 7 |
| P-47-003917 | CA-SIS-3917-H | Historic | Refuse Scatter | 2003 | 7 |
| P-47-003918 | CA-SIS-3918-H | Historic | Refuse Scatter | 2003 | 7 |
| P-47-003919 | CA-SIS-3919 | Prehistoric | Lithic Scatter | 2003 | 7 |
| P-47-003920 | CA-SIS-3920 | Prehistoric | Lithic Scatter | 2003 | 7 |

| Primary No. | State Trinomial | Component Age | Site Type | Year(s) Recorded or Updated | NRHP Eligibility* |
|---|---|---|---|---|---|
| P-47-003921 | CA-SIS-3921 | Prehistoric | Village | 2003 | 7 |
| P-47-003922 | CA-SIS-3922-H | Historic | Copco Village Dump | 2003 | 7 |
| P-47-003923 | CA-SIS-3923 | Prehistoric | Village and Rockshelter | 2003 | 3S |
| P-47-003924 | CA-SIS-3924 | Prehistoric | Lithic Scatter | 2003 | 7 |
| P-47-003925 | CA-SIS-3925 | Prehistoric | Lithic Scatter | 2003 | 7 |
| P-47-003926 | CA-SIS-3926 | Prehistoric | Village | 2003 | 7 |
| P-47-003927 | CA-SIS-3927-H | Historic | Refuse Scatter and Feature | 2003 | 7 |
| P-47-003928 | CA-SIS-3928-H | Historic | Rock Wall | 2003 | 7 |
| P-47-003929 | CA-SIS-3929/H | Multiple | Prehistoric Village; Historic Artifact Scatter | 2003 | 7 |
| P-47-003930 | CA-SIS-3930 | Prehistoric | Lithic Scatter | 2003 | 7 |
| P-47-003931 | CA-SIS-3931 | Prehistoric | Lithic Scatter and Midden | 2002 | 7 |
| P-47-003932 | CA-SIS-3932-H | Historic | Habitation with Artifact Scatter and Features | 2002 | 7 |
| P-47-003933 | CA-SIS-3933 | Prehistoric | Lithic Scatter and Features | 2003 | 3S |
| P-47-003934 | CA-SIS-3934-H | Historic | Rock Piles | 2003 | 7 |
| P-47-003935 | CA-SIS-3935 | Prehistoric | Lithic Scatter | 2003 | 7 |
| P-47-003936 | CA-SIS-3936-H | Historic | Rock Piles and Rock Alignments | 2003 | 7 |
| P-47-003937 | CA-SIS-3937-H | Historic | Rock Wall | 2003 | 7 |
| P-47-003938 | CA-SIS-3938 | Prehistoric | Lithic Scatter | 2003 | 7 |
| P-47-003939 | CA-SIS-3939/H | Multiple | Prehistoric Rockshelter; Historic Artifact Scatter | 2003 | 7 |
| P-47-003940 | CA-SIS-3940-H | Historic | Habitation with Artifact Scatter and Features | 2003 | 7 |
| P-47-003941 | CA-SIS-3941-H | Historic | Ditch | 2002 | 7 |
| P-47-003942 | CA-SIS-3942- | Historic | Rock Wall | 2003 | 7 |

| Primary No. | State Trinomial | Component Age | Site Type | Year(s) Recorded or Updated | NRHP Eligibility* |
|---|---|---|---|---|---|
| | H | | | | |
| P-47-003943 | CA-SIS-3943-H | Historic | Rock Wall | 2003 | 7 |
| P-47-003944 | CA-SIS-3944-H | Historic | Rock Wall | 2003 | 7 |
| P-47-003945 | CA-SIS-3945-H | Historic | Rock Piles | 2003 | 7 |
| P-47-003946 | CA-SIS-3946 | Prehistoric | Lithic Scatter and Feature | 2003 | 7 |
| P-47-004089 | CA-SIS-4089-H | Historic | Road | 2002 | 7 |
| P-47-004212 | N/A | Historic | Bridge | 2004 | 2 |
| P-47-004134 | CA-SIS-4134/H | Multiple | Prehistoric Lithic Scatter; American Bar Mine | 2003, 2004, 2008, 2009 | 7 |
| P-47-004303 | N/A | Historic | Hilt Mine with Artifact Scatter | 2007 | 7 |
| P-47-004304 | CA-SIS-4304/H | Multiple | Prehistoric Quarry; Historic Artifact Scatter and Features | 2007 | 7 |
| P-47-004305 | N/A | Historic | Rock Wall | 2007 | 7 |
| P-47-004315 | CA-SIS-4315-H | Historic | Mine and Ditch | 2007 | 7 |
| P-47-004321 | CA-SIS-4321 | Prehistoric | Quarry and Feature | 2007 | 7 |
| P-47-004322 | CA-SIS-4322 | Prehistoric | Quarry | 2007 | 7 |
| P-47-004323 | CA-SIS-4323 | Prehistoric | Quarry | 2007 | 7 |
| P-47-004326 | CA-SIS-4326-H | Historic | Mine | 2007 | 7 |
| P-47-004414 | N/A | Historic | Ash Creek Bridge | 2000 | 2 |
| P-47-004427 | N/A | Historic | Habitation with Artifact Scatter and Features | 2000 | 7 |
| P-47-004945 | CA-SIS-4945-H | Historic | Garvey Gulch Arrastra and Mine | 2008 | 7 |
| P-47-004999 | N/A | Historic | Mine | 2000 | 7 |
| P-47-005000 | N/A | Historic | Rock Wall | 2000 | 7 |
| P-47-005255 | CA-SIS-5255-H | Historic | California Oregon Stage Road | 2015 | 3S |
| P-47-005256 | CA-SIS-5256-H | Historic | Anderson Ditch | 2015 | 6Z |

| Primary No. | State Trinomial | Component Age | Site Type | Year(s) Recorded or Updated | NRHP Eligibility* |
|---|---|---|---|---|---|
| P-47-005346 | CA-SIS-5346-H | Historic | Topsy Road | 2015 | 7 |
| N/A | N/A | Unknown | Pollock Site 3 | Unknown | 7 |
| N/A | N/A | Unknown | Pollock Site 4 | Unknown | 7 |
| N/A | N/A | Unknown | Pollock Site 5 | Unknown | 7 |
| N/A | N/A | Unknown | Pollock Site 6 | Unknown | 7 |
| N/A | N/A | Unknown | Pollock Site 7 | Unknown | 7 |
| N/A | N/A | Unknown | Pollock Site 10 | Unknown | 7 |
| N/A | N/A | Unknown | Pollock Site 13 | Unknown | 7 |
| N/A | N/A | Historic | Habitation with Artifact Scatter and Features | 2013, 2016 | 7 |
| N/A | N/A | Prehistoric | Lithic Scatter | 1992 | 7 |
| N/A | N/A | Prehistoric | Lithic Scatter | 1992 | 7 |
| N/A | N/A | Historic | Klamath Kamp Service Station and Habitation | 2015 | 6Z |
| N/A | N/A | Historic | Habitation | 2015 | 6Z |

*NRHP Eligibility from Cardno ENTRIX (2012) and/or NEIC site records:

1B Listed in the National Register as a contributor to a district and separately;
2 Determined eligible for listing in the National Register;
2D1 Contributor to a district determined eligible by the Keeper;
3 Appears eligible for listing in the National Register;
3S Appears eligible for separate listing;
3B Appears eligible for separate listing and contributor to a district that has been fully documented according to OHP instructions and appears eligible for listing;
4S2 May become eligible for separate listing in the National Register when more historical or architectural research is performed on the property;
6Z Found ineligible for listing in the National Register;
7 Not evaluated.

## Isolated Finds

The KRRC records search identified 68 isolated finds, including 65 prehistoric resources, 2 historic-period isolates, and 1 isolated feature of unknown age (Table 3.5-4). Prehistoric isolates include one small rock cairn, one bedrock milling feature, one location with two possible cupule boulders, one incised cobble, one piece of possible ground stone, one unifacial mano, one cobble mortar, one basalt maul, three obsidian biface fragments, one chert biface fragment, one basalt core, nine chert cores, one jasper core, two chert flake tools, one chert barbed projectile point, one chert projectile point midsection, one chert scraper, and four obsidian unifaces. Forty-one isolate locations were found to contain debitage, ranging from 1 flake to as many as 13 flakes in a single location. Debitage includes obsidian, chert, and basalt. Eleven isolates contain both tools and debitage.

The historic-period isolates consist of one rusted horseshoe and the remains of a wagon. The isolate of unknown age is described as a rocky depression measuring 2.5 m in diameter.

### Table 3.5-4 Previously Recorded Isolated Finds

| Isolate Description | Component | | | Total |
|---|---|---|---|---|
| | Prehistoric | Historic | Unknown | |
| Small rock cairn | 1 | -- | -- | 1 |
| Rocky depression | -- | -- | 1 | 1 |
| Bedrock milling feature | 1 | -- | -- | 1 |
| Two possible cupule boulders | 1 | -- | -- | 1 |
| Incised cobble | 1 | -- | -- | 1 |
| Single ground stone tool | 4 | -- | -- | 4 |
| Single piece of debitage or shatter | 21 | -- | -- | 21 |
| Multiple pieces of debitage and/or shatter | 11 | -- | -- | 11 |
| Single flaked stone tool | 11 | -- | -- | 11 |
| Multiple flaked stone tools | 1 | -- | -- | 1 |
| Flaked stone tool(s) and debitage | 11 | -- | -- | 11 |
| Flaked stone tool, battered stone tool, and debitage | 1 | -- | -- | 1 |
| Ground stone tool and debitage | 1 | -- | -- | 1 |
| Horseshoe | -- | 1 | -- | 1 |
| Wagon | -- | 1 | -- | 1 |
| **TOTAL** | 65 | 2 | 1 | 68 |

#### 3.5.1.3 Archaeological Districts

### FERC Relicensing Study Proposed Archaeological Districts

As part of the Klamath Hydroelectric Project relicensing study (FERC 2007), five areas of multiple prehistoric sites were identified along the same section of the Klamath River which was considered as a potential National Register District (PacifiCorp 2004:3-198-199; FERC 2007:3-544). This district included four groups of multiple sites in Oregon located at the head of Link River and the mouth of Upper Klamath Lake, Teeter's Landing, Spencer Creek/mouth of upper Klamath River Canyon, and near Frain Ranch. In California, a cluster of three villages near Fall Creek, in the Copco Lake area, comprised the fifth potential district group. The National Register eligibility of this district has not been finalized.

A historic-period archaeological district was also considered for the Frain Ranch, in Oregon (PacifiCorp 2004:3-200). Due to their association with early homesteading and the beginning of ranching and agriculture within the upper Klamath River, four Frain ranch area sites were envisioned for this district. The National Register eligibility of this district has not been finalized at this time.

### Klamath River Hydroelectric Project District

The Klamath Hydroelectric Project comprises seven hydroelectric generation facilities and their related resources located along the Klamath River and its tributaries in Klamath County, Oregon and Siskiyou County, California. Beginning at the Link River Dam, in Klamath Falls, Oregon, the Project boundary continues southwest along the Klamath River to include the Keno Dam Complex and the J.C. Boyle Complex in Oregon. Within California, the Klamath Hydroelectric Project boundary includes the Fall Creek, Copco No. 1 and Copco No. 2 complexes, and terminating at Iron Gate Dam. The Klamath Hydroelectric Project facilities were constructed between 1903 and 1958 by the California Oregon Power Company (COPCO) and its predecessors and are now owned and operated by PacifiCorp under FERC License Nos. 2082 (Kramer 2003a) and 14803.

The proposed Klamath River Hydroelectric Project District (P-47-004015) includes the hydroelectric facilities and various diversion dams; support structures; linear elements such as flumes, canals, and tunnels; and other related buildings and structures. A historic context statement (Kramer 2003b) and Determination of Eligibility (Kramer 2003a) developed for the Klamath Hydroelectric Project notes its eligibility to the National Register as a District under Criterion A for its association with the industrial and economic development of southern Oregon and northern California (Kramer 2003a). The California and Oregon SHPOs have not concurred with this eligibility recommendation. Table 3.5-5 identifies key features of the three hydroelectric complexes located in California that are part of the Lower Klamath Project and their National Register eligibility recommendation.

### Table 3.5-5 Summary of National Register Eligibility Recommendations

| Facility/Description | Date | National Register Eligibility Recommendation and Reference | |
|---|---|---|---|
| | | Kramer 2003a | EIS/R 2012 |
| **Copco No. 1 Complex** | | | |
| Dam | 1912-1918, 1921-1922 | Historic Contributing | Historic Contributing |
| Gatehouse 1 | 1918 | Historic Contributing | Historic Contributing |
| Gatehouse 2 | 1922 | Historic Contributing | Historic Contributing |
| Gate Hoist System/Rails | 1918 | Historic Contributing | Historic Contributing |
| Single and Double Penstocks | 1912-1918 | Historic Contributing | Historic Contributing |
| Powerhouse | 1918 | Historic Contributing | Historic Contributing |
| Copco Guesthouse (remains) | 1917, 1980s | Historic Contributing | - |
| House/Garage 1 | ca.1922 | Historic Contributing | - |
| House/Garage 2 (21600 Copco Rd) | ca.1922 | Historic Contributing | - |

| Facility/Description | Date | National Register Eligibility Recommendation and Reference | |
|---|---|---|---|
| | | Kramer 2003a | EIS/R 2012 |
| Garage/Warehouse | ca.1922 | Historic Contributing | - |
| **Copco No. 2 Complex** | | | |
| Dam | 1925 | Historic Contributing | Historic Contributing |
| Water Conveyance Features | 1925 | Historic Contributing | Historic Contributing |
| *Headgate* | 1925 (rebuilt) | Historic Contributing | Historic Contributing |
| *Tunnel Intake* | 1925 | Historic Contributing | Historic Contributing |
| *Concrete-lined Tunnel* | 1925 | Historic Contributing | Historic Contributing |
| *Wood Stave Pipeline* | 1925 | Historic Contributing | Historic Contributing |
| *Concrete Tunnel* | 1925 | Historic Contributing | Historic Contributing |
| *Steel Penstocks* | 1925 | Historic Contributing | Historic Contributing |
| Timber Cribbing | 1925 | Historic Contributing | Historic Contributing |
| Coffer Dam | 1925 | Historic Contributing | Historic Contributing |
| Powerhouse | 1925, 1996 | Historic Contributing | Historic Contributing |
| *Control Center/Office* | ca. 1980 | Non-Contributing | - |
| *Maintenance Building* | 1991 | Non-Contributing | - |
| Oil and Gas Shed | | Historic Contributing | - |
| Cookhouse/Bunkhouse | ca. 1925 | Historic Contributing | - |
| *Modern Bunkhouse* | ca. 1960 | Non-Contributing | - |
| *Garage/Accessory Building* | ca. 1960 | Non-Contributing | - |
| Ranch Housing | ca. 1965 | | |
| *Ranch House 1* | ca. 1965 | Non-Contributing | - |
| *Ranch House 2* | ca. 1965 | Non-Contributing | - |
| *Ranch House 3* | ca. 1965 | Non-Contributing | - |
| Bungalow Housing | ca. 1925 | | |
| *Bungalow/Garage 1* | ca. 1925 | Historic Contributing | - |
| *Bungalow/Garage 2* | ca. 1925 | Historic Contributing | - |
| *Bungalow/Garage 3* | ca. 1925 | Historic Contributing | - |
| Modular Residences | 1985 | | |
| *Modular 1* | 1985 | Non-Contributing | - |
| *Modular 2* | 1985 | Non-Contributing | - |
| *Modular 3* | 1985 | Non-Contributing | - |
| *School House/Community Center* | 1965 | Non-Contributing | - |

| Facility/Description | Date | National Register Eligibility Recommendation and Reference | |
|---|---|---|---|
| | | Kramer 2003a | EIS/R 2012 |
| **Iron Gate Dam Complex** | | | |
| Dam | 1960-1962 | Non-Contributing | Historic Contributing |
| Spillway | ca. 1980 | Non-Contributing | Historic Contributing |
| Diversion Tunnel | 1960-1962 | Non-Contributing | Historic Contributing |
| Water Conveyance System | 1960-1962 | | Historic Contributing |
| Water Way/Trash Racks | 1960-1962 | Non-Contributing | Historic Contributing |
| Pipeline | 1960-1962 | Non-Contributing | Historic Contributing |
| Penstock | 1960-1962 | Non-Contributing | Historic Contributing |
| Powerhouse | 1960-1962 | Non-Contributing | Historic Contributing |
| Communication Building | ca. 1980 | Non-Contributing | Historic Contributing |
| Restroom Building | ca. 1980 | Non-Contributing | Historic Contributing |
| Dam Fisheries Facilities | | | Historic Contributing |
| *Holding Tanks* | 1962 | Non-Contributing | Historic Contributing |
| *Spawning Building* | 1962 | Non-Contributing | |
| *Fish Ladder* | 1962 | Non-Contributing | |
| *Aerator* | 1962 | Non-Contributing | |
| Fish Hatchery | 1965, ca.1994 | | |
| *Hatchery Building* | 1962 | Non-Contributing | |
| *Warehouse* | 1962 | Non-Contributing | |
| *Office* | 1962 | Non-Contributing | |
| *Workers Housing 1* | 1962 | Non-Contributing | |
| *Workers Housing 2* | 1962 | Non-Contributing | |
| *Workers Housing 3* | 1962 | Non-Contributing | |
| *Workers Housing 4* | 1962 | Non-Contributing | |
| *Fish Rearing Ponds* | 1962 | Non-Contributing | |
| *Fish Ladder* | 1962 | Non-Contributing | |
| *Visitors Center* | 1962 | Non-Contributing | |

### Upper Klamath River Stateline Archaeological District

The newly designated Upper Klamath River Stateline Archaeological District (Bureau of Land Management 2016) is located along the Klamath River, in California, less than 0.5-mile from the California-Oregon border. The district encompasses three pre-contact village sites (contributing) and one lithic scatter (non-contributing). Archaeological research indicates site use in the district extended from circa 1000 years before the common era (BCE) or earlier to possibly as late as 1840 BCE (Bureau of Land Management 2016). The district was determined eligible for the National Register at the local level of significance under Criterion D in the areas of Prehistoric Archaeology, Native American Ethnic Heritage, Commerce, Economics, Religion, and Politics/Government. The California SHPO and the Keeper of the National Register have concurred with the district's eligibility.

#### 3.5.1.4 Ethnographic Information and Traditional Cultural Properties (TCPs)

The KRRC's review of ethnographic information for the California portion of the Lower Klamath Project identified TCPs and other culturally sensitive areas along and near the Klamath River based on ethnographic inventory reports prepared by the Klamath Tribe (Deur 2003), Shasta Nation (Daniels 2003, 2006), Karuk Tribe (Salter 2003), and Yurok Tribe (Sloan 2003) for the FERC Relicensing study.

The Klamath Tribe identified 11 TCPs in the Klamath Basin area, and noted adverse effects to tribal fisheries resulting from impediment of anadromous fish passage due to Klamath River dams (Deur 2003). The Klamath Tribe also identified three sites along the Klamath River between J.C. Boyle Dam (Oregon) and the Scott River (California) that have cultural value (Theodoratus et al. 1990).

The Shasta Nation report (Daniels 2003, 2006) presents a list of village sites recorded in the ethnographic literature, a list of locations that the Shasta consider TCPs, and another inventory of 11 locations, drawn from the first two listings, that are eligible for the National Register.

The Karuk (Salter 2003) and Yurok (Sloan 2003) ethnographic reports draw upon oral interviews, other writings, ethnographical literature, and a review of natural and cultural resources within the Klamath River to discuss each tribe's traditional and historical relationships with the river and its resources to subsistence, material and spiritual culture, and identity.

#### 3.5.1.5 Klamath Cultural Riverscape

The Klamath River Inter-Tribal Fish and Water Commission incorporated information from the tribal ethnographic studies, in addition to information provided by the Hoopa Valley Tribe, into an integration report (King 2004) that focused on the Klamath River. The entire length of the river was identified as a type of cultural or ethnographic landscape, termed the Klamath Riverscape, due to the relationship between the Klamath Tribes, Shasta, Karuk, Hoopa, and Yurok Tribes and the river and its resources (Gates 2003; King 2004). The characteristics that contribute to the riverscape's cultural character include natural and cultural elements such as the river itself; its anadromous and resident fish; its other wildlife and plants; and its cultural sites, uses, and perceptions of value by the tribes (King 2004). Gates (2003) and King (2004) recommended the Klamath Riverscape as eligible for the National Register based on its association with broad patterns of tribal environmental stewardship, spiritual life, and relationships between humans and the non-human world. The riverscape and/or ethnographic reports and eligibility determination have not been submitted by a Federal agency to the Oregon and California SHPOs for National Register eligibility concurrence (USBR and

California Department of Fish and Game (CDFG)[14] 2012: Vol. 1, 3.13-29). Further research and consultations to define and update the riverscape cultural landscape as a historic property is identified as a Cultural Resources mitigation measure for the Project.

### 3.5.1.6 Historical Landscape Analysis

As part of the records search, the KRRC conducted a historical landscape analysis to identify locations where post 1850s era settlement and resource developments occurred within the records search area. The materials for this study included the review of the General Land Office (GLO) records, including California plat maps (1856, 1876, 1880, and 1881) and surveyor's notes; a variety of published and manuscript resources (Beckham 2006; Boyle 1976; Kramer 2003; PacifiCorp 2004; USDI 1989); and USGS maps available at http://historicalmaps.arcgis.com/usgs. Other map searches included the David Rumsey collection, Northwestern California map collection at Humboldt State University, Library of Congress digital collections, and Online Archive of California. Historical landscape information was digitized into a GIS format and a table prepared with site-specific information annotated by Township/Range/Section (Table 3.5-6).

**Table 3.5-6 Historic Landscape Analysis Results for California**

| Township | Range | Section | Notes |
|---|---|---|---|
| 47N | 4W | 1 | Yreka & Linkville Road at northeast corner of Section on 1881 GLO [when road digitized, appears to be T48N/R4W] |
| 47N | 4W | 2 | Approximate location of Snackenburg Gulch Cemetery in gulch 0.25-mile from county road; all evidence burned in a 1956 fire (Beckham 2006:235). |
| 47N | 5W | General | "It is well watered by the Klamath River which flows through it. There are quite a number of settlers in the Township" (GLO 1880, in Beckham 2006:29). Other settlements listed in Township: Cooper's Hollow [no section given], sheep camp by name of Cooper (Beckham 2006:224); Hearn's Flat [no section given] homestead in 1901 (Beckham 2006:226). Settlements depicted across the township on 1881 GLO. |
| 47N | 5W | 4 | Army camped at mouth of creek in mid-1850s (Beckham 2006:223). The location of Rufley's camp was near the mouth of the creek [no section given] who manufactured pickets in 1890s (Beckham 2006:233). Wanaka Butte named for man named Wanaka who lived in a ranch at mouth of creek (Beckham 2006:237). Mouth of Camp Creek the original location of Lowood School; school burned in 1907, rebuilt then relocated (Beckham 2006:202). Lowood School described in Beckham (2006:230) in the NW ¼ of Section. Lowood School depicted on 1941 *Macdoel, Calif*. topographic quadrangle. Roads depicted on 1881 GLO, but mapping appears incomplete. Fence and irrigation ditch on 1881 GLO. Road and Southern Pacific Railroad on *Macdoel, Calif*. 1941 |

[14] California Department of Fish and Game is now known as the California Department of Fish and Wildlife.

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| | | | topographic quadrangle. |
| 47N | 5W | 8 | Only ranch on Brush Creek (Beckham 2006:229). Beers homesteaded the property in the 1880s, the ranch had several owners including Liskey in 1930s (Beckham 2006:229). Cabin depicted in NW 1/4 on 1881 GLO. Road, trail, and two unidentified buildings on *Macdoel, Calif*. 1941 topographic quadrangle. |
| 47N | 5W | 9 | Iron Gate, bluffs on both sides of the river, wagon road cut through rocks on west side, deep rock cut for railroad grade on east side to allow railroad to pass by water's edge (Beckham 2006:227); homestead patented in 1890, Partial road and fence depicted on 1881 GLO. House in NE 1/4 of NE 1/4 (PacifiCorp 2004: Appendix 2D), depicted on 1881 GLO. Road, Southern Pacific Railroad, and unpaved road or trail on *Macdoel, Calif*. 1941 topographic quadrangle. Iron Gate Dam and tram on *Copco, Calif*. 1954 topographic quadrangle. |
| 47N | 5W | 10 | Partial road and fence depicted on 1881 GLO. Unpaved road or trail on *Macdoel, Calif*. 1941 topographic quadrangle. |
| 47N | 5W | 16 | Bogus Creek enters Klamath downstream of Iron Gate dam, location of Bogus Ranch and Indian village; ranch sold to COPCO [no section, appears to be 16/17] (Beckham 2006:221). Fence on 1881 GLO. Unpaved road or trail, unidentified building, and Southern Pacific Railroad on *Macdoel, Calif*. 1941 topographic quadrangle. Bogus Ranch in northwestern portion of Section as described in Beckham (2006:221). |
| 47N | 5W | 17 | Irrigation ditch and fence depicted on 1881 GLO. Road, unpaved road or trail, unidentified building, and Southern Pacific Railroad on *Macdoel, Calif*. 1941 topographic quadrangle. Footbridge on *Copco, Calif*. 1954 topographic quadrangle. Bogus Ranch in northeastern portion of Section and Wright's Ranch in southwestern portion of Section as described in Beckham (2006:221, 225). |
| 47N | 5W | 18 | Fence on 1881 GLO. Wright's Ranch in southeastern portion of Section as described in Beckham (2006:225). |
| 47N | 5W | 19 | House and barn depicted in NE 1/4 of section on 1881 GLO. Geo. Deal's fence, unnamed fence, and irrigation ditch depicted on 1881 GLO. Road, unpaved road or trail, and Southern Pacific Railroad on *Macdoel, Calif*. 1941 topographic quadrangle. Wright's Ranch in northwestern portion of Section as described in Beckham (2006:225). Unidentified building on *Macdoel, Calif*. 1941 topographic quadrangle. Two footbridges on *Copco, Calif*. 1954 topographic quadrangle. |
| 47N | 5W | 20 | Nothing depicted on 1881 GLO. Southern Pacific Railroad, unidentified building, and unpaved road or trail on *Macdoel, Calif*. 1941 topographic quadrangle. Wright's Ranch in northeastern portion of Section as described in Beckham (2006:225). |
| 47N | 5W | 30 | Wm. Lairds Fence depicted on 1881 GLO in SW 1/4. Southern Pacific Railroad on *Macdoel, Calif*. 1941 topographic quadrangle. |

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| 47N | 6W | 19 | Wright Ranch at mouth of Dry Creek, settled in early 1870s; ditch dug on property (Beckham 2006:225) [Section 19 appears too far to be within project area, not mapped] |
| 47N | 6W | 20 | The village of Cottonwood in the southwest 1/4 of section 20 contains some 15 or 20 houses and several miners' cabins. The inhabitants number from 75 to 100. (GLO 1875, in Beckham 2006:29-30). Cottonwood Road and Oregon Road on 1856 GLO. Cottonwood House on 1856 GLO, noted as Old Chimney on 1876 GLO. Ditch, Stage Road from Yreka via Anderson's Ferry, California and Oregon Stage Road, Perry Johnson's Field, Deal's Orchard, and old water wheels/abandoned mill on 1876 GLO. |
| 47N | 6W | 21 | Cottonwood Road and Oregon Road on 1856 GLO. Ditch, Perry Johnson's Field, California and Oregon Stage Road, Nathan Brickhouse's House, and Old Road on 1881 GLO. |
| 47N | 6W | 24 | Wright's Road on 1876 GLO; continuation of Geo. Deal's fence depicted in SE corner on 1881 GLO. Road and unpaved road or trail depicted on *Macdoel, Calif*. 1941 topographic quadrangle. |
| 47N | 6W | 25 | Oregon Road on 1856 GLO. Road to Deal's Ranch, G. Deal's Ranch, and Jos. Beal's [sic] field north of Klamath River; Emigrant Road from Oregon; irrigation ditch; and continuation of Wm. Laird's fence (SE corner) depicted on 1876 GLO. Two unidentified buildings on *Macdoel, Calif*. 1941 quadrangle. Southern Pacific Railroad on *Macdoel, Calif*. 1941 topographic quadrangle and on *Copco, Calif.* 1954 topographic quadrangle [routes do not align between quadrangles]. |
| 47N | 6W | 26 | NW 1/4 of section location of town of Klamathon, fire consumed town in 1902; included a dam to hold water and logs, fish ladder, sawmill, box factory, business district, and residences (Beckham 2006:228). Jos. Beal's field, Bell's ferry over Klamath River, and Emigrant Road from Oregon depicted on 1876 GLO. Oregon Road on 1856 GLO. Southern Pacific Railroad on *Copco, Calif.* 1954 topographic quadrangle. |
| 47N | 6W | 27 | Oregon Road on 1856 GLO. Jas. Bell's hen house in NE corner and Emigrant Road from Oregon north of Klamath River depicted on 1876 GLO. |
| 47N | 6W | 28 | Oregon Road depicted on 1856 GLO. Emigrant road via Bell's Ferry, ditch, Jos. Bell's field, California and Oregon Stage Road), Emigrant Road from Oregon, Old Road, channel of "Old Brass Wire" placer claim depicted on 1876 GLO. |
| 47N | 6W | 29 | Stage Road from Yreka via Anderson's Ferry, quartz mine, Hilt's Tail Trace [mine trace]; Emigrant Road from Oregon via Bell's Ferry and miner's cabin depicted on 1876 GLO |
| 47N | 6W | 30 | "The following sections and parts of sections are more valuable for mineral than agricultural purposes. Sections... 30" (GLO 1875, in Beckham 2006:29-30). Mines depicted on 1876 GLO |
| 47N | 6W | 31 | Ditch depicted on 1876 GLO. |
| 47N | 6W | 32 | Stage Road from Yreka via Anderson's Ferry, cabin, flume, Carson's |

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| | | | field, ditch, and mining race depicted on 1876 GLO. |
| 47N | 6W | 33 | Carson's field, ditch, and mining race depicted on 1876 GLO. |
| 48N | 3W | General | "It is well watered by Klamath River which flows through it. There are some settlers in the township" (GLO 1880, in Beckham 2006:28) |
| 48N | 3W | 13 | Road on *Ashland, OR.* 1897 topographic quadrangle. Road to Klamath Falls and telephone line on 1917 GLO. |
| 48N | 3W | 14 | Linkville Road on east side of Klamath River on 1881 GLO. Road in approximate same alignment as Linkville Road on *Macdoel, Calif*. 1941 topographic quadrangle. [Both roads mapped to account for any shifts in alignment or mismappings at state border]. Road on *Ashland, OR.* 1897 topographic quadrangle. Klamath Falls Road, irrigation ditch, and two telephone lines on 1917 GLO. |
| 48N | 3W | 15 | Homestead patent by Trafton 1884 (PacifiCorp 2004: Appendix 2D). Linkville Road on east side of Klamath River on 1881 GLO. Road in approximate same alignment as Linkville Road on *Macdoel, Calif*. 1941 topographic quadrangle. [Both roads mapped to account for any shifts in alignment]. |
| 48N | 3W | 22 | Homestead patent by Trafton 1884 (PacifiCorp 2004: Appendix 2D). Location of Hessig Ranch in SE ¼, settled in 1927. Hessig's on river in 1884 (Beckham 2006:227). Point for Hessig Ranchon *Macdoel, Calif*. 1941 topographic quadrangle. Cabin depicted in SE 1/4 on 1881 GLO; Linkville Road on east side of Klamath River on 1881 GLO. Road in approximate same alignment of Linkville Road on *Macdoel, Calif*. 1941 topographic quadrangle. [Both roads mapped to account for any shifts in alignment]. |
| 48N | 3W | 23 | Nothing depicted. |
| 48N | 3W | 27 | Site of Beswick located in SW 1/4 of Section; site of a store, post office, saloon, hotel, stage barn, and Klamath Hot Springs (Beckham 2006:220);. Linkville Road, road, and ditch on 1881 GLO. Hot Spring and road on *Macdoel, Calif*. 1941 topographic quadrangle. Road in approximate same alignment on 1881 GLO (possible continuation of Linkville Road). [Both roads mapped to account for any shifts in alignment]. Seven unidentified buildings in boundary of Beswick polygonon *Macdoel, Calif*. 1941 topographic quadrangle. |
| 48N | 3W | 28 | Location of Pokegama log chute (Beckham 2006:228). Spring, ditch, and Linkville Roadon 1881 GLO. Road on *Macdoel, Calif*. 1941 topographic quadrangle. Road in approximate same alignment on 1881 GLO (possible continuation of Linkville Road). |
| 48N | 3W | 29 | Nothing depicted on 1881 GLO |
| 48N | 3W | 32 | Approximate location of Spannaus Ranch (Beckham 2006:103). Ditch and Linkville & Yreka Road on 1881 GLO. Two unidentified buildings within Spannus Ranch polygon and road on *Macdoel, Calif*. 1941 topographic quadrangle. Road in approximate same alignment on 1881 GLO. |
| 48N | 3W | 33 | NE 1/4 of section location of Oak Grove School, founded as early |

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| | | | as 1879, near steel bridge at Copco, fire destroyed building 1905/1908, rebuilt and then moved after dam (Beckham 2006:231). House, barn, cabin, and ditch in NW 1/4 of Section on 1881 GLO. Road on *Macdoel, Calif*. 1941 topographic quadrangle. Road in approximate same alignment (likely Linkville Road) on 1881 GLO. [Both roads mapped to account for any shifts in alignment]. |
| 48N | 4W | General | "It is well watered by Klamath River which flows through it. Some portions of the Township are well adapted to grazing and agriculture. There are quite a number of settlers in this township" (GLO 1880, in Beckham 2006:28) |
| 48N | 4W | 21 | Klamath Railroad switchback (Beckham 2006:126). Boyle 1976 depicts ditches, dams, buildings, etc., including Klamath Lake Railroad switchback. Trailon 1881 GLO. Unpaved road or trail and building in Beaver Basinon *Macdoel, Calif*. 1941 topographic quadrangle. |
| 48N | 4W | 25 | Spannaus Gulch, Spannaus family secured homestead patents between 1908 and 1919 in sections 25, 26, 35 (Beckham 2006:236). |
| 48N | 4W | 26 | Nothing depicted. |
| 48N | 4W | 27 | Linkville & Yreka Road and irrigation ditch on 1881 GLO. Lennox's barn on west Section line on 1881 GLO. Unpaved road or trail on *Macdoel, Calif*. 1941 topographic quadrangle. |
| 48N | 4W | 28 | Klamath Lake Railroad switchback (Beckham 2006:126). Boyle (1976) depicts layout of dam construction project showing ditches, dams, buildings, etc., including Klamath Lake Railroad switchback. Linkville & Yreka Road and irrigation ditch on 1881 GLO. Lennox's barn on east Section line on 1881 GLO. Likely Ward barn on west Section line on 1881 GLO. Unpaved road or trail on *Macdoel, Calif*. 1941 topographic quadrangle. |
| 48N | 4W | 29 | Klamath Lake Railroad switchback (Beckham 2006:126). Extinct bison remains found (in 1914?), in pothole while excavating the west abutment of Copco dam (Boyle 1976:12). "Ward's camp or camp No. 3...only a few men were there living in tents with an old barn for a cookhouse....It was also a place where Indian Jake (of the Shasta Indians) used to sit and fish" (Boyle 1976:9). Copco announced (in 1917) that it would put a force of 300 men to work on its dam and powerplant at Copco No. 1 Kramer (2003:39). Map showing Camp Ward and other buildings at Copco No. 1 in Boyle (1976). Post office at "Ward's Canyon" (Boyle 1976:18). Hahn Ranch located south of Klamath River at the Copco No. 1 Diversion Dam (Kramer 2003: Figure 10). Copco built a beautiful, rustic and (large) spacious guest house, built on the bluff (a few feet back about 50-75 yards above the dam) at Copco No. 1, overlooking dam, powerhouse and lake; to get to the guest house one walked along the cinder path from the cableway winch house over a bridge-like walkway with a railing, onto a wide veranda (Kramer 2003:40). Other buildings in the Copco No. 1 workers village: a concrete plant, railroad switch yard, turntable, winch house, blacksmith shop |

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| | | | (located north of adit (Kramer 2003: Figure28, page 47), carpentry shop and various others (Kramer 2003:40-41). A series of buildings are depicted on the 1941 *Macdoel, Calif*. topographic quadrangle (see below). Construction of the dam required a "branch feeder railroad," the old Klamath Lake logging railroad, that connected to the main line of the Southern Pacific Railroad south of Hornbrook (Kramer 2003:40). Likely road on 1881 GLO. Ward's House, spring, and barn along section line between 28 and 29 on 1881 GLO. Unpaved road or trail, Copco Dam, and Iron Gate Powerhouse, Southern Pacific Railroad, and four unidentified buildings on *Macdoel, Calif.* 1941 topographic quadrangle. |
| 48N | 4W | 30 | Community of Copco (construction site for dam), included a post office that operated between 1914 and 1954 (Beckham 2006:224); possible location of Fall Creek School (Beckham 2005:226). Klamath Hot Springs Station (RR) located in the northern 1/2 of section (Boyle 1976 [page 43 of PDF]. Two bungalows were building for the engineers at Fall Creek during the 1921-22 expansion work at Copco No. 1; many workers brought their families so another school house was built at Fall Creek, a few feet north of the first - 1922 school in place until Copco No. 2 was completed in 1965 (Kramer 2003:41). Copco No. 2 Village is a series of dwellings built for workers and other company employees, storage buildings, a former cookhouse and 1965 school building that was in use as a community center in 2003 (Kramer 2003:44, 48). Most of the workers' cottages were removed or replaced by more modern "ranch" housing; several ca. 1930s cottages as well as the cookhouse remain (Kramer 2003:45). Likely road on 1881 GLO. Unpaved road or trail, two unidentified buildings, State Fish Hatchery, and Southern Pacific Railroad on *Macdoel, Calif*. 1941 topographic quadrangle. |
| 48N | 4W | 31 | "During Fall Creek Power Plant construction there was quite a camp of tents, tent houses, etc., however, a boardinghouse built just a bit easterly above the plant was run by Mrs. Beck and her daughter - this burned in the 1930s and replaced with a modern cottage" (Kramer 2003:49). Location of Mrs. Beck's boarding house unknown. Unpaved road or trail on *Macdoel, Calif*. 1941 topographic quadrangle. Cluster of buildings, power house, water tank, and radio station on *Copco, Calif*. 1954 topographic quadrangle. |
| 48N | 4W | 32 | Unpaved road or trail on *Macdoel, Calif*. 1941 topographic quadrangle. Road depicted on Boyle (1976) map from south to the Copco No. 1 then crossing Klamath River and meeting up with Copco Road, may be 1941 road. |
| 48N | 4W | 33 | Road depicted on Boyle (1976) map from south to the Copco No. 1 then crossing Klamath River and meeting up with Copco Road. Road on *Macdoel, Calif*. 1941 topographic quadrangle. Road in approximate same alignment on 1881 GLO. G.S. Raymond's Home on 1881 GLO [appears outside project area]. |
| 48N | 4W | 34 | Lennox Rock and Lennox Ranch within Section. Lennox's secured |

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| | | | homestead in 1882; Siskiyou Electric Power… crews maintained survey headquarters at ranch (Beckham 2006:229; Boyle 1976:8-9). Headquarters at ranch where the Ager - Klamath Falls road approached the Klamath River (Boyle 1976:8). Boyle (1976) layout of project showing ditches, dams, buildings, etc., including Lenox Ranch buildings. The Ager - Klamath Falls Road is depicted on Boyle's (1976) map. G. Pecard's field, irrigation ditch, J. Lennox Homestead in NW ¼, and Linkville & Yreka Road on 1881 GLO. Roadon *Macdoel, Calif*. 1941 topographic quadrangle. Road in approximate same alignment on 1881 GLO. |
| 48N | 4W | 35 | Spannaus Gulch within Section. Spannaus family secured homestead patents between 1908 and 1919 in sections 25, 26, 35 (Beckham 2006:236). G. Pecard's field, irrigation ditch, Ang. Kempler's Meadow, and Linkville and Yreka Road depicted on 1881 GLO. Unpaved road or trail and road on *Macdoel, Calif*. 1941 topographic quadrangle. 1941 Road in approximate same alignment as on 1881 GLO. |
| 48N | 4W | 36 | Circa 1902 Siskiyou Electric Power Co worked on Fall Creek Power Plant...a camp has been set up on the flat near the flume and penstock…and the Plant will be located on the North Bank wagon road upon the Klamath River (Kramer 2003:16). No specific location identified within the Section for work camp. Linkville and Yreka Road, Ang. Kempler's Meadow, and irrigation ditch depicted on 1881 GLO. Unpaved road or trail and road on *Macdoel, Calif*. 1941 topographic quadrangle. 1941 Road in approximate same alignment as on 1881 GLO. |
| 48N | 5W | 25 | Road and Southern Pacific Railroad on *Macdoel, Calif*. 1941 topographic quadrangle. |
| 48N | 5W | 26 | Dutch Creek, a cobbler built cabin on this creek (Beckham 2006:225). Location of cabin unknown. |
| 48N | 5W | 30 | Spaulding's Camp, homestead and cabin (Beckham 2006:236). Location of camp unknown. |
| 48N | 5W | 31 | Possible road in SE 1/4 on 1881 GLO appears outside project area. Unpaved road or trail on *Macdoel, Calif*. 1941 topographic quadrangle. |
| 48N | 5W | 32 | Small road segment in SE 1/4 of 1881 GLO. Unpaved road or trail on *Macdoel, Calif*. 1941 topographic quadrangle. |
| 48N | 5W | 33 | Possible location of Madero Ranch (Beckham 2006:230-231). Small road segment and irrigation ditch on 1881 GLO. Two unpaved roads or trails, road, Southern Pacific Railroad on *Macdoel, Calif*. 1941 topographic quadrangle. Ranch with two buildings visible in 1953 aerial. |
| 48N | 5W | 34 | Location of steel bridge for Klamath Railroad crossing (Beckham 2006:236) [appears incorrect - bridge shown on 1941 topo in Section 35, though there is a bridge over Jenny Creek in this section]. Road and Southern Pacific Railroad on *Macdoel, Calif*. 1941 topographic quadrangle. Bridge over Jenny Creek on 1953 aerial. |

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| 48N | 5W | 35 | Location of truss steel bridge for Klamath Railroad crossing river (under reservoir) (Beckham 2006:126); location of Grieve Lower Ranch, founded just after Civil War, under Iron Gate Reservoir (Beckham 2006:226). Road, unidentified building, and Southern Pacific Railroad on *Macdoel, Calif*. 1941 topographic quadrangle. |
| 48N | 5W | 36 | Location of Fall Creek School, dated from 1911, site on the south side of headwaters of Iron Gate (Beckham 2006:203). Spearin Ranches on lower Fall Creek, flooded by Iron Gate (Beckham 2006:104). Road, unpaved road or trail, and Southern Pacific Railroad on *Macdoel, Calif*. 1941 topographic quadrangle. Two gage stations on the river on *Copco, Calif*. 1954 topographic quadrangle. |

### 3.5.2 2017 Cultural Resource Site Reconnaissance

Three local waste disposal sites are currently planned to accommodate concrete rubble and loose earth materials associated with dam removal. The disposal sites include one area for J.C. Boyle Dam (see Figure 5.2-1(C), Sheet 1), a combined site for Copco No. 1 and Copco No. 2 Dams (see Figure 5.3-1 (C), Sheet 1), and one area for Iron Gate Dam (see Figure 5.5-1(C), Sheet 2).

#### 3.5.2.1 J.C. Boyle Disposal Site

The J.C. Boyle Dam disposal site encompasses a 6-acre area located near the current right dam abutment (see Figure 5.2-1(C), Sheet 1). This area was included within the cultural resources inventory conducted by PacifiCorp for the Klamath Hydroelectric Project Relicensing study (PacifiCorp 2004). Therefore, the KRRC did not undertake a new cultural resources inventory. The PacifiCorp survey did not identify any archaeological sites, isolated finds, or built environment resources within the disposal area.

#### Copco No. 1 and Copco No. 2 Disposal Site

The Copco No.1 and Copco No. 2 disposal site is located between the two dams, on the northern hillslope above the Klamath River (Figure 5.3-1(C), Sheet 1). This area also was included within the cultural resources inventory conducted by PacifiCorp for the Klamath Hydroelectric Project Relicensing study (PacifiCorp 2004). Therefore, the KRRC did not undertake a new cultural resources inventory. The PacifiCorp survey did not identify any archaeological sites or isolated finds within the disposal area.

Two extant buildings are located within the Copco No.1 and Copco No. 2 disposal site, consisting of a ca. 1922 residential building and a small garage. These buildings are associated with the Copco No. 1 complex of Klamath Hydroelectric Project. PacifiCorp prepared a Determination of Eligibility for the Klamath Hydroelectric Project (Kramer 2003) that documents its regional significance and eligibility for listing in the National Register of Historic Places under Criterion A for its association with the industrial and economic development of southern Oregon and northern California.

Copco No. 1 was the first project developed on the river by the California-Oregon Power Company and was placed into service in 1918 and further expanded in 1922 (Kramer 2003:8). The Copco No. 1 complex includes seven features consisting of the Copco No. 1 dam, water conveyance system (two penstocks), powerhouse, the remains of a guesthouse, two residential buildings and associated garages surviving from the original worker's housing village, and a separate garage/warehouse (Kramer 2003:8). PacifiCorp evaluated the seven features, constructed between the period of 1912 and 1922, as contributing elements to the NRHP-eligible Klamath Hydroelectric Project (Kramer 2003).

#### 3.5.2.2 Iron Gate Disposal Site

The Iron Gate disposal site encompasses an approximately 36-acre area located approximately 750-feet east of Iron Gate Dam, within a small basin that overlooks Iron Gate Reservoir to the northwest (Figure 5.5-1 (C), Sheet 2). An area within the western portion of the disposal site, totaling approximately 9 acres, was included within the cultural resources inventory conducted by PacifiCorp for the Klamath Hydroelectric Project Relicensing study (PacifiCorp 2004). The PacifiCorp survey did not identify any archaeological sites, isolated finds, or built environment resources within the disposal area.

To provide 100 percent coverage of the disposal area, in July 2017, the KRRC conducted a cultural resources inventory of the remaining acres. The inventory was conducted using a standard systematic pedestrian survey that employed transects spacing of 15 m (65 ft.). The survey convention included a buffer of 46 m (150 ft.) around the footprint of the proposed disposal site. The inventory identified one historic-period archaeological site (LKP-RB-1) and one historic-period isolated find (LKP-EN1-IF).

Site LKP-RB-1 consists of a ca. 1960s refuse disposal site comprised of a concentration of discarded heavy equipment tires and several push piles or earthen berms, one of which contains a dispersed artifact scatter. The tire concentration includes 14 well-worn rubber tires with manufacturer's marks that include "FIRESTONE ROCK GRIP EXCAVATOR, FIRESTONE SUPER ROCK GRIP DEEP TREAD, FIRESTONE RIB EXCAVATOR, SILVERTOWN UNIVERSAL, and GENERAL ROCK RIB. The tire concentration is visible on a 1973 aerial photograph of the disposal site area, but it does not appear on earlier 1944, 1951, or 1954 aerial images. An artifact concentration associated with the western-most earthen berm contains a mix of domestic and structural-related items. These artifacts and features (berms) are likely associated with the Iron Gate Dam and Reservoir construction period in the early 1960s.

Site LKP-RB-1 is a near-surface cultural deposit. The site lacks association with nearby eligible properties (such as Klamath Hydroelectric Project complexes) for which historic contexts are or can be established. The deposit represents variable and idiosyncratic behavior by unknown persons or groups, and without a historic context, it cannot contribute to property significance. As an isolated refuse deposit that lacks integrity and association, the KRRC recommends Site LKP-RB-1 as not eligible to the National Register of Historic Places (NHRP) or the CRHR. The site does not meet eligibility criteria by being associated with specific events important in history (Criterion A/Criterion 1), association with persons important in history (Criterion B/Criterion 2), design/construction (Criterion C/Criterion 3), or ability to yield information important in history (Criterion D/Criterion 4).

Isolate LKP-EN-1-IF consists of a single, weathered, partially upright juniper fencepost. The isolate is part of a former fence line, portions of which are still visible outside the southeastern edge of the disposal area.

A review of the 1944, 1951, and 1954 aerial photographs of the Iron Gate waste disposal site area shows a linear feature that crosses northeast/southwest through the disposal site for a distance of several hundred feet. Interpretation of this linear feature suggests that it was a former fence line, and one that was distinct from the fence line possibly associated with Isolate LKP-EN-1-IF. The linear feature is not depicted in a 1973 aerial photograph, and no evidence of it was found during the current survey effort.

## 3.6 Copco No. 1 Foundation Removal

During construction of Copco No. 1 Dam, approximately 100 feet of alluvium was removed below channel grade and backfilled with concrete (Figure2.2-4 (B)). When the dam is demolished, the depth of the foundation removal needs to be sufficient so that river bed sediment mobilization through natural channel processes does not expose the concrete and create a fish passage barrier or prevent bedload movement in the active bed layer. The KRRC performed a scour analysis to determine a conservative depth of bed material mobilized by the restored river to recommend a depth of foundation removal for the project.

Copco No. 1 dam has captured most of the coarse sediment that either entered the river or was mobilized between J.C. Boyle Dam and Copco No. 1 Dam. Any sediment downstream of Copco No. 2 Dam that was mobilized by storm flows, therefore, was not replaced by the inflowing upstream of sediment. This has likely resulted in the removal of sediment downstream of Copco No. 2, especially the finer sediment, and possibly a steepening of the slope. The removal of Copco No. 1 and Copco No.2 will release any sediment that has been retained in the reservoirs and more importantly will allow any bedload sediment mobilized upstream of Copco No. 1 to move through the Copco reach. Over time the slope of the stream should return to the pre-project condition. This may result in a slope that is different than the existing slope downstream of the dams.

The concrete needs to be removed to a depth below pre-dam channel grade sufficient to allow the passage of bedload during storm events. This requires an estimate of the future grade at Copco No. 1and the depth or thickness of the bedload transport layer below grade. . The equilibrium slope is used to estimate the future stream bed elevation at the dam based on extending that grade from the bedrock controls in the channel downstream of Copco No. 2 Dam. Presumably the stream slope will return to its pre-project slope; however, if the particle size distribution in the future contains more fines and less coarse material, than pre-dam bed material (e.g., Lake Ewauna continues to retain coarse material) the slope could be shallower than pre-dam slope resulting in a somewhat lower post-project bed elevation at the dam. The "active layer thickness" was calculated to estimate the depth required to allow bedload transport.

### 3.6.1 Future Stream Grade at Copco No. 1 (Equilibrium Slope)

The equilibrium slope is the slope at which the shear stress on the bed during the design condition just equals the critical shear stress needed to initiate sediment motion. The calculation of critical shear stress typically requires the selection of a representative particle size of the stream bed material. The median particle size (i.e., d50) is often used though larger sizes such as the d75 or higher have been used. An alternative approach is to use a probabilistic approach.

The representative particle size approach assumes that when the shear stress exceeds the critical shear stress of the representative particles size 100% of the sediment smaller than the representative size is in motion and 0% of the larger particles are. In streams with relatively uniform particle sizes this is usually sufficient (e.g., sand bed stream); however, in streams such as the Klamath River with widely varying particles sizes it does not represent actual conditions very well.

The equilibrium slope was calculated using the method developed by Gessler (1967) as descried in Ferro and Porto (2011) and Porto and Gessler (1999). Rather than using a representative particle size, a representative particle size distribution is used. An assumption behind the method is that an armored layer will form, and the method calculates a probability that a given size particle in the distribution remains in the armored layer. A representative particle size is then calculated that results in the same bed stability as the particles that are likely to make up the armor layer. That is, instead of picking a representative particle size a priori, a value is calculated that is representative of the particles likely to make up the armor layer based on the particle distribution and their corresponding critical shear stresses.

Input data needed for the analysis include: stream characteristics (flow, depth, and slope) and particle size distribution. A 2-year flow was assumed for the design flow event. This is assumed to be representative the long term average flow for movement of sediment. Based on the frequency analysis discussed in Section 4.3, a flow of 6,000 cfs was used. There is no bathymetry data between the Copco No. 1 and Copco No. 2 dams, so stream characteristics from the HEC-RAS model (Section 4) for the reach downstream of Copco No. 2 Dam were used. The depth of flow downstream of the Copco No. 1 Dam was between 6 and 7 feet for the 2-year event.

#### 3.6.1.1 Particle Size Distribution

Particle size distribution data for sediments downstream of Copco No. 1 and Copco No. 2 dams were not available. However, the USBR sediment transport study (USBR 2012c) provides a figure (Figure 5-18 in USBR 2012c) showing values for the d16, d50 and d84 particle sizes for a station near the Copco Dams (RM 198 in that report) and above Copco Lake (RM 206-208 in that report). Table 3.6-1 below lists the values estimated from that figure. Note that since the values were plotted by river mile versus particle diameter, it is not possible to group the data by sample; that is, it is not known which d16 value goes with which d50 and which d84. Therefore, the average values for each particle size were used.

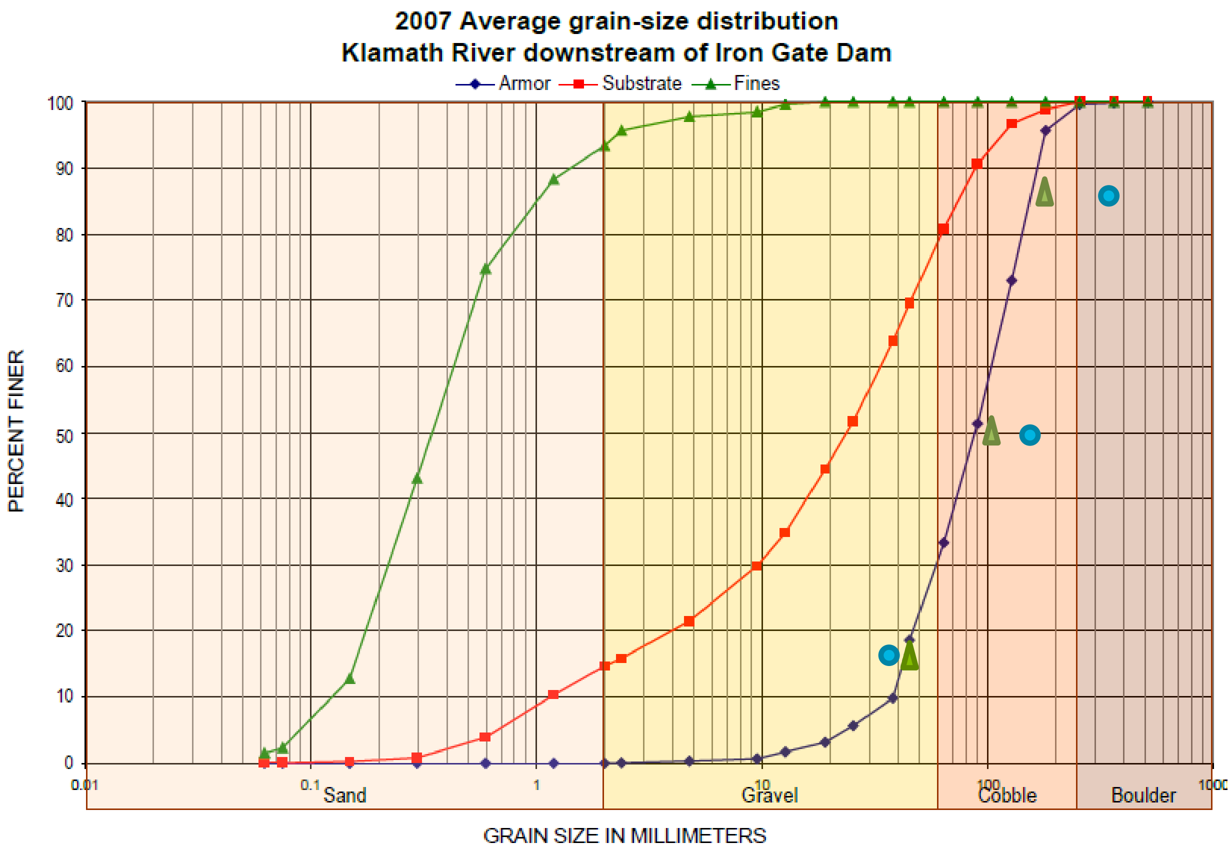
## Table 3.6-1 Particle Size Data near Copco Dams

| Site[1] | D16 | D50 | D84 |
|---|---|---|---|
| RM 198 | 22 | 80 | 130 |
| | 28 | 120 | 320 |
| | 31 | 160 | 400 |
| | 62 | 220 | 520 |
| | | | |
| Average | 35.75 | 145 | 342.5 |
| RM 206-208 | 7 | 42 | 81 |
| | 26 | 51 | 98 |
| | 27 | 60 | 105 |
| | 40 | 100 | 200 |
| | 42 | 105 | 200 |
| | 61 | 110 | 205 |
| | 63 | 120 | 220 |
| | 64 | 130 | 310 |
| | 91 | 190 | |
| Average | 46.8 | 100.9 | 177.4 |

Source: Figure 5-18 USBR Sediment Study (USBR 2012c)
Note: Adjacent values may not be from the same sample
[1] Site river miles are as reported in USBR 2012c. Corresponding revised river miles in this report are 201.8 and 210.3-212.3, respectively.

To use a probabilistic method for calculating equilibrium slope, a particle size distribution is needed. Several distributions are presented in Holmquist-Johnson and Milhous (2010), the closest located below Iron Gate Dam at RM 187[15]. The USBR data and the Holmquist-Johnson and Milhous distributions are plotted together in Figure 3.6-1. The USBR data generally follows the same distribution as the armor layer reported in Holmquist-Johnson and Milhous. The particle size distribution for the armor layer was used in the analysis below except for sizes greater than d75 which were approximated by a curve going through the USBR data.

[15] As reported in that paper. Corresponding revised river mile is about 190.1.




*RM198 ( blue circles), RM206-208 ( green triangles). River miles are as reported in USBR 2012c. Corresponding revised river miles in this report are 201.8 and 210.3-212.3, respectively.*

**Figure 3.6-1 Particle Size Distribution Data from Holmquist-Johnson and Milhous (2010) Compared to USBR data collected near Copco Dams**

### 3.6.1.2 Methods

The calculation of equilibrium slope proceeded using the following steps (see Ferro and Porto 2011 for details on the calculations):

1. The bed shear stress was calculated for the 2-year event as:

$$\tau_0 = \gamma h S \qquad \text{Equation 3.6-1}$$

   Where:

   $\tau_0$ = boundary (bed) shear stress
   $\gamma$ = specific weight of water
   h = depth of flow
   S = bed slope

2. The particle distribution was divided into 20 increments of 5% each
3. For each increment the critical shear stress was calculated using Shields relationship

4. The probability of a particle not be removed (i.e., remaining in the armor layer) is calculated using the relationship:

$$q_i = \left\{1 - exp\left[-a\left(\frac{\tau_{ci}}{\tau_0}\right)^b\right]\right\}^n \qquad \textbf{Equation 3.6-2}$$

Where:

$q_i$ = probability particle i will remain in the armor layer (i.e., will not be removed)
a, b, n = empirical coefficients equal to: 0.5641, 2.0386, and 0.7612, respectively.
$\tau_{ci}$ = critical shear stress for particle i

$\tau_0$ = bed shear stress

5. Calculate the average stability of the armor layer. The most stable layer is when $q_{bar}$ = 0.5:

$$q_{bar} = \frac{\int_{D_{min}}^{D_{max}} q^2 p_0 dD}{\int_{D_{min}}^{D_{max}} q p_0 dD} \qquad \textbf{Equation 3.6-3}$$

Where:

$q_{bar}$ = average stability of armor layer
$D_{max}$, $D_{min}$ = maximum and minimum particle size
q = stability of particle
$p_0$ = relative weight of particle in original distribution (= 0.05 in these calculation, i.e., distribution divided into 20 equal increments)

D = particle diameter

6. Calculate the average particle size in the armor layer the corresponds to an average stability of 0.5 (which is the most stable layer), = 0.27m for stream below Copco based on particle size distribution in Figure 3.6-1
7. Calculate the critical shear stress of the armor layer based on particle size in step 6.
8. Find the slope that corresponds to a bed shear stress equal to the critical shear stress from step 7.

#### 3.6.1.3 Results

Based on the armor particle size distribution and the average water depth from the HEC-RAS model developed for the drawdown study (Section 4), the minimum equilibrium slope is 0.0093. Applying this slope starting at a bedrock grade control located about 1200 feet downstream from Copco No. 2 Dam the elevation at the dam is 2474.5 feet. This is about 10 feet below estimated pre-dam channel grade at Copco No. 1 dam.

The original slope and grade was estimated from Copco No. 2 drawings G-3444, D-3722, and F-4261 and drawings 6043-CD-4 and F-1475 for Copco No. 1. Drawing F-1109 for Copco No. 1 also provided information on original grades but was not consistent with the other drawings so was not used. Based on this data, the original slope before construction was 0.013, slightly steeper than estimated above (note, the drawings show a much steeper slope below Copco No.2 than between Copco No.1 and No.2, 0.013 is the average)

The depth of water varies in the HEC-RAS model. If the shallowest water depth is used rather than the average, the equilibrium slope could be as high as 0.012. In this case the projected grade at Copco No. 1 Dam would be about 2 feet below estimated pre-dam channel grade.

### 3.6.2 Active Layer Thickness

The thickness of the active layer was estimated using Technical Supplement 14B Scour Calculations of the National Engineering Handbook (NRCS 2007). The active layer thickness is:

$$T = \frac{D_x}{(1-e)P_x} \quad \text{Equation 3.6-4}$$

Where:

$D_x$ = the size of the smallest non-transportable particle present in the streambed
$P_x$ = the fraction of bed material of a size equal to or coarser than $D_x$
e = the porosity of the bed material, assumed equal to 0.43

The smallest non-transportable particle in the bed was calculated using the relationship below:

$$D_x = K\left(\frac{yS_e}{\Delta s_g}\right)^a \left(\frac{u_*}{\nu}\right)^b \quad \text{Equation 3.6-5}$$

Where:

y = flow depth
$S_e$ = energy slope
$\Delta s_g$ = relative submerged density of bed-material sediment ≅ 1.65
$U_*$ = shear velocity
$\nu$ = kinematic viscosity of water
a, b, K = 0,1,17 (from Table TS14B-4 in NRCS 2007)

The values for flow depth and shear velocity were taken from the equilibrium slope calculations. The energy slope was assumed equal to the equilibrium slope.

With the above assumptions the minimum transportable particle size varied from 0.0189 to 0.219 m (0.621 to 0.719 feet) for storm events from 2-year to 100-year. The depth of the active layer varied from 5.8 to 7.5 feet.

The above analysis did not account for the presence of immobile boulders in the river. The presence of boulders will decrease the bed load transport in the river relative to what is estimated from sediment transport relationships. The over-estimation could be by several times. Neglecting the impacts of boulders on the sediment transport will result in an over estimation on the thickness of the active layer. The amount of overestimation is dependent upon the size and spatial density of boulders in the river. Therefore, the estimation of active later thickness should be considered conservative and the actual thickness could be much less.

### 3.6.3 Depth of Removal for Cutoff Wall and Foundation

Based on the equilibrium slope and active layer thickness results, the cutoff wall should be removed to a minimum of 8 feet below grade (for the active layer thickness) and up to 18 feet below grade (for the equilibrium slope and the active layer thickness). The recommended removal depth is 20 feet below the pre-dam stream bed to elevation 2463.5 feet.

## 3.7 Topographic and Bathymetric Surveys

New topographic and bathymetric surveys of the dam and powerhouse facilities, reservoirs, and nearby river reaches are planned for October and November of 2017. The surveys specifically include:

- Photogrammetric survey using a small unmanned aircraft system (sUAS) of the dams and related infrastructure, supplemented by limited field surveys, to collect detailed information on the dam itself and key infrastructure
- Topo-bathymetric LiDAR of the dams and shallow portions of the reservoirs using an airborne system
- Bathymetric surveys of the reservoirs and downstream using multi-beam sonar

Surveys will generally cover the area from approximately 1 river mile downstream of Iron Gate Dam to approximately 1 river mile upstream of Copco Lake and from approximately 0.2 river mile downstream of J.C. Boyle Powerhouse to approximately 1.5 river miles upstream of J.C. Boyle Reservoir.

The KRRC will require the contractor to conduct post-dam removal topographic and bathymetric surveys to document the extent of sediment removal and to provide a baseline for the reservoir restoration.

## 3.8 Data Collection at Shovel Creek

The SWRCB requested that the KRRC collect flow and water temperature data above and below the Klamath Hot Springs. The springs are located just downstream from the confluence of Shovel Creek and the Klamath River at approximate RM 211 (upstream of Copco Lake). The purpose of the data collection is to assess potential effects of the hot springs on salmonid fish migration upstream of Shovel Creek.

In October 2017, the KRRC will monitor and record flow and water temperature at the following locations:

- The Klamath River immediately upstream of Shovel Creek. River flow will be as reported at USGS gage 11510700 (Klamath River blw John C. Boyle pwerplnt, nr Keno, OR).
- The Klamath River immediately downstream of Klamath Hot Springs.
- Shovel Creek at Ager Beswick Road. Flow will be estimated based upon the staff gauge located at the Ager Beswick Road bridge over Shovel Creek.
- Any observed direct river discharge points of the hot springs, if any. Flow from any river discharge point(s) from the hot springs will be estimated using a gauge bucket.

The KRRC will tabulate these results in a memorandum and include published information on the effects of hot springs and related temperature thresholds on the migration of salmonids.

# 4. Reservoir Drawdown & Diversion Plan

## 4.1 Introduction

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

Drawdown of the reservoirs will generally take place between January 1 and March 15 of the drawdown year. However, the proposed plan includes early drawdown of Copco No. 1 and delayed cessation of power generation at Copco No. 2. Early drawdown of Copco No. 1 is necessary for the reservoir drawdown to be completed by about March 15 (prior to spring salmonid migration). To offset lost revenue from shutting Copco No. 1 down prior to January 1, generation of power at Copco No. 2 Dam (with sediment-laden flow) could continue for up to four months after January 1 of the drawdown year (or until May 1). This assumes the Copco No. 2 generating equipment will be capable of operating under such conditions. Power generation at Copco No. 1 Dam would end after the reservoir reaches the minimum operating level at reservoir water surface (RWS) elevation 2604.5, which would be nearly 2 months before January 1 of the drawdown year. These operational changes may need to be approved by PacifiCorp if drawdown occurs before January 1, 2020.[16] Reservoir drawdown below the minimum operating level would commence at each dam when power generation has ceased at that dam. The proposed plan assumes power generation at each of the dams would end as shown in Table 4.1-1.

### Table 4.1-1 End Date for Power Generation

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

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

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

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

The bulleted list below provides a roadmap for specific requests (Item 6a) made by the SWRCB in their August 2017 Request for Additional Information:

- Total anticipated discharge (cfs) associated with drawdown for each reservoir is discussed in Section 4.4
- Description of structures used for drawdown operation and associated flows is provided in Section 4.2
- Description of notching at Copco No. 1 is provided in Section 4.2.2 (Option 1 – no longer included)
- Proposed duration and timing of drawdown operations is discussed in Sections 4.2 and 4.4
- Proposed reservoir elevation change per day is provided in Section 4.4
- Description of measures associated with possible tunnel failure is provided in Section 4.6.1
- Additional information concerning the retrofit of the diversion tunnels is provided in Section 4.2
- Slope stability monitoring during and after reservoir drawdown is discussed in Section 4.5
- Measures to implement if slope stability issues are identified are discussed in Sections 4.6.2 and 4.6.3
- Measures to implement if tribal resources and/or human remains are found during drawdown are discussed in Section 4.8
- Measures to implement to reduce impacts to aquatic species are discussed in Section 4.6.4 and Section 7.2
- Studies conducted to verify reservoir drawdown rates are protective of slope stability and potential flooding are discussed in Section 4.7

The bulleted list below provides a roadmap for specific requests (Item g) made by ODEQ in their July 2017 Request for Additional Information:

- Schedule and sequence for drawdown of all Lower Klamath Project dams is provided in Section 4.4
- Adaptive strategy for adjusting schedule based on interruptions in drawdown sequence is provided in Sections 4.6.1(tunnel blockage) and 4.8 (cultural resource interruption)
- Physical modifications to the dam to facilitate drawdown are summarized in Section 4.2
- Strategies for managing drawdown under low, medium and high flow conditions are provided in Section 4.4
- Drawdown flows in cfs are provided in Section 4.4
- Reconnaissance plan to inspect areas of expected inundation prior to drawdown is provided in Section 4.7

- Measures to ensure drawdown rates do not adversely affect slope stability of structures or reservoir embankments are included in Sections 3.2 (stability of dam embankments), 3.3 (stability along rim and associated structures), and 7.4 (OR66)

## 4.2 Diversion Facilities

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

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

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

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

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

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

### 4.2.1 J.C. Boyle Reservoir

Water releases for reservoir drawdown at J.C. Boyle will be made through the gated spillway (crest elevation 3785.2), the power canal (intake invert elevation 3771.7), and through the two 9.5- by 10-foot diversion culverts (invert elevation 3755.2) located below the gated spillway (see Figure 4.2-1(B). Modifications of these facilities are not required prior to drawdown. Discharge rating curves for the J.C. Boyle facilities, as well as the stage-storage curve for J.C. Boyle Reservoir, are shown in Figure 4.2-2.

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

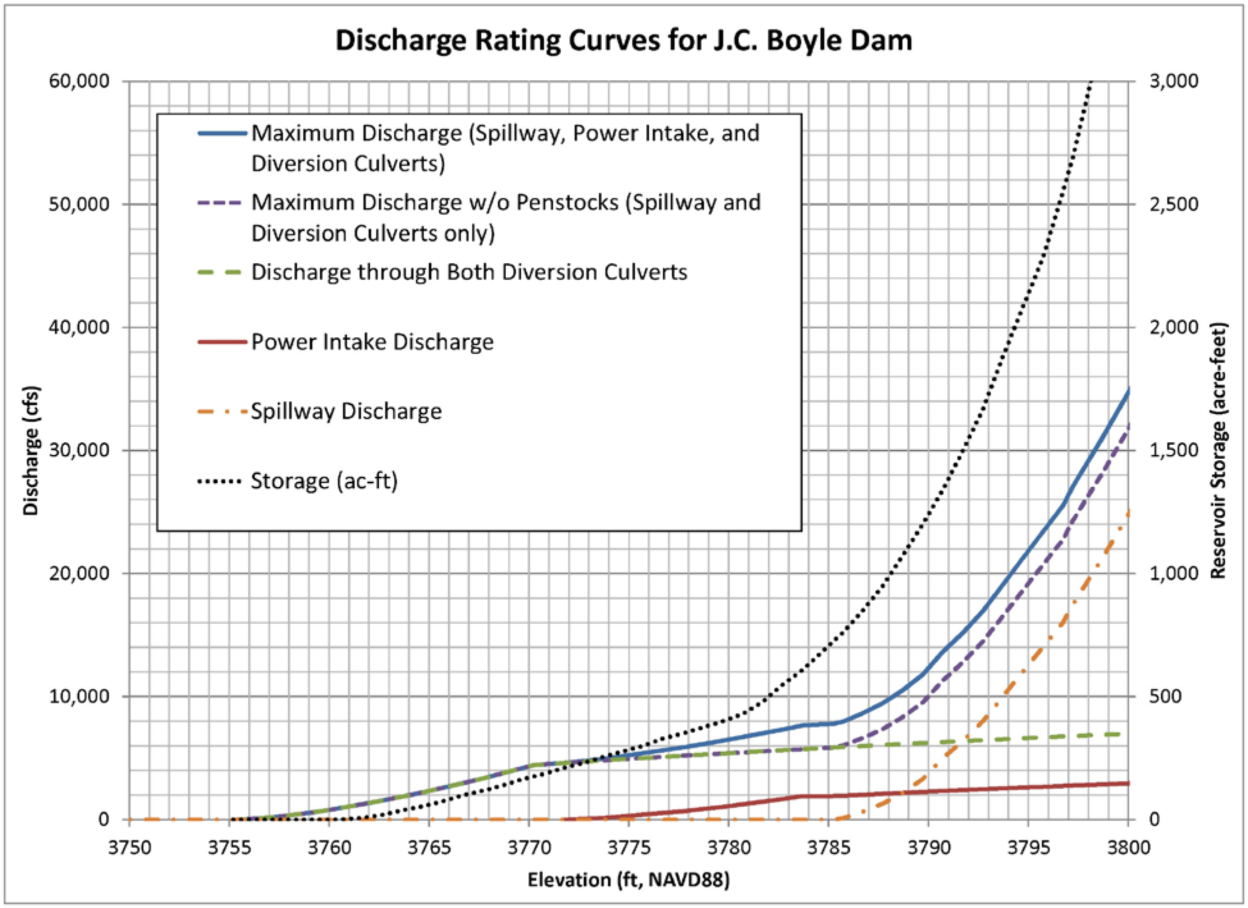



**Figure 4.2-2 Discharge Rating Curve and Stage-Storage Curve for J.C. Boyle**

### 4.2.2 Copco Lake

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

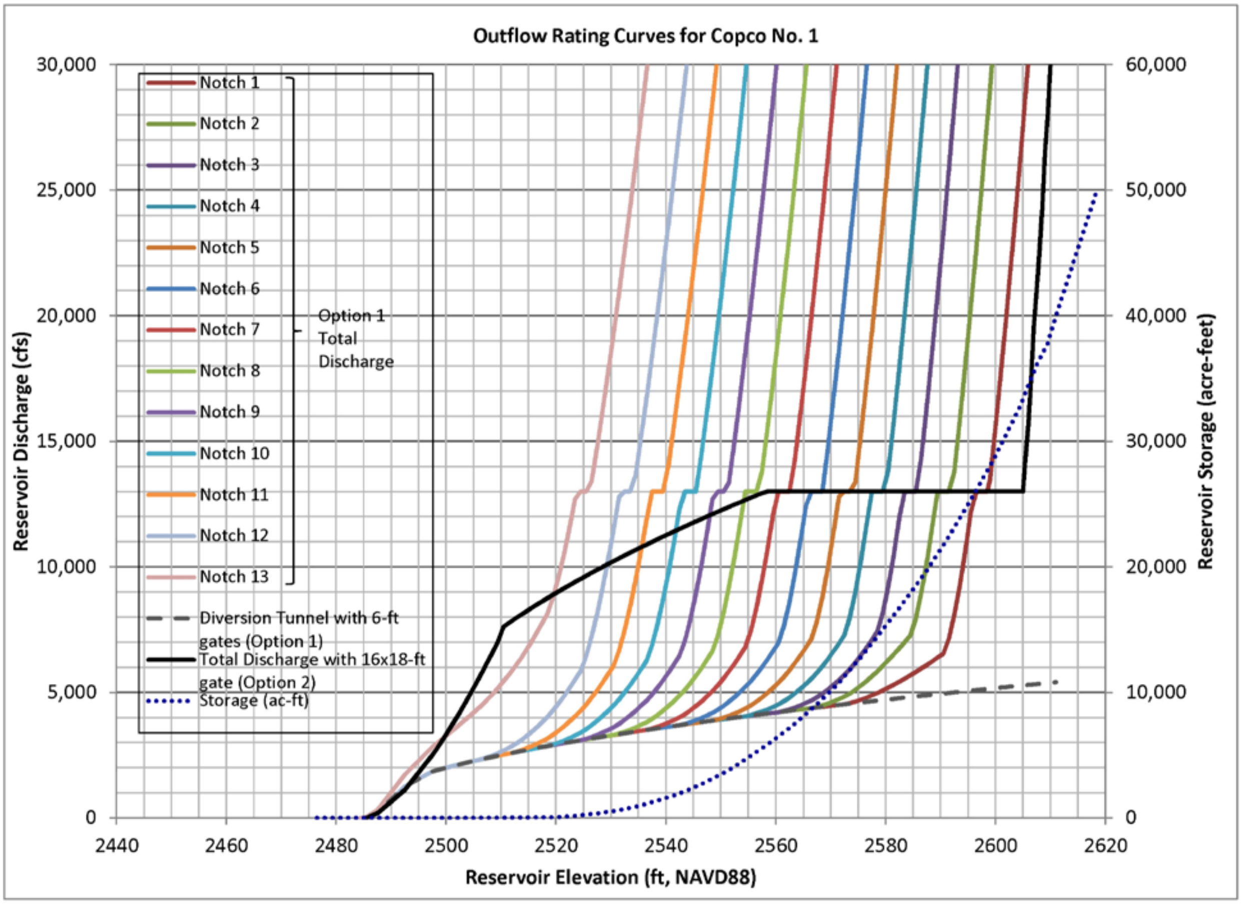



**Figure 4.2-3 Discharge Rating Curve and Stage-Storage Curve for Copco No. 1**

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

#### 4.2.2.1 Option 1 – Diversion Tunnel Modification to Restore Release Capacity

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

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

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

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

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

#### 4.2.2.2 Option 2 – Diversion Tunnel Modification to Increase Release Capacity

1. Design, fabricate, and deliver new 16.5- by 18-foot roller gate.
2. Construct new gate shaft with new gate structure and 16.5-foot by 18-foot roller gate at downstream end of diversion tunnel (see Figure 4.2-6 (B)).
3. Mobilize barge-mounted crane onto Copco Lake (assume normal RWS elevation 2609.5). Remove sediment from diversion tunnel (see Figure 4.2-4(B)) intake using clamshell or suction dredge, as required.
4. Remove three existing 72-inch flap (or "clack") gates on upstream face of diversion intake structure (invert elevation 2485.5) under balanced head and no flow conditions, using hard hat divers (124-foot depth). Upstream tunnel should be full of water (due to valve leakage since tunnel was plugged), but should be confirmed. Install three new 6-foot blind flanges (see Figure 4-2.4(B)) using hard hat divers.
5. With new blind flanges in place, drill drain and air vent holes through concrete tunnel plug from downstream side to unwater tunnel (see Figure 4.2-5(B)). Remove concrete tunnel plug in dry conditions. Inspect the unlined diversion tunnel for possible reinforcement (lining with shotcrete or concrete) or repairs. Line tunnel with shotcrete or concrete, if determined to be necessary.
6. Remove three existing 72-inch butterfly valve disks from downstream side of inlet in dry conditions, after drilling drain and air vent holes through each disk.
7. Close new large gate and fill tunnel upstream of gate with water.[17] Under balanced head and no flow conditions, remove the 6-foot blind flanges at the inlet using hard hat divers.
8. Using hard hat divers, demolish intake structure and install grating to minimize potential for large debris entering the diversion tunnel.

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

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

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

### 4.2.3 Iron Gate Reservoir

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

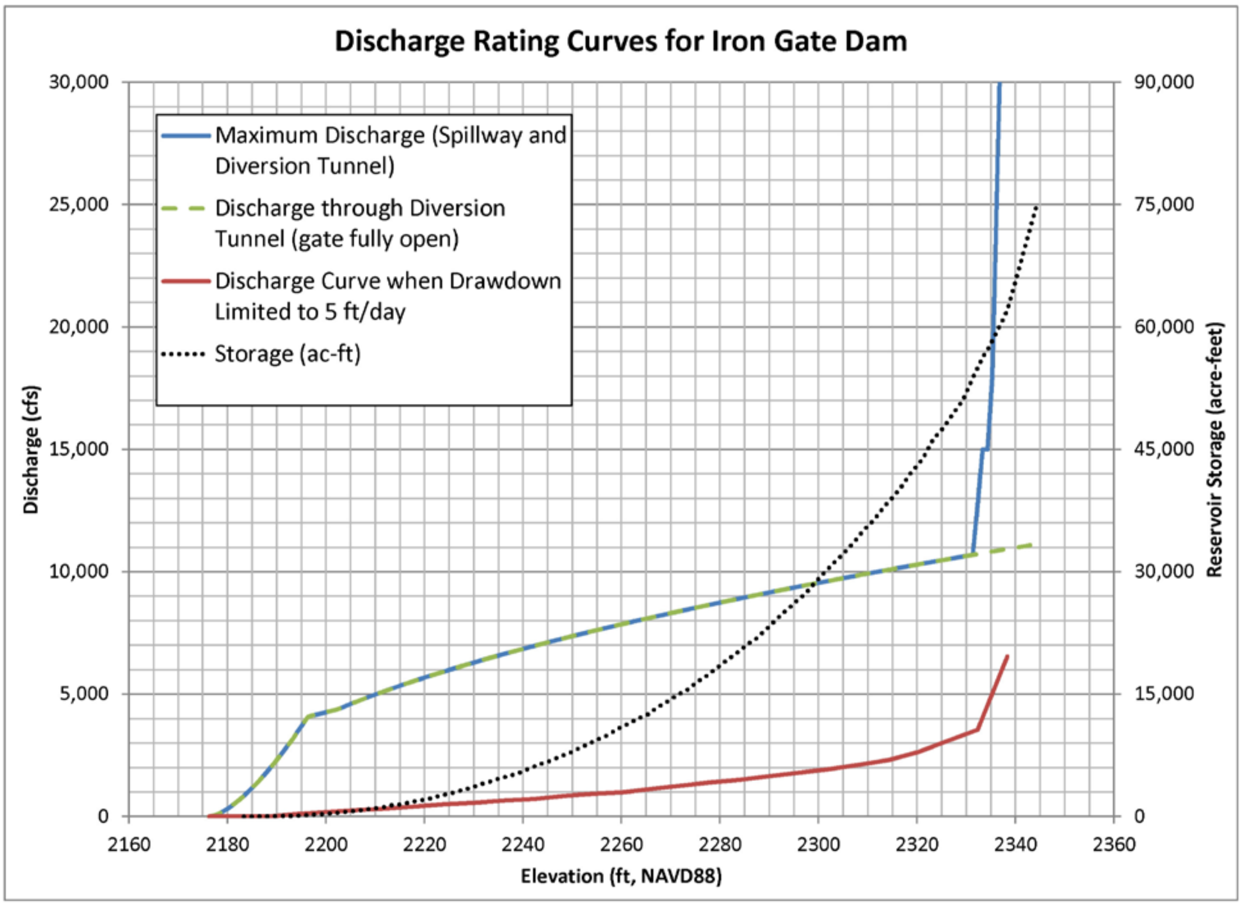



**Figure 4.2-7 Discharge Rating Curve and Stage-Storage Curve for Iron Gate**

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

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

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

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

### 4.2.4 Drawdown Controls

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

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

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

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

## 4.3 Flood Frequency Analysis

Flood frequency analyses were performed at four locations on the Klamath River using the USACE HEC-SSP software (V2.1), following the Bulletin 17B method for Log-Pearson Type III distributions (USGS 1982)[18]. Details of the gages are provided in Table 4.3-1. J.C. Boyle and Copco records correlate well with the Keno data. Therefore, the records at J.C. Boyle and Copco were extended based on linear correlations with USGS gauge data at Keno to allow for a coincident period of analysis. Appendix F provides the correlations used to extend the data. A good correlation with Keno data was not obtained for Iron Gate gage, likely due to significant tributary inflows. Therefore, the historical period of record (1960 to 2017) was used for Iron Gate.

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

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

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

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

**Table 4.3-2 Annual Flood Frequency Results**

| Location | 2-Year | 5-Year | 10-Year | 20-Year | 50-Year | 100-Year | 500-Year |
|---|---|---|---|---|---|---|---|
| Keno | 4,329 | 6,957 | 8,830 | 10,699 | 13,210 | 15,156 | 19,872 |
| Blw J.C. Boyle [1,2] | 4,736 | 7,719 | 9,438 | 10,862 | 12,405 | 13,370 | 15,104 |
| Blw Fall Creek nr Copco[2] | 5,974 | 9,114 | 11,340 | 13,567 | 16,580 | 18,937 | 24,742 |
| Below Iron Gate | 5,942 | 10,895 | 14,912 | 19,295 | 25,744 | 31,169 | 45,796 |

1 Flows below 3,400 cfs were censored as low flow outliers due to the influence of Link River Dam.
2 The gage record was extended to cover 1932 to 2017 based on the flows measured at the Keno gage.

## 4.4 Reservoir Drawdown Releases

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

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

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

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

The range of likely additional outflow due to reservoir drawdown is provided in Table 4.4-1. For the modeling, the starting elevations of Iron Gate and Copco No. 1 were assumed to be at the spillway crest on January 1.[19] The starting elevation at J.C. Boyle was assumed to be the normal operating elevation on January 1.

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

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

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

### Table 4.4-1 Range of Release Flows from Reservoirs due to Drawdown

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

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

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Iron Gate | 155.0 | 50941 | 435 | 12% | 2% | 810 | 23% | 4% |

[1] Minimum assumes 59 days to drain reservoir

[2] Maximum assumes continuous 5 feet per day drawdown

[3] Based on average release from Keno in January and February of 2,270 cfs and additional 1,261 cfs inflow to Iron Gate

[4] Based on maximum release from Keno in January or February of 14,300 cfs and additional 7,388 cfs inflow to Iron Gate

### 4.4.1 Detailed Modeling

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

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

#### 4.4.1.1 Topography/Bathymetry

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

#### 4.4.1.2 Inflow Rate

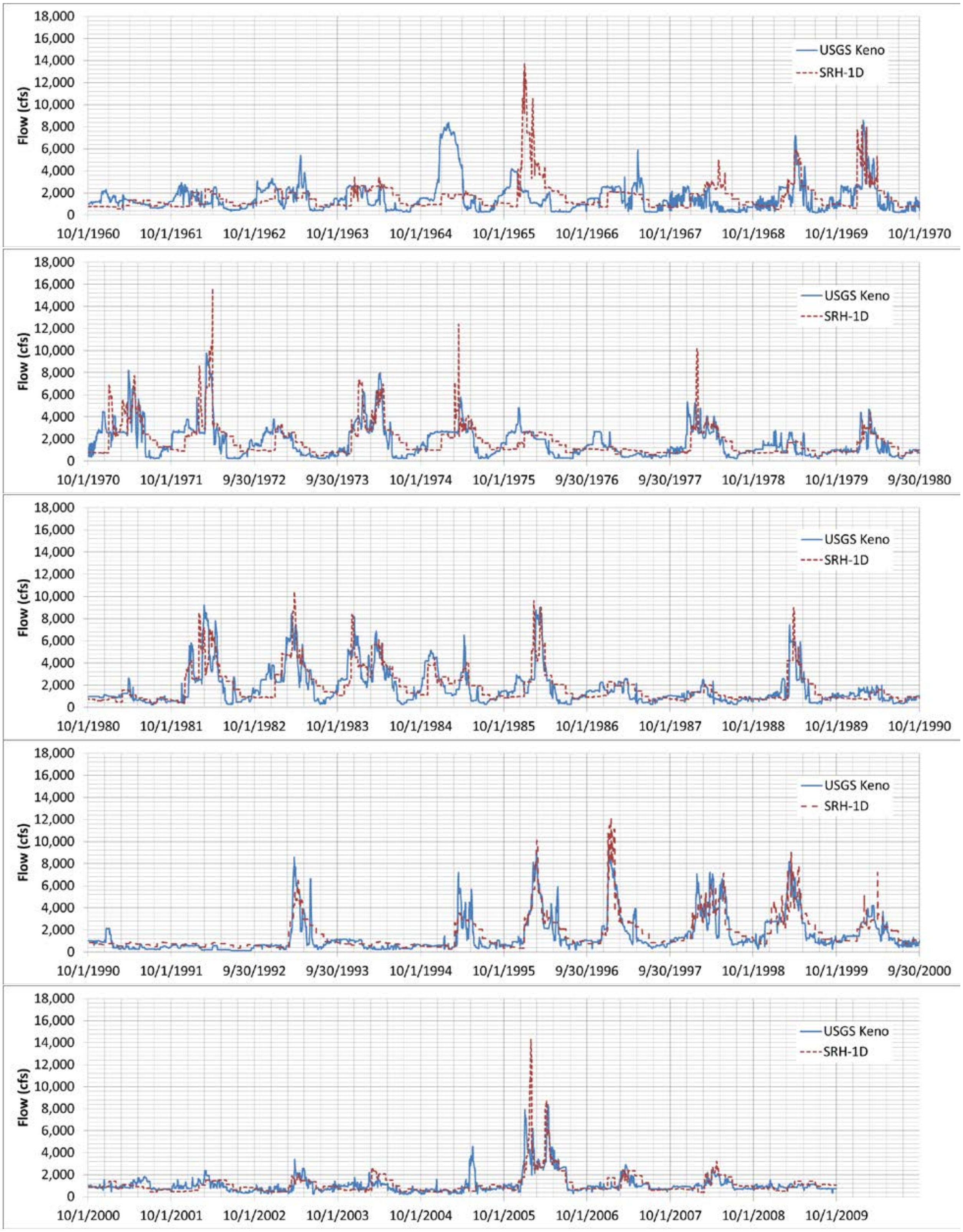
Inflow data based on the Klamath Basin Restoration Agreement (KBRA) flows were used as river flows (Keno flows).[20] These flows were obtained from the SRH1-D model input files (USBR 2012c). The data were compared to the measured flows at the USGS gage at Keno (gage no. 11509500, Klamath River at Keno, OR). Figure 4.4-1 compares the USGS measured data at Keno to the SRH1-D data used in the model. As seen in the figure, the Keno flows closely follow the measured flows at the USGS Keno gage but some of the variability has been “smoothed” out as during non-storm periods when the Keno flows are relatively constant by month. During large storms the Keno flows data occasionally have a sharp peak that exceeds the USGS measured flows. These sharp peaks generally last a few days. During the winter

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

(January – April) when drawdown will occur, the flow frequency curve for the flows used in the model and the measured USGS flows are very similar. The data prior to 1969 appears to be time shifted or mislabeled by approximately 1 year.

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

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




## Figure 4.4-1 Comparison of Gaged Flows at Keno to Modeled Flows in SRH-1D

### 4.4.2 J.C. Boyle Reservoir

#### 4.4.2.1 Drawdown Procedure

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

1. Reservoir drawdown would begin on January 1 of the drawdown year, by making controlled releases through the gated spillway (crest elevation 3785.2) and the power intake (invert elevation 3771.7). Additional discharges to the river during drawdown using the spillway and power canal would be on the order of the values shown in Table 4.4-1 but these would be short term. Once the reservoir drawdown elevation (dependent on base inflow) stabilizes with both the spillway and power intakes fully open, the reservoir elevation would be held for about a week. However, because of the minimal storage available above the power intake invert, the water level in the reservoir would fluctuate in concert with the changing inflow. The maximum flow through the power intake is about 2,800 cfs. About 25% of years have an average flow in January greater than 2,800 cfs and almost 40% have a maximum flow greater than 2,800 cfs. Flows above about 2,800 cfs will go over the spillway.
2. With the reservoir at the lowest possible level (depending upon inflow) using spillway and power intake, drawdown would continue by removing the concrete stoplogs from one 9.5- by 10-foot bay of the 2-bay diversion culvert (invert elevation 3755.2) by blasting, if necessary.[21] There is relatively little storage below the spillway crest elevation compared to storm volumes, so the elevation will change rapidly with changes in inflow rate. Additional drawdown releases would rapidly increase to a maximum of about 3,000 cfs for a short duration dropping back to near the inflow value over a period of a few hours. For reference, the 2-year and 5-year flow events downstream of J.C. Boyle Dam are 4,736 cfs and 7,719 cfs, respectively. The reservoir elevation would be allowed to stabilize and be held for one to two weeks to allow dissipation of pore pressures in the embankment and the reservoir rim.
3. With the reservoir at the lowest possible level (depending upon inflow), drawdown would continue by removing the concrete stoplogs from the remaining two 9.5- by 10-foot diversion culverts (invert elevation 3755.2) by blasting, if necessary.[22] Additional drawdown releases would rapidly increase to a maximum of 1,000 to 2,000 cfs for a short duration dropping back to the inflow value over a period of about an hour or less. This would provide the maximum reservoir drawdown possible prior to removal of the dam embankment section, except for the natural drawdown resulting from the subsequent reduction of streamflow. The reservoir drawdown should be completed by January 31of the drawdown year, to minimize potential impacts at the downstream dam removal sites. The potential formation of reservoir ice in January at this site is assumed to not impact reservoir drawdown significantly during this period. Reservoir releases at the dam would be maintained below any ice cover.
4. The timing of the removal of the stoplogs from either diversion culvert will take into consideration inflow conditions with a possibility of shifting stop log removal to avoid

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

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

#### 4.4.2.2 Results

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

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

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

For the wettest year (1966[23], see Figure 4.4-2) the reservoir was mostly drawn down by March, but did not completely drain until April. This is the only wet year that did not allow for complete drawdown before March, so there is a relatively low risk of this occurring during drawdown. In addition, it is likely that the majority of accumulated sediment was evacuated prior to March in that year.

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

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

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

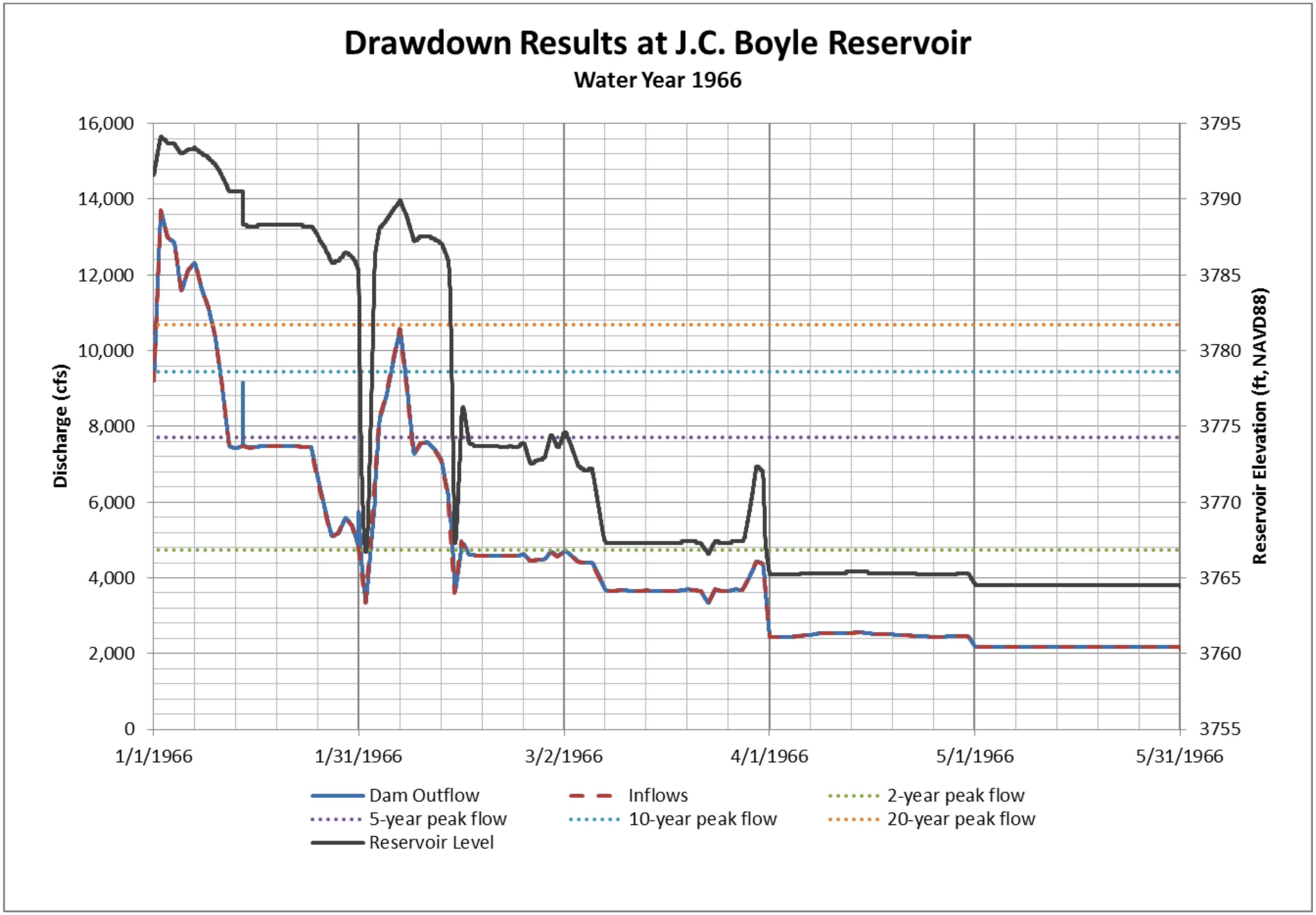



**Figure 4.4-2 J.C. Boyle Reservoir Drawdown, Water Year 1966 (Wettest Year)**

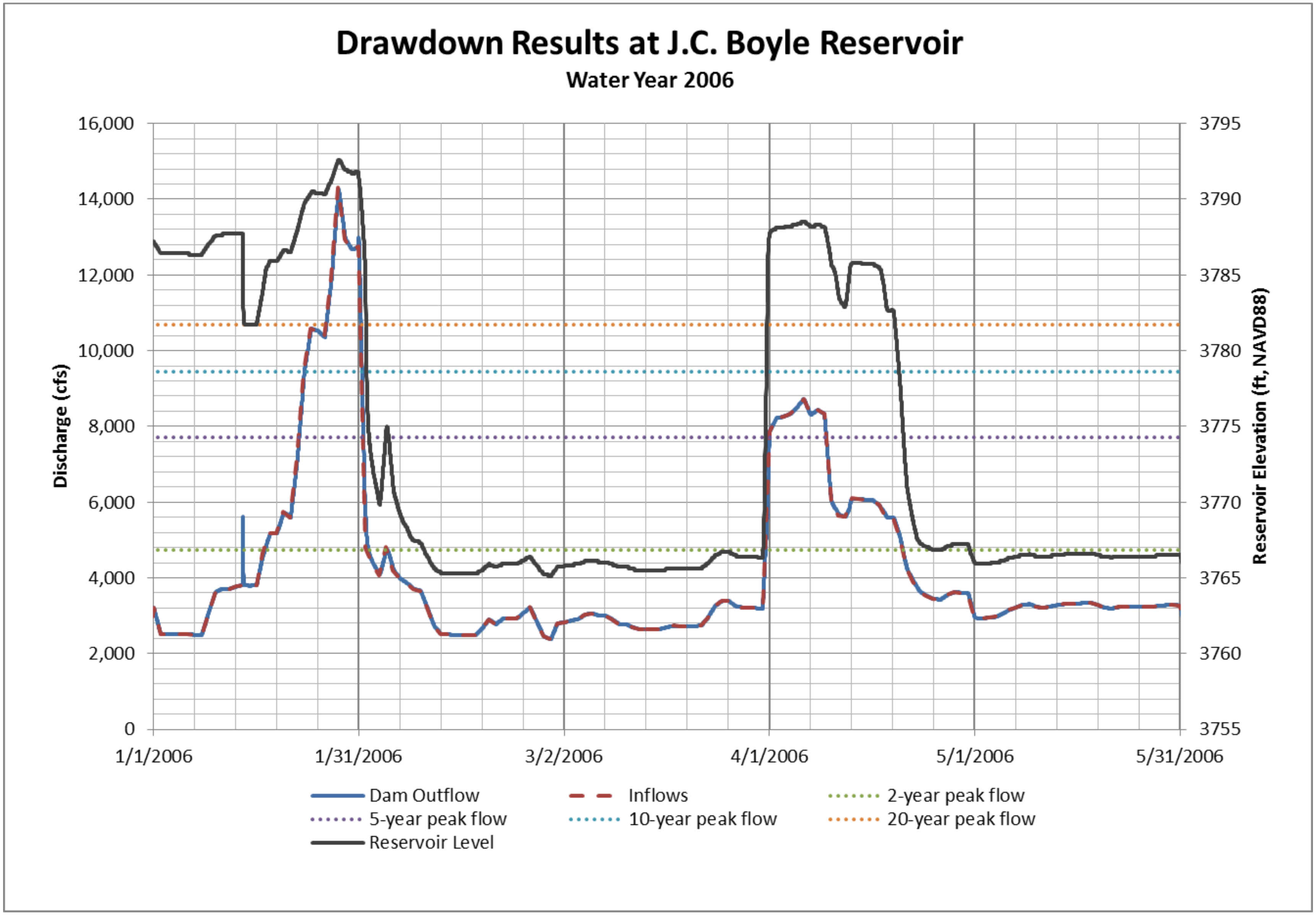



**Figure 4.4-3 J.C. Boyle Reservoir Drawdown, Water Year 2006 (Wet Year)**

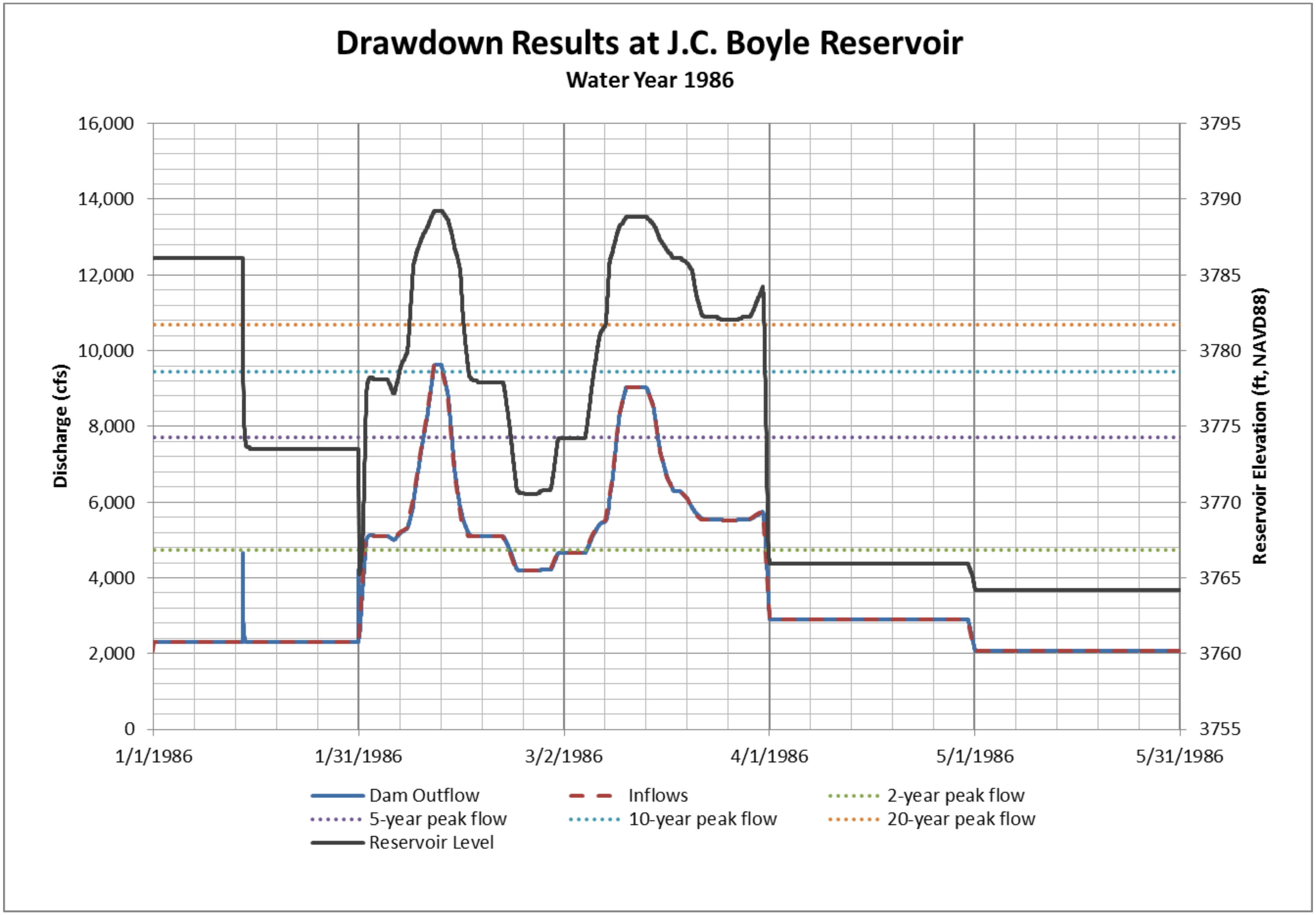



**Figure 4.4-4 J.C. Boyle Reservoir Drawdown, Water Year 1986 (Wet Year)**

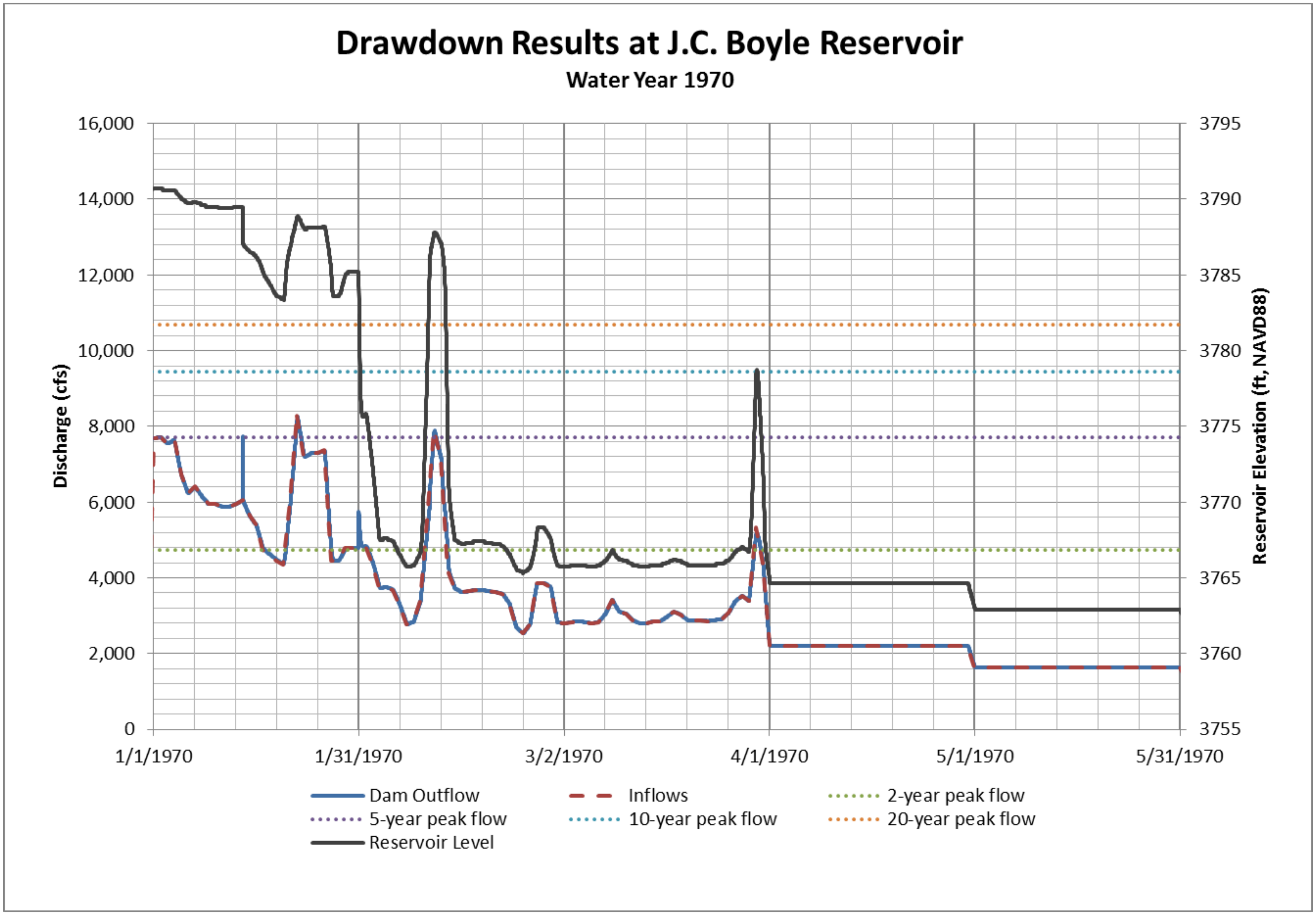



**Figure 4.4-5 J.C. Boyle Reservoir Drawdown, Water Year 1970 (Above Normal Year)**

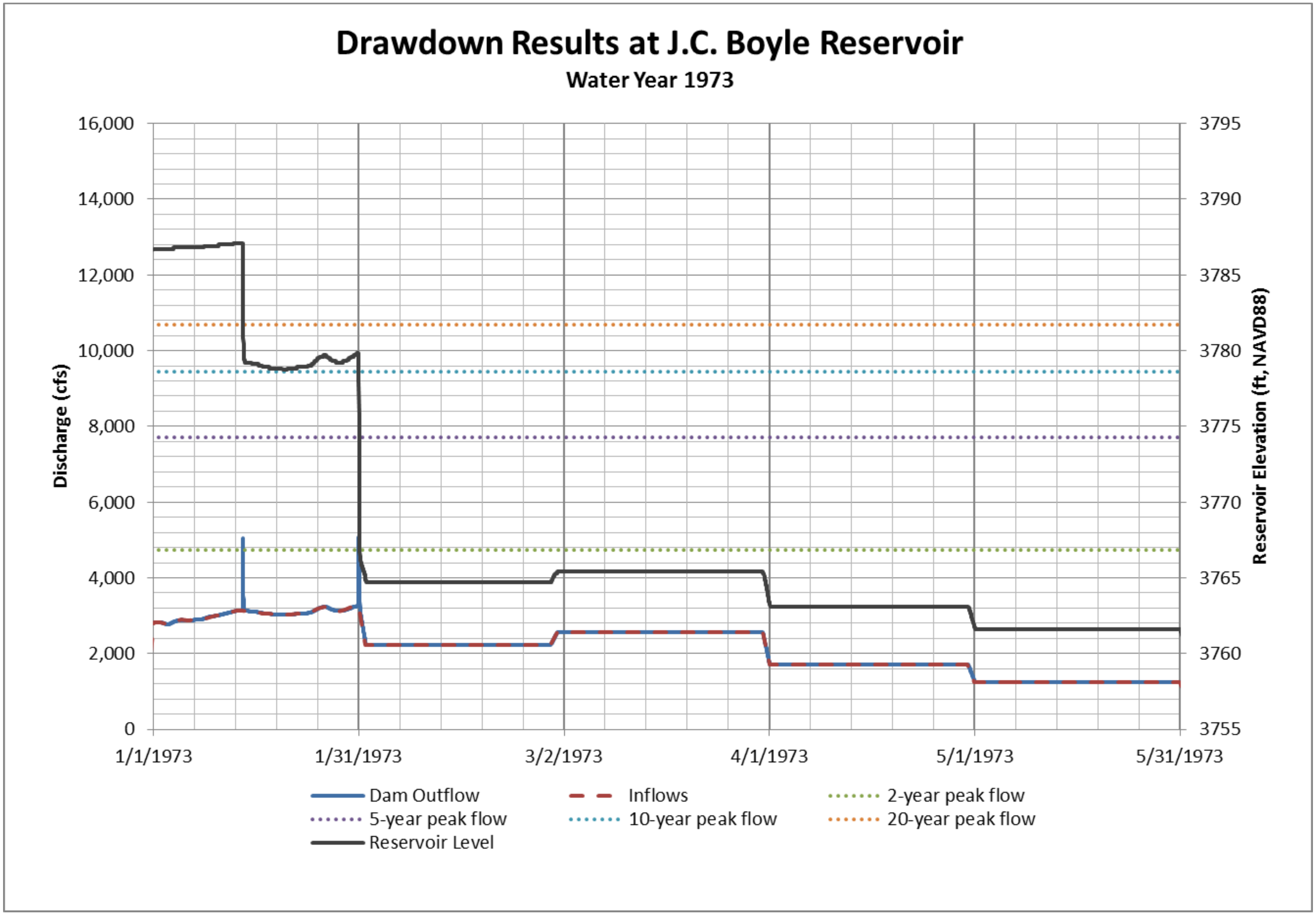



**Figure 4.4-6 J.C. Boyle Reservoir Drawdown, Water Year 1973 (Normal Year)**

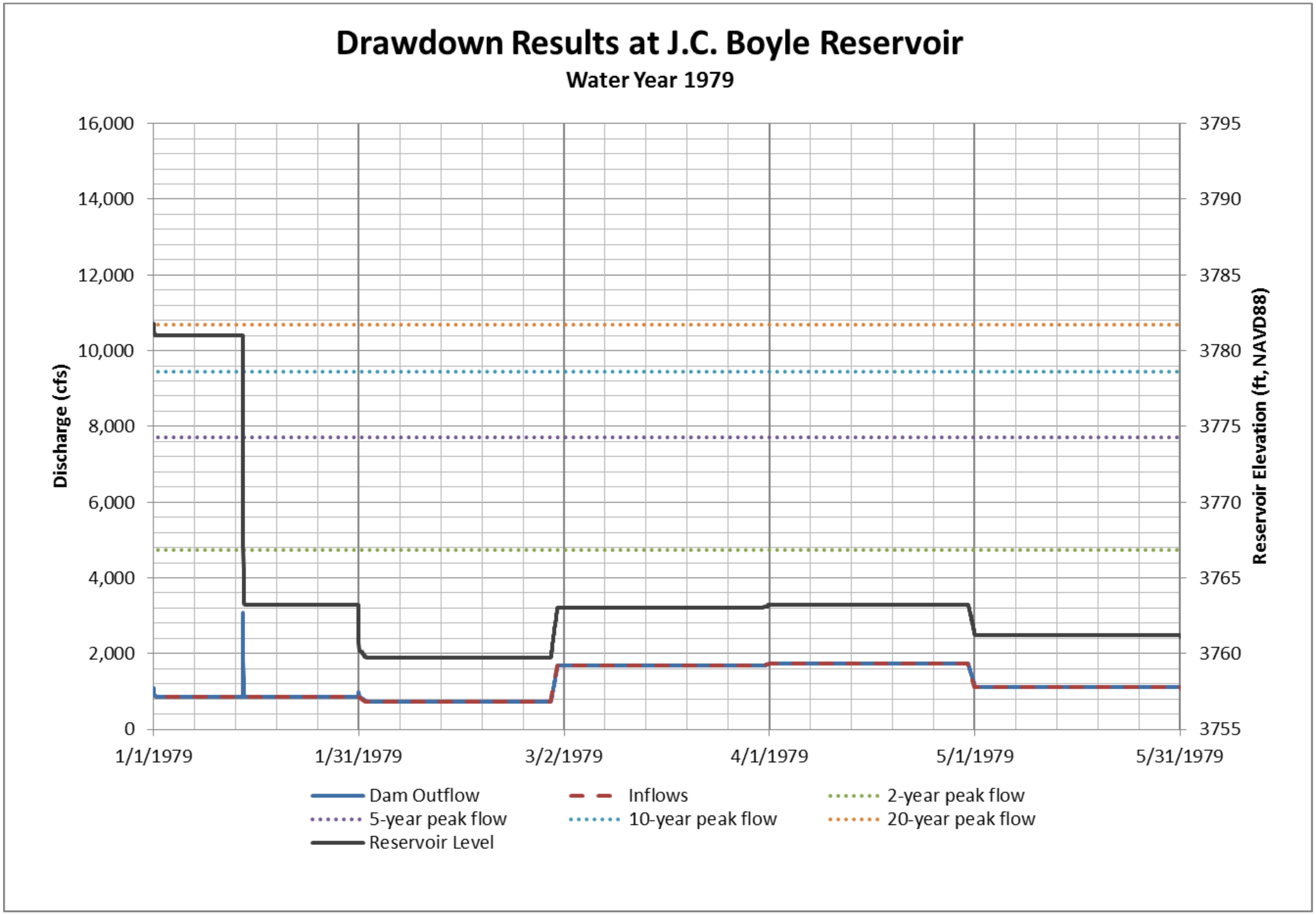



Figure 4.4-7 J.C. Boyle Reservoir Drawdown, Water Year 1979 (Dry Year)

### 4.4.3 Copco Lake

#### 4.4.3.1 Drawdown Procedure

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

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

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

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

6. Successful reservoir drawdown using Option 1 is highly dependent on successful dam demolition and notching during January and February. There are several risks associated with Option 1 that need to be considered:
    a. Safety of construction workers operating on very narrow, steep access roads during winter months with wet and icy conditions.
    b. Weather impacts to production that are likely to be worse in the wettest years when reservoir drawdown will rely more notching than in dry years.
    c. During wet years complete drawdown may not occur until notching is complete. If notching is delayed, drawdown will be delayed by an equal amount. [24]

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

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

1. Begin reservoir drawdown from normal operating elevation 2609.5 feet on November 1in the year prior to the main drawdown by making controlled releases through the gated spillway (crest elevation 2597.0) and from the modified diversion tunnel. Continue releases to the powerhouse for power generation for as long as possible (minimum operating elevation 2604.5), although plant shutdown on November 1 has been assumed. Limit initial reservoir drawdown to the maximum historical drawdown rate of about 2 feet per day. No significant sediment release is expected for this upper range of reservoir levels and rate of drawdown.
2. Once drawdown has begun, remove spillway features using a barge mounted crane (see Section 5.3).
3. Starting January 15 of the drawdown year, make controlled releases from the new gate structure. With Option 2, drawdown releases are delayed two weeks after drawdown releases begin at Iron Gate Dam (January 1) to create additional reservoir capacity at Iron Gate, [25] which will better handle drawdown releases from Copco Lake and help attenuate outflows from Iron Gate Reservoir due to storms. Limit reservoir drawdown to 5 feet per day to maintain reservoir rim slope stability and control drawdown releases from both reservoirs upstream of Iron Gate Reservoir.
4. Maximum additional discharge downstream of the dam due to drawdown activities is about 6,000 cfs when the gate is opened on January 15. During other times the increase is generally 1,000 to 2,000 cfs. The total discharge capacity of the new gate structure with the reservoir at the spillway crest elevation 2597.0 feet is about 16,000

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

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

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

#### 4.4.3.2 Results

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

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

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

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

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

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

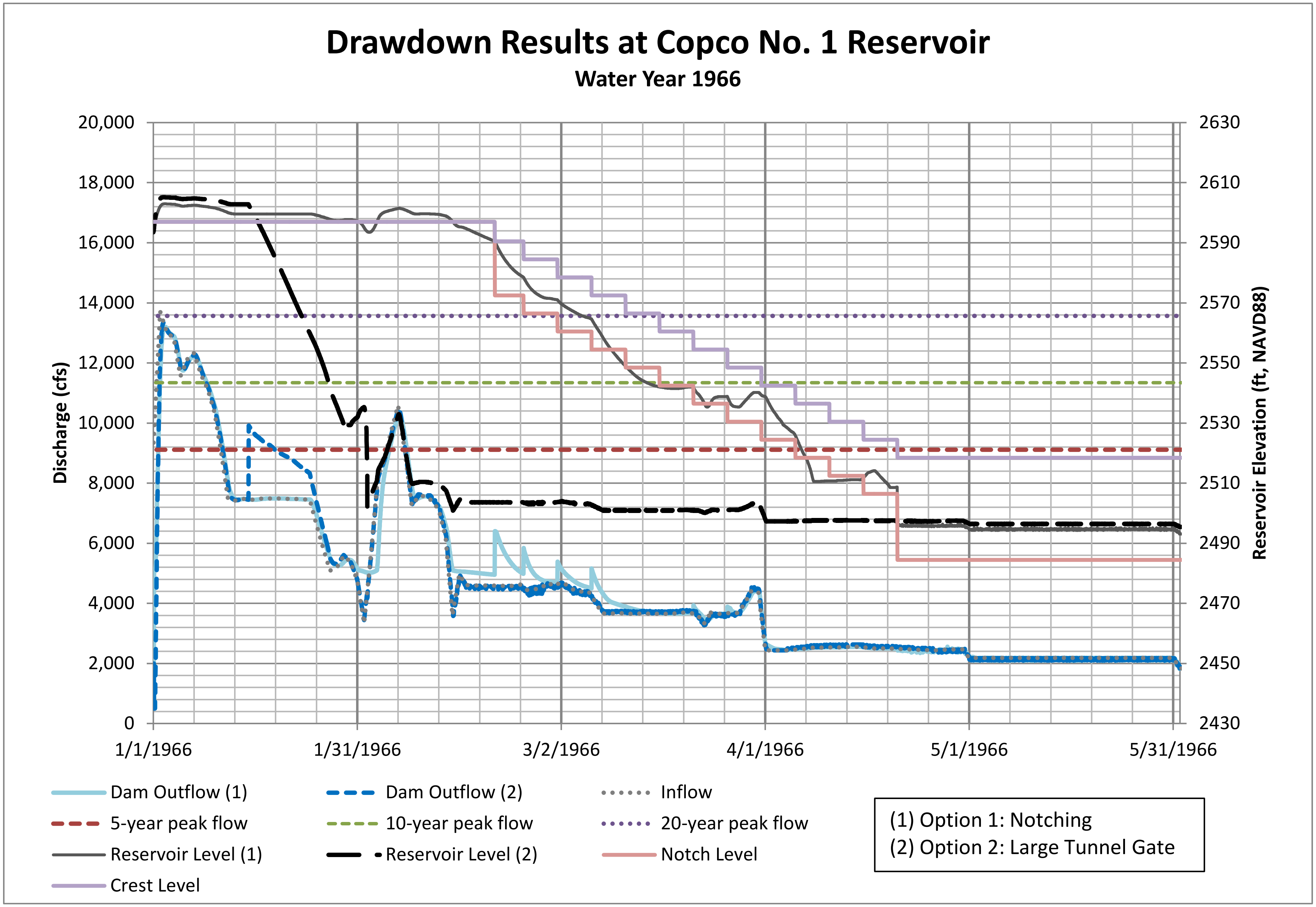



**Figure 4.4-8 Copco No. 1 Reservoir Drawdown, Water Year 1966 (Wettest Year)**

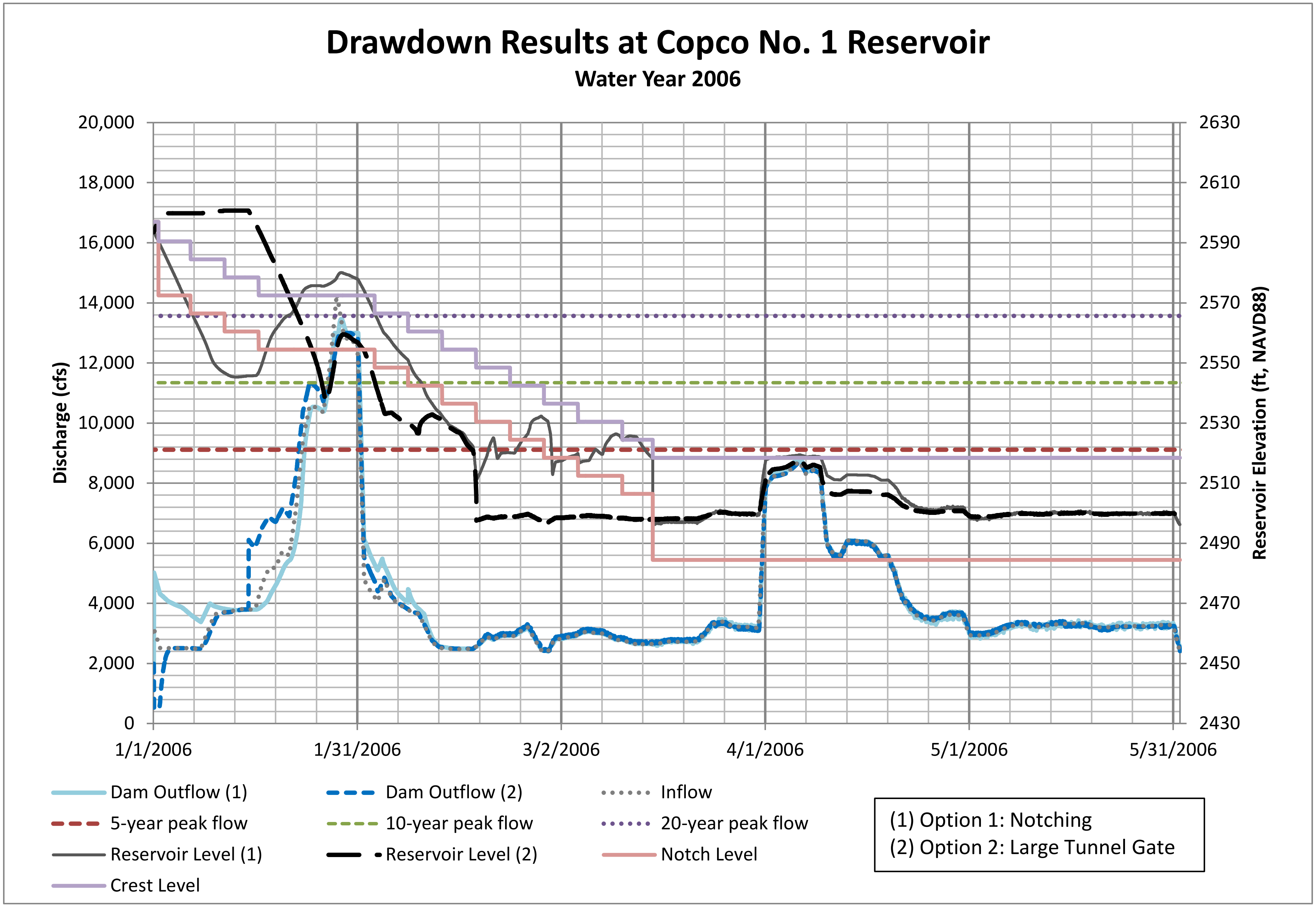



**Figure 4.4-9 Copco No. 1 Reservoir Drawdown, Water Year 2006 (Wet Year)**

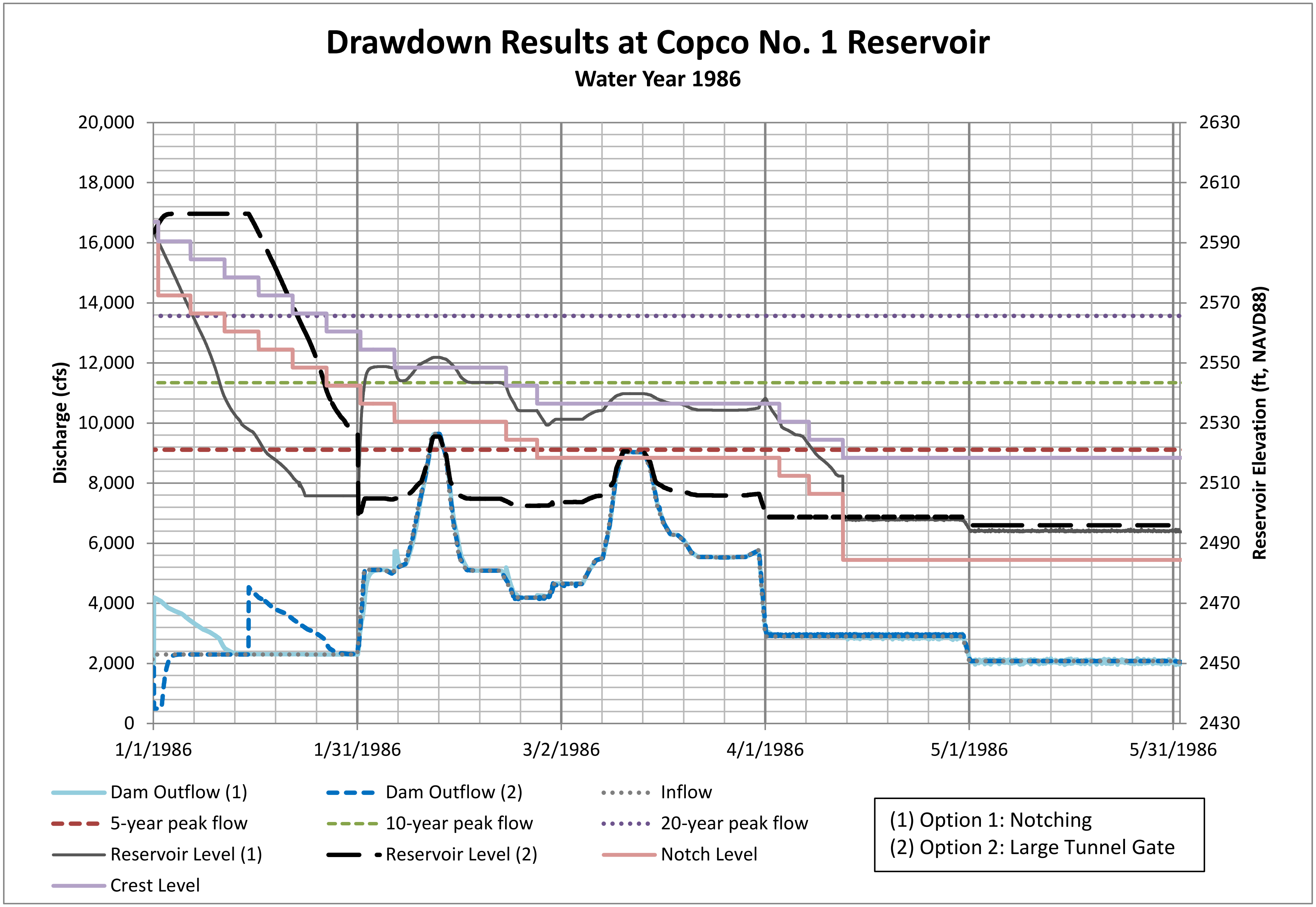



**Figure 4.4-10 Copco No. 1 Reservoir Drawdown, Water Year 1986 (Wet Year)**

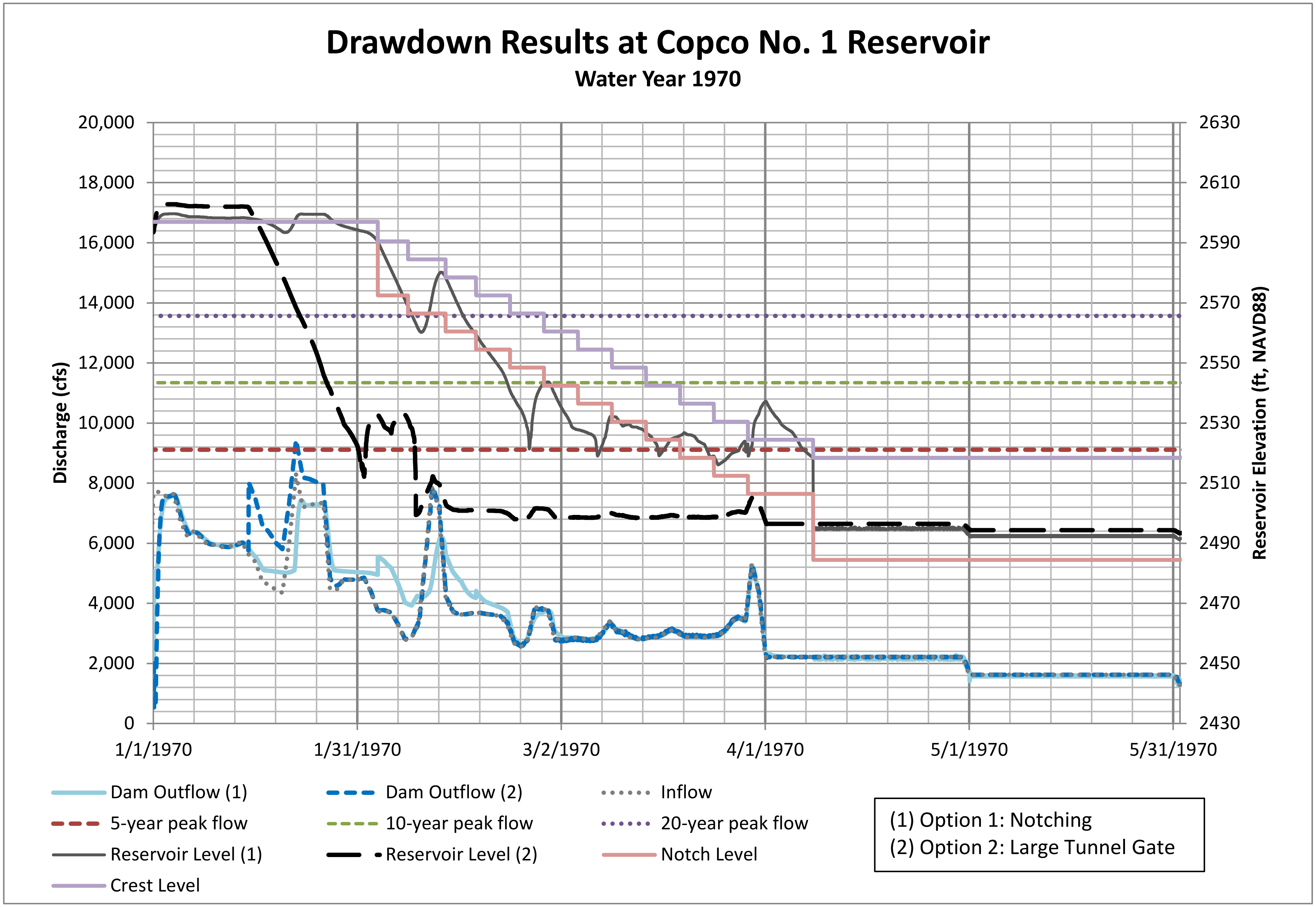



Figure 4.4-11 Copco No. 1 Reservoir Drawdown, Water Year 1970 (Above Normal Year)

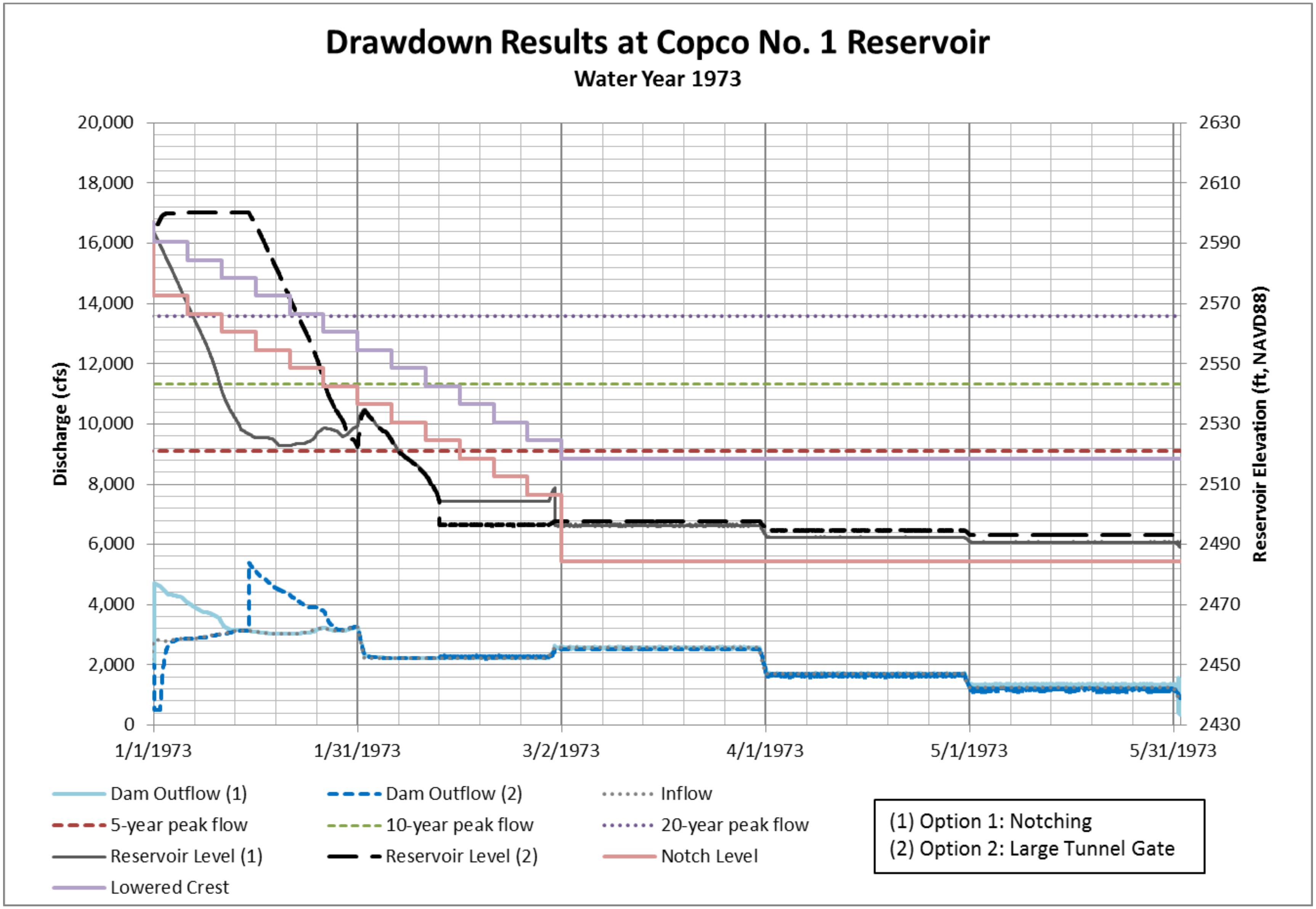



**Figure 4.4-12 Copco No. 1 Reservoir Drawdown, Water Year 1973 (Median Year)**

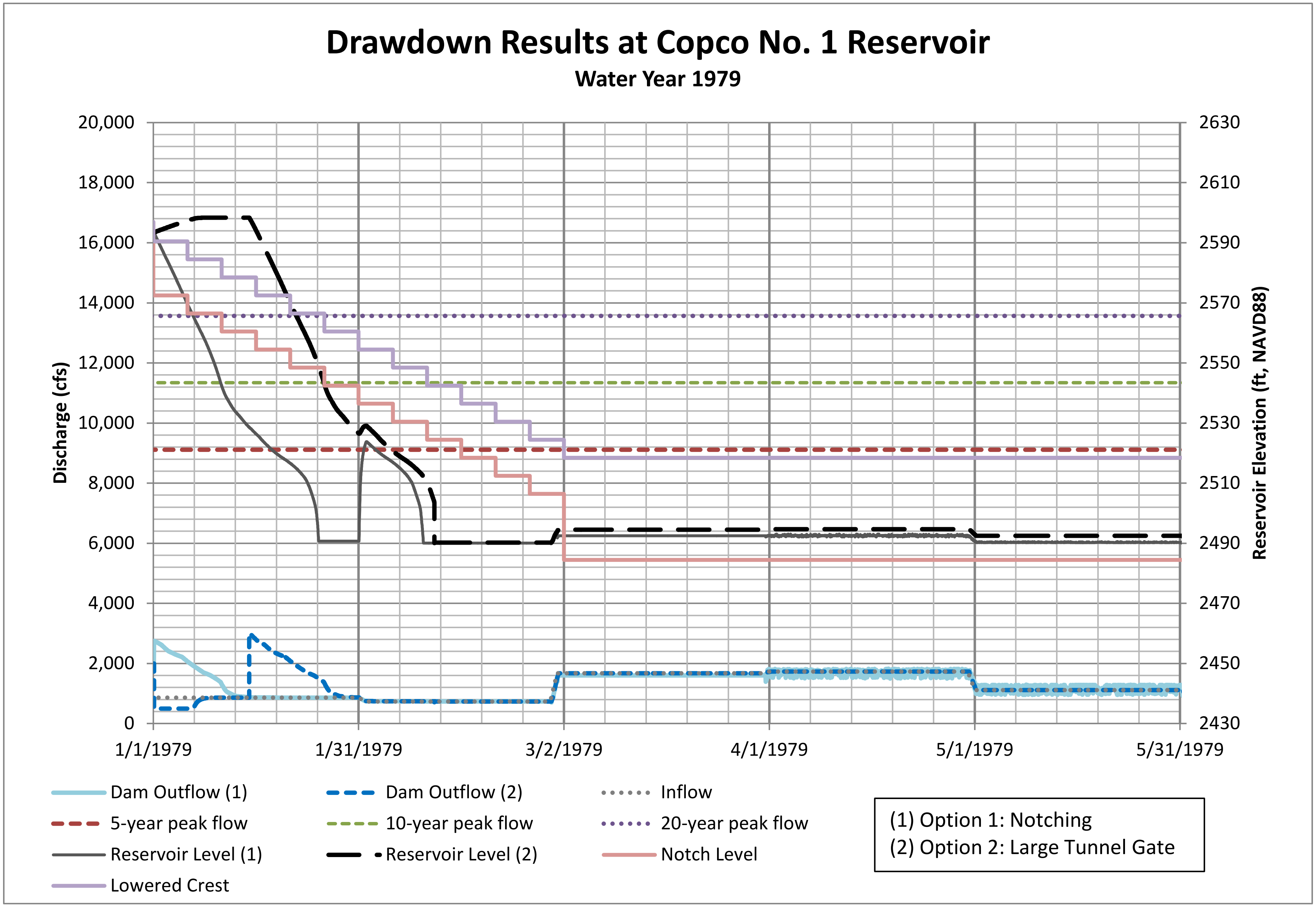



**Figure 4.4-13 Copco No. 1 Reservoir Drawdown, Water Year 1979 (Dry Year)**

## 4.4.4 Iron Gate Reservoir

### 4.4.4.1 Drawdown Procedure

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

### 4.4.4.2 Results

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

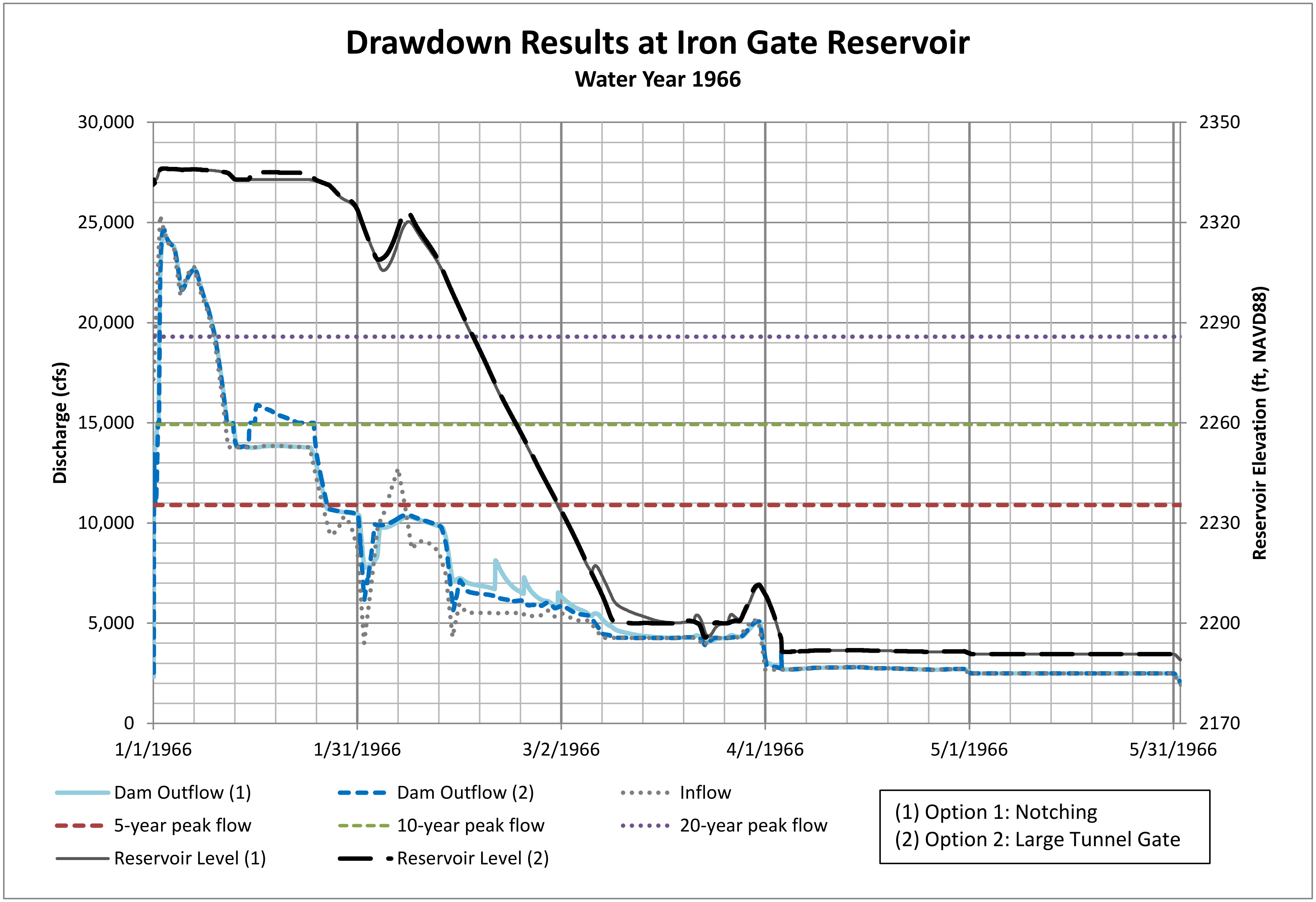
During the representative drier years (1973 and 1979, see Figures 4.4-18 and 4.4-19), the reservoir was easily drawn down by early February, and it did not refill after that point.

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

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

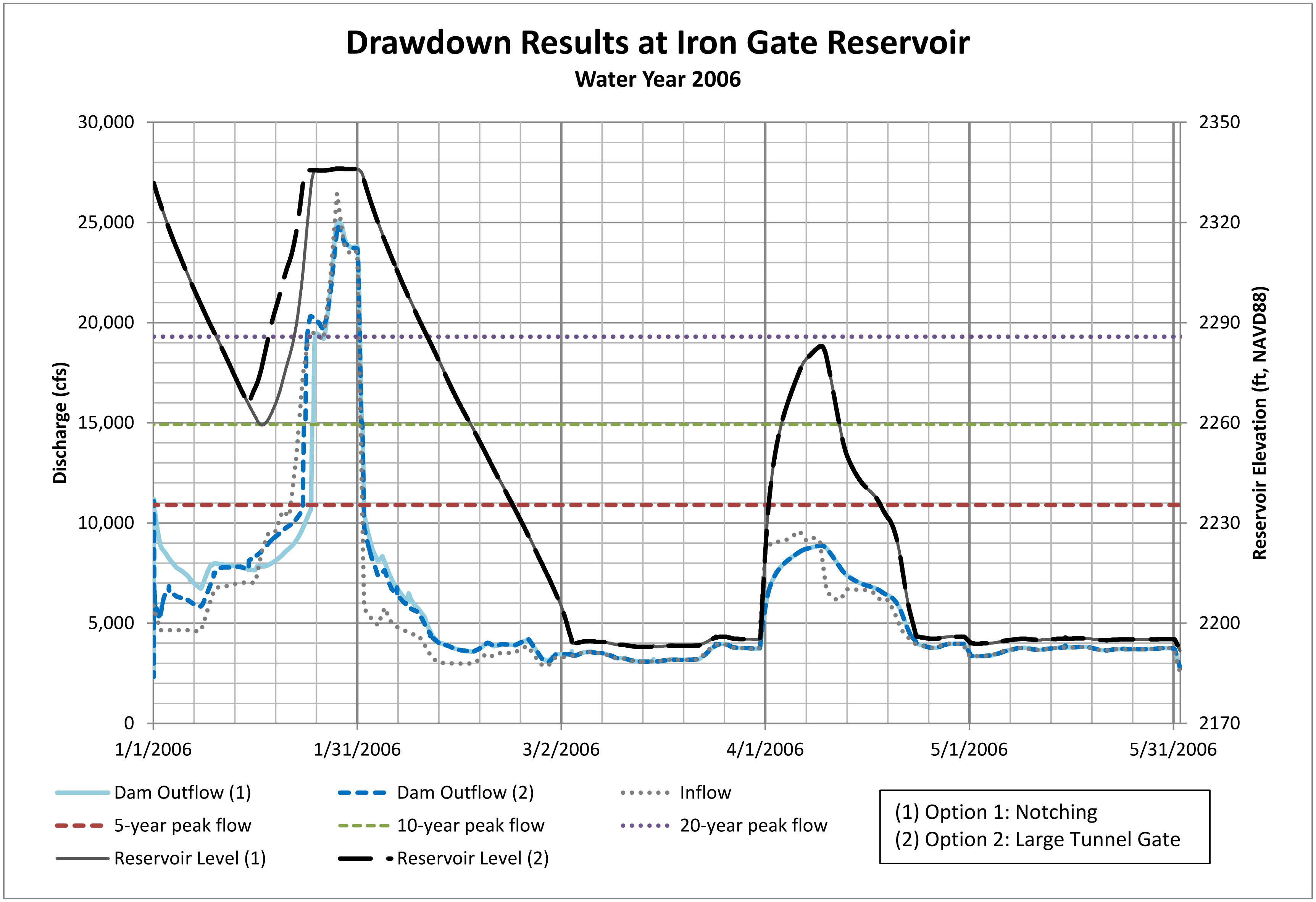
During the wetter years of 1966, 2006, 1986, and 1970 (see Figures 4.4-14 and 4.4-17), flows are higher than what would be expected via the spillway alone (i.e., without drawdown), but the increases are limited to those periods when flows are below the 10-year flood elevation. As discussed above (see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

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



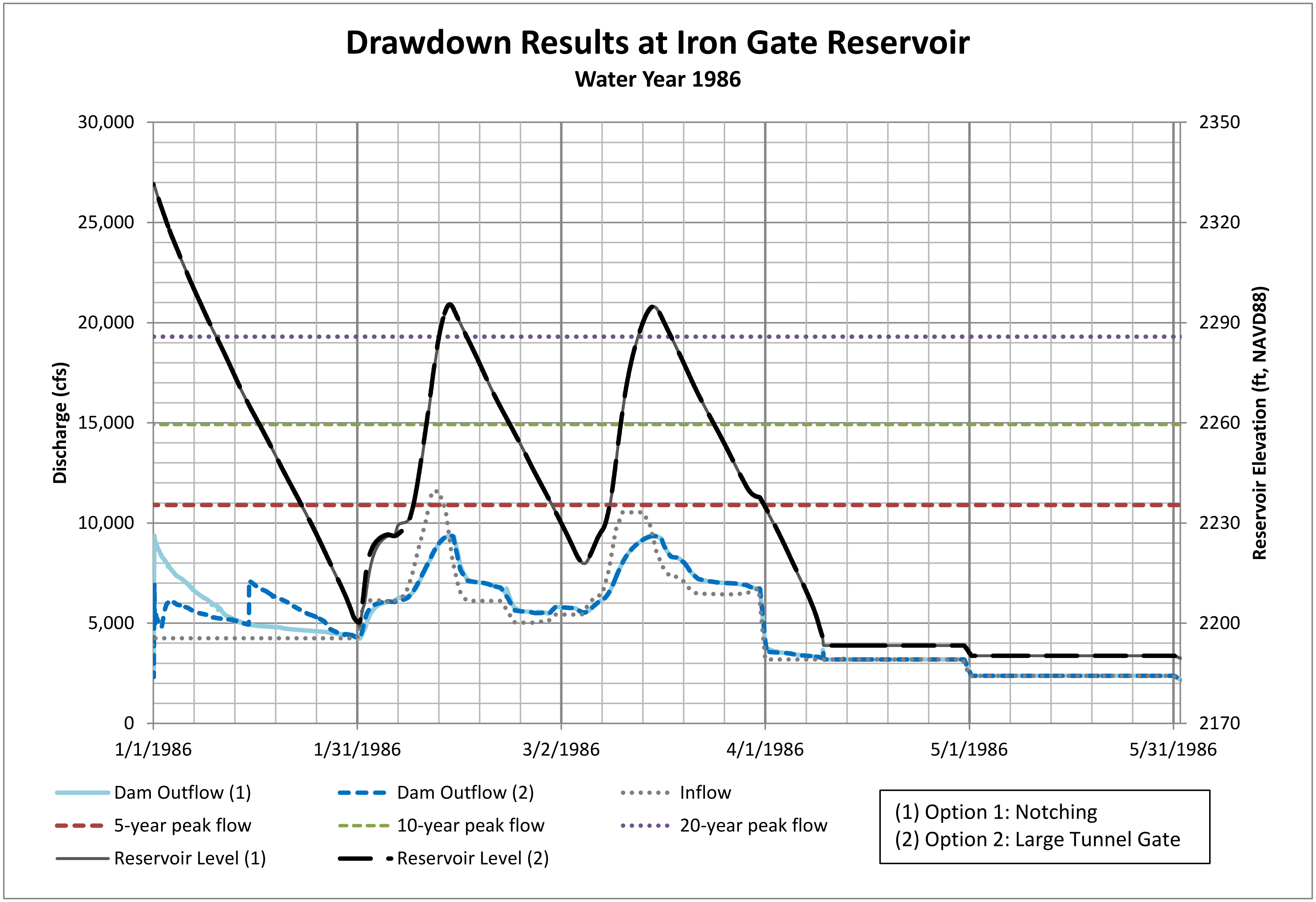

*References to Options 1 and 2 in the plots are the resulting effects at Iron Gate based on either Option 1 or 2 being implemented at Copco No. 1 Dam.*

**Figure 4.4-14 Iron Gate Reservoir Drawdown, Water Year 1966 (Wettest Year)**



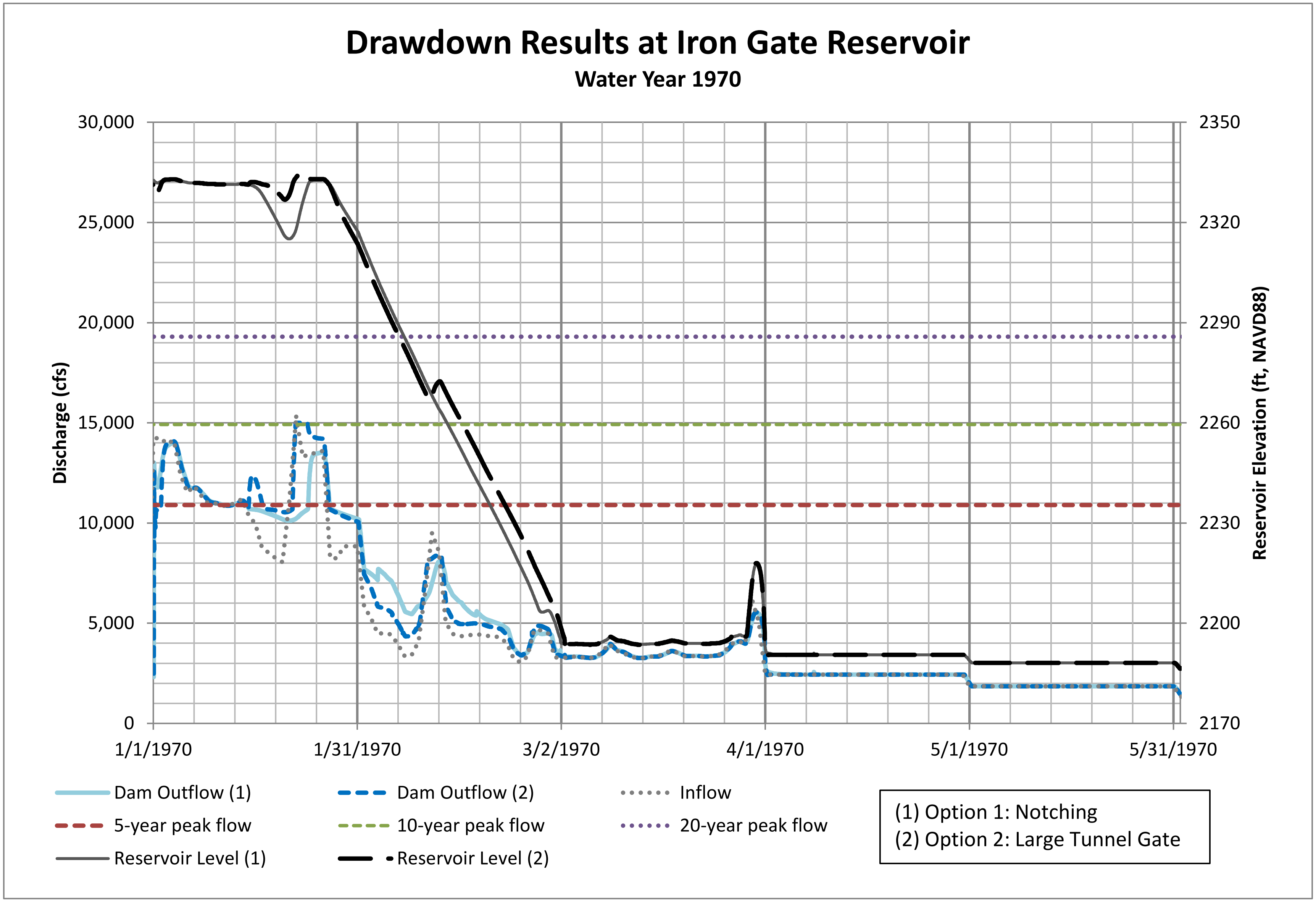

*References to Options 1 and 2 in the plots are the resulting effects at Iron Gate based on either Option 1 or 2 being implemented at Copco No. 1 Dam.*

**Figure 4.4-15 Iron Gate Reservoir Drawdown, Water Year 2006 (Wet Year)**



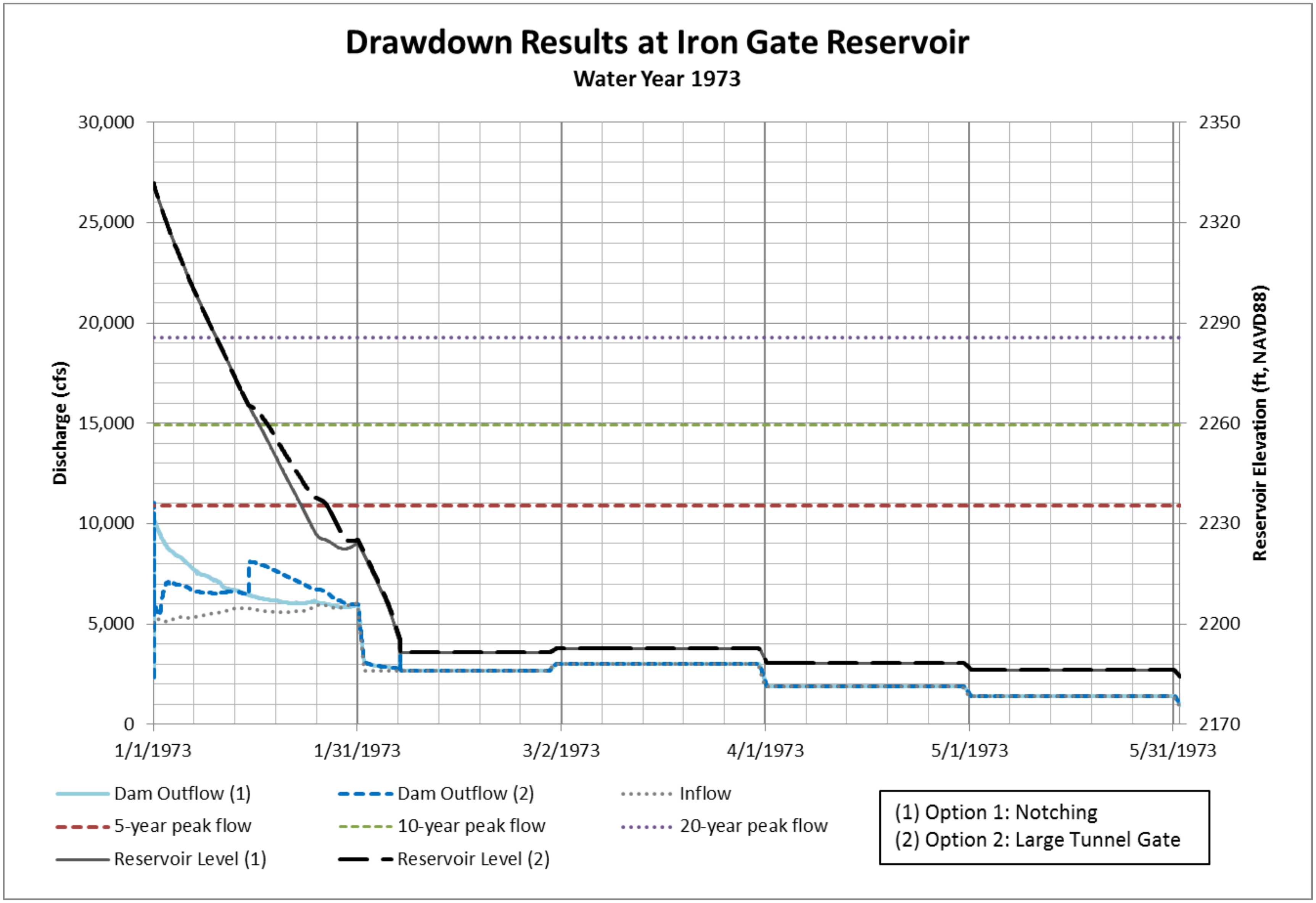

*References to Options 1 and 2 in the plots are the resulting effects at Iron Gate based on either Option 1 or 2 being implemented at Copco No. 1 Dam.*

**Figure 4.4-16 Iron Gate Reservoir Drawdown, Water Year 1986 (Wet Year)**



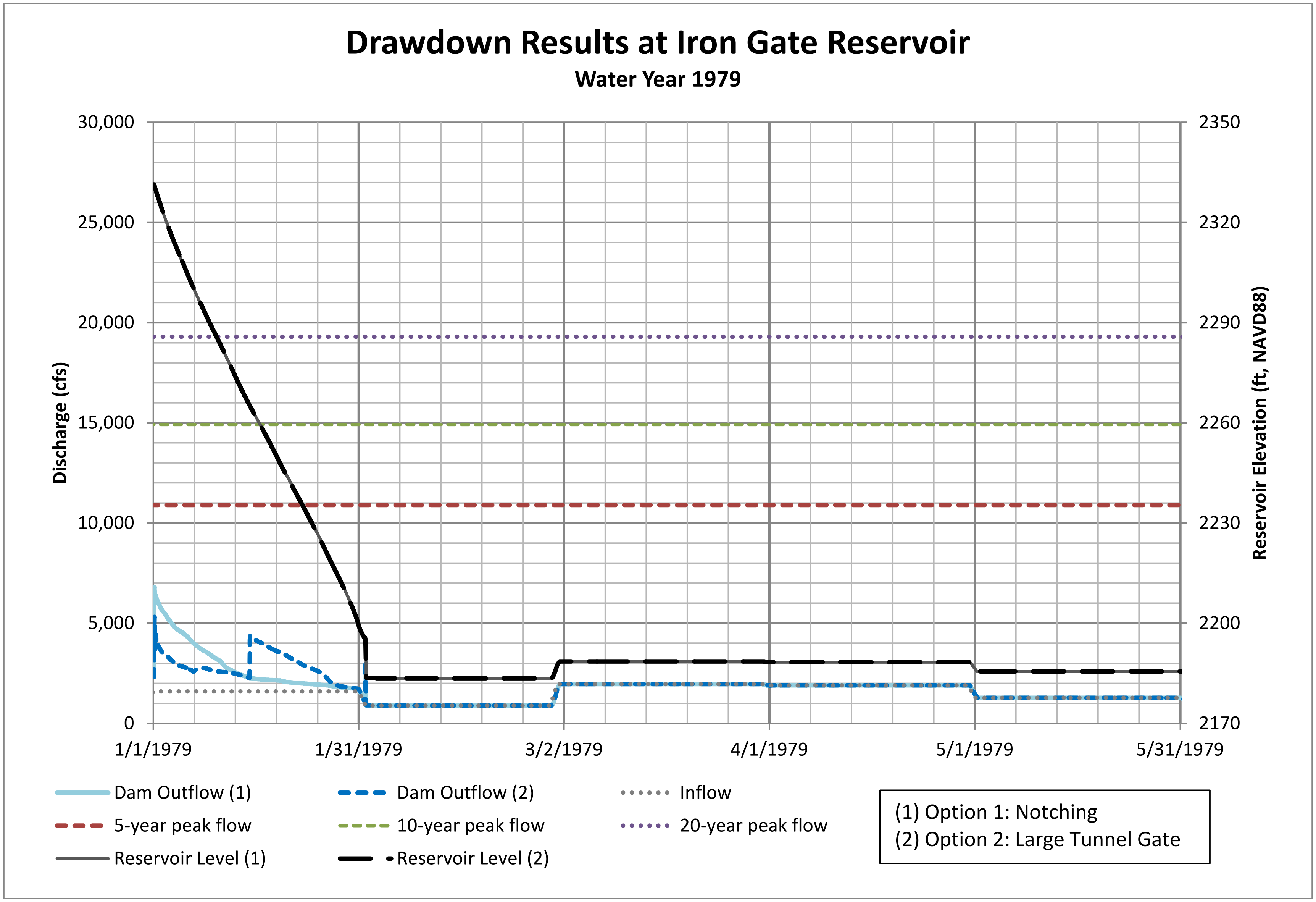

*References to Options 1 and 2 in the plots are the resulting effects at Iron Gate based on either Option 1 or 2 being implemented at Copco No. 1 Dam.*

**Figure 4.4-17 Iron Gate Reservoir Drawdown, Water Year 1970 (Above Normal Year)**




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

**Figure 4.4-18 Iron Gate Reservoir Drawdown, Water Year 1973 (Median Year)**




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

**Figure 4.4-19 Iron Gate Reservoir Drawdown, Water Year 1979 (Dry Year)**

## 4.5 Monitoring During Reservoir Drawdown

Iron Gate Dam and the embankment section of J.C. Boyle Dam would be monitored during reservoir drawdown for evidence of impending embankment instability significant enough to be indicative of upstream slope failure that would threaten the safety of the embankments. Shallow slumps that may occur on the upstream slope would not represent a significant risk to the safety of the embankments. Monitoring would include daily visual observations of the upstream slope for signs of instability such as cracking or slumping. Survey monuments and a minimum of two inclinometers installed in each embankment during the year prior to reservoir drawdown would be monitored on a daily basis for evidence of deep failures within the upstream shell. Piezometers would also be installed in the upstream shell (a minimum of 2) and the core (a minimum of 2) of the embankments for monitoring during reservoir drawdown to confirm that changes in pore pressure during drawdown are similar to or greater than assumed in the analyses (See Section 3.2).

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

Monitoring during drawdown related to cultural resources is discussed in Section 4.8.

## 4.6 Potential Measures to Implement During Reservoir Drawdown

### 4.6.1 Blockage of Diversion Facilities

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

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

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

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

### 4.6.2 Stability of Embankments

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

### 4.6.3 Stability of Reservoir Rim

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

Based on the assessment included in Section 3.3, the potential for deep-seated large landslides that would impact residences or other resources is low at each reservoir. At J.C. Boyle and Iron Gate, the potential is low enough that additional geotechnical investigations and associated stability analyses are not anticipated during detailed design. At Copco Lake, the geology is more complex, and additional reconnaissance and geotechnical investigations are proposed (see Section 3.1.2.5), along with associated stability analyses, to confirm the preliminary findings.

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

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

### 4.6.4 Measures to Reduce Impacts to Aquatic Species

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

## 4.7 Potential for Flooding and Slope Instability Downstream of the Project

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

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

## 4.8 Inadvertent Discovery Protocol for Cultural Resources during Reservoir Drawdown

Drawdown of the Project reservoirs has the potential to expose previously recorded and unidentified cultural resources, including archaeological resources and human remains. Detailed plans addressing the discovery of such resources will be developed during agency and tribal consultation. These plans will include measures that will be implemented in and downstream of reservoirs if tribal cultural/burials/human remains are discovered during drawdown activities. The outline below provides a basis and framework for the development of those plans.

### 4.8.1 Inadvertent Discovery of Cultural Resources

1. The KRRC will develop and implement procedures for their personnel and contractors to implement if historical properties (i.e. National Register-eligible) are discovered or unanticipated effects on historical properties occur during and after the reservoir drawdown period. These procedures shall be presented in a detailed Monitoring and Inadvertent Discovery Plan developed prior to the initiation of dam removal in accordance with 36 CFR § 800.13 (a)(2)(b) Post-review Discoveries.
2. The Monitoring and Inadvertent Discovery Plan shall address situations where unanticipated non-human cultural materials, historical properties, or human remains are encountered on private, non-federal public, or federal lands. The procedures will also include the appropriate agency and tribal contacts for all such situations.
3. The KRRC's Monitoring and Inadvertent Discovery Plan will address such situations occurring once reservoir drawdown has commenced and throughout the dam removal and restoration process. The procedures may be governed by applicable federal, tribal, and state laws.
4. Environmental inspectors will receive instruction regarding the cultural resources that could be discovered during project activities. All personnel involved in project field activities will be instructed on site discovery, avoidance, and protection measures, including information on the statutes protecting cultural resources.
5. If previously unidentified cultural resources are discovered during drawdown or other project activities, provisions outlined in the approved Monitoring and Inadvertent Discovery Plan shall be implemented immediately. The KRRC shall immediately notify BLM, USFS, or other appropriate land management agencies. Where a discovery is made by the KRRC or its contractors, the Environmental Monitor will ensure protection of the find to the extent feasible. It is most likely that a discovery would be exposed in sediment remaining in place during drawdown, and could be provided with protection in place. Drawdown will be allowed to continue if the discovery can be protected and is not in immediate danger of destruction from drawdown activities. The KRRC’s Environmental Monitor will notify the KRRC’s qualified archaeologist of the find. Ongoing work in the location of the find, if any, will be redirected or halted, if feasible, for a period adequate to assess the nature of the discovery and to identify and implement the necessary course of action as determined by the qualified archaeologist in consultation with the lead federal agency and the land management agency. The KRRC’s qualified archaeologist will complete a letter report to assess and document a discovery each time project activities are redirected for such a discovery. Work will not resume in the area of discovery until authorized by the lead federal agency and the land management agency. Specific procedures for dealing with discoveries will be developed in conjunction with the development of site-specific Treatment Plans.

### 4.8.2 Treatment of Human Remains

1. The federal lead and land management agencies shall ensure that any human remains encountered during Project construction are treated in a respectful manner. Any and

all identified human remains shall be treated in accordance with an approved Plan for the Treatment of Human Remains. Identification of such remains, if any, is likely to occur within sediments exposed during drawdown, rather than within flowing sediments. While drawdown is expected to continue following the identification of human remains, no additional project activities will be allowed within 200 feet of the discovery until written authorization is provided by the appropriate agency. As appropriate, the activity that resulted in the inadvertent discovery can resume five (5) days after certification by the notified Federal agency of receipt of the written notification of inadvertent discovery if the resumption of the activity is otherwise lawful. The activity may resume, if otherwise lawful, at any time that a written binding agreement is executed between the Federal agency and the affiliated Indian tribes with rights of disposition (43 CFR 10.4(b)(2)). For human remains inadvertently discovered on Federal land, the lead agency will make a reasonable and good-faith effort to identify the appropriate Native American tribe(s), or other ethnic group(s) related to the burial. The lead agency will consult with the appropriate group regarding the appropriate treatment of the remains and associated grave goods. The lead and land management agencies shall ensure that any human remains and associated funerary objects encountered during the project are treated in accordance with the wishes of the descendants or the authorized group. The lead and land management agencies will make determinations for associated burial objects.

2. If human remains are encountered on Federal lands the lead and land management agencies shall consult with the Native American tribe or other ethnic groups related to the human remains identified to determine the treatment and disposition measures consistent with the applicable Federal laws (ergo Native American Graves Protection and Repatriation Act [NAGPRA]) (Public Law 101-601; 25 U.S.C. 3001 et seq.), regulations, and policies.
3. If human remains are encountered on State or private lands, the appropriate County Coroner will be contacted. All human remains will be treated according to the provisions of the applicable State laws, regulations or policies, as determined through consultation with the appropriate SHPO and the Native American tribe or other ethnic groups related to the human remains.
4. Human remains and associated artifacts may be discovered during drawdown, other project activities, or during controlled archaeological excavations. If human remains are discovered under any circumstances, they will be secured and protected until appropriate disposition has been determined, in accordance with applicable local, state, and Federal statutes. The provisions of the NAGPRA govern inadvertent discoveries of Native American human remains on Federal or tribal lands. Archaeological excavation and/or construction activities in the immediate vicinity of the discovery will cease immediately. Upon discovery, the KRRC's Environmental Monitor, in accordance with the procedures outlined below, will secure the location with appropriate security and avoidance measures. It may be necessary for the KRRC to provide 24-hour on-site security for NAGPRA associated discoveries and for other discoveries as determined by the lead federal agency.

5. Specific procedures to be followed will depend on the ownership status of the lands where the human remains and associated artifacts are discovered. In all cases, the lead federal agency, along with the relevant county coroner or sheriff (as appropriate) will be immediately notified by phone by the KRRC's representative or their consultant. This will be followed by written notification to the lead agency, of any discoveries of human remains, associated and unassociated funerary objects, sacred objects, or objects of cultural patrimony. The lead agency would be responsible for compliance with the NAGPRA and its implementing regulations (43CFR10) for all NAGPRA-related inadvertent discoveries and discovery situations on Federal or tribal lands.
   a. In California, treatment of burials found on State or private lands are covered under the Public Resources Code, Division 5, Parks and Monuments [5001 - 5873] ( Division 5 added by Stats. 1939, Ch. 94. ) Chapter 1.75. Native American Historical, Cultural, and Sacred Sites [5097.9 - 5097.991] and the California Native American Graves Protection and Repatriation Act of 2001 (Chapter 5 (commencing with Section 8010) of Part 2 of Division 7 of the Health and Safety Code).
   b. In Oregon, treatment of burials found on State or private lands are covered under Oregon Revised Statute (ORS) 97.745. If human remains are encountered, the state police, Oregon SHPO, the Commission on Indian Services, and the appropriate Tribe(s) (which are determined by the Commission on Indian Services) need to be immediately contacted.

# 5. Dam Removal Plans

## 5.1 Introduction

The general strategy for dam removal assumes 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 of the drawdown year. The reservoir drawdown and associated sediment release would be accomplished through regulated releases from the diversion facilities described in Section 4.2, to draw down the reservoirs in a controlled manner. Facilities removal, as defined by the KHSA, is to produce a free-flowing river at all four hydroelectric dam sites (J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate) by the specified December 31 completion date.

Removal of all appurtenant features at each dam site, except for buried features, represents the Full Facilities Removal. 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, represent Partial Removal Options (PROs) that might be exercised during project implementation if the forecast construction costs exceed the available project funds. Those PROs that would not be buried would be sealed or fenced to prevent unauthorized entry and for public safety, and would likely involve long-term maintenance costs. Hazardous materials are to be removed from each dam site and from any PRO if it were to be implemented during construction.

Quantity estimates for all features to be removed, including earth fill volumes, 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 dam site 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. New topographic and bathymetric surveys are planned for October 2017 that will be used to confirm earthwork quantities.

The following sections define the removal limits, PROs, access roads, staging areas, disposal sites, likely demolition methods, and waste disposal requirements for each dam and hydropower facility. Drawings have been prepared for each facility to define the proposed removal limits for the dam and for each appurtenant feature in plan and cross-sectional view, and are included in Appendix B (CEII) and Appendix C (non CEII). An overview of the work areas and major access routes is shown on Figure 5.1-1(C).

**Figure 5.1-1 Project Limits of Work and Access (Appendix C)**

The bulleted list below provides a roadmap for specific waste disposal requests (Item 6d) made by the SWRCB in their August 2017 Request for Additional Information:

- Location and size of disposal sites are summarized in Sections 5.2.3 (J.C. Boyle), 5.3.3 (Copco No.1), 5.4.3 (Copco No. 2) and 5.5.3 (Iron Gate). Disposal site location and approximate grading can be found on Figures 5.2-1(C), 5.3-1(C), and 5.5-1(C). Additional detail (plan and profile) for the disposal sites is provided on Figures 5.2-8 (C), 5.2-9 (C), 5.3-8 (C), 5.5-4 (C), and 5.5-5(C).
- Description and results of resource assessment surveys conducted for proposed disposal sites are provided in Sections 3.4 (Biological Resources) and 3.5 (Cultural Resources).
- Description of materials (quantity and type) being buried at each disposal site is provided in Sections 5.2.7, 5.3.7, 5.4.7 and 5.5.7.
- Measures and monitoring associated with disposal site erosion are summarized in Sections 5.2.3, 5.3.3, 5.4.3 and 5.5.3.
- Description of materials (quantity and type) that will be disposed of at local landfills, including an estimate of truck trips, is provided in Sections 5.2.7, 5.3.7, 5.4.7 and 5.5.7.
- Description of material (quantity and type) that will be recycled is provided in Sections 5.2.7, 5.3.7, 5.4.7 and 5.5.7.
- Description of hazardous material (quantity and type) that may be encountered, and plans for safe handling and disposal is provided in Section 7.7.5.

## 5.2 J.C. Boyle Dam and Powerhouse

### 5.2.1 Removal Limits

J.C. Boyle Dam is located within a relatively narrow canyon on the Klamath River at RM 229.8. Minimum requirements for a free-flowing condition and for volitional fish passage on the Klamath River through the J.C. Boyle dam site 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. Features to be removed or potentially retained as PROs are summarized in Table 5.2-1, and shown on Figure 5.2-1 (C).

**Figure 5.2-1 J.C. Boyle Dam Removal Features and Limits (Appendix C)**

### Table 5.2-1 J.C. Boyle Dam and Powerhouse, Removal Requirements

| Feature | Full Removal | Partial Removal Options | Comments[a] |
|---|---|---|---|
| Embankment Dam, Cutoff Wall | Remove | ------ | |
| Spillway Gates and Crest Structure | Remove | ------ | |
| Concrete Box Diversion Culverts | Remove | ------ | |
| Fish Ladder and Diffusion Box | Remove | ------ | |
| Timber Bridge | Remove | ------ | |
| Steel Pipeline and Supports | Remove | Yes | Retain as footbridge, supports would remain in 100-year floodplain |
| Canal Intake (Screen) Structure | Remove | Yes | Seal openings, install security fence |
| Left Concrete Gravity Section | Remove | Yes | |
| Canal Headgate Structure | Remove | Yes | Retain as observation point |
| Power Canal (Flume) | Remove | Yes | Retain invert slab |
| Shotcrete Slope Protection | Retain | ------ | Removal would destabilize excavated rock slopes and increase potential for rock falls |
| Forebay Spillway Control Structure and Discharge Chute | Remove | ------ | |
| Tunnel Inlet Portal Structure | Remove | ------ | |
| Surge Tank | Remove | ------ | Potential future seismic stability |
| Penstocks, Supports, Anchors | Remove | ------ | Avoid maintenance, facilitate wildlife migration |
| Tunnel Portals | Plug | ------ | Plug with reinforced concrete |
| Powerhouse Gantry Crane | Remove | ------ | |
| Powerhouse (incl. mechanical and electrical equipment) | Remove | Yes | Substructure below roadway, seal openings |
| Powerhouse Hazardous Materials (transformers, batteries, insulation, petroleum products) | Remove | ------ | |
| Tailrace Flume Walls | Remove | ------ | |
| Tailrace Channel Area | Backfill | ------ | |
| Canal Spillway Scour Area | Backfill | ------ | Backfill to extent possible with concrete rubble from dam, canal, and powerhouse |
| Three 69-kV Transmission Lines, 3.56 mi total (incl. poles and transformers) | Remove | ------ | |
| Switchyard (incl. fencing, poles, and transformers) | Remove | ------ | |
| Buildings: office building (the Red | Remove All | Yes | Retain some structures |

| Feature | Full Removal | Partial Removal Options | Comments[a] |
|---|---|---|---|
| Barn), maintenance shop, fire protection building, communications building, 2 residences, storage shed, reservoir level gages house | | | |

[a] PROs would involve long-term maintenance costs, including the preservation of any exposed items with coatings containing heavy metals (such as the penstocks).

Retention of the portions of the J.C. Boyle powerhouse below the roadway as a PRO would require the structure to be sealed. 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. Retention of the lower portion of the powerhouse would not impact the 100-year floodplain.

### 5.2.2 Construction Access

Construction access roads and associated improvements that may be required for removal of J.C. Boyle Dam and Powerhouse are shown on Figure 5.1-1(C) and Figure 5.2-1(C). Existing conditions of the highways, local roads, and structures to be used were observed in the field to identify deficiencies and determine if improvements are necessary for mobilization and/or hauling during construction and demolition activities. Access road improvements would need to be completed prior to associated construction and removal at the dam and powerhouse. The following sections summarize the assessment completed of each road or highway identified for use during construction, and specific improvements are identified, as appropriate.

#### 5.2.2.1 The Dalles California Highway (US97)

The Dalles California Highway (US Route 97) is classified as a rural principal arterial road that runs north-south in Oregon and intersects with Keno Worden Road. It is a two-lane undivided roadway with a posted speed limit of 65 mph. It is anticipated that this stretch of highway will be used for mobilization of construction equipment and as a haul route to carry demolished materials other than earth and concrete rubble from the dam and powerhouse site to approved commercial landfills. The alignment and pavement are in good condition and well maintained. Improvements and upgrades to this highway for mobilization or hauling of materials are not anticipated for the Project. Pavement rehabilitation may be required during or post-construction. Temporary traffic control will be used for any pavement rehabilitation. It is anticipated that transportation permits will be required from the department of transportation for mobilizing "wide-load" truck trailers with construction equipment. Hauling permits may be needed if US97 is used for carrying oversize loads of materials removed from the site.


**Figure 5.2-2 US97 & Keno Worden Rd**

### 5.2.2.2 Oregon Route 66 (OR66, Green Springs Highway)

OR66 is classified as a rural minor arterial that runs east-west in Oregon and north of the Klamath River. It is a two-lane undivided roadway with posted limits of 35 to 45 mph. The highway's western terminus is at Oregon 99 near Ashland and its eastern terminus is at The Dalles California Highway (US97) and Oregon 140 near Klamath Falls. It is anticipated that the segment of roadway between J.C. Boyle Dam/Powerhouse Access Road and US97 will be used for mobilization and as a haul route for materials being taken to commercial landfills. The pavement is in fair condition. Improvements and upgrades to this highway for mobilization and hauling are not anticipated for the Project. Pavement rehabilitation may be required during or post-construction. Temporary traffic control will be used for any pavement rehabilitation. This portion of OR66 includes Spencer Bridge (ODOT Bridge No. 19789).

#### 5.2.2.3 Spencer Bridge

Spencer Bridge (OR66) is a 3-span continuous welded steel plate girder bridge that is approximately 558 feet long and 43 feet wide. It was built in 2005 for a HL-93 truck design load. The structure has a reinforced concrete deck with two12-foot lanes and 8-foot shoulders. The structure is supported on two column bents founded on 6-foot diameter shafts and seat type abutments. The west abutment is founded on 2-foot diameter shafts and the east abutment is founded on a spread footing placed on compacted stone fill.

**Figure 5.2-3 Spencer Bridge (OR66)**

It is anticipated that this structure will be used for mobilization and as a haul route for materials being taken to commercial landfills. The alignment and deck are in excellent condition and well maintained. Improvements and upgrades to this structure for mobilization are not anticipated for the Project. Temporary traffic control is also not anticipated.

#### 5.2.2.4 Keno Worden Road

Keno Worden Road is a county road classified as a rural minor collector and connects to The Dalles California Highway to the southeast and OR66 to the northwest in Oregon. It is a two-lane undivided roadway with posted speed limits of 20 to 35 mph. It is anticipated that the roadway will be used for mobilization and as a haul route for materials being taken to commercial landfills. The existing pavement of Keno Warden Road is in fair condition. Improvements and upgrades to this highway for mobilization and hauling are not anticipated for the Project. Pavement rehabilitation may be required during or post-construction. Temporary traffic control will be used for any pavement rehabilitation.

#### 5.2.2.5 Topsy Grade Road

Topsy Grade Road runs east of and parallel to the Klamath River with the northeast terminus at OR66 just east of Spencer Bridge and becomes Copco Lake Road at the California/Oregon border to the southwest. It is a two-way access road ranging in width between 14 feet and18 feet. Most of the roadway is gravel and some short sections are asphalt, particularly near the Topsy Campground (managed by BLM) at J.C. Boyle Reservoir. It is anticipated that the section of roadway between the Topsy Recreation Site and OR66 will be used for mobilization and material hauling. Improvements and upgrades to this roadway are not anticipated for the Project. Pavement rehabilitation may be required during or post-construction. Temporary traffic control will be used for any pavement rehabilitation.

#### 5.2.2.6 Access Road from OR66 to J.C. Boyle Dam

The Access Road from OR66 to J.C. Boyle Dam is a gravel road ranging in width between 16 to 18 feet. The pavement is in fair condition. It is anticipated that this section of roadway will be used for mobilization and material hauling. Improvements such as regrading uneven or rutted areas will be required on parts of the road. At the intersection with OR66, tree removal and widening of the intersection on the access road approach will improve corner sight distance for mobilization and hauling activities. In addition, advance signage will notify vehicles using OR66 of construction trucks entering/exiting at the intersection.

#### 5.2.2.7 J.C. Boyle Powerhouse Road

The Powerhouse Access Road is an access road that runs between the J.C. Boyle Powerhouse and Dam sites. It is a two-way undivided gravel road 16 to 22 feet wide. The existing gravel road condition is fair. It is anticipated that this section of roadway will be a primary haul route to transport material from the powerhouse to the scour hole below the forebay, and to haul some excavated material from the dam to the tailrace. The average one-way haul distance from the powerhouse to the scour hole below the forebay is approximately 1.8 miles. The average one-way haul distance from the dam to the tailrace is approximately 4.2 miles. Improvements and upgrades for this roadway are not anticipated for the project. Temporary traffic control will not be required.

#### 5.2.2.8 Timber Bridge

A timber bridge spans over the Klamath River just south of the dam. The structure is a single span rolled steel beam bridge that is 100-foot long and 18 feet wide with a 16-foot travel lane. It was built in 2003 for a HS20-44 truck design load. It is used to access the power canal and powerhouse. The bridge has a timber deck supported on 4 beams that are welded to steel floor beam at the abutments. The floor beam is founded on 4 steel piles. The alignment and deck are in good condition and well maintained.

The bridge will not be used for mobilization of construction access, and improvements and upgrades to this structure are not required. Temporary traffic control will not be required.

**Figure 5.2-4 Topsy Grade Road - Causeway Road**

#### 5.2.2.9 Power Canal Access Road

The power canal access road runs between the dam and forebay spillway. It is a gravel road immediately adjacent to the power canal and has a width of approximately 14 feet. The surface is in poor condition. It is anticipated that this section of roadway will be used for construction access only until the power canal has been completely removed. Minor periodic roadway maintenance such as re-grading will likely be required to address roadway deterioration during construction. Temporary traffic control is not anticipated.

**Figure 5.2-5 Timber Bridge at J.C. Boyle**

### 5.2.2.10 Disposal Access Road

The disposal access road runs between the dam and on-site disposal area just north of the dam. It is anticipated that this road will be used for material hauling. The average one-way haul distance is approximately 0.4 miles. Improvements for this roadway include regrading uneven and rutted areas and widening in some segments to facilitate two-way traffic. Temporary traffic control is not anticipated as this is not a public road.

### 5.2.2.11 Right Abutment Access Road

The right abutment access road runs between the dam and Topsy Grade Road. It is a gravel road in fair condition. It is anticipated that the roadway will be used for mobilization material hauling. Improvements to the road are not anticipated for the project. Temporary traffic control is not anticipated.

**Figure 5.2-6 Power Canal Access Road**

#### 5.2.2.12 Penstock Access Roads

Several dirt roads extend from the J.C. Boyle Powerhouse Road up to various elevations along the penstocks. It is anticipated that these roads would be used to access the penstocks for demolition and related material hauling. Improvements to the roads are not anticipated for the project. Temporary traffic control is not anticipated.

### 5.2.3 Staging Areas, and Disposal Sites

Construction staging areas and disposal sites for removal of J.C. Boyle Dam and Powerhouse are shown within the limits of work on Figure 5.2-1(C) and are discussed in the following sections. The contractor will have to mobilize construction equipment to the site by about October in the year leading up to drawdown, to prepare the staging areas and prepare the right abutment disposal site for dam removal post-drawdown.

**Figure 5.2-7 Right Abutment Access Road**

#### 5.2.3.1 Staging Areas

Equipment staging areas (Figure 5.2-1(C)) would be located at the left abutment of the dam and near the forebay and downstream powerhouse. Identified staging areas include a 5.0 acre area and a 7.1 acre area on the right abutment of the dam, a 1.1 acre area at the forebay, and a 1.8 acre area at the powerhouse. The staging areas would be prepared by clearing vegetation and minor grading. The staging areas would be restored post construction by minor grading and hydroseeding. See Section 6 for additional detail associated with restoration.

#### 5.2.3.2 Disposal Sites

Earth materials generated from removal of the J.C. Boyle facilities will be permanently buried on-site in a portion of the original borrow pit located on the right abutment of the dam (see Figure 5.2-1(C) and sections in Figures 5.2-8(C) and 5.2-9(C)) within PacifiCorp property. Excavated embankment materials would be hauled along improved existing access roads to the northwest portion of the former borrow pit just north of the cleared transmission line corridor, covering an area of approximately 6 acres. The disposed material would be graded as a hill (maximum fill height of about 35 feet) contoured to blend into the surrounding topography as shown in plan and section on Figure 5.2-1(C), Sheet 1. Preparation of the disposal site would include clearing of existing vegetation and stripping and stockpiling of what little topsoil is present. The top 12 inches of the downstream face of the dam would be excavated and stockpiled near the disposal site for later use as topsoil for restoration of the disposal site. Special precautions would be required for work below the high voltage transmission lines, but adequate clearance should be available. After final grading for drainage and aesthetics, the disposal site would be covered with topsoil and hydroseeded. Compaction other than by equipment travel would not be necessary. See Section 6 for additional detail associated with restoration. Erosion monitoring will be completed on an annual basis for 5 years following placement to assess whether significant erosion and slope deterioration has occurred. If significant erosion occurs, the eroded area shall be repaired to the satisfaction of the appropriate regulatory agency.

**Figure 5.2-8 J.C. Boyle Right Abutment Disposal Site Plan & Sections (Appendix C)**

**Figure 5.2-9 J.C. Boyle Forebay Spillway Scour Hole Backfill Plan & Sections (Appendix C)**

Concrete rubble from the dam, flume, forebay, and powerhouse will be placed in the eroded scour hole below the forebay spillway structure (Figure 5.2-1(C), Sheet 8), and covered with 3 to 5 feet of rock and soil debris that has eroded and been moved downslope of the scour hole. The previously eroded rock and soil, which will be obtained from the slope below the scour hole, will be used as top cover so that the restored scour hole will blend more naturally into the adjacent slopes. The scour hole, which is approximately 100 feet deep with near vertical side slopes, was eroded into a steep slope (1.3H:1V to as steep as 1H:1V) of talus and colluvium. Filling of the scour hole to match the original slope and maintain an adequate factor of safety for slope stability would not be feasible. The concrete rubble, which has a high shear strength, would be spread in lifts and track walked with a small bulldozer to a finished slope of 1.5H:1V. The finished slope would have a factor of safety of more than 1.3. The volume of available concrete rubble will fill the hole to within about 66 feet of the top of the hole (Figure 5.2-1(C), Sheet 8). The vertical slopes extending above the finished fill grade would be flattened to 1H:1V. The fill would be shaped to drain toward the center of the fill, which would be rock lined to provide for erosion protection. Use of the previously eroded rock and soil debris would allow similar vegetative cover to be used for restoration as is currently present on the slopes upstream and downstream of the scour hole.

### 5.2.4 J.C. Boyle Dam and Powerhouse Removal

#### 5.2.4.1 Dam Removal

Immediately following reservoir drawdown with the reservoir level below the spillway crest (see Section 4.2.1), all three spillway gates and operators, the spillway bridge deck, the spillway piers, and the log boom would be removed in the dry. The left abutment wall with fish ladder that supports the left side of the embankment would be retained for flood protection until after spring runoff when embankment removal could begin.

Sufficient embankment 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 requirement would be to provide 100-year flood protection for the time of year that embankment dam removal is occurring. Excavation of the J.C. Boyle embankment section would not be allowed to start until July 1 of the drawdown year, and would have to be completed by September 30 of the same year to minimize hydrologic risk.

Removal of the remaining features at the dam would be as follows:

1. At the beginning of embankment excavation, reservoir inflows will have reduced to a level that is below the crown of the diversion culverts (elevation 3765.2).
2. Remove dam embankment in July and August to no lower than elevation 3770.7 (about 30 feet above bedrock at upstream toe) to provide an upstream cofferdam (Figure 5.2-10 (B)) sufficient to ensure minimum 100-year flood protection (with freeboard) in September for flows up to about 3,500 cfs through left abutment. Remove riprap from upstream and downstream slopes as embankment is removed and temporarily stockpile for later use on downstream slope of upstream cofferdam. Remove embankment materials downstream of upstream cofferdam limits to final channel grade, including concrete cutoff wall. Remove the left abutment wall with fish ladder concurrent with dam removal.
3. Place excavated rockfill (from stockpile) on downstream face of upstream cofferdam as required for controlled breach of cofferdam embankment to bedrock elevation 3740.7 at upstream toe.
4. Remove the concrete spillway crest structure down to the top of the diversion culvert, and remove the canal intake structure and the left gravity wall in July, concurrently with the beginning of embankment removal (Figure 5.2-10 (B)).
5. Prior to September 30, but following breaching of the upstream cofferdam at Iron Gate Dam (to minimize downstream impacts), breach the J.C. Boyle upstream cofferdam by notching below reservoir level (expected to be below RWS elevation 3763.7). Breaching would occur with a reservoir head behind the cofferdam of about 20 feet. Final reservoir drawdown would be achieved by natural erosion of the armored cofferdam to the original streambed level. The cofferdam breach at J.C. Boyle could release up to 5,000 cfs.
6. Following the cofferdam breach, remove any remaining embankment materials from river channel in the wet (during low flow period) as required, and remove remaining diversion culvert concrete in the dry.
7. Remove all other features (buildings, paving on access roads, etc.) as required. Restore dam site and right abutment disposal site as required, including the placement of topsoil and seeding.

**Figure 5.2-10 J.C. Boyle Dam Removal (Appendix B)**

#### 5.2.4.2 Canal Removal

Removal of the power canal would likely be from the downstream end to the upstream end. In portions of the canal that are two-walled, both walls and the invert slab would be demolished using mechanical methods (e.g. hydraulic shears or hoe-ramming). In portions of the canal that are single-walled, the wall and the invert slab would be demolished, but shotcrete that may have been used to stabilize portions of the inside wall formed by exposed rock would be left in place. Removal of the shotcrete could destabilize the rock slope increasing the potential for rock falls during and after construction. Reinforcement would be removed from the concrete as the demolition proceeds upstream. The concrete rubble and gravel underlying the invert slab would be hauled downstream and placed in the forebay structure spillway scour hole (see Section 5.2.3.2). Following removal of the canal structure, the excavated bench the canal was built on would be restored by grading the bench to drain, armoring portions of the bench where drainage from uphill areas would cross the bench, and removing vehicular access to the bench. The outer portion of the bench (current location of the access road), would be decompacted using tines on the back of a motor grader and hydroseeded. See Section 6 for additional detail associated with restoration.

#### 5.2.4.3 Powerhouse Removal

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. Removal of the remaining features at the powerhouse would be as follows:

1. Use sump pumps to dewater area, as required. Retain the cofferdam as partial backfill for tailrace channel.
2. Remove penstocks and plug tunnel openings.
3. Remove switchyard and warehouse building.
4. Backfilling of the tailrace channel would be completed by removing up to 5 feet of alluvial material from upstream and downstream of the tailrace channel (Figure 5.2-1(C), Sheet 9) that originally came from excavation of the powerhouse and tailrace and placing the material in the channel by pushing using a bulldozer or placement using a large excavator.
5. A turbidity curtain would be placed along the downstream edge of the channel to minimize water quality impacts to the river during placement of the backfill.

### 5.2.5 Demolition Methods, Estimated Equipment and Workforce

The following demolition methods, estimated equipment requirements, and estimated workforce requirements have been assumed for planning purposes based on similar projects and engineering judgment. Alternative methods, equipment, and workforce that would also meet project requirements are possible and could be refined by the selected contractor.

#### 5.2.5.1 Demolition Methods

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 lower portion of the concrete spillway section would be removed by hoe-ramming or by drilling and blasting in the dry. Drilling for blasting would include small- to mid-sized hydraulic track drills and perhaps air-track drills supported by 850 to 1,200 cubic feet per minute (CFM) 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 or 12 to 15 ton tandem-axle highway trucks to the scour hole below the 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 an approved off-site disposal area.

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 CY excavators to reach the required average production rate of 400 CY per hour, or 16,000 CY per week (5 days per week, single shift) for removal of the dam embankment within 8 to 9 weeks. Dozers are expected to be used for knockdown and grading at the disposal sites as well as to support higher production, mass excavation operations.

#### 5.2.5.2 Estimated Equipment and Workforce Requirements

The estimated equipment that would be used for the removal of J.C. Boyle Dam and Powerhouse and for restoration of the reservoir area pre and post- drawdown are shown in Table 5.2-2.

### Table 5.2-2 J.C. Boyle Dam and Powerhouse, Estimated Equipment List

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

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.

### 5.2.6 Imported Materials

Some materials will need to be imported to the site to support dam removal. The most likely materials to be imported include gravel surfacing from a commercial quarry for temporary haul roads (approximately 2,800 tons, 100 truck trips), seed and mulch materials, and minor quantities of ready-mix concrete and reinforcing steel from local commercial sources for tunnel plugs.

### 5.2.7 Waste Disposal

Estimated quantities of materials generated during removal of J.C. Boyle Dam and Powerhouse, numbers of truck trips, and approximate haul distances for waste disposal are shown in Table 5.2-3. Excavated concrete will be placed in the scour hole below the emergency spillway. Excavated embankment materials will primarily be placed in the right abutment disposal area. Reinforcing steel would be separated from the concrete prior to placement in the scour hole and hauled to a local recycling facility. All mechanical and electrical equipment would be hauled to a suitable commercial landfill or salvage collection point.

### Table 5.2-3 Waste Disposal for Full Removal of J.C. Boyle Dam

| Waste Material | In-Situ Quantity | Bulk Quantity [a] | Disposal Site | Peak Daily Trips [c] | Total Trips [d] |
|---|---|---|---|---|---|
| Earth | 102,000 CY | 122,000 CY | Right abutment disposal area | 5 units/160 trips (unpaved road) | 5,600 trips (1 mile RT) |
| | 7,000 CY | 8,000 CY | Powerhouse tailrace | 5 units/160 trips (unpaved road) | 360 trip (8 miles RT) |
| Concrete at: | | | | | |
| Dam | 1,900 CY | 2,600 CY | Forebay spillway scour hole | 2 units/50 trips (unpaved road) | 120 trips (4 miles RT) |
| Power canal | 30,600 CY | 39,800 CY | | | 1,810 trips (2 miles RT) |
| Powerhouse | 4,600 CY | 6,000 CY | | | 270 trips (4 miles RT) |
| Rebar at: | | | | | |
| Dam | 200 tons | --- | Landfill near Klamath Falls | 2 units/10 trips (OR66) | 20 trips (44 miles RT) |
| Power canal | 3,800 tons | | | | 380 trips (48 miles RT) |
| Powerhouse | 100 tons | | | | 10 trips (52 miles RT) |
| Mech. and Elec at: | | | | | |
| Dam | 700 tons | --- | Landfill near Klamath Falls | 2 units/10 trips (OR66) | 90 trips (44 miles RT) |
| Power canal | 300 tons | | | | 40 trips (48 miles RT) |
| Powerhouse | 1,500 tons | | | | 200 trips (52 miles RT) |
| Building Waste | 10 buildings 12,000 $ft^2$ | 2,700 CY | Landfill near Klamath Falls | 2 units/10 trips (OR66) | 270 trips (44 miles RT) |
| Power lines [b] | 3.5 miles of 69-kV | --- | Landfill near Klamath Falls | | |

Notes:

[a] Volumes increased 30 percent for concrete rubble, 20 percent for loose earth materials.

[b] Quantities from Detailed Plan; verification of quantity awaiting further input from PacifiCorp.

[c] Peak daily trips for each site are based on the number of vehicles (units) shown, operating within one 8-hour shift.

[d] Total trips of earthfill and concrete assume off-highway articulated trucks with a nominal load capacity of 22 CY. Total trips for hauling rebar using truck tractor-trailers is based on 10 tons per trip. Total trips for hauling mechanical and electrical items using truck tractor-trailers is based on 8 tons per trip. Total trips for building waste using truck tractor-trailers is based on 10 CY per trip.

Potential commercial landfills or salvage collection points are shown in Table 5.2-4. Potential hazardous materials at J.C. Boyle Dam and Powerhouse and their disposal are discussed in Section 7.7.5.

### Table 5.2-4 Waste Disposal Facilities near J.C. Boyle Dam

| Name of Facility | Location | Distance from Site | Remaining Capacity | Materials Accepted |
|---|---|---|---|---|
| Klamath County landfill | Klamath Falls, OR | 20 miles | 435,000 CY (2010) | construction and demolition waste, asbestos, contaminated soils, and recyclables |

## 5.3 Copco No. 1 Dam and Powerhouse

### 5.3.1 Removal Limits

Copco No. 1 Dam is located within a narrow canyon on the Klamath River at RM 201.8. Minimum requirements for a free-flowing condition and for volitional fish passage on the Klamath River through the Copco No. 1 Dam site requires 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 2463.5, or 20 feet below the existing streambed level at the dam (see Section 3.6), to prevent the development of a potential fish barrier at the site in the future. Features to be removed or potentially retained as PROs are summarized in Table 5.3-1, and shown on Figure 5.3-1(C).

**Figure 5.3-1 Copco No. 1 and Copco No. 2 Dams Removal Features and Limits (Appendix C)**

**Table 5.3-1 Copco No. 1 Dam and Powerhouse, Removal Requirements**

| Feature | Full Removal | Partial Removal Option | Comments[b] |
|---|---|---|---|
| Concrete Dam | Remove[a] | ------ | |
| Spillway Gates, Deck, Piers | Remove | ------ | |
| Penstocks | Remove | Yes | Seal openings, install security fence |
| Powerhouse Intake Structure | Remove | Yes | Seal openings, install security fence |
| Gate Houses on Right Abutment | Remove | Possible | Likely to be removed for access and for large crane for dam removal. |
| Diversion Control Structure | Retain | Yes | Remove gate hoists, stems, and wire ropes, demolish unstable concrete |
| Tunnel Portals | Plug | ------ | Plug with reinforced concrete |
| Powerhouse (incl. mechanical and electrical equipment) | Remove | Yes | If retained would remain in 100 year floodplain |
| Powerhouse Hazardous Materials (transformers, batteries, insulation) | Remove | ------ | |
| Four 69-kV Transmission Lines (3.03 mi total) (incl. poles and transformers) | Remove | ------ | |
| Switchyard | Remove | ------ | |
| Warehouse and Residence | Remove | ------ | |

[a] Remove to El. 2463.5 which is 20 feet below original channel bottom (see Section 3.6).
[b] PROs would involve long-term maintenance costs, including the preservation of any exposed items with coatings containing heavy metals (such as the penstocks).

Retention of the Copco No. 1 Powerhouse as a PRO 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.

### 5.3.2 Construction Access

Construction access roads and associated improvements that may be required for removal of Copco No.1 Dam and Powerhouse, and associated work, are shown on Figure 5.1-1(C) and Figure 5.3-1(C). Existing conditions of the highways, local roads, and structures to be used were observed in the field to identify deficiencies, and determine if improvements are necessary for mobilization and/or hauling during construction and demolition activities. Access road improvements would need to be completed prior to associated construction and removal at the dam and powerhouse.

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.

#### 5.3.2.1 Interstate 5 (I-5)

The Cascade Wonderland Highway (I-5) is classified as an interstate freeway that runs north-south through California and Oregon. The existing Henley Hornbrook interchange (Exit 789) provides access from the freeway to Copco Road. I-5 is a divided roadway with two-lanes on each direction with paved shoulders with a posted speed limit of 70 mph. It is anticipated that I-5 will be used for mobilization of construction equipment and as a haul route to carry demolished materials other than earth and concrete rubble from the dam and powerhouse site to approved commercial landfills. The alignment and pavement are in very good condition and well maintained. Improvements and upgrades to this highway for mobilization or hauling of materials are not anticipated for the Project. Temporary traffic control is also not anticipated. It is anticipated that transportation permits will be required from the department of transportation for mobilizing “wide-load” truck trailers with construction equipment. Hauling permits may be needed if I-5 is used for carrying oversize loads of materials removed from the site.

#### 5.3.2.2 Copco Road

Copco Road is a county road that runs east-west along the Klamath River. Copco Road provides access to various local access roads that lead to Iron Gate Dam and Powerhouse, Copco No. 1 Dam and Powerhouse, and Copco No. 2 Dam and Powerhouse. Copco Road will be a primary hauling and access road for all three California dam sites for transporting materials and equipment. Construction area signs will be required to provide advance warnings to trucks and other road users to improve safety. In addition, road maintenance is anticipated in some areas during construction, where existing pavement is anticipated to be damaged due to construction trucks.

Copco Road is divided up into five sections for discussion of the existing conditions and proposed improvements needed for the project.

### Copco Road from I-5 to Ager Road (3.1 miles)

Copco Road from Interstate 5 to Ager Road is a County road and classified as a major collector. It is a two-way undivided road with pavement in good condition. Improvements and upgrades to this highway for mobilization and hauling are not anticipated for the Project. Pavement rehabilitation may be required during or post-construction. Temporary traffic control will be used for any pavement rehabilitation. This portion of Copco Road includes Cottonwood Creek Bridge.

Cottonwood Creek Bridge is a single span reinforced concrete slab bridge that is approximately 89 feet long and 32 feet wide. The structure has two 12-foot lanes and 4-foot shoulders. It was built in 1980 with an HS20-44 design loading. The structure is supported on pinned diaphragm abutments founded on spread footings. The alignment and deck are in good condition and well maintained. Improvements and upgrades to this structure for mobilization are not anticipated for the Project. Temporary traffic control will not be required.

### Copco Road from Ager Road to Lakeview Road (5 miles)

Copco Road from Ager Road to Lakeview Road is a County road and classified as a minor collector. It is a two-way undivided road with pavement in poor condition and a posted speed limit of 35 mph. Improvements and upgrades to this highway for mobilization and hauling are not anticipated for the Project. Pavement rehabilitation may be required during or post-construction. Temporary traffic control will be used for any pavement rehabilitation. This portion of Copco Road includes Dry Creek Bridge (Caltrans Bridge No. 2C0144).

Dry Creek Bridge is a single span bridge that is approximately 24 feet long and 31 feet wide, and was built in 1960. It has timber beams and a timber deck with an asphalt overlay. The structure has two 14-foot lanes and no shoulders. The structure is supported by seat type abutments. No information is available at this time regarding the foundation type.

The structural members, which are over 55 years old, appear inadequate to carry the current legal/permit loads as well as Project mobilization and hauling trucks. It is anticipated that Dry Creek Bridge will be replaced by a single span bridge of similar length and width as the existing structure. The new bridge structure will be constructed along the existing bridge alignment. A temporary structure and detour over Dry Creek will be constructed to maintain traffic during construction of the replacement bridge. The type of temporary structure over the Dry Creek will be determined during the design phase. Temporary structure options include temporary railcar bridge, box culvert or pipe culvert. See Figure 5.3-2 for the existing bridge location and proposed detour. Minimal impact to the existing traffic is anticipated for the planned improvements. Impact to traffic will be limited to the traffic switch from the existing road alignment to the detour and temporary structure.


*Blue rectangle and hatching shows the extent of existing bridge and location of bridge replacement. Orange hatching shows temporary structure location, and orange lines show roadway detour.*

**Figure 5.3-2 Copco Road Structure Replacement at Dry Creek Bridge**

### Copco Road between Lakeview Road and Daggett Road (9.6 miles)

Copco Road from Lakeview Road to Daggett Road is a County road classified as a minor collector and runs along the norths side of the Klamath River.  It is a two-way undivided county road about 24 feet wide with posted speed limit of 35 mph.  Pavement condition along this stretch is poor and will require pavement maintenance during construction. Improvements and upgrades for this road prior to dam removal are not anticipated. Pavement rehabilitation may be required during or post-construction. Temporary traffic control will be used for any pavement rehabilitation. This portion of Copco Road includes Brush Creek Bridge (Caltrans No. 2C0280) and Jenny Creek Bridge (Caltrans No. 2C0280).

Brush Creek Bridge is a single span 18-inch deep reinforced concrete slab bridge that is approximately 25 feet long and 24 feet wide.  It was built in 1976 with an HS20-44 design loading.  The structure has two12-foot lanes and no shoulders.  The structure is supported on strutted abutments founded on spread footings. The alignment and deck are in fair condition and well maintained.  Improvements and upgrades to this structure for mobilization are not anticipated for the Project. Temporary traffic control is not anticipated. Post project erosion is not anticipated.

Jenny Creek Bridge is a single span precast pre-stressed deck bulb tee girder bridge that is approximately 114 feet long and 27 feet wide (Figure 5.3-3). It was built in 2008 with an HL-93 design loading. The deck has an asphalt overlay with two12-foot lanes with no shoulders. The structure is supported on seat type abutments founded on pile caps with steel H-piles. Abutment 2 has a portion of the previous abutment left in place in front of the new abutment.


**Figure 5.3-3 Jenny Creek Bridge**

The alignment and deck are in very good condition and well maintained. The bridge is suitable for the access and hauling requirements of the project, but it is anticipated to be replaced as a necessary long term improvement with reservoir drawdown. Refer to Section 7.4.3.9 for more details.

### Copco Road from Daggett Road to Copco Access Road (2.6 miles)

Copco Road from Daggett Road to Copco Access Road is classified as a minor collector with a roadway width of 14 feet. The surface is primarily dirt and has very low traffic volume. Major improvements and upgrades prior to dam removal are not anticipated for the Project. Road surface maintenance may be required during or post-construction. Temporary traffic control will be used for any road surface maintenance. This portion of Copco Road includes Fall Creek Bridge (Caltrans Bridge No. 2C0198).

Fall Creek Bridge is a single span bridge with timber beams of unknown age and a concrete deck (Figure 5.3-4). The structure is supported on seat type abutments. No information is available at this time regarding foundation type. Since the superstructure is timber beams of unknown age and the beams appear inadequate to carry the legal/permit loads as well as Project mobilization and hauling trucks. It is anticipated that this structure will be replaced by a single span bridge of similar length and width as the existing structure.

The new bridge structure will be constructed at the existing bridge alignment with a temporary structure and detour of Copco Road to maintain the traffic during construction of the replacement bridge. The type of temporary structure over Fall Creek will be determined during the design phase. The temporary structure options include temporary railcar bridge, box culvert or pipe culvert. See Figure 5.3-5 for the existing bridge location and proposed detour. Impact to traffic will be limited to the traffic switch from the existing road alignment to the detour road and temporary structure.

**Figure 5.3-4 Fall Creek Bridge on Copco Road**


*Orange hatching shows new structure location. Orange lines and blue hatching show temporary structure location and temporary roadway detour.*

## Figure 5.3-5 Fall Creek Bridge Replacement and Temporary Detour

### Copco Road from Copco Access Road to Copco Road Bridge (5.9 miles)

Copco Road from Copco Access Road to Copco Road Bridge is classified as a minor collector with a roadway width of 12 feet. The road surface is primarily dirt and has very low traffic volume. It is anticipated that this portion of Copco Road will not be used for dam or powerhouse removal but will be used for construction access to various post construction improvements, such as culvert replacements and installing rock slope protection. See Section 7.4 for details. Major improvements and upgrades prior to dam removal are not anticipated. Temporary traffic control is also not anticipated. The east end of this segment of Copco Road crosses Copco Lake at Copco Road Bridge (Caltrans No. 2C0039).

Copco Road Bridge is a two span cast-in-place post-tensioned concrete box girder bridge that is approximately 203 feet long and 25 feet wide (Figure 5.3-6). It was built in 1988 for a HS 20-44 truck design load. The structure has two 12-foot lanes and no shoulders. The structure is supported by a pier wall founded on a pile cap with steel H-piles that are grouted into rock. The abutments are diaphragm type founded on a pile cap with steel H-piles. It is anticipated that this structure will not be used for mobilization of construction equipment. The alignment and pavement are in very good condition and well maintained. Improvements and upgrades to this structure for mobilization are not anticipated for the Project. Temporary traffic control is also not anticipated.

**Figure 5.3-6 Copco Road Bridge**

#### 5.3.2.3 Copco Access Road

Copco Access Road between Copco Road and the dam provides access to Copco No. 1 Dam and powerhouse sites and Copco No. 2 Dam site (Figure 5.3-7). The road surface is primarily dirt with a roadway width of 14 feet up to the chain link gate, then past the gate the pavement type changes to asphalt concrete in good condition traversing through Copco No. 1

residential area. Past the residential area, the road surface changes to a dirt road with steep descending hilly terrain towards Copco No. 1 and Copco No. 2 dam sites. The Copco No. 1 Dam access portion is a dirt road with a hairpin bend. It appears landslides have occurred on the hillside above this hairpin bend. A second hairpin bend occurs on the segment down to Copco No. 2 Dam, and a third hairpin bend occurs if travelling between Copco No. 1 Dam and powerhouse.

The lower side of this access road is very steep with no barrier protection. It is anticipated that this segment of the dirt/gravel road will need to be regraded by clearing and grubbing the available space between the toe of the higher hillside and the existing edge of the dirt/gravel road to provide a wider road section for construction and hauling trucks. One-way traffic with turnouts is assumed for the access road. Turnarounds for haul trucks would be at the powerhouse and at the disposal site or the staging area. The average one-way haul distance from the base of the dam to the disposal site is 0.5 miles.

Construction area signage and some temporary traffic control devices are recommended to improve safety during construction. During mobilization, equipment would be off-loaded in the staging area and the equipment would track down to the dam and powerhouse area.

Barge access to the outlet of the diversion tunnel for construction of a new gate structure would occur from the right bank just upstream of the Copco No. 2 Dam.

Barge access to Copco Lake is possible at an existing boat ramp located at Copco Cove on the western shore (Figure 5.1-1(C)). Access to the boat ramp is likely to require minor improvement of the Copco Cove access road for placing the barge-mounted crane on the reservoir. The boat ramp is also likely to require extension into the reservoir to be able to remove the barge following removal of the spillway structure.

#### 5.3.2.4 Ager Beswick Road

Ager Beswick Road between Copco Road to the east and Ager Road to the west is classified as a minor collector road with a posted speed limit of 25mph. It is a two-way undivided County road with pavement condition ranging from fair to good. The road is not anticipated to be used for hauling but may be used for mobilization of a barge-mounted crane from the existing boat ramp at Mallard Cove on the southern shore. Upgrades and improvements to this road prior to dam removal are not anticipated for the Project. Access to the boat ramp is likely to require minor improvements to the access road off of Ager Beswick Road to enable placing a barge-mounted crane in the reservoir. The boat ramp is also likely to require extension into the reservoir to be able to remove the barge following removal of the spillway structure. Temporary traffic control is not anticipated.

**Figure 5.3-7 Copco Access Road**

### 5.3.3 Staging Areas and Disposal Sites

Construction staging areas and a disposal site for removal of Copco No.1 Dam and Powerhouse are shown within the limits of work on Figure 5.3-1(C) and are discussed in the following sections. The contractor will have to mobilize construction equipment to the site by about June of the year prior to drawdown to prepare the staging areas and disposal site, and construct the diversion tunnel improvements described in Section 4.2.

#### 5.3.3.1 Staging Areas

The primary 2.3 acre staging area will be located on the right abutment near the existing switchyard as shown on Figure 5.3-1(C), Sheet 1. Two smaller staging areas are located in the same vicinity (0.6 acre across the road and 0.46 acre by the penstocks).

#### 5.3.3.2 Disposal Sites

A single disposal site, located on the right abutment at the current location of a maintenance building and a vacant residence (Figure 5.3-1(C) and Figure 5.3-8(C)), would be used for concrete debris generated from the removal of the dam and powerhouse. The disposal area covers an area of approximately 3.5 acres. The disposed site would be graded as a hill (maximum fill height of about 55 feet) contoured to blend into the surrounding topography as shown in plan and section on Figure 5.3-1(C), Sheet 1. Preparation of the disposal area would include clearing of vegetation, demolition of the two structures, removal of transmission lines, and stripping and stockpiling of excavated topsoil for later use. After placement of the concrete debris (without rail and rebar), the on-site disposal area would be covered with topsoil and the excavated embankment material from Copco No. 2 Dam (see Section 5.4), graded, sloped for drainage, and hydroseeded. Compaction of materials placed in the disposal area other than by bulldozers spreading the materials and equipment travel would not be required. See Section 6 for additional detail associated with restoration. Erosion monitoring will be completed on an annual basis for 5 years following placement to assess whether significant erosion and slope deterioration has occurred. If significant erosion occurs, the eroded area shall be repaired to the satisfaction of the appropriate regulatory agency.

**Figure 5.3-8 Copco No. 1 & Copco No. 2 Disposal Site Plan & Sections (Appendix C)**

### 5.3.4 Copco No. 1 Dam and Powerhouse Removal

Common to both options are removal of the spillway gates and operators, the spillway bridge deck, and the spillway piers in December 2019 as the reservoir is drawn down to below the spillway crest (completed January 1, 2020). With the reservoir drawn down to approximate elevation 2590, a barge-mounted crane would be used to remove all 13 spillway gates and operators, spillway bridge deck, and spillway gate piers in the dry. The barge-mounted crane would then be removed from the site.

As the reservoir is drawn down through the new large gate structure at the downstream end of the diversion tunnel, the following work would be performed:

1. Close the penstock gates and demolish the right abutment gate houses and mobilize large crane to the right abutment above the dam to provide construction access and support for dam removal.
2. Demolish the penstocks, remove the mechanical and electrical equipment from the powerhouse, and demolish the above grade portion of the powerhouse and prepare it for use as a part of construction access to the downstream side of the dam.
3. The following activities would occur after May 15 of the drawdown year.
4. Excavate the dam in lifts (assumed to be 12-foot high) between abutments in the dry (Figure 5.3-9(B)). Drop concrete rubble to the base of the dam to form a temporary access between the dam base and the powerhouse. Haul concrete rubble by truck from the base of the dam to the disposal site on right abutment (Figure 5.3-1(C), Sheet 1).

5. Remove concrete in powerhouse intake structure on the right abutment in the dry concurrent with dam demolition. Extend temporary access road to the dam toe upstream for removal of the concrete rubble from the intake structure.
6. Construct and 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.
7. Demolish remaining portion of powerhouse and remove all rubble using trucks along access road. Use sump pumps to unwater low areas as required.
8. Remove cofferdams from river channel when no longer needed.
9. Plug upstream diversion tunnel intake.
10. Demolish new diversion gate structure and plug downstream portal of the diversion tunnel with concrete.
11. Restore dam site, staging area, and concrete disposal site. Place topsoil and seed where required.
12. Demobilize from site.

**Figure 5.3-9 Copco No. 1 Dam Removal (Appendix B)**

### 5.3.5 Demolition Methods, Estimated Equipment and Workforce

The following demolition methods, estimated equipment requirements, and estimated workforce requirements have been assumed for planning purposes based on engineering judgment. Alternative methods, equipment, and workforce that would also meet project requirements are possible and could be refined by the selected contractor.

#### 5.3.5.1 Demolition Methods

The concrete gravity arch dam was constructed with large (cyclopean) boulders placed in the concrete matrix, and reinforced throughout with an estimated 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 CY of concrete). Dam demolition would likely be performed in horizontal lifts using conventional drilling and blasting methods. Drilling, using small air track or hydraulic track drills that could safely operate on the dam crest, would likely control overall production. Up to five drill crews would be required working two 8-hour shifts 5-days per week. Production would be impacted by the need for redrilling where rail steel is encountered. Blasting is estimated to occur an average of between three and six shots per day for up to 16 weeks depending on which option for reservoir drawdown and dam removal is used.

Acetylene torches would be needed to cut rail steel in the dam. A large crawler-mounted crane would likely be used on the right abutment to help remove the rail steel from the dam. A sheet-pile or H-pile cofferdam would 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, and hauling. Concrete rubble would likely be loaded into articulated off-road rock trucks having a haul capacity of 30 tons, using either a hydraulic track excavator or a front-end loader. 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 CY in-place volume) to be removed from the dam within approximately 16 weeks.

Mass concrete in the right abutment intake structure would probably be removed in lifts, similar to the concrete in the dam, 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 the powerhouse deck, wall, and floor slabs would be excavated by mechanical methods (e.g. hydraulic shears and hoe-ramming).

#### 5.3.5.2 Estimated Equipment and Workforce Requirements

The estimated equipment that would be used for the removal of Copco No. 1 Dam and Powerhouse and for restoration of the reservoir area is shown in Table 5.3-2.

### Table 5.3-2 Copco No. 1 Dam and Powerhouse, Estimated Equipment List

| Name of Equipment | Pre Draw Down | Post Draw Down |
|---|---|---|
| Crawler-mounted lattice boom crane, 100 to 120 ton, 160- to 200-foot boom | X | X |
| Rough terrain hydraulic crane, 35 to 75 ton | X | X |
| Mid-size hydraulic excavator, 28,000 to 60,000 lb, 1 to 2 CY bucket | X | X |
| Cat 336 hydraulic track excavator, 80,000 lb, 3.5 CY bucket | | X |
| Hydraulic track excavators, 65,000 to 120,000 lb, with Cat H120 hoe-ram, thumb and shear attachments | | X |
| Cat 966 (52,000 lb, 5 CY bucket) or Cat 988 (65,000 lb, 6 CY bucket) articulated wheel-loaders | | X |
| Cat 725 or Cat 730 articulated rear dump trucks, 30 ton (22 CY) | X | X |
| D-6 or D-7 standard crawler dozers | X | X |
| Front-end wheel loader, integrated tool carrier, 25,000 lb | | X |
| Cat TL943 rough terrain telescoping forklift | X | X |
| Rough terrain telescoping manlift | | X |
| Cat 140 motorgrader | | X |
| Flexifloat sectional barges | X | X |
| Truck-mounted seed sprayer, 2500 gallon | | X |
| On-highway, light duty diesel pickup trucks, ½ ton and 1 ton crew | X | X |
| On-highway flatbed truck with boom crane, 16,000 lb | X | X |
| On-highway truck tractors, 45,000 lb | X | X |
| Off-highway water tanker, 5,000 gallon | | X |
| On-highway water truck, 4,000 gallon | | X |
| Engine generators, 6.5 KW to 40 KW, diesel or gasoline | X | X |

| Name of Equipment | Pre Draw Down | Post Draw Down |
|---|---|---|
| Air compressors, 100 psi, 185 to 600 cfm, diesel | X | X |
| Airtrack drill or hydraulic track drill | | X |
| Hand-held drilling, cutting, and demolition equipment | X | X |
| Portable welders and acetylene torches | X | X |
| 4-inch submersible trash pumps, electric | X | X |
| Light plants, 2,000 to 6,000 watt, 10 to 25 hp, diesel | | X |

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. The peak workforce required during demolition of the concrete dam could reach 50 to 55 people.

### 5.3.6 Imported Materials

Some materials will need to be imported to the site to support dam removal. The most likely materials to be imported include gravel surfacing from a commercial quarry for temporary haul roads (approximately 320 tons, 10 truck trips), sheetpile or H-piles for construction of cofferdams, topsoil (approximately 10,200 CY and 850 truck trips assuming 12 CY per truck or tractor trailer), seed and mulch materials, and minor quantities of ready-mix concrete and reinforcing steel from local commercial sources for tunnel plugs. Construction of the new gate structure in the year prior to dam removal would require importing mechanical equipment, and additional reinforcing steel and ready-mix concrete for lining the diversion tunnel and constructing the new gate structure. Construction of the

### 5.3.7 Waste Disposal

Estimated quantities of materials generated during removal of Copco No. 1 Dam and Powerhouse, numbers of truck trips, and approximate haul distances for waste disposal are shown in Table 5.3-3. Excavated concrete will be placed in the on-site disposal site. Rail and reinforcing steel would be separated from the concrete prior to placement in the disposal area and hauled to a local recycling facility. All mechanical and electrical equipment would be hauled to a suitable commercial landfill or salvage collection point.

Potential commercial landfills or salvage collection points are shown in Table 5.3-4. Potential hazardous materials at Copco No. 1 Dam and Powerhouse and their disposal are discussed in Section 7.7.5.

**Table 5.3-3 Waste Disposal for Full Removal of Copco No. 1 Dam**

| Waste Material | In-Situ Quantity | Bulk Quantity [a] | Disposal Site | Peak Daily Trips [c] | Total Trips [d] |
|---|---|---|---|---|---|
| Concrete | 70,100 CY | 97,500 CY | On-site | 2 units/50 trips (unpaved road) | 4,430 trips (2 miles RT) |
| Rebar | 1,000 tons | --- | Transfer station near Yreka | 1 unit/5 trips (Copco Road) | 100 trips (62 miles RT) |
| Mech. and Elec | 1,100 tons | --- | Transfer station near Yreka | 1 unit/5 trips (Copco Road) | 140 trips (62 miles RT) |
| Building Waste | 2 buildings 1,300 $ft^2$ | 300 CY | Transfer station near Yreka | 1 unit/5 trips (Copco Road) | 30 trips (62 miles RT) |
| Power lines [b] | 3.0 miles of 69-kV | --- | Transfer station near Yreka | | |

Notes:

[a] Volumes increased 30 percent for concrete rubble from reinforced concrete and 40 percent from mass concrete.
[b] Quantities from Detailed Plan; verification of quantity still in progress.
[c] Peak daily trips for each site are based on the number of vehicles (units) shown, operating within one 8-hour shift.
[d] Total trips of concrete assume off-highway articulated trucks with a nominal load capacity of 22 cubic yards. Total trips for hauling rebar using truck tractor-trailers is based on 10 tons per trip. Total trips for hauling mechanical and electrical items using truck tractor-trailers is based on 8 tons per trip. Total trips for building waste using truck tractor-trailers is based on 10 CY per trip.

**Table 5.3-4 Waste Disposal Facilities near Copco No. 1 Dam**

| Name of Facility | Location | Distance from Site | Remaining Capacity | Materials Accepted |
|---|---|---|---|---|
| Yreka Transfer Station | Yreka, CA | 30 miles | 3,924,000 CY (2010) | Class III sanitary landfill accepting construction and demolition waste and mixed municipal waste, and<br><br>Medium volume transfer station accepting metals and mixed municipal recyclable materials |

## 5.4 Copco No. 2 Dam and Powerhouse

### 5.4.1 Removal Limits

Copco No. 2 Dam is located within a narrow canyon on the Klamath River at RM 201.5. Minimum requirements for a free-flowing condition and for volitional fish passage on the Klamath River through the Copco No. 2 Dam site would require the removal of the concrete gated spillway structure and concrete end sill between the existing sidewalls. Features to be removed or potentially retained as PROs are summarized in Table 5.4-1and as shown on Figure 5.3-1(C).

## Table 5.4-1 Copco No. 2 Dam and Powerhouse, Removal Requirements

| Feature | Full Removal | Partial Removal Option | Partial Removal Option Description[a] |
|---|---|---|---|
| Concrete Dam | | | |
| Spillway Gates, Structure | Remove | ------ | |
| Power Penstock Intake Structure and Gate | Remove | Yes | Seal openings, install security fence |
| Tunnel Portals | Concrete Plug | Yes | Intake structure gate could be closed |
| Embankment Section and right sidewall | Remove | ------ | |
| Basin Apron and End Sill | Remove | ------ | |
| Remnant Cofferdam Upstream of Dam | Remove | ------ | |
| Wood-stave Penstock | Remove | ------ | |
| Concrete Pipe Cradles | Remove | Yes | |
| Steel Penstock, Supports, Anchors | Remove | Yes | Could be retained for historic purposes Seal openings, install security fence |
| Powerhouse (incl. mechanical and electrical equipment) | Remove | Yes | Could be retained for historic purposes Seal openings, install security fence |
| Powerhouse Hazardous Materials (transformers, batteries, insulation) | Remove | ------ | |
| Powerhouse Control Center Building, Maintenance Building, Oil and Gas Storage Building | Remove | ------ | |
| 69-kV Transmission Line, 0.14 mi | Remove | ------ | |
| Switchyard | Retain | ------ | Must remain in service with 230-kV switchyard on north side of river |
| Tailrace Channel | Backfill | ------ | |
| Copco Village (incl. Former Cookhouse/Bunkhouse, Modern Bunkhouse, Garage/Storage Building, Bungalow with Garage, 3 Modular Houses, 4 Ranch-Style Houses, and School house/Community Center) | Remove | ------ | |

[a] Partial removal options would involve long-term maintenance costs, including the preservation of any exposed items with coatings containing heavy metals (such as the penstocks).

Retention of the Copco No. 2 Powerhouse as a PRO 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.

### 5.4.2 Construction Access

Construction access roads and associated improvements that may be required for removal of Copco No.2 Dam would be the same as for Copco No. 1 Dam and Powerhouse as shown on Figure 5.1-1(C) and Figure 5.3-1(C) and as discussed in Section 5.3.2. The construction access roads for removal of Copco No.2 Powerhouse and the wood-stave penstock are shown within the limits of work on Figure 5.3-1(C), and are discussed in the following sections. Access road improvements would need to be completed prior to associated construction and removal at the dam and powerhouse.

#### 5.4.2.1 Copco Road

Copco Road from I-5 provides the primary access to Copco No. 2 Dam and Powerhouse. Refer to Section 5.3.2 Copco No. 1 Dam construction access for more details. The main haul and access road included in that section is applicable to Copco No. 2 Dam. The average one-way haul distance from Copco No. 2 dam to the disposal site is approximately 0.3 miles.

The delivery of off-road construction equipment, including cranes, large excavators, and loaders would be by special tractor-trailer vehicles operating under “wide load” restrictions and at appropriate speeds. Equipment used for dam removal would be off-loaded in the staging area and the equipment would track down to the dam under their own power.

#### 5.4.2.2 Daggett Road

Copco No. 2 Powerhouse and the wood-stave penstock are accessed from Copco Road via Daggett Road. Daggett Road is a gravel access road with a roadway width of 14 feet. The surface is primarily dirt and has very low traffic volume. One-way traffic with turnouts is assumed for the access roads, for an average haul distance of 0.5 miles from the powerhouse to the bridge. Major improvements and upgrades prior to dam removal are not anticipated for the Project. Road surface maintenance may be required during or post-construction. Temporary traffic control will not be required because this is not a public road. This portion of Daggett Road includes Daggett Road Bridge.

The delivery of off-road construction equipment, including cranes, large excavators, and loaders would be by special tractor-trailer vehicles operating under “wide load” restrictions and at appropriate speeds. Equipment used for dam removal would be off-loaded in the staging area and the equipment would track down to the dam under their own power. Equipment used for removal of the powerhouse and wood-stave penstock would be off-loaded in Copco Village and the equipment would track down to the powerhouse area and wood-stave penstock under their own power.

#### 5.4.2.3 Daggett Road Bridge

Daggett Road Bridge is four span continuous steel bridge that utilizes rolled beams in the approach spans and a riveted steel plate girder for the main span. The structure has a timber deck and railings and is approximately 233 feet long and 14 feet wide. It has one 12-foot lane and no shoulders. The structure is supported on concrete pier walls at Bents 3 and 4 that are founded on what appears to be rock masonry footings. Bent 1 is composed of steel H-pile extensions with a steel cap. The abutments are seat type. The main span girder and Bents 3 and 4 were constructed in, approximately, 1924 and incorporated into the reconstructed structure in 1983. The reconstructed structure was built for a HS20 truck design load. The structure has been posted with load limits based upon an unknown analysis. No information is available at this time regarding the foundations.

It is anticipated that this structure will be used for mobilization of construction equipment and for hauling of demolished materials to commercial landfills. Because the bridge has been posted with a reduced load limit that is less than the current legal/permit loads on bridges and the loads of vehicles that will use it for the Project, it is anticipated that this structure will need to be replaced by a bridge of similar length and width as the existing structure. The new structure will be constructed adjacent to the existing bridge on a revised alignment and the old bridge removed after completion of the new structure. The approach roadway will be realigned slightly for the new bridge location (Figure 5.4-1). Impacts to traffic will be limited to the traffic switch from the existing road alignment to the new one.

### 5.4.3 Staging Areas and Disposal Sites

Staging areas and disposal sites for removal of Copco No.2 Dam would be the same as for Copco No. 1 Dam and Powerhouse as shown on Figure 5.3-1 (C) and as discussed in Section 5.3.3. The staging areas and disposal sites for removal of Copco No.2 Powerhouse and the wood-stave penstock are shown within the limits of work on Figure 5.3-1(C), Sheet 2 and are discussed in the following sections.

#### 5.4.3.1 Staging Areas

Equipment staging areas for dam removal would be the same as described for Copco No. 1 (see Section 5.3.3). Work areas for removal of the wooden lathe penstock and the powerhouse would be as shown on Figure 5.3-1(C), Sheets 2 and 3. An additional 0.9 acre staging area is located at the powerhouse.

#### 5.4.3.2 Disposal Sites

Concrete rubble generated from removal of Copco No. 2 Dam will be permanently buried in the disposal site described in Section 5.3.3.2 for Copco No. 1. Earth materials generated from removal of Copco No. 2 Dam would be used as cover over the concrete rubble in the disposal site.


*Orange hatching shows new structure location, and orange lines show realigned roadway approaches.*

**Figure 5.4-1 Daggett Road Bridge Replacement**

Concrete rubble generated from removal of the Copco No. 2 Powerhouse will be permanently buried in the powerhouse tailrace covering an area of about 1 acre. After placement of the concrete rubble (sans rail and rebar), the on-site disposal area would be covered with materials excavated from nearby areas that were graded around the powerhouse facilities during original construction, graded, sloped for drainage, and hydroseeded. Compaction of materials placed in the tailrace channel other than by bulldozers spreading the materials and equipment travel would not be required. Erosion monitoring will be completed on an annual basis for 5 years following placement to assess whether significant erosion and slope deterioration has occurred. If significant erosion occurs, the eroded area shall be repaired to the satisfaction of the appropriate regulatory agency.

### 5.4.4 Copco No. 2 Dam and Powerhouse Removal

#### 5.4.4.1 Dam Removal

Dam removal would begin on about May 1of the drawdown year by closing the caterpillar gate at the power penstock intake structure to stop releases to Copco No. 2 Powerhouse and cease power generation. Controlled releases would be made through the gated spillway (crest elevation 2476.5) during the low flow period to draw the reservoir down from RWS elevation 2486.5 to RWS elevation 2481.5 in one day using the two right-hand side spillway gates. Remove of the dam would include the following steps.

1. Remove equipment and concrete pad from dike crest to provide room for demolition equipment and for construction access.
2. Construct a temporary cofferdam within the river channel to isolate the two left-hand spillway bays and the power penstock intake structure (see Figure 5.4-2(B)). Remove the spillway gates, hoists, bridge deck, and concrete crest structure to elevation 2457.5 in the dry. Remove trash racks, caterpillar gate, and concrete structure, and construct tunnel plug in the dry. Restore left river bank. Remove temporary cofferdam and allow reservoir to stabilize at approximately RWS elevation 2463.5 through left-hand dam breach.
3. Construct a second temporary cofferdam within the river channel to isolate the three remaining spillway bays on the right-hand side (Figure 5.4-2 (B)). Remove the spillway gates, hoists, bridge deck, and concrete crest structure to elevation 2457.5 in the dry. Remove earth embankment. Remove temporary cofferdam.
4. Complete any remaining demolition work as required. Restore Dam site and on-site disposal area (shared with Copco No. 1 demolition) as required by October post-drawdown, including the placement of topsoil and seeding. Demobilize from site.

**Figure 5.4-2 Copco No. 2 Dam Removal (Appendix B)**

#### 5.4.4.2 Powerhouse and Wood-Stave Penstock

Removal of the wooden stave penstock and powerhouse would occur following closure of the caterpillar gate and shutdown of the powerhouse on about May 1 of the drawdown year, as follows:

1. Remove wood-stave penstock and concrete features and construct reinforced concrete tunnel plugs at the tunnel portal at each end of the wood-stave penstock.
2. Construct cofferdam in tailrace channel for removal of powerhouse in the dry during low flow period. Use sump pumps to unwater area. Leave cofferdam in place within tailrace channel and backflll to restore left river bank.

### 5.4.5 Demolition Methods, Estimated Equipment and Workforce

The following demolition methods, estimated equipment requirements, and estimated workforce requirements have been assumed for planning purposes based on engineering judgment. Alternative methods, equipment, and workforce that would also meet project requirements are possible and could be refined by the selected contractor.

#### 5.4.5.1 Demolition Methods

The spillway gates and traveling hoists would be removed by a large crane for loading onto highway trucks and heavy-haul trailers. 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 dewatered. Drilling for blasting would include small- to mid-sized hydraulic track drills and perhaps air-track drills supported by 850 to 1,200 CFM 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. 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).

#### 5.4.5.2 Estimated Equipment and Workforce

The estimated equipment that would be used for the removal of Copco No. 2 Dam and Powerhouse and for restoration of the reservoir area is shown in Table 5.4-2.

**Table 5.4-2 Copco No. 2 Dam and Powerhouse, Estimated Equipment List**

| Name of Equipment | Pre Draw Down | Post Draw Down |
|---|---|---|
| Crawler-mounted lattice boom crane, 100 to 120 ton, 160- to 200-foot boom | | X |
| Rough terrain hydraulic crane, 35 to 75 ton | X | X |
| Mid-size hydraulic excavator, 28,000 to 60,000 lb, 1 to 2 CY bucket | X | X |
| Cat 336 hydraulic track excavator, 80,000 lb, 3.5 CY bucket | | X |
| Hydraulic track excavators, 65,000 to 120,000 lb, with Cat H120 hoe-ram, thumb and shear attachments | | X |
| Cat 966 (52,000 lb, 5 CY bucket) or Cat 988 (65,000 lb, 6 CY bucket) articulated wheel-loaders | | X |
| Cat 725 or Cat 730 articulated rear dump trucks, 30 ton (22 CY) | | X |
| D-6 or D-7 standard crawler dozers | | X |
| Front-end wheel loader, integrated tool carrier, 25,000 lb | X | X |
| Cat TL943 rough terrain telescoping forklift | X | X |
| Rough terrain telescoping manlift | X | X |
| On-highway, light duty diesel pickup trucks, ½ ton and 1 ton crew | X | X |
| On-highway flatbed truck with boom crane, 16,000 lb | X | X |
| On-highway truck tractors, 45,000 lb | X | X |
| Off-highway water tanker, 5,000 gallon | | X |
| On-highway water truck, 4,000 gallon | X | X |
| Engine generators, 6.5 KW to 40 KW, diesel or gasoline | X | X |
| Air compressors, 100 psi, 185 to 600 cfm, diesel | X | X |
| Airtrack drill or hydraulic track drill | | X |
| Hand-held drilling, cutting, and demolition equipment | X | X |
| Portable welders and acetylene torches | X | X |
| 4-inch submersible trash pumps, electric | X | X |

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.

### 5.4.6 Imported Materials

Some materials will need to be imported to the site to support dam removal. The most likely 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.

### 5.4.7 Waste Disposal

Estimated quantities of materials generated during removal of Copco No. 2 Dam and Powerhouse, numbers of truck trips, and approximate haul distances for waste disposal are shown in Table 5.4-3. Concrete rubble generated during dam removal would be placed within the same on-site disposal area on the right abutment (Figure 5.3-1(C), Sheet 1) used for Copco No. 1 Dam. Excavated embankment material would be used as topsoil to cover the on-site disposal area after grading and being sloped for drainage. Concrete rubble resulting from demolition of the powerhouse would be buried within the existing tailrace channel. Reinforcing steel would be separated from the concrete prior to placement in the disposal area or tailrace channel and hauled to a local recycling facility. All mechanical and electrical equipment would be hauled to a suitable commercial landfill or salvage collection point.

**Table 5.4-3 Waste Disposal for Full Removal of Copco No. 2 Dam**

| Waste Material | In-Situ Quantity | Bulk Quantity [a] | Disposal Site | Peak Daily Trips | Total Trips |
|---|---|---|---|---|---|
| Earth | 1,800 CY | 2,200 CY | On-site | 2 units/50 trips (unpaved road) | 100 trips (2 miles RT) |
| Concrete at dam | 6,600 CY | 8,500 CY | On-site | 2 units/50 trips (unpaved road) | 390 trips (2 miles RT) |
| Concrete at powerhouse | 6,300 CY | 8,100 CY | Tailrace area | Dispose at site (no hauling) | 0 |
| Rebar at:<br>Dam<br>Powerhouse | 300 tons<br>100 tons | --- | Transfer station near Yreka, CA | 1 unit/5 trips (Copco Road) | 30 trips (62 miles RT)<br>10 trips (56 miles RT) |
| Mech. And Elec at:<br>Dam<br>Powerhouse | 300 tons<br>1,900 tons | --- | Transfer station near Yreka, CA | 1 unit/5 trips (Copco Road) | 40 trips (62 miles RT)<br>240 trips (56 miles RT) |
| Building Waste | XX buildings 10,6000 $ft^2$ | 2300 CY | Transfer station near Yreka, CA | 1 unit/5 trips (Copco Road) | 230 trips (56 miles RT) |
| Treated wood (wood-stave penstock) | 700 tons | | Landfill near Anderson, CA | 1 unit/2 trips (Interstate 5) | 70 trips(140 miles RT) |

| Waste Material | In-Situ Quantity | Bulk Quantity [a] | Disposal Site | Peak Daily Trips | Total Trips |
|---|---|---|---|---|---|
| Power lines [b] | 0.14 miles of 69-kV | --- | Transfer station near Yreka, CA | | |

Notes:

[a] Volumes increased 30 percent for concrete rubble, 20 percent for loose earth materials.
[b] Quantities from Detailed Plan; verification of quantity still in progress.
[c] Peak daily trips for each site are based on the number of vehicles (units) shown, operating within one 8 hour shift.
[d] Total trips of earthfill or concrete assume off-highway articulated trucks with a nominal load capacity of 22 CY. Total trips for hauling rebar using truck tractor-trailers is based on 10 tons per trip. Total trips for hauling mechanical and electrical items using truck tractor-trailers is based on 8 tons per trip. Total trips for building waste using truck tractor-trailers is based on 10 CY per trip.

Potential commercial landfills or salvage collection points are shown in Table 5.4-4. Potential hazardous materials at Copco No. 2 Dam and Powerhouse and their disposal are discussed in Section 7.7.5.

**Table 5.4-4 Waste Disposal Facilities near Copco No. 2 Dam**

| Name of Facility | Location | Distance from Site | Remaining Capacity | Materials Accepted |
|---|---|---|---|---|
| Yreka Transfer Station | Yreka, CA | 30 miles | 3,924,000 CY (2010) | Class III sanitary landfill accepting construction and demolition waste and mixed municipal waste, and<br><br>Medium volume transfer station accepting metals and mixed municipal recyclable materials |

## 5.5 Iron Gate Dam and Powerhouse

### 5.5.1 Removal Limits

Iron Gate Dam is located in a relatively narrow canyon on the Klamath River at RM 193.1. Minimum requirements for a free-flowing condition and for volitional fish passage on the Klamath River through the Iron Gate Dam site require the complete removal of the zoned earthfill embankment, concrete cutoff walls, and fish trapping and holding facilities located on random fill downstream of the dam between the rock abutments 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. Features to be removed or retained for the dam removal alternatives are summarized in Table 5.5-1 and shown on Figure 5.5-1(C).

The lower portion of the outdoor-type powerhouse, if retained as a Partial Removal Option would be within the 100-year floodplain.

### Table 5.5-1 Iron Gate Dam and Powerhouse, Removal Requirements

| Feature | Full Removal | Partial Removal Options | Partial Removal Option Description |
|---|---|---|---|
| Embankment Dam, Cutoff Walls | Remove | ------ | |
| Penstock Intake Structure and Footbridge | Remove | ------ | |
| Penstock | Remove | ------ | |
| Water Supply Pipes and Aerator | Remove | ------ | |
| Spillway Structure | Retain | ------ | Bury to extent practicable |
| Powerhouse (incl. mechanical and electrical equipment) | Remove | Yes | Lower portion with openings sealed |
| Powerhouse Hazardous Materials (transformers, batteries, insulation) | Remove | ------ | |
| Powerhouse Tailrace Area | Backfill | ------ | |
| Fish Facilities on Dam (fish ladder and trapping and holding facilities) | Remove | ------ | |
| Fish Hatchery | Retain | ------ | See Section 8.10 |
| Switchyard | Remove | ------ | |
| Diversion Tunnel Intake Structure and Footbridge | Remove | ------ | |
| Diversion Tunnel Portals | Concrete Plug | ------ | |
| Diversion Tunnel Control Tower, Hoist, and Gate | Remove | ------ | |

### Figure 5.5-1 Iron Gate Dam Removal Features and Limits (Appendix C)

Retention of the Iron Gate Powerhouse as a PRO 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.

### 5.5.2 Construction Access

Construction access roads and associated improvements that may be required for removal of Iron Gate Dam and Powerhouse are shown within the limits of work on Figure 5.5-1(C) and are discussed in the following sections. The conditions and improvements needed for Copco

Road are discussed in Section 5.3.2. Existing conditions of the local roads and structures to be used were observed in the field to identify deficiencies and determine if improvements are necessary for mobilization and/or hauling during construction and demolition activities of the Iron Gate Dam and Powerhouse. The assessments are discussed in the following sections. Access road improvements would need to be completed prior to associated construction and removal at the dam and powerhouse.

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.

#### 5.5.2.1 Lakeview Road between Copco Road and the Disposal Site

Lakeview Road is a gravel access road approximately 24 feet wide, running between Copco Road and the disposal site just east of Iron Gate Reservoir (Figure 5.5-2). The posted speed limit is 20 mph. The gravel road surface is in stable condition and suitable for construction use. The road (with the powerhouse access road) could be used for one-way hauling traffic with turnouts and would have an average one-way haul distance of 1.4 miles from the dam to the center of the disposal site. Improvements and upgrades for mobilization and hauling are not anticipated for the project. Road surface maintenance may be required during or post-construction. Temporary traffic controls would be required during maintenance activities. This portion of Lakeview Road includes Lakeview Road Bridge (Caltrans Bridge No. 2C0255).

#### 5.5.2.2 Lakeview Road Bridge

Lakeview Road Bridge is a nine span simply supported rolled steel beam bridge constructed in 1960, and is approximately 272 feet long and 14.5 feet wide. It has a reinforced concrete deck with one 12-foot lane and no shoulders. The structure is posted with load limits following an investigation by the California Department of Transportation (Caltrans), Structure Maintenance and Investigation that was requested by the Siskiyou County Department of Public Works. The structure is supported on bents composed of timber pile extensions with timber or steel caps and timber abutments. No information is available at this time regarding the foundations.

Because the bridge has been posted with a reduced load limit that is less than the current legal/permit loads on bridges and loads of vehicles that will use it for the Project, it is anticipated that this structure will be replaced. The new bridge will be similar in length and width and constructed on a revised alignment adjacent to the existing bridge (Figure 5.5-3). The old bridge will be removed after completion of the new bridge. The approach roadway will be realigned slightly for the new bridge location. The impact to traffic will be limited to the switch from the existing road alignment to the new one.

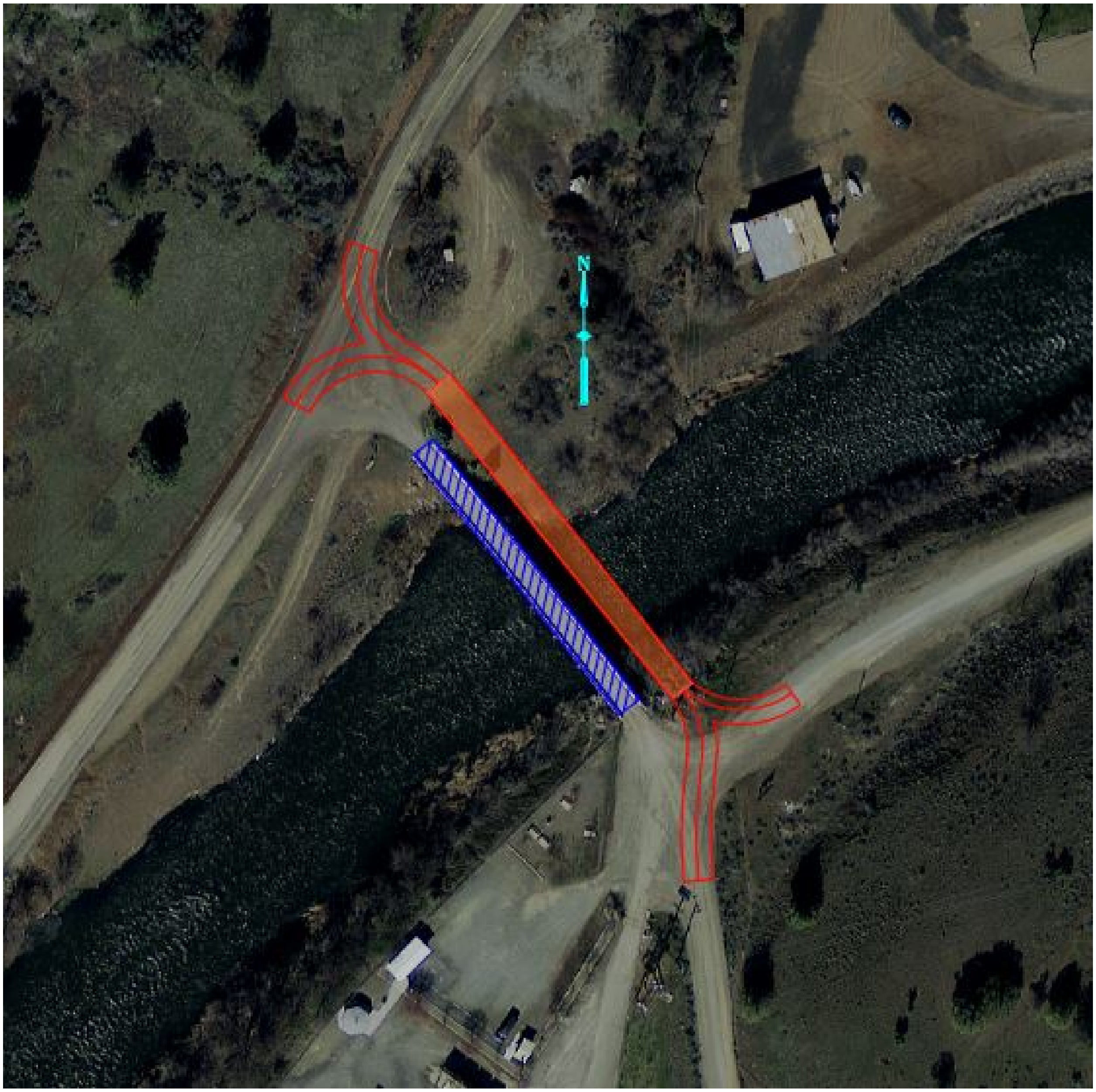

**Figure 5.5-2 Lakeview Road**

### 5.5.2.3 Powerhouse Access Road

The powerhouse access road is located immediately to the east of the Lakeview Road bridge south abutment, and it runs east-west between Lakeview Road and the Iron Gate powerhouse. The road has a gravel surface between Lakeview Road intersection and the security swing gate. East of the security gate, the road is asphalt concrete about 14 feet wide and in good condition. It is anticipated that this road will be used as a haul route. Improvements and upgrades for mobilization and hauling are not anticipated for the project. Road surface maintenance may be required during or post-construction. Temporary traffic controls would be required during maintenance activities. Additional signage and stop control along the access road approach to the Lakeview Road intersection will be provided during construction.

### 5.5.2.4 Left Abutment Access Road

This access road runs between Lakeview Road and the left abutment of the dam. It is a gravel road about 24 feet wide. The road surface is in fair condition. It is anticipated that this road will be used as a haul route to the proposed disposal site. Improvements and upgrades to this road are not anticipated for the Project. Temporary traffic control will not be required as this is not a public road. This access road and ramps will be restored at the completion of dam removal.




*Blue rectangle and hatching shows the extent of existing bridge. Orange hatching shows new structure location, and orange lines show the realigned roadway approaches.*

**Figure 5.5-3 Lakeview Road Bridge Replacement**

#### 5.5.2.5 Upstream Left Abutment Access Road

The original haul route from an upstream borrow area to the dam will be reopened once the reservoir has been drawn down. This will allow two-way traffic to the north side of the disposal site with an average haul distance of 0.9 miles from the dam to the disposal site. As the dam embankment excavation descends, the original ramps out of the canyon that were used during original construction may be able to be reused. This access road and ramps will be restored at the completion of dam removal.

### 5.5.3 Staging Areas and Disposal Sites

Construction staging areas and disposal sites for removal of Iron Gate Dam and Powerhouse are shown within the limits of work on Figure 5.5-1(C), Sheets 1 and 2 and are discussed in the following sections. The contractor will have to mobilize construction equipment to the site by June of the drawdown year to prepare the staging and disposal areas, and to construct the diversion tunnel improvements described in Section 4.4.4 for subsequent dam removal after drawdown.

#### 5.5.3.1 Staging Areas

Staging areas that could be used for equipment or material staging include 7.7 acres above the left abutment of the dam, 1.4 acres southwest of the disposal site, and 1.4 acres northeast of the disposal site as shown on Figure 5.5-1(C), Sheet 2. Also shown on Figure 5.5-1(C), Sheet 1 is 1.9 acres near the right abutment downstream of the dam (currently occupied by two PacifiCorp residences and some outbuildings) that could be used for construction offices. The staging areas would be prepared by clearing vegetation and minor grading, and would be restored by minor grading and hydroseeding. See Section 6 for additional detail concerning restoration. Staging of mechanical and electrical debris would likely occur at the downstream toe of the dam in the parking area and the area of the fish collection facilities.

#### 5.5.3.2 Disposal Sites

Most of the earth materials and all of the concrete rubble generated from removal of the Iron Gate facilities will be permanently buried on-site in a disposal site covering about 36 acres located on PacifiCorp property about 1 mile south of the dam. The disposed material would be graded to conform to the existing topography as shown in Figure 5.5-1(C), Sheet 2 and Figure 5.5-4 (C). The disposed material would be placed to a maximum fill height of about 50 feet. Concrete rubble would be covered by a minimum of 3 feet of earth materials. Final grading of the disposal site would include relatively flat slopes (8H:1V to 5H:1V) to reduce the potential for erosion. Preparation of the disposal site requires clearing of vegetation and stripping and stockpiling of topsoil for later use for restoration of the disposal site. After final grading for drainage and aesthetics, the disposal site would be covered with topsoil and hydroseeded. Compaction other than by equipment travel would not be necessary. See Section 6 for additional detail associated with restoration. Erosion monitoring will be completed on an annual basis for 5 years following placement to assess whether significant erosion and slope deterioration has occurred. If significant erosion occurs, the eroded area shall be repaired to the satisfaction of the appropriate regulatory agency.

**Figure 5.5-4 Iron Gate Disposal Site Plan & Sections (Appendix C)**

Up to 200,000 CY of earth materials excavated from the dam will be placed in the existing concrete-lined side-channel spillway, chute, and flip-bucket terminal structure (located on the right abutment of the dam) to the extent practicable for restoration. Plan and section of the backfilled spillway are shown in Figure 5.5-1(C), Sheet 1 and Figure 5.5-5(C). Finished grades of the backfill would be no steeper than about 4H:1V. Following backfilling, the uphill portion of the spillway excavation would still be visible. After final grading for drainage and aesthetics, the disposal site would be covered with topsoil and hydroseeded. Compaction other than by equipment travel would not be necessary. See Section 6 for additional detail associated with restoration.

**Figure 5.5-5 Iron Gate Spillway Backfill Plan & Sections (Appendix C)**

### 5.5.4 Iron Gate Dam and Powerhouse Removal

Dam removal would begin following spring runoff on June 1 of the drawdown year. Sufficient freeboard to pass a 100-year flood for that time of year would have to be maintained at all times between the elevation of the excavated embankment surface and any remaining reservoir to reduce the potential for flood overtopping embankment. Excavation of the embankment section at Iron Gate Dam would not be allowed to begin before June 1 of the drawdown year, and requires completion by September 30 to minimize the risk of flood overtopping.

Dam removal would be as follows:

1. Drawdown reservoir, but maintain a minimum flood release capacity of approximately 7,700 cfs in June (RWS elevation 2254.3), to accommodate the passage of at least a 100-year flood for that time of year.
2. Remove fish facilities near downstream toe of embankment (including fish ladder and holding tanks) and dam crest sheet piles in the dry.
3. Retain embankment dam crest at level needed for flood protection, and the existing access bridge to the gate control house for regulating tunnel releases.
4. Begin embankment excavation for dam removal (see Figure 5.5-6(B)), but maintain a minimum flood release capacity of approximately 7,000 cfs in July (RWS elevation 2242.3) and 3,000 cfs in August and September (RWS elevation 2194.3), to accommodate the passage of at least a 100-year flood for that time of year.
5. Remove an estimated 150,000 CY (7,500 CY per day) in June, 285,000 CY (14,250 CY per day) in July, and 635,000 CY (16,000 CY per day) in August and early September leaving upstream cofferdam (Figure 5.5-6 (B)). Excavation assumes 2 shifts working 5 day per week. Temporarily stockpile rockfill during excavation for placement on downstream slope of cofferdam.
6. Provide access to gate control house between base of tower at elevation 2257.3 and deck at elevation 2341.3 (84 feet high — assume vertical stairway structure, or longer footbridge from spillway crest) throughout excavation for flow control.
7. Draw down reservoir to maximum extent (during minimum streamflow and with no upstream drawdown releases) by September 1 of drawdown year. Place rockfill on downstream face of cofferdam (having a crest no lower than elevation 2194.3) for

controlled breach of armored cofferdam embankment above the existing bedrock surface at elevation 2157.3.

8. Breach cofferdam at Iron Gate Dam prior to breach of cofferdam at J.C. Boyle Dam to minimize potential downstream impacts. Breach by notching below the reservoir level (expected to be below RWS elevation 2186.3. Maximum breach outflow from cofferdam at Iron Gate Dam is estimated to be approximately 5,000 cfs.
9. Following the cofferdam breach remove any remaining embankment materials from river channel in the wet, during low flow period, as required.
10. Remove diversion tunnel intake structure (invert elevation 2175.3), topple gate control tower for removal (base elevation 2254.3), 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.
11. Construct cofferdam in tailrace channel for removal of powerhouse. Use sump pumps to dewater area. Remove cofferdam when no longer needed.
12. Remove all other features (buildings, switchyard, etc.) as required. Restore dam site and right abutment disposal site as required, including the placement of topsoil and seeding. See Section 6 for additional detail associated with restoration.
13. Demobilize from site when construction activities are complete.

**Figure 5.5-6 Iron Gate Dam Removal (Appendix B)**

### 5.5.5 Demolition Methods, Estimated Equipment and Workforce

The following demolition methods, estimated equipment requirements, and estimated workforce requirements have been assumed for planning purposes based on engineering judgment. Alternative methods, equipment, and workforce that would also meet project requirements are possible and could be refined by the selected contractor.

#### 5.5.5.1 Demolition Methods

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 allow 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 likely use conventional earthmoving equipment consisting of excavators and off-road articulated or fixed-wheel haul units to reach the required average production rate of 16,000 CY per hour in August and September (Figure 5.5-6(B)). 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 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 CY 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 CY of embankment material 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.

#### 5.5.5.2 Estimated Equipment and Workforce Requirements

The estimated equipment that would be used for the removal of Iron Gate Dam and Powerhouse and for restoration of the reservoir area is summarized in Table 5.5-2.

**Table 5.5-2 Iron Gate Dam and Powerhouse, Estimated Equipment List**

| Name of Equipment | 2019 | 2020 |
|---|---|---|
| Crawler-mounted lattice boom crane, 150 to 200 ton, 160- to 200-foot boom | | X |
| Rough terrain hydraulic crane, 35 to 75 ton | X | X |
| Hitachi hydraulic excavator, 180,000 to 240,000 lb, 6 to 8 CY bucket | | X |
| Cat 336 hydraulic track excavator, 80,000 lb, 3.5 CY bucket | | |
| Hydraulic track excavators, 65,000 to 100,000 lb, with Cat H120 hoe-ram, thumb and shear attachments | | X |
| Cat 966 (52,000 lb, 5 CY bucket) or Cat 980 or Cat 988 (65,000 lb, 6 or 10 CY bucket) articulated wheel-loader | X | X |
| Cat 740 articulated rear dump trucks, 30 ton (22 CY) or Cat 770 fixed haul unit, 40 ton (30 CY) | X | X |
| D-7 or D-9 standard crawler dozers | X | X |
| Front-end wheel loader, integrated tool carrier, 25,000 lb | | X |
| D-8 support and knockdown dozer | | X |
| Front-end wheel loader, integrated tool carrier, 25,000 lb | | X |
| Cat TL943 rough terrain telescoping forklift | | X |
| Rough terrain telescoping manlift | | X |
| Cat 14 or Cat 16 motorgrader | X | X |

| Name of Equipment | 2019 | 2020 |
|---|---|---|
| Flexifloat sectional barges | X | |
| Truck-mounted seed sprayer, 2500 gallon | | X |
| On-highway, light duty diesel pickup trucks, ½ ton and 1 ton crew | X | X |
| On-highway flatbed truck with boom crane, 16,000 lb | | X |
| On-highway truck tractors, 45,000 lb | | X |
| Off-highway water tanker, 5,000 to 9,000 gallon | | X |
| Wheel-mounted asphalt paver | | X |
| Self-propelled rubber tire and drum vibratory compactor, 5 to 15 ton | | X |
| Engine generators, 6.5 KW to 40 KW, diesel or gasoline | | X |
| Air compressors, 100 psi, 185 to 600 cfm, diesel | | X |
| Hand-held drilling, cutting, and demolition equipment | | X |
| Portable welders and acetylene torches | | X |
| 4-inch submersible trash pumps, electric | | X |
| Light plants, 2,000 to 6,000 watt, 10 to 25 hp, diesel | | X |

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.

### 5.5.6 Imported Materials

Some materials will need to be imported to the site to support dam removal. The most likely materials to be imported include gravel surfacing from a commercial quarry for temporary haul roads (approximately 5,300 tons, 190 truck trips), seed and mulch materials, and minor quantities of ready-mix concrete and reinforcing steel from local commercial sources for tunnel plugs. Modification of the diversion tunnel would require importing mechanical equipment, and additional reinforcing steel and ready-mix concrete for lining the diversion tunnel and installing a new gate in the existing gate structure.

### 5.5.7 Waste Disposal

Estimated quantities of materials generated during removal of Iron Gate Dam and Powerhouse, numbers of truck trips, and approximate haul distances for waste disposal are shown in Table 5.5-3. Excavated concrete will be placed in the on-site disposal area. Reinforcing steel would be separated from the concrete prior to placement in the disposal area and hauled to a local recycling facility. All mechanical and electrical equipment would be hauled to a suitable commercial landfill or salvage collection point.

### Table 5.5-3 Waste Disposal for Full Removal of Iron Gate Dam

| Waste Material | In-Situ Quantity | Bulk Quantity [a] | Disposal Site | Peak Daily Trips [c] | Total Trips [d] |
|---|---|---|---|---|---|
| Earth | 160,000 CY | 190,000 CY | Spillway | 12 units/800 trips (unpaved road) | 8,640 trips (.5 mile RT) |
| | 910,000 CY | 1,070,000 CY | Disposal area | | 48,640 trips (2 mile RT) |
| Concrete | 16,000 CY | 20,800 CY | Disposal area | 2 units/50 trips (unpaved road) | 950 trips (2 miles RT) |
| Rebar | 700 tons | --- | Transfer station near Yreka, CA | 1 unit/5 trips (Copco Road) | 70 trips (54 miles RT) |
| Mech. And Elec | 1,200 tons | --- | Transfer station near Yreka, CA | 1 unit/5 trips (Copco Road) | 150 trips (54 miles RT) |
| Building Waste | 4 buildings 2,700 $ft^2$ | 600 CY | Transfer station near Yreka, CA | 1 unit/5 trips (Copco Road) | 60 trips (54 miles RT) |
| Power lines [b] | 0.14 miles of 69-kV | --- | Transfer station near Yreka, CA | | |

Notes:

[a] Volumes increased 30 percent for concrete rubble, 20 percent for loose earth materials.
[b] Quantities from Detailed Plan; verification of quantity still in progress.
[c] Peak daily trips for each site are based on the number of vehicles (units) shown, operating within one 8-hour shift.
[d] Total trips of earthfill assume off-highway articulated trucks with a nominal load capacity of 22 CY. Total trips of concrete assume off-highway articulated trucks with a nominal load capacity of 20 CY. Total trips for hauling rebar using truck tractor-trailers is based on 10 tons per trip. Total trips for hauling mechanical and electrical items using truck tractor-trailers is based on 8 tons per trip. Total trips for building waste using truck tractor-trailers is based on 10 CY per trip.

Potential landfills are shown in Table 5.5-4. Potential hazardous materials at Iron Gate Dam and Powerhouse and their disposal are discussed in Section 7.7.5.

### Table 5.5-4 Waste Disposal Facilities near Iron Gate Dam

| Name of Facility | Location | Distance from Site | Remaining Capacity | Materials Accepted |
|---|---|---|---|---|
| Yreka Transfer Station | Yreka, CA | 25 miles | 3,924,000 CY (2010) | Class III sanitary landfill accepting construction and demolition waste and mixed municipal waste, and<br><br>Medium volume transfer station accepting metals and mixed municipal recyclable materials |

# 6. Reservoir and Other Restoration

The purpose of this section is to summarize the proposed plan to stability remaining reservoir sediment post-drawdown and to restore the former reservoir areas at each facility to native habitat. The full Reservoir Area Management Plan is provided in Appendix G.

The bulleted list below provides a roadmap for specific requests (Item 6b) made by the SWRCB in their August 2017 Request for Additional Information:

- Restoration plan for all portions of the project summarized in Section 6.1 and 6.2, and provided in Appendix G
- Measures to manage remaining sediment following drawdown are discussed in Section 6.1.1
- Monitoring of remaining sediments and adaptive management measures to reduce potential impacts associated with the Project is discussed in Section 6.1.2
- Measures to restore the Klamath River within the former reservoir areas are provided in Section 6.1.3
- Quantification of the number of wetlands impacted will be provided in December 2017 after additional desktop analyses have been completed to verify existing data. The actual wetland delineation would not be completed until early to mid-2018. A short summary of existing wetlands within the Project area is provided in Section 3.4.6 and a more detailed discussion, along with a summary of proposed surveys, is provided in Appendix E, Section 6.2.
- Description of wetlands created are provided in Sections 3.4.6 and 6.1.3

## 6.1 Reservoir Restoration

As part of the 2012 EIS/R and 2013 Secretarial Determination of Record (SDOR, DOI and NMFS 2013), a Reservoir Area Management Plan (USBR 2011b) was developed by the USBR with assistance from the National Marine Fisheries Services (NMFS) and agencies from the Department of the Interior. The document describes anticipated conditions in the reservoir areas after removal of the four dams based on extensive hydraulic modeling, sediment characteristics, and several reservoir drawdown scenarios. The 2011 Plan provides goals and objectives developed with a multi-disciplinary team of professionals for the Reservoir Area Management Plan. The 2011 Plan was developed primarily with the intent to minimize invasive vegetation and stabilize the remaining accumulated sediments not eroded during drawdown to reduce the likelihood of future undesirable sediment releases.

As part of the ongoing design and compliance processes, the KRRC assembled a working group of regulatory, tribal, and consulting professionals representing expert knowledge from recent dam removal restoration plans to provide recommendations for updating the 2011 Plan. The group held a workshop in August 2017 and recommended updating the goals and objectives on the 2011 Plan based on current knowledge of reservoir restoration and experience gained from recent dam removal and restoration plans. Table 6.1-1 provides preliminary updates to the goals and objectives that guide the update to the Reservoir Area Restoration Plan.

### 6.1.1 Measures to Manage Remaining Sediment

J.C. Boyle Reservoir, Copco Lake, and Iron Gate Reservoir were well documented prior to construction of the dams. Each reservoir had a topographic survey and numerous pictures of conditions prior to construction of each dam as well as construction photos for each dam. As a result, ideal vegetation communities and site potential are easily discernable and techniques for stabilizing remaining sediments are readily apparent.

The 2011 Plan focused on control of invasive exotic vegetation (IEV) species and revegetation of the reservoir areas with native grasses, shrubs and trees as the primary method for restoration. This approach is consistent with nearly all dam removal and reservoir restoration plans in the past 10 years where restoration efforts have emphasized revegetation of newly exposed floodplain areas with native plants while actively controlling IEV. To implement this plan and manage the remaining reservoir area sediments, a two-pronged approach is put forth that consists of revegetation and active habitat restoration with monitoring and adaptive management. The following sequence describes the activities and restoration features that will be implemented in the reservoir areas to manage remaining sediments not eroded during drawdown:

1. Pre-dam removal (1-2 years pre-drawdown): conduct pre-treatment of invasive exotic vegetation species, collect seeds and grow-out of trees and shrubs by local nurseries.
2. Reservoir drawdown (January to March, year of drawdown): perform reservoir drawdown with natural erosion and evacuation of accumulated reservoir sediment deposits, stabilize sediments and exposed areas with hydroseeding.
3. Post-drawdown first summer/fall (dry season immediately after drawdown): conduct additional seeding application where needed for exposed areas and remaining reservoir deposits with grasses and ground cover, manual removal/treatment of IEV, and installation of riparian trees and shrubs.
4. Post-removal (year after dam removal is complete): maintain vegetation, continue to remove and treat invasive exotic vegetation, install habitat features.
5. Establishment period (years 2 through 5 post-dam removal): continued monitoring and maintenance of vegetation, removal of IEV, fish passage monitoring, and enhancement of habitat features as needed.
6. Long term (years 5 through 10 post-dam removal): continued monitoring and adaptive management, removal of IEV, and fish passage monitoring.

## Table 6.1-1 Preliminary Goals, Objectives, and Restoration Activities for Reservoir Area Restoration

| Period | Goal | Objective | Restoration Activity |
|---|---|---|---|
| Pre-construction Period | Prepare native plant materials for revegetation | Collect and propagate native plant seed and grow container plants | Identify potential seed collection, seed propagation, pole harvest cutting areas, and container plant grow contractors |
| | | | Perform surveys to identify and map seed collection and pole harvest areas |
| | | | Prepare seed collection, seed propagation, container plant growing, and pole harvest contract documents |
| | | | Award and monitor native plant and seed contracts |
| | | | Develop revegetation contract documents |
| | Reduce invasive exotic vegetation (IEV) | Reduce and minimize the local sources of IEV | Gather existing IEV data and perform EIV surveys |
| | | | Review potential herbicides and potential impact on fish and water quality |
| | | Implement an IEV management program | Create management plan and review with stakeholders |
| | | | Procure local contractor to perform IEV removal |
| | | | Inspect and monitor IEV removal execution |
| | Understand evolution of reservoir post-removal and response to restoration and reservoir management | Conduct studies to fill in data gaps from 2011 Plan | Sample sediment and perform tests to investigate wetting and drying characteristics, plant nutrient availability, and natural revegetation |
| | | | Perform revegetation pilot tests for native seed mixes |
| | | | Identify reference physical and ecological conditions in tributaries |

| Period | Goal | Objective | Restoration Activity |
|---|---|---|---|
| Dam removal period (0 to 1 year) | Allow natural erosion and transport of reservoir deposits and dispersal in the ocean | Maximize erosion of reservoir deposits during drawdown | Allow erosion of reservoir deposits during drawdown |
| | Stabilize remaining reservoir sediments | Initiate native plant revegetation | Prepare and amend sediment based on pilot test plot results |
| | | | Install irrigation system |
| | | | Hydroseed sediment by planting zones |
| | | | Install pole cuttings, acorns, and container plants |
| | Restore volitional fish passage in mainstem and tributaries. | Monitor and rectify any non-natural fish passage barriers | Conduct field monitoring of mainstem/tributaries, fix non-natural barriers |
| | Minimize IEVs | Implement and monitor IEV removal during revegetation | Include criteria for IEV removal during revegetation implementation |
| | | | Bi-weekly inspections of revegetation areas to verify IEV compliance |
| Short-term (1 to 5 years after removal) | Restore natural ecosystem processes | Continue native plant revegetation, maintenance and monitoring | Monitor establishment and adaptively replace failed pole cuttings, acorns, and container plants |
| | | | Maintain irrigation system |
| | | | Re-seed poorly established areas |
| | Minimize IEV | Continue IEV monitoring and removal | Include criteria for IEV removal during establishment |
| | | | Perform monthly inspections to verify IEV removal compliance |
| | Restore volitional fish passage in mainstem and tributaries | Monitor and rectify any non-natural fish passage barriers | Conduct field monitoring of mainstem/tributaries, fix non-natural barriers |
| Long-term (5 to 10 years) | Restore natural ecosystem processes | Continue revegetation monitoring and adaptive management | Monitor establishment and adaptively replace failed pole cuttings, acorns, and container plants |
| | Minimize IEV | Continue IEV monitoring and removal | Perform quarterly site inspections and verify compliance |
| | Restore volitional fish passage in mainstem and tributaries | Continue monitoring for non-natural fish passage barriers | Remove all non-natural fish passage barriers |

The use of vegetation to stabilize reservoir sediments is a common practice and well documented approach to improve ecosystem processes. For instance, all of the dam removal and reservoir restoration plans that were reviewed as part of this work (Appendix G) had native vegetation establishment in reservoir areas as the primary component to provide long-term stabilization of exposed soils. Likewise, revegetation experiments, performed in 2008 by Ellen Mussman for the Elwha River dams, showed that vegetation reduced erosion of reservoir sediments by 33% and mulch could reduce erosion by as much as 99% (Mussman 2008).

We also draw upon similar wildland restoration efforts found in wildfire area restoration, natural disaster areas (i.e. Mount St. Helens), and human-induced impacted areas since these altered and often barren landscapes are very similar to the remaining reservoir sediments. Establishment of native vegetation provides many important benefits for the stability of the remaining sediments in these disturbed areas. For instance, as described in *Repairing Damaged Wildlands: A Process-Oriented, Landscape-Scale Approach*, plants can reduce flow velocities, protect the soil surface from raindrop impact, increase soil stability, and increase the amount of water infiltrating into the soil (Whisenant 1999). A comprehensive update to the 2011 Plan is provided in Appendix G and outlines in detail the proposed revegetation for the reservoir areas. In addition, the updated plan outlines active restoration treatments that can be used to further improve sediment stability and long-term success for restoration.

### 6.1.2 Measures to Monitor Remaining Sediment

Monitoring associated with the restoration aspects of the project is designed to measure progress toward achieving the project goals, inform potential adaptive management and maintenance needs, and provide feedback into river and reservoir area conditions to determine if the sites are trending towards or away from achieving project goals. Based on the project goals and compliance with stated objectives, physical site characteristics are appropriate monitoring parameters to produce data that can be objectively used to monitor and adaptively manage reservoir area restoration efforts.

After drawdown of the reservoirs and removal of the dams, the following actions are proposed to establish “baseline” or “initial conditions”. The initial conditions reference data will be used for monitoring and adaptive management related to reservoir restoration:

1. Permanent ground photo points will be established throughout the reservoir areas that enable sufficient vantage points of critical areas within the reservoirs. Photos will be taken to provide initial conditions for monitoring data to develop informed maintenance and corrective actions. Each photo ground point will be monumented with 5/8 inch rebar and aluminum cap for long-term stability and documented with a northing, easting, and elevation using a survey-grade GPS.
2. High resolution vertical aerial photos, sub-meter accuracy, will be completed for the reservoir areas.
3. LiDAR will be collected for the reservoir areas after sediment evacuation and initial ground cover stabilization and used to create initial conditions surface models.

Baseline data will provide a clear starting point for initial conditions in the project area to help evaluate reservoir restoration trends and trajectories. Appendix G contains the updated Reservoir Area Management Plan that has a comprehensive outline of parameters that will be monitored, which include: stability of remaining reservoir sediments, fish passage, invasive exotic vegetation, native plant revegetation, and restoration of natural ecosystem processes.

### 6.1.3 Measures to Restore the Klamath River within Reservoirs

Review of historical photos of the reservoir areas prior to dam construction and inundation show river processes and conditions of the Klamath River pre-dams. The Klamath River was predominantly a narrow, volcanic bedrock dominated canyon with a single-thread river. Isolated areas within the canyon are wider such as in Copco Lake and upper portion of the J.C. Boyle Reservoir. In these wider valley sections, the gravel-bed river planform is controlled by the locally resistant topography constraints and contains floodplains and off-channel features such as remnant channels and wetlands. Furthermore, there is little evidence of large wood playing a significant role in channel planform and characteristics throughout the river.

The Klamath River in the reservoir areas is expected to re-occupy the historical channel alignment due to geological constraints and the erosion of fine sediments accumulated in the reservoir bottoms. This conclusion was reached from both a geomorphic evaluation and two-dimensional hydraulic modeling analysis by USBR 2012c. Since the river channel was not altered since construction of the dams, it is anticipated that the river will return to a natural gravel-bed river and behave similar to pre-dam conditions. One exception is that riparian vegetation, primarily willows, will not be established on the banks but will be planted with the revegetation efforts. Appendix G provides a detailed riparian revegetation plan that will be implemented to restore the Klamath River in the reservoir areas and restart natural river processes.

Critical to restoring natural ecosystem processes and restoring the Klamath River is habitat restoration on the floodplains and tributaries that flow into the Klamath River in the reservoir areas. The following restoration techniques will be implemented in the reservoir areas as appropriate:

1. **Tributary Connectivity**: As reservoir water surfaces are lowered during drawdown and beyond, tributaries will be further exposed creating longer reaches of free-flowing water conditions. The newly exposed tributaries will flow over depositional areas of fine sediment that will likely be transported downstream, however, some larger sediment and debris may create fish passage barriers or un-natural discontinuities in the longitudinal profile. To rectify this, it is anticipated that light equipment and manual labor will be able to move materials and enhance access and longitudinal connectivity of the tributaries with the mainstem Klamath River. In addition, large wood (LW) may be added to tributaries to promote habitat complexity.
2. **Wetlands, Floodplain and Off-Channel Habitat Features**: Incorporating floodplain features into newly exposed floodplains is a restoration strategy that promotes floodplain diversity. Based on historical pictures, it appears that three main types of floodplain features could be supported on the newly exposed floodplain areas: wetlands, floodplain swales, and side channels.

    a. Wetlands are depressional or low-lying features with standing water or saturated soils for a portion of the growing season sufficient to support wetland vegetation such as willows, sedges and rushes. Wetlands provide a wide range of ecological functions such as water quality improvement, flood attenuation, and habitat for both terrestrial and aquatic organisms. Including wetlands in the restoration will help address several limiting factors including water quality and lack of habitat diversity for wildlife. Wetland restoration strategies for the reservoir areas include preservation of existing wetlands, hydrologic connection of off-channel wetlands with the river, or creation of new wetlands at lower elevations corresponding to the post-dam removal surfaces and hydrologic regime.

b. Floodplain swales are small depression features incorporated into the floodplain that provide microsites where floodplain vegetation can establish at slightly lower elevations (closer to the water table) than adjacent floodplain surfaces. Floodplain swales also provide storage for flood water and sediment at variable flows, in addition to broadening the range of ecological niches available on the floodplain surface to support different life stages (and behaviors) of plant, bird, amphibian, and many other terrestrial wildlife species. To maximize diversity, floodplain swales should vary in size and depth, but should not extend below the anticipated baseflow elevation.

c. Side channel restoration is a strategy to improve instream habitat diversity. Side channels provide off-channel habitat for juvenile rearing and high flow refugia for other aquatic species. Like floodplains, side channels exchange water, sediment and nutrients between the main channel and off-channel areas thus supporting diverse vegetation communities. Side channel restoration strategies include modifying inlet and outlet hydraulics, improving hydraulic complexity with structures or realignment, and delivery of water to higher floodplain surfaces.

3. **Floodplain Roughness**: Floodplain roughness is a strategy applied to newly exposed areas where frequent interaction with the river channel is anticipated. Floodplain roughness helps address the geomorphic limiting factor of lack of established vegetation. Floodplain roughness also reduces browse pressure by making access more difficult, particularly for geese which require unobstructed runways for landing and takeoff. Installation of roughness features creates complexity and microsites on new floodplain surfaces to trap and protect seed and other plant propagules, and to provide resistance to erosion by reducing velocities and limiting rill formation. Floodplain roughness is created using equipment to roughen the floodplain surface with microtopography and partially bury brush and woody debris in the soil. Microtopography creates variation in the constructed floodplain surface ranging from 0.5 feet above to 0.5 feet below the design floodplain surface. Woody debris increases soil moisture retention, creates protective microsites for establishing seed and plants, and promotes soil development by introducing organic material.
4. **Bank Stability and Channel Fringe Complexity**: Lack of initial roughness along channel margins results in higher near-bank velocity and shear stress. This increase in active channel margin energy negatively affects aquatic species by requiring increased energy for migration and holding while also transporting desired gravels and depositional features downstream. Velocity shadows created by bankline complexity and large wood create zones of complex hydraulic interactions that provide resting zones, feeding seams, cover and velocity refugia during high flow. Reaches that would benefit from these treatments are typically single thread, like the Klamath River, where the channel is laterally confined. In addition, bank roughness can improve bank stability and reduce un-natural erosion that degrades water quality. Channel fringe complexity is best improved through the riparian revegetation and strategic addition of LW as described in the updated Reservoir Area Management Plan in Appendix G.

5. **Large Wood Habitat Features**: Large wood is a naturally occurring element in the Klamath Basin that hydraulically influences the movement of debris and sediment, causing local scour and deposition as well as hydraulic energy dissipation. LW obstructions lead to flow mechanics that result in a fining of stream substrate particles. Suspended sediment particles are able to drop out of the water column due to flow deceleration caused by LW skin roughness, form drag and turbulent energy dissipation around LW obstructions, hydraulic jumps over LW steps, and a general decline in water surface slope and energy gradient due to physical blockage of flow and backwater effects caused by LW obstructions (Buffington 1995). LW can be used to disperse flow energy (Buffington and Montgomery 1999), stabilize channel banks and bed forms (Bilby 1984), increase aquatic habitat (Bryant and Sedell 1995), narrow a stream and reduce the width to depth ratio (Sedell and Froggatt 1984), cause localized deposition, form pools (Bilby and Ward 1989), and route flood water. Although historical photos do not show LW as a predominant geomorphic feature, it can be used to improve habitat and promote reservoir area conditions that restore natural ecosystem processes and protect vegetation during the initial years of establishment.

Appendix G contains maps and additional information on reservoir area restoration with these techniques and applicable locations for implementation.

## 6.2 Restoration Activities outside of Reservoir

Areas disturbed by construction activities, but outside of the former reservoir areas (e.g. staging areas, spoil disposal areas, temporary access roads, etc.) will be revegetated similarly to revegetation described in Appendix G for upland planting zone areas.

Disturbed areas outside of the former reservoir areas include the following:

1. Disposal areas for placement of embankment or concrete material: These areas typically include between 10 to 50 feet of fill, and will be graded to match existing topographic features in the vicinity. Disposal areas will include a cover depth of topsoil material suitable for revegetation and all of them are located at elevations suitable for upland planting. Existing native vegetation will be preserved and protected where feasible. No ripping will be performed within twice the canopy diameter distance from protected tree trunks to protect existing roots.
2. Staging areas and temporary access road areas adjacent to demolition of other work areas: The majority of these areas are at elevations appropriate for upland planting, although in some cases they include a variety of planting zones. Many of these areas are already compacted to a high degree due to their current use, but regardless, all staging and temporary access road areas adjacent to demolition of other work areas will be decompacted by deep ripping and disking to facilitate seed germination and plant establishment. Existing native vegetation will be preserved and protected, where feasible, both during their active use and during revegetation. No ripping, equipment and vehicle parking, or material storage will be allowed within twice the canopy diameter distance from protected tree trunks to protect their existing roots from crushing.

3. Hydropower infrastructure demolition areas: The majority of PacifiCorp buildings and other hydropower infrastructure will be demolished as part of the Project. In each former facility location, after removal of all demolition debris and man-made materials, the remaining disturbed areas will be decompacted by deep ripping and disking, and restored to native habitat. These areas occur in a variety of planting zones and will be restored accordingly as described in Appendix G. Existing native vegetation will be preserved and protected, as feasible. No ripping will be performed within twice the canopy diameter distance from protected tree trunks to protect existing roots.
4. Former recreation areas: Numerous existing recreation areas around the reservoir rims will be demolished completely, or in part. All disturbed former recreation areas will be fully restored to native habitats. The majority of them are located at elevations suitable for upland seeding and planting. Many of these areas are heavily compacted because of their current use, but regardless of the degree of compaction, all recreation areas will be decompacted by deep ripping and disking to facilitate seed germination and plant establishment. Existing native vegetation will be preserved and protected. No ripping will be performed within twice the canopy diameter distance from tree trunks to protect existing roots.
5. J.C. Boyle canal demolition area: The J.C. Boyle canal will be demolished along its entire length. The former canal area will likely be heavily compacted from previous canal construction activities, but regardless of the degree of compaction, all associated areas will be decompacted by deep ripping and disking to facilitate seed germination and plant establishment. In addition, as part of the demolition activity, earthen materials from the river-side of the former canal width will be excavated up to 3 feet and placed throughout the former canal width to support vegetation growth.
6. J.C. Boyle spillway scour hole: The J.C. Boyle scour hole will be filled using onsite material as described in detail in Section 5.2.3. Final grading will be slope to drain and the top 5 feet of fill will include local native material appropriate for vegetation establishment. The majority of the final graded slope is located at elevations suitable for upland seeding and planting (summarized in Appendix G). In general, restoration objectives, species lists and monitoring requirements will match those identified for upland planting zone in Appendix G. Adjacent slopes will be utilized as a reference site for refining species lists and coverage objectives in this location.

Short-term revegetation of these areas will be implemented in compliance with the approved SWPPP/Erosion Control Plan. Long-term revegetation will be performed similarly as described for upland areas, however, these areas will additionally be decompacted by deep ripping and disking.

# 7. Other Project Components

## 7.1 Overview

There are numerous Project components that fall outside of the reservoir drawdown, dam removal, and reservoir restoration activities that are discussed in Sections, 4, 5 and 6. These additional Project components are partially derived from the previous list of mitigation measures found in the Detailed Plan (USBR 2012b) and the 2012 EIS/R, and are summarized in this section. These features have been incorporated into the proposed Project to reduce the Project's potential environmental impacts.

The numbered list below provides the work component categories and Table 7.1-1 provides an overview of each project components, with references to the 2012 EIS/R mitigation measure, where appropriate:

1. **Aquatic Resource Measures:** Surveys and other measures proposed to reduce the Project effect on aquatic resources
2. **Terrestrial Resource Measures:** Surveys and avoidance and minimization measures proposed to reduce the Project effect on terrestrial resources
3. **Road Improvements:** Road and bridge improvements to provide a similar level of service to existing conditions
4. **Yreka Water Supply Improvements:** Pipeline and diversion facility improvements to provide a similar level of service to existing conditions
5. **Recreation Removal:** Details on recreation facility demolition and associated habitat restoration
6. **Other Plans:** Management plans to provide a framework and initial requirements for traffic, water quality, groundwater, fire management, hazardous material management, emergency response, and noise and vibration

### Table 7.1-1 Summary of Other Project Components and Mitigation Measures

| Report Section | Project Component | Description | 2012 EIS/R Mitigation Measure Reference |
|---|---|---|---|
| | Aquatic Resources | | |
| 7.2 | Mainstem spawning | Surveys and associated protection measures | AR-1 |
| 7.2 | Outmigrating juveniles | Sampling and associated protection measures | AR-2 |
| 7.2 | Fall flow pulses | Work to date indicates that pulse flows are not feasible, and are therefore not included | AR-3 |
| 7.2 | Iron Gate Fish Hatchery | Delayed fish release to avoid poor water quality | AR-4 |
| 7.2 | Pacific lamprey | Lack of species presence (2015/2017 surveys by others) results in minimal effect to species; No additional measures are needed | AR-5 |
| 7.2 | Suckers | Surveys and relocation | AR-6 |

| Report Section | Project Component | Description | 2012 EIS/R Mitigation Measure Reference |
|---|---|---|---|
| 7.2 | Freshwater mussels | Surveys and relocation | AR-7 |
| | Terrestrial Resources | | |
| 7.3, 6 | Habitat restoration plan | Plan to stabilize remaining sediments and restore reservoir and other disturbed areas | TER-1 |
| 7.3 | Nesting bird surveys | Surveys and avoidance and minimization measures | TER-2 |
| 7.3 | Bald and Golden Eagles | Surveys and avoidance and minimization measures | TER-3 |
| 7.3 | Special-status plants | Surveys and avoidance and minimization measures | TER-4 |
| 7.3 | Wetlands | Delineation and incorporation of wetland features into restoration plan, to the extent feasible | TER-5 |
| 7.3 | Special status bats | Surveys and avoidance and minimization measures | TER-6 |
| 7.3 | Northern Spotted Owl | Surveys and avoidance and minimization measures | - |
| | Transportation | | |
| 7.4 | Bridge and culvert relocations | Improve roads, bridges and culverts affected by the Project | TR-1 |
| | Water Supply | | |
| 7.5 | Yreka water supply improvements | Relocate Yreka waterline and improve fish screens at diversion facility | - |
| | Recreation | | |
| 7.6 | Recreation facility removal | Removal of numerous existing recreation facilities, and restoration with native vegetation | REC-1 |
| | Management Plans | | |
| 7.7.1 | Traffic Management | Framework and initial requirements for traffic management. Final plan to be developed by contractor | - |
| 7.7.2 | Water Quality | Water quality monitoring and analysis | - |
| 7.7.3 | Replace groundwater wells | Well monitoring; Return the production rate of all affected groundwater wells to their pre-dam-removal condition, as necessary | GW-1 |
| 7.7.4 | Fire Management Plan | Framework and initial requirements for fire management. Final plan to be developed by contractor | PHS-2 |
| 7.7.5 | Hazardous Material Management | Framework and initial requirements for hazardous materials management. Phase 1 assessment to be completed in 2017. | - |
| 7.7.6 | Emergency response plan | Framework and initial requirements for emergency response. Final plan to be developed by contractor | H-1 |
| 7.7.7 | Noise and Vibration Control Plan | Framework and initial requirements for noise and vibration. Final plan to be developed by contractor | NV-1 |

## 7.2 Aquatic Resources Measures

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

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

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

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

Hydroelectric Reach. A target of 44,100 $yd^2$ of mainstem spawning gravel is required to offset the effects to 2,100 mainstem-spawning fall Chinook salmon redds. A target of 4,700 $yd^2$ of tributary spawning gravel is necessary to offset the effects to 179 tributary-spawning steelhead redds. If mainstem and tributary spawning gravel availability is less than target values, spawning gravel augmentation will be completed in the mainstem Klamath River between Shovel Creek (RM 209.0) confluence and upstream end of Copco Lake (RM 208.0), and in associated Hydroelectric Reach tributaries (including, but not limited to Jenny Creek, Fall Creek, Shovel Creek and Spencer Creek).

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

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

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

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

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

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

iv. The second component of the monitoring and adaptive management plan will include monitoring juvenile salmonids and water quality conditions in 13 key tributary confluences between Iron Gate Dam (RM 192.9) and the Trinity River (RM 43.4). Water temperatures will be monitored beginning March 1 of the drawdown year. A tributary water temperature trigger of 22°C (7-day average of the daily maximum values) and Klamath River suspended sediment concentration trigger of 665 mg/L will necessitate capturing fish from confluence areas, loading them to aerated transport trucks, and relocating them to cool water tributaries including but not limited to Beaver Creek, Cade Creek, Elk Creek, Tom Martin Creek, and Sandy Bar Creek as well as constructed off-channel ponds located on Seiad Creek, West Grider Creek, Camp Creek, and Stanshaw Creek. A one-day salvage effort for juvenile fish will be conducted at each tributary confluence area by a 4-person crew and 2 transport trucks.

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

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

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

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

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

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

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

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

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

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

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

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

      i. Lost River and shortnose suckers will be sampled in the Klamath River and in Hydroelectric Reach reservoirs in 2017 and 2018. Reservoir sampling will be completed in fall of 2017 and fall of 2018, river sampling will be completed in spring of 2018. The purpose of sampling is to document the abundance and genetics of Lost River and shortnose suckers in the Hydroelectric Reach. Sampling will include placing trammel nets in the reservoirs (reservoir sampling) and in Klamath River segments upstream of the reservoirs (river sampling) to determine the abundance. Captured fish will be marked with a passive integrated transponder (PIT) tag, fin clipped for genetic material, measured, and released. Recaptured fish will be used to estimate the sucker population abundance. Fin clips will be used to determine the genetics of the sampled fish. USFWS is currently developing genetic markers for Lost River and shortnose suckers.

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

7. **Freshwater Mussels (AR-7)**

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

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

i. A reconnaissance will be completed in 2018 to assess the distribution and density of freshwater mussels in the 8 mile-long bedload deposition reach from Iron Gate Dam (RM 192.9) downstream to the Cottonwood Creek confluence (RM 184.9). The reconnaissance will confirm mussel beds identified in the 2007-2010 surveys and estimate abundance at a subset of the mussel beds in the reach.

ii. Based on the reconnaissance, a portion of the freshwater mussels located between Iron Gate Dam (RM 192.9) and Cottonwood Creek (RM 184.9) will be salvaged and relocated to reduce dam decommissioning effects to the mussel community. Mussel surveys are estimated to take 5 days and the salvage and translocation effort will take 10 days. The percentage of the existing mussel beds that will be salvaged and translocated is predicated on the available habitat in the Klamath River between Keno Dam (RM 238.2) and the upstream extent of J.C. Boyle Reservoir (RM 233.0), and the abundance of mussels between Iron Gate Dam (RM 192.9) and Cottonwood Creek (RM 184.9). Approximately 15,000 to 20,000 mussels are planned for translocation. The proposed number of translocated mussels is likely less than 10 percent of freshwater mussels in the mainstem Klamath River in the Hydroelectric Reach and downstream from Iron Gate Dam.

## 7.3 Terrestrial Resources Measures

The 2012 EIS/R (USBR and CDFW 2012) included several measures to avoid or reduce potential impacts on terrestrial biological resources including measures TER-1 through TER-6. In addition, the Joint Preliminary Biological Opinion (JPBO) included several measures specifically addressing potential effects on northern spotted owl (NSO 1 through 4) (USFWS and NMFS 2012). The KRRC has reviewed, modified, and incorporated the following into the current Project description, as summarized below:

1. **Habitat Rehabilitation Plan (TER-1)**: A restoration plan for the Project is summarized in Section 6 and attached as Appendix G.
2. **Nesting Bird Surveys (TER-2)**: Surveys are described in several sections of Appendix E including Northern Spotted Owl, Bald and Golden Eagles, and Special Status Wildlife Species. Avoidance and minimization measures would include monitoring, exclusion, buffers, and construction planning to time activities for less sensitive times of the year.
3. **Nesting Habitat of Bald and Golden Eagle and Other Migratory Birds (TER-3)**: Surveys are described in the Bald and Golden Eagles and Special Status Wildlife Species sections of Appendix E. Avoidance and minimization measures would include monitoring, buffers, and construction planning to time activities for less sensitive times of the year.
4. **Special Status Plants (TER-4)**: Surveys are described in the Special Status Plant Species Section of Appendix E. Project design and construction planning will incorporate avoidance measures to the extent practicable. Minimization measures would include propagation and establishment in new locations as part of the site restoration as described in Sections 6.
5. **Wetlands at Reservoirs (TER-5)**: The Project will comply with regulatory requirements of the USACE, CDFW, and the Oregon Department of State Lands in delineating wetlands and evaluating potential impacts to acreage and functions as described in Appendix E in the Wetlands and Vegetation Communities section. All areas within the limits of construction will be evaluated for the presence of wetlands that could be affected by the Project including potential disposal areas. The acreages will be confirmed through the field surveys. The restoration plans for the reservoir and non-reservoir areas, described in Sections 6.1 and 6.2, respectively, will include designs for wetland and riparian habitat restoration to result in no net loss of wetland or riparian habitat functions.

6. **Special Status Bats (TER-6)**: The bats section of Appendix E describes the field surveys that have been conducted and that are planned for 2018. Avoidance and minimization measures would include monitoring, exclusion, seasonal restrictions on demolition, preservation of existing habitat, and development of alternative habitat. Specific measures will be incorporated into the project design as the surveys are completed.
7. **Northern Spotted Owl**: Survey protocols are described in the Northern Spotted Owl section of Appendix E. Avoidance and minimization measures may include seasonal restrictions on certain activities and a prohibition of aircraft or helicopter flights over sensitive areas as identified through the surveys. These restrictions will be incorporated into the project description and construction planning.

The KRRC has begun the pre-construction surveys contemplated in these measures, the results of which will be incorporated into the final project design and construction planning to avoid and minimize effects. Specific actions will be developed in coordination with the USFWS, the CDFW, and the ODFW and would be incorporated into any regulatory approvals required by the Project. The work plans and planned avoidance and minimization measures are located in Appendix E.

## 7.4 Road Improvements

Several road, intersection, structure and culvert improvements are required as part of the Project to:

- Facilitate access for project related vehicles and equipment associated with dam removal (Section 5)
- Ensure a safe environment for both public and project road users during the dam removals
- Return roads used by Project related vehicles to the respective owners and users in an acceptable state, mitigating any potential reduction in function attributed to the removal works.

A site visit and desktop study were performed to assess the state of road infrastructure that is expected to be used throughout the Project. The findings are shown in tables in Appendix I.

This was followed by an assessment of which elements may require improvement at some stage for either construction access, or to offset a potential impact associated with dam removal. The improvements will be implemented at various phases throughout the Project. Some will require completion prior to the dam removals, and others will be contingent on a future assessment of road elements once reservoir drawdown or hauling activities are complete. There will also be some ongoing activities throughout the Project to maintain roads heavily trafficked by project construction vehicles. The various transportation related improvements are described in the following sections. Table 7.4-1 provides a summary of the road segments, bridges, and culverts discussed and the proposed improvements.

## Table 7.4-1 Roadway and Access Improvements

| Location | Improvements | Purpose: Construction Access | Purpose: Post-Drawdown Effects | Purpose: Road Rehabilitation |
|---|---|---|---|---|
| **J.C. Boyle** | | | | |
| The Dalles California Highway (US97) | • Potential pavement rehabilitation during or post-project | | | X |
| Green Springs Highway (OR66) | • Potential pavement rehabilitation during or post-project | | | X |
| Spencer Bridge | • None | | | |
| Keno Worden Road | • Potential pavement rehabilitation during or post-project | | | X |
| Keno Access Road | • None | | | |
| Unnamed Culvert at Unnamed Road near J.C. Boyle Reservoir | • None | | | |
| Topsy Grade Road | • Potential pavement rehabilitation during or post-project | | | X |
| Culvert at Unnamed Creek | • Potential sediment removal and downstream erosion protection | | X | |
| J.C. Boyle Dam Access Road from OR66 | • Regrading uneven or rutted areas | X | | |
| Junction of OR66 and J.C. Boyle Dam Access Road | • Intersection widening<br>• Tree removal<br>• Signage | X | | |
| J.C. Boyle Powerhouse Road | • None | | | |
| Timber Bridge | • Remove | X | | |
| Power Canal Access Road | • Periodic roadway maintenance grading during construction | X | | |
| J.C. Boyle Disposal Access Road | • Regrading<br>• Minor widening | X | | |
| J.C. Boyle Left Abutment Access | • None | | | |

| Location | Improvements | Purpose | | |
|---|---|---|---|---|
| | | Construction Access | Post-Drawdown Effects | Road Rehabilitation |
| Road | | | | |
| **Copco and Iron Gate** | | | | |
| Interstate 5 (I-5) | • None | | | |
| Copco Road (I-5 to Ager Road) | • Potential pavement rehabilitation during or post-project | | | X |
| Cottonwood Creek Bridge | • None | | | |
| Copco Road (Ager Road to Lakeview Road) | • Potential pavement rehabilitation during or post-project | | | X |
| Dry Creek Bridge | • Replace | X | | |
| Copco Road (Lakeview Road to Daggett Road) | • Pavement maintenance during construction<br>• Potential pavement rehabilitation during or post-project | X | | X |
| Brush Creek Bridge | • None | | | |
| Unnamed Culverts between Brush Creek and Scotch Creek | • Potential rehabilitation or replacement post-construction | | | X |
| Scotch Creek Culvert | • Replace | | X | |
| Camp Creek Culvert | • Replace with bridge | | X | |
| Jenny Creek Bridge | • Replace | | X | |
| Copco Road (Daggett Road to Copco Access Road) | • Potential road surface maintenance during or post-project | | | X |
| Fall Creek Bridge | • Replace | X | | |
| Copco Road (Copco Access Road to Copco Road Bridge) | • None | | | |
| Beaver Creek and E.F. Beaver Creek Culverts | • Potential erosion protection | | X | |
| Raymond Gulch Culvert | • Potential erosion protection | | X | |
| Copco Road Bridge | • Potential abutment erosion protection | | X | |

| Location | Improvements | Purpose | | |
|---|---|---|---|---|
| | | Construction Access | Post-Drawdown Effects | Road Rehabilitation |
| Copco Access Road | • Clear, grub and regrade.<br>• Minor widening into hillside if possible | X | | |
| Copco Cove Access | • Minor works to enable barge mobilization | X | | |
| Patricia Avenue | • None | | | |
| Culverts at Unnamed Creeks (Copco Lake) | • Potential erosion protection | | X | |
| Ager Beswick Road | • None | | | |
| Mallard Cove Boat Ramp Access | • Minor works to enable barge mobilization | X | | |
| Daggett Road | • Minor grading improvements<br>• Potential road surface maintenance during and post-project | X | | X |
| Daggett Road Bridge | • Replace | X | | |
| Lakeview Road (Copco Road to Iron Gate disposal site) | • Potential road surface maintenance during and post-project | | | X |
| Lakeview Road Bridge | • Replace | X | | |
| Iron Gate Powerhouse Access Road | • Signage<br>• Potential road surface maintenance during construction | X | | X |
| Iron Gate Left Abutment Access Road | • Restore after construction is complete | | | |
| Iron Gate Upstream Left Abutment Access Road | • Restore after construction is complete | | | |

### 7.4.1 Construction Access Improvements

Various improvements are required to ensure the provision of adequate access and haul routes associated with Project construction. These all require completion prior to the commencement of dam removals. A detailed discussion can be found in Sections 5.2.2, 5.3.2, 5.4.2, and 5.5.2.

### 7.4.2 Ongoing and Post-Project Maintenance Activities

Some roads may require ongoing maintenance at various points throughout the Project or post-project to maintain an acceptable road surface. See Table 7.4-1 for a list of the road segments that may require pavement rehabilitation or road surface maintenance during or post-project. Pavement rehabilitation is for asphalt concrete paved roads and includes overlay or localized pavement replacement. Road surface maintenance is for gravel and dirt roads and includes minor regrading and gravel placement.

A baseline and post-Project pavement condition assessment would be conducted to the determine extent of maintenance required. Temporary traffic control will be required on public roads during roadway surface maintenance and will involve one-way traffic control with flaggers and construction area signs.

### 7.4.3 Long Term Road Infrastructure Improvements

Some improvements will be required to ensure existing roads maintain the state and function held prior to the Project. The proposed improvements would mitigate potential reduction in functionality of road infrastructure caused by:

- A reduction in flood protection under altered hydraulic conditions in the Klamath River and its tributaries.
- Embankment or culvert stability following the drawdown of the reservoirs and the resulting change to sediment and water levels. The reservoir drawdown creates the potential for creek bed levels to readjust back down to their pre-dam state. This will in some areas cause incision into fine sediments that have settled during the operation of the reservoirs. Where road infrastructure was constructed atop these sediments, the erosion of sediments from beneath or near road elements could result in damage or failure.

The construction of improvements could be completed at various stages throughout the Project depending on their timeline for completion requirements, but many will require implementation prior to drawdown. The following sections summarize permanent proposed improvements to roads and bridges included in the Project.

#### 7.4.3.1 Spencer Bridge (OR66/Green Springs Highway)

The Spencer Bridge left abutment embankment was constructed with highly pervious, strong basalt material, and it is expected that the embankment would remain stable during and following the drawdown of J.C. Boyle Reservoir, but some minor erosion of the riprap outer layer, not affecting stability, could occur. The embankment will be inspected following the drawdown, and any damage to the riprap outer layer would be repaired. The restored Klamath River channel is anticipated to locate between the $2^{nd}$ and $3^{rd}$ bridge bents, both of which were constructed on bedrock. Scour at the bents following dam removal is not anticipated. Temporary traffic control would be required during these improvements.

#### 7.4.3.2 Timber Bridge

A timber bridge spans the Klamath River immediately downstream of J.C. Boyle dam. It is anticipated that this structure will be removed after dam removal. No traffic control would be required as the bridge is not a public road.

#### 7.4.3.3 Topsy Grade Road Culvert at Unnamed Creek

Topsy Grade Road crosses an unnamed creek, roughly 1,900 feet to the east of the J.C. Boyle Dam. The road is found on an embankment roughly 400 feet long with three 24-inch culverts draining a watershed of roughly 5 square miles. Reservoir sediment currently covers and obscures the culverts. The culverts may have been constructed prior to J.C Boyle Dam, and if so, they would likely not be impacted by reservoir sediment sloughing. However, the J.C. Boyle as-built drawings indicate that the culverts are not aligned with the original thalweg of the creek. The addition of riprap armor to the downstream face of the embankment, along with removal of sediment and debris from the culverts may be required to protect the road embankment. The need for these minor improvements would be confirmed following drawdown and associated monitoring. See Figure 5.1-1(C) for the limits of work associated with these improvements. Minor temporary traffic control would be required during these improvements.

#### 7.4.3.4 Unnamed Culvert at Unnamed Road (near J.C. Boyle Reservoir)

Approximately 0.9 mile north of OR66, off Keno Access Road, an unnamed road crosses an unnamed creek. The road is found on an embankment, with two 36-inch diameter corrugated metal pipe (CMP) culverts allowing drainage of the creek. The culverts are well above the reservoir water level and so are not likely built on reservoir sediments. The upstream and downstream ends have silt build-up. The addition of riprap armor to the downstream face of the embankment to protect it from downstream channel incision into reservoir sediments, and removal of sediment and debris from the culvert may be required. The need for these minor improvements would be confirmed following drawdown. Minor temporary traffic control would be required during these improvements.

#### 7.4.3.5 Copco Road Bridge

Copco Road Bridge crosses Copco Lake immediately north of the junction of Copco Road and Ager Beswick Road. Section 5.3.2.2 includes additional information on the bridge. Both drawdown and post-project flows have the potential to cause erosion at the abutments or central pier. This will require further evaluation during the detailed design phase and erosion protection may be required at the abutments or pier. Minor temporary traffic control would be required during these improvements.

#### 7.4.3.6 Copco Road Culvert at Raymond Gulch

A 60-inch diameter CMP culvert pipe passes beneath Copco Road at Raymond Gulch adjacent the Copco Lake. The culvert is elevated well above the reservoir level and is not expected to be built on reservoir sediments. Minor improvements such as, the addition of riprap armor to the face of the embankments may be required if erosion of reservoir sediments affects this culvert. This would be confirmed following drawdown of Copco Lake and associated monitoring. Minor temporary traffic control would be required during these improvements.

#### 7.4.3.7 Copco Road Culverts at Beaver Creek

60-inch diameter CMP culvert pipes pass beneath Copco Road at both Beaver Creek and East Fork Beaver Creek adjacent to Copco Lake. Both pipes are elevated well above the reservoir water level and are not expected to be built on reservoir sediments. Minor improvements such as, the addition of riprap armor to the face of the embankments may be required if erosion of reservoir sediments affects this culvert. This would be confirmed following drawdown of Copco Lake and associated monitoring. Minor temporary traffic control would be required during these improvements.

#### 7.4.3.8 Patricia Avenue Culverts at Unnamed Creek (Copco Lake)

Patricia Avenue passes over two unnamed creeks near Copco Lake and the Copco Lake Fire Department. Beneath each crossing is a 60-inch diameter CMP culvert. The drainage culverts are elevated well above the reservoir water level and are not expected to be built on reservoir sediments. Minor improvements such as, the addition of riprap armor to the face of the embankments may be required if erosion of reservoir sediments affects this culvert. This would be confirmed following drawdown of Copco Lake and associated monitoring. Minor temporary traffic control would be required during these improvements.

#### 7.4.3.9 Jenny Creek Bridge

Jenny Creek Bridge crosses the mouth of Jenny Creek at Iron Gate Reservoir. Section 5.3.2.2 includes further details of the bridge. The abutments are built on material deposited after the dam construction and the dam removal may cause significant erosion that could possibly undermine the abutments. A new bridge would be constructed upstream side of the existing structure, on a modified alignment, to preclude damage to the structure after the drawdown (Figure 7.4-1).

It is anticipated that the new bridge will be a multi-span bridge long enough to span over the creek sediments and/or reservoir deposited material and the bent supports would be founded on native soil or rock. The abutment supports for the replacement structure will be placed away from the area that is susceptible to reservoir sediment erosion. As opposed to relocating the crossing further upstream away from reservoir sediments, this approach will minimize realignment of the existing Copco Road and potential impacts to right of way. The new bridge will be built 'offline' so the impact to traffic will be limited to the traffic switch from the existing road alignment to the new realigned road.

*Orange hatching shows new structure location, and orange lines show realigned roadway approaches.*

**Figure 7.4-1 Copco Road Realignment and Jenny Creek Bridge Replacement**

### 7.4.3.10 Copco Road Culvert at Camp Creek

A 10 foot diameter CMP arch culvert passes beneath Copco Road at Camp Creek adjacent Iron Gate Reservoir. Significant erosion is anticipated in this area following drawdown of the reservoir due to incision into reservoir sediments. Due to the difficulty in knowing exactly when the erosion would occur, it is expected that replacement of the culvert with a bridge will be necessary. A temporary structure and detour road just upstream of the culvert would be constructed to maintain thoroughfare during the works. Figure 7.4-2 shows a potential temporary detour alignment.

### 7.4.3.11 Copco Road Culvert at Scotch Creek

A 36-inch diameter CMP culvert passes beneath Copco Road at Scotch Creek, adjacent to Iron Gate Reservoir. Some erosion is anticipated in the vicinity of the culvert following drawdown of the reservoir due to incision into reservoir sediments. The culvert will likely need to be replaced with a larger box culvert and provided with suitable erosion protection to account for the potential drop in creek bed elevation. A temporary structure and detour road would be constructed immediately upstream of the culvert to maintain traffic during the replacement. Figure 7.4-3 shows a potential temporary detour alignment.


*Orange hatching shows temporary bridge locations, and orange lines show road detour locations. A permanent bridge would be constructed in the current culvert location.*

**Figure 7.4-2 Temporary Structure and Detour Road at Camp Creek**

### 7.4.3.12 Copco Road Drainage Culverts between Brush Creek and Camp Creek

A number of culverts ranging in diameter from approximately 12-inch to 18-inch diameter pass beneath Copco Road between Brush Creek and Camp Creek. An assessment of the condition of these pipes would be performed upon completion of the dam removals and hauling, to assess whether any damage occurred during construction. Rehabilitation or replacement would be performed if necessary. Minor temporary traffic control would be required during these improvements.


*Orange hatching shows temporary bridge, and orange lines show road detour locations. A permanent crossing would be constructed in the current location.*

## Figure 7.4-3 Temporary Structure and Detour Road at Scotch Creek

### 7.4.3.13 Daggett Road Bridge

The existing Daggett Road Bridge will be replaced due to structural deficiency. The approach road to the new bridge alignment will be reconfigured to match with existing roadway section and pavement type. This segment of the Daggett Road is a gravel road about 14 feet wide that provides access to the Copco No. 2 Powerhouse, penstock area and proposed disposal site. The existing grade around the bridge approach is relatively flat; thus, minimal regrading will be required for the realigned approaches to match the new bridge alignment.

### 7.4.3.14 Lakeview Road Bridge

The existing Lakeview Bridge will be reconstructed due to structural deficiency. The roadway approaches will be realigned to match the new bridge alignment. This segment of Lakeview

Road is a gravel road; about 14 feet wide, that provides access to the Iron Gate powerhouse and dam site. The existing road grade is relatively flat; thus, minimal regrading of the realigned roadway will be required to match the new bridge alignment.

## 7.5 Yreka Water Supply

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 24-inch diameter steel water supply pipeline crosses the Klamath River near the upstream end of Iron Gate Reservoir as shown on Figure 7.5-1. The steel water supply pipeline is minimally buried in the reservoir bed. When Iron Gate dam is removed, the pipe would become exposed to high velocity river flows and would likely sustain damage. During preparation of the Detailed Plan a HEC-RAS model was used to estimate the hydraulic properties at the pipe crossing post-dam removal, and predicted scour ranged from 5 to 10 feet (USBR, 2012). A replacement pipe crossing is needed before dam removal and reservoir drawdown to ensure uninterrupted water supply for the City of Yreka.

The primary water intake for this water pipeline is located at Dam A, located downstream of a PacifiCorp power plant near Fall Creek and diverts flow to a pumping station further downstream along Fall Creek. A secondary intake at Dam B located on Fall Creek is used when the power plant is shut down and supplies water through a pipeline to the intake at Dam A. Based on the Detailed Plan for Dam Removal (USBR, 2012), the existing flat panel fish screens for the water supply intakes at Dams A and B may not meet current regulatory agency screen criteria for anadromous fish. It appears that the fish screens have recently been updated, but their compliance to current regulatory agency screen criteria for anadromous fish still needs to be confirmed. These fish screens would have to meet the criteria from NMFS, USFWS, and CDFW, and would require updates, if found to be non-compliant.

### 7.5.1 Water Supply Pipeline

#### 7.5.1.1 Existing Conditions

At the Klamath River crossing, the existing steel pipe is minimally buried in the reservoir bed. The published surface geology by USGS (Wagner and Saucedo 1987) on both sides of the Klamath River at the location of the existing Yreka Pipeline Crossing is mapped to be Western Cascade Volcanic (*Tv*) rock unit, predominantly Andesite with some basalt and dacite ($Tv^a$), Andesite and basalt intrusions and plugs ($Ti^a$) and Andesite tuff breccia ($Tv^p$) units. The as-built records of the existing pipeline (Piemme, Neill, and Bryan and Clair A. Hill Associates, 1968) indicate that the existing pipeline was constructed by directly laying the pipe on the then existing reservoir bed within a riprap berm. The static and static & surge hydraulic internal pressures at this location on the Klamath River are approximately 306 and 374 psi, respectively (Drawing GP-3, Piemme, Neill, and Bryan and Clair A. Hill Associates 1968).

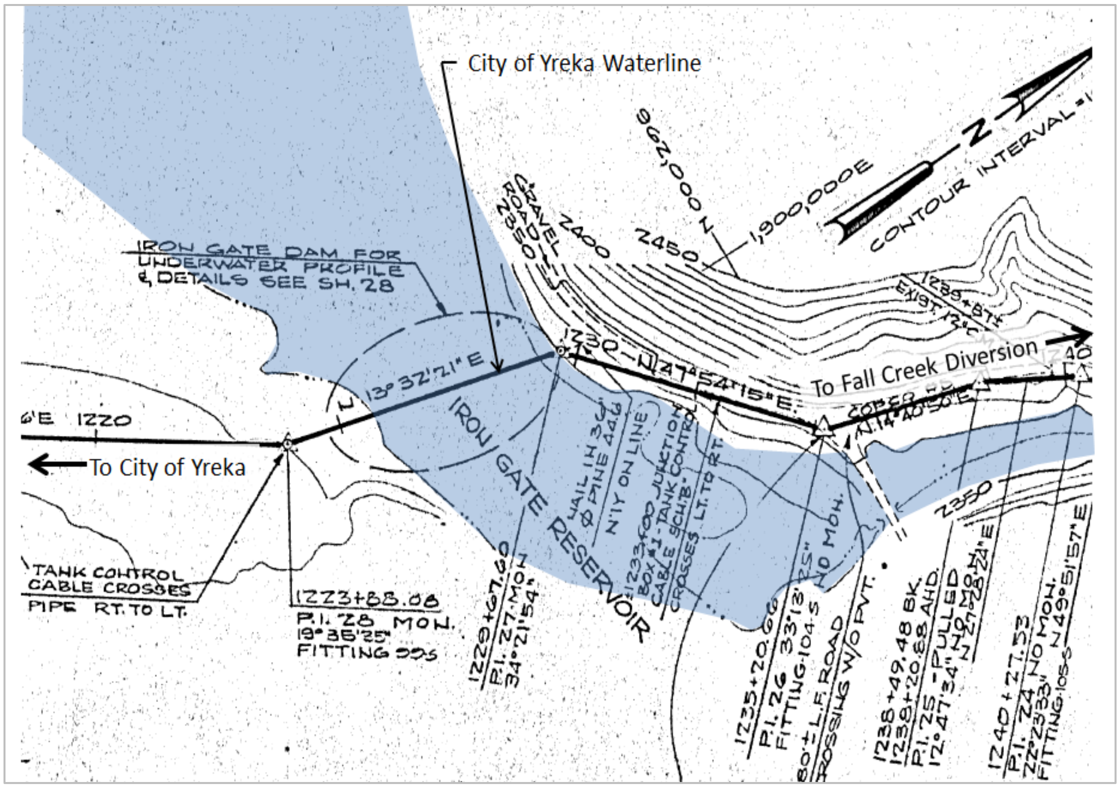



**Figure 7.5-1 City of Yreka Pipeline Crossing**

### 7.5.1.2 Proposed Modifications

Conceptual level buried and aerial relocation crossings of the pipeline across the Klamath River have been identified for feasibility and further evaluation. It is desired that the buried crossing should have adequate cover to compensate for the vertical scour during dam removal and the subsequent variations in the river flows and longitudinal profile. As the construction of the relocated crossing needs to happen prior to Iron Gate Dam removal, the cover over the pipe will likely have to exceed 12 feet. An open-cut construction approach would therefore, potentially require significant sediment and rock excavation under water and is not considered as a viable option. Considering this, the following three options have been identified for the reconstruction of the Klamath River crossing of the Yreka pipeline:

1. A new buried pipeline by micro-tunneling in the immediate vicinity of the existing waterline crossing
2. A new aerial pipeline on a dedicated utility pipe crossing in the immediate vicinity of the existing waterline crossing
3. A new buried pipeline and an aerial pipeline crossing on the existing timber traffic bridge along Daggett Road located approximately 2,000 feet upstream of the existing waterline crossing

The alignments for the three options are illustrated on Figure 7.5-2(C) and detailed descriptions for each are presented below.

**Figure 7.5-2 Alignments for Klamath River Crossing (Appendix C)**

### Option 1 – Micro-tunneled Crossing

Option 1 consists of the installation of either a new 24-inch-diameter steel pipeline within a tunnel casing or a larger diameter carrier pipe constructed using a micro-tunnel construction approach. The pipeline profile for this concept level alternative has been presented in Figure 7.5-3 (C). The micro-tunnel will be approximately 550 feet long, at least 36-inch internal diameter, and will be at least 30 feet below the current bottom of Iron Gate Reservoir. The tunnel would be aligned parallel to, but offset approximately 25 feet downstream from the existing pipeline crossing to avoid damage to the existing pipe and thereby any unplanned interruptions to water supply during construction. The new pipe would be connected to the existing pipeline on both the north and south sides of the Klamath River through new piping and fittings as shown in Figures 7.5-2(C) and 7.5-3(C). Based on the reviewed surface geology map and the rock outcrops observed at the site, portions of or entire micro-tunnel alignment will likely be through bedrock formations. Rock hardness and abrasiveness of the bedrock will have an impact on wear of cutting tools, which and type of the micro-tunnel equipment would impact the maximum drive length. Therefore, selection of the micro-tunnel diameter, type of the micro-tunnel equipment, and the actual elevation of the micro-tunnel crossing as well as the locations and depths of the driving and receiving shafts would depend on the subsurface profile and surface topography of the on-shore and off-shore ground surface. Based on the concept profile illustrated, the driving and receiving shafts would be approximately 58 feet and 56 feet deep, respectively.

**Figure 7.5-3 Profiles for Klamath River Crossing (Appendix C)**

To advance the final design, a geotechnical subsurface investigation, topographic survey, and bathymetric survey of the site will be undertaken. Based on the subsurface profile from the investigation, the location of the tunnel profile will be evaluated and selected to minimize the micro-tunneling installation risks and costs. Also, other types of trenchless approached such as Direct Pipe, which is a hybrid method combining micro-tunneling and horizontal directional drilling (HDD) approaches, may become attractive alternatives with lower cost and/or risk. It is recommended that the geotechnical explorations include on-shore borings at the proposed locations of the driving and receiving shafts and three off-shore borings to establish the subsurface profile along the tunnel alignment. These borings shall be extended to at least an depth 50 feet below the thalweg of the river (i.e., lowest elevation of the lake bed at the crossing location).

### Option 2 – Aerial Crossing on New Utility Bridge

A prefabricated steel 7.5-foot-wide box truss bridge has been proposed in the Detailed Plan (USBR 2012b), which has been carried forward as Option 2. This utility bridge would be just wide enough to accommodate the new 24-inch-diameter pipeline and an adjacent walkway for maintenance purposes. 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 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. Figures 7.5-2(C) and 7.5-3(C) show the proposed alignment and profile for this option, respectively.

As in Option 1, a geotechnical subsurface investigation, topographic survey, and bathymetric survey of the site will be undertaken to advance the final design. It is recommended that the geotechnical explorations include on-shore borings near the proposed locations of the bridge abutments and three off-shore borings near the proposed locations of the bridge support piers. These borings shall be extended to at least an elevation 50 feet below the thalweg of the river (i.e., lowest elevation of the lake bed at the crossing location). The locations of these borings may be selected by combining the geotechnical investigation needs for Options 1 and 2.

### Option 3 – Aerial Crossing on Daggett Road Bridge

In the cost estimate for the Detailed Plan (USBR 2012b), construction of an aerial crossing using the existing timber traffic bridge along the Daggett Road located approximately 2,000 feet upstream of the existing waterline crossing was considered. However, the suitability of the existing timber bridge to house this 24-inch pipeline was not evaluated during the development of the Detailed Plan. This concept has been selected as Option 3 for the waterline relocation.

This option would also require that the pipeline crosses Fall Creek. The existing Fall Creek culvert under the Daggett Road has very little cover, therefore pipeline crossing above the culvert is not viable without significant regrade of Daggett Road. Installing the new pipeline below the existing culvert using either a trenchless construction approach or open-cut construction approach is possible. Figures 7.5-2(C) and 7.5-3(C) show the proposed alignment and profile for this option, respectively

In this option, the aerial portion of the crossing will be about 300 feet long, and the remaining approximately 3,600 feet long realigned pipe will be buried and will be installed using open-cut construction approach, including Fall Creek crossing. This option adds significant length to the relocated pipeline alignment. The Daggett Road Bridge will be replaced as part of the project due to structural deficiency, and the new pipeline could be incorporated into the new bridge design and construction.

### Connections to Existing Pipeline

In all three options, the new pipeline would be connected to the existing buried pipeline at each end of the river crossing. Adequate additional length along the existing pipeline may be replaced with welded steel pipe to provide sufficient length of restrained piping to resist any thrust forces arising from the 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 old pipeline may be removed in the dry after reservoir drawdown.

#### 7.5.1.3 Permissible Water Delivery Outage

A short water delivery outage would be required to make the final connections following construction of any of the new pipe crossings. Based on preliminary discussions with City of Yreka (Taylor, R., Personal Communications, August 15, 2017), the permissible outage period would typically be planned and limited to 12 hours and should preferably occur during the winter to avoid a disruption to the Yreka's water supply. The permissible outage period would be based on the available storage capacity for Yreka, which should be able to meet demand for up to 60 hours in the winter and 18 hours in the summer, and up to an additional 27 hours with implementation of water rationing in the summer.

### 7.5.2 Water Supply Intake

#### 7.5.2.1 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 the PacifiCorp Fall Creek powerhouse on a bypass reach from 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. Subsequent to the preparation of the Detailed Plan (USBR 2012b), City of Yreka appears to have made some fish screen modifications, but their compliance to current regulatory agency screen criteria for anadromous fish still needs to be confirmed. The bays at the headworks structure connect into a common channel leading to the gated supply pipeline. The City's water right and diversion capacity at the site is 15 cfs.

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 trash racked 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.

#### 7.5.2.2 Proposed Modifications

The existing screens for the water supply intakes at Dam A need to be evaluated to confirm that the current regulatory agency screen criteria from NMFS, USFWS, and CDFW, for anadromous fish are met. If the existing fish screens are deficient or non-compliant, they may need to be updated. Dam B does not have a fish screen and is located about 100-feet downstream of the Fall Creek falls which are not passable by salmonids. Dam A is located in an artificially created bypass reach serving the powerhouse. Both streams feeding Dams A and B have little to no salmonid habitat. Ideally, both locations should be blocked to prevent anadromous fish migration into either of these reaches that contain limited viable habitat for redds or juveniles. If anadromous screens are required, the concepts presented in the Detailed Plan (USBR 2012b) for each intake will be used as described below.

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 cfs. To meet the screen criteria, the Tee screen would provide an approach velocity not greater than 0.33 fps, 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 trash rack 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 trash racked intake would be modified to accommodate the cylindrical Tee screen system. The existing trash racks 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-footsquare 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. A new fish screen at Dam B would require a new power line and drop connection.

## 7.6 Recreation Facilities Removal

Recreation facilities are currently provided at J.C. Boyle Reservoir, Copco Lake, and Iron Gate Reservoir. There are no recreation facilities associated with Copco No. 2 Dam. The following descriptions are based on the information presented in the Detailed Plan (USBR 2012b) and are not anticipated to change significantly through detailed design. Confirmation of facility features and removal components will occur during the project detailed design phase.

### 7.6.1 J.C. Boyle Reservoir

Developed recreation sites at J.C. Boyle Reservoir include campgrounds, day use areas, and boat launches (Figure 5.1-1(C)). 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

#### 7.6.1.1 Pioneer Park

Managed by PacifiCorp as part of the Lower Klamath 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 will include all features to be removed and the access roads and parking areas to be regraded, seeded, and planted as described in Section 6.2.

#### 7.6.1.2 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 will include 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 as described in Section 6.2. The remainder of the campground would be retained for public use.

### 7.6.2 Copco Lake

Developed recreation sites at Copco Lake include camping areas, day use areas, and boat launches (Figure 5.5-1(C)). 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

#### 7.6.2.1 Mallard Cove

Located on the south shore of Copco Lake, 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-footwide 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 will include 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 as described in Section 6.2.

#### 7.6.2.2 Copco Cove

Managed by PacifiCorp, Copco Cove is located on the western shoreline of Copco Lake, off 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 will include 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 as described in Section 6.2.

### 7.6.3 Iron Gate Reservoir

Developed recreation sites at Iron Gate Reservoir include campgrounds, day use areas, and boat launches (Figure 5.5-1(C)). 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

#### 7.6.3.1 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. The site is managed by PacifiCorp. 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 removed and restored or could be retained following the removal of Iron Gate Dam. The site is adjacent to the CDFW Fall Creek fish hatchery and provides access to the Fall Creek Trail, where visitors can hike up to Fall Creek Falls. The ultimate disposition of this facility is uncertain.

#### 7.6.3.2 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 removed and restored or could be retained following the removal of Iron Gate Dam, as it provides a creekside setting for picnicking and bank fishing.  However, the ultimate disposition of this facility is uncertain.

#### 7.6.3.3 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 will include 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 as described in Section 6.2.

#### 7.6.3.4 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-footlong, 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 will include 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 will be regraded, seeded, and planted as described in Section 6.2. Additional earthwork will 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.

#### 7.6.3.5 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 will include 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 as described in Section 6.2. Additional earthwork would include the removal or burial of approximately 50 boulders.

#### 7.6.3.6 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 will include 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 as described in Section 6.2. Additional earthwork would include the removal or burial of approximately 120 boulders.

#### 7.6.3.7 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 800foot-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 will include all features to be removed, and approximately 0.5 acres of the site and access road to be regraded, seeded, and planted as described in Section 6.2.

#### 7.6.3.8 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 will include 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 as described in Section 6.2.

#### 7.6.3.9 Iron Gate Hatchery Public Use Areas

The Iron Gate fish hatchery is located downstream of Iron Gate Dam and is operated by CDFW, 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 recreation facilities are expected to be unaffected by the removal of Iron Gate Dam.

### 7.6.4 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 Lake, 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 action will be taken to restore or modify the dispersed recreational sites.

## 7.7 Other Plans

### 7.7.1 Traffic Management Plan

The Transportation Management Plan (TMP) is a specialized program tailored to minimize impacts of a construction project by applying a variety of techniques such as *Public Information, Motorist Information, Incident Management and Construction Strategies.* The major objectives of the TMP are to maintain efficient and safe movement of vehicles through the construction zone; and to provide intensive public awareness of potential impacts to traffic on both haul routes and access roads to all the four dam sites.

Construction activities can create additional traffic delay and safety concerns on these highways and roadway during construction. With an increase in construction traffic demand, planning work activities and balancing traffic demand with highway capacity becomes more critical during construction or maintenance. To prevent unreasonable traffic delays resulting from planned work, TMPs must be carefully developed and implemented to maintain acceptable levels of service, traffic circulation and safety during all work activities on the state and count highway/roadway system.

The objective of this initial TMP is to outline the structure and key requirements that will be incorporated by the construction contractor into a final traffic management plan. The final plan would incorporate the contractor’s specific means and methods for construction, which could refine the approach to access and traffic management.  The final plan would meet all applicable regulatory permit requirements, as well as state and local ordinances. During this process, the following agencies would be coordinated with:

- Oregon Department of Transportation (ODOT)
- California Department of Transportation (Caltrans)
- Klamath and Siskiyou Counties
- Oregon State Police
- California Highway Patrol (CHP)

#### 7.7.1.1 Access Summary

Throughout Project construction, various roads in the vicinity of the four dams will experience some change to traffic conditions, with the potential to impact other road users if not managed effectively. Anticipated changes to traffic could result from the following activities:

- Delivery of construction equipment
- Short haul of deconstructed dam materials (concrete and soil) for near-site disposal
- Long haul of deconstructed dam, hydropower and other materials for off-site disposal
- Delivery of rehabilitation materials
- Road, bridge and culvert improvements
- Worker access
- Fish hauling, as applicable
- 

The proposed haul routes for each site are summarized in Table 7.7-1, and generally shown in Figures 1.2-1(C). Additional details concerning access and associated road improvements can be found in Section 5 (Dam Removal Plans) and Section 7.4 (Road Improvements).

**Table 7.7-1 Primary Access Route Summary**

| Dam Site | Interstate Access | Regional Access | Local Access |
|---|---|---|---|
| J.C. Boyle | Interstate 5 (in Oregon) and US97 | Oregon Route (OR) 66 | Topsy Grade Road, Keno Worden Road |
| Copco No.1 and Copco No. 2 | Interstate 5 (in California) | Copco Road | Ager-Beswick Road, Patricia Ave. |
| Iron Gate | Interstate 5 (in California) | Copco Road | Lakeview Road, Daggett Road |

#### 7.7.1.2 Management Strategies

This section describes proposed strategies to minimize construction-related traffic delays and maintain safe movement of vehicles through the construction zone. The strategies are of a general nature and are meant to reduce the overall level of congestion. More detailed techniques for management of potential impacts will be outlined in the final management plan developed by the contractor. The proposed management strategies can be grouped into the following four broad categories including (1) public information, (2) motorist information, (3) incident management, and (4) construction strategies. Each category and associated details are summarized in the numbered list below.

1. **Public Information:** Various methods would be adopted to ensure the public have easy access to information regarding any current or upcoming interruptions to the local or state road network. Proposed methods, at a minimum, will include the use of telephone hotlines, a Traveler Information System via the project website, local community outreach (meetings, newsletters, etc.), press release(s), and local news media, as appropriate.

2. **Motorist Information Strategies:** A motorist information system would be developed to provide advance notices regarding potential delays throughout the project and associated access routes. Proposed methods will include portable changeable message signs, stationary mounted signs, and highway advisory radio.
3. **Incident Management:** An incident management procedure will be devised to outline traffic procedures to be adopted in the case of an incident on a road or highway. The procedure will be developed in in collaboration with local and state agencies (listed above), and in accordance with local and state requirements.
4. **Construction Strategies:** The following construction strategies will be incorporated into the contractor's final traffic management plan:

    a. Roadway Closures: During construction, some road closures will occur, though only on minor dam access roads where it is deemed that no public interruption would occur. Some short duration road closures would occur on more frequented roads, to enable bridge, culvert and road upgrades or replacements. Scheduling of these would be done in consideration of road users and appropriate public and motorist information regarding detours would be issued in due course.

    b. Traffic Handling and Stage Construction: During construction, signage and traffic control will be provided where project generated traffic will impact road users. The extent of signage and traffic control will be determined though consideration of the changes to road conditions caused by the activities, with consideration of the amount of public traffic using the roads. Signage and traffic control plans will be developed further through detailed design, and provided with the final plan.

    c. Construction Access to Work Zones: Informational signs will be located along the roads directly adjacent or leading to construction work zones, to direct construction traffic and notify other motorists of their presence. Where possible, trip schedules will be planned to minimize impacts, i.e. avoiding peak traffic times. Ingress and egress of construction trucks will be regulated when exiting and entering the work areas to and from the respective highways.

    d. Haulage: Various waste materials will originate from the deconstruction of the four dams. The majority of waste volume - the embankment dam fill and concrete, will be disposed of onsite, requiring minimal haulage. Some materials such as reinforcing steel, mechanical and electrical equipment and other building waste will be hauled to local recycling facilities or dump sites. Haul trips will be scheduled to minimize interruption on the road network, such as by avoiding peak hour times. In addition, signage will provide warning of truck haulage activities to warn other motorists and allow them to anticipate the trucks accordingly.

    e. Emergency Detour Plan: Emergency service routes within the project area will be identified, as appropriate, during detailed design, in coordination with state and local jurisdictions. Typically, emergency detour routes serve hospitals, fire/police stations, emergency shelters, command centers, and other facilities that provide essential services in times of emergencies, either natural or man-made. No material impacts are anticipated on emergency service routes, though the potential of minor impacts due to increased traffic will nevertheless be considered.

f. Traffic Safety Effects: Identified traffic safety hazards caused by the planned truck hauling for the project include the use of blind or sharp corners and turnouts, slow vehicles conflicting with roadway speed limits, and visibility reduction due to dust. These will be managed by appropriate adoption of best practice signage, traffic management systems and dust control. The locations at which they are provided will be determined by a risk assessment of all intersections and roadways, which will be documented in the final plan.

g. Pedestrians and Bicycles: Areas will be identified where pedestrians and cyclists would potentially share roads with construction vehicles. Appropriate signage would be installed to notify of both construction vehicle drivers and non-motorized users of each other's potential presence on the roads. If this is deemed to still present an unacceptable level of risk to non-motorized users, appropriate detours will be arranged to allow continued movement for these users.

### 7.7.2 Water Quality Monitoring Plan

#### 7.7.2.1 Introduction

This Water Quality Monitoring Plan (WQ Plan) provides the proposed water quality monitoring prior to, during, and following completion of the Project. This plan has been developed following receipt of an informational request from the SWRCB dated August 24, 2017 requesting, among other things, a water quality monitoring program to fully evaluate the water quality effects of decommissioning the four dams. The SWRCB specifically requested the following elements to be included in the WQ Plan:

- Assessment of general Klamath River water quality parameters (dissolved oxygen, temperature, turbidity, suspended sediment, nutrients) collected prior to, during, and following dam removal.
- Sampling and analysis for the presence of blue-green algae (microcystis) during and following dam removal.
- Toxicity assessment of residual reservoir sediments, and sediments deposited downstream of the Project reservoirs in the Klamath River and estuary following dam decommissioning.

This plan presents a general overview of the water quality monitoring that is presently being conducted in the Klamath River through Interim Measure 15 - Water Quality Monitoring (IM-15), the KRRC's approach to augment this monitoring during dam decommissioning, and the KRRC's approach to sampling the river and estuary for presence of toxicity following dam decommissioning. The information collected under this plan will assist the KRRC in making adaptive management decisions during and following dam decommissioning to lessen impacts to aquatic resources by implementing aspects of the KRRC's Aquatic Resource Measures (Section 7.2).

#### 7.7.2.2 Klamath Interim Measure 15 Water Quality Monitoring

The amended KHSA includes provisions for the interim operation of the Lower Klamath Project by PacifiCorp prior to decommissioning and included several Interim Measures (IMs) to mitigate conditions created by the dams and to collect baseline information prior to dam decommissioning. The KHSA includes IM-15 that requires PacifiCorp to fund baseline water quality monitoring from Upper Klamath Lake to the Klamath River estuary at the Pacific Ocean. The water quality monitoring under IM-15 entered its ninth year in 2017 and PacifiCorp has an obligation to continue IM-15 monitoring until dam decommissioning begins. IM-15 contains the following water quality monitoring elements:

- Cyanobacteria and cyanotoxin grab sampling for public health protection at 18 locations from Upper Klamath Lake to the estuary, including nine locations downstream of Iron Gate Dam in the Klamath River.
- Baseline water quality monitoring at 18 sites on the Klamath River from Link River Dam to the estuary. Additional water quality monitoring is conducted at the mouth of the four major Klamath River tributaries (Shasta, Scott, Salmon, and Trinity).
- Hourly sonde data collection at six locations between Iron Gate Dam and the community of Klamath for temperature, dissolved oxygen, pH, and electrical conductivity.
- Seasonal (May-October), monthly, and bimonthly (excluding January and February) discrete grab sampling conducted for nutrients, including total nitrogen and phosphorus, nitrate and nitrite, ammonia, particulate and organic phosphorus and dissolved carbon.

The above monitoring is conducted by the U.S. Bureau of Reclamation (BOR), PacifiCorp, and the Yurok and Karuk tribes and is funding through PacifiCorp. The Klamath Basin Monitoring Program (KBMP), a consortium of in-basin regulatory and resource agencies and interested stakeholders, maintains the water quality monitoring data collected under IM-15. KBMP's Klamath River monitoring data and location maps can be found at http://www.kbmp.net. The KRRC intends to utilize the existing KBMP data set and new data collected before dam decommissioning as part of the WQ Plan data set.

#### 7.7.2.3 Rationale for Water Quality Monitoring Plan

Removal of the four dams is anticipated to impact aquatic resources on the lower river through the release of reservoir sediment. USBR's 2012 EIS/R for dam removal anticipated that the reservoir sediments, composed largely of organic silt and clay size particles would exhibit high chemical oxygen demand (COD) and high suspended sediment concentrations downstream of Iron Gate Dam. The highly turbid water and low dissolved oxygen caused by sediment release will result in stress and mortality to fish and other aquatic organisms in the mainstem Klamath River during reservoir drawdown. The KRRC plans to conduct pre, concurrent, and post water quality monitoring to assess the impacts of dam removal on the aquatic environment from J.C. Boyle Dam to the estuary. The KRRC will also collect water quality sampling at Keno Dam upstream from the Project to assess baseline river conditions.

### 7.7.2.4 Monitoring Locations

Table 7.7-2 provides the location of proposed sonde monitoring stations that would operate 12 months of the year at least one year prior to dam removal and up to three years following dam removal. Each proposed monitoring location is also an existing KBMP monitoring site-some with operable sondes, and several of the sites have a companion USGS flow gauge as indicated in Table 7.7-2 and shown on Figure 7.7-1(C). The KRRC was informed by the KBMP monitoring entities that all locations will require strengthening of the sonde holding mechanism to withstand winter conditions during January and February (currently, there is no data collected during this time by KBMP). Due to difficulty collecting data during the winter months (ice and algae buildup, high flows, etc.) and the importance of the data collection effort, duplicate sondes may be deployed at specific monitoring locations during dam decommissioning.

**Table 7.7-2 Sonde Monitoring Summary**

| Location | River Mile | Current Monitoring Entity | Existing Sonde | New Sonde | USGS Gage Station |
|---|---|---|---|---|---|
| Klamath River below Keno Dam | 233.4 | USBR | n | x | y |
| Klamath River below J.C. Boyle Dam | 224.6 | PacifiCorp | n | | n |
| Klamath River below Iron Gate Dam | 189.7 | PacifiCorp | y | x | y |
| Klamath River at Walker Bridge | 156.3 | Karuk Tribe | n | | n |
| Klamath River below Seiad | 128.5 | Karuk Tribe | y | x | y |
| Klamath River at Orleans (USGS) | 59.1 | Karuk Tribe | y | | y |
| Klamath River near Klamath | 6.0 | Yurok Tribe | y | x | y |

The KRRC will conduct a field inspection of each of the monitoring sites in coordination with the current KBMP monitoring entity to assess the necessary strengthening upgrades to support winter sonde monitoring.

### 7.7.2.5 Monitoring Parameter and Frequency

Table 7.7-3 shows the constituents that the KRRC proposes to monitor at each of the sonde locations summarized in Table 7.7-2 and Figure 7.7-1(C). Sufficient time series water quality data is being collected by sondes for most parameters by KBMP parties for the pre-dam removal period. However, these sondes do not collect data during January and February, as described above. The KRRC plans to coordinate with the KBMP to upgrade the current sonde locations to collect data during January and February of each year. A new sonde will be installed at the three locations shown in Table 7.7-2. At a minimum, water quality sampling will be conducted one year before and three years following dam decommissioning. Collection of discrete grab samples will be collected throughout the dam decommissioning process to validate sonde data and collect samples requiring laboratory analysis, as shown in Table 7.7-3.

## Figure 7.7-1 Water Quality Monitoring Locations (Appendix C)

## Table 7.7-3 Monitoring Parameter and Frequency

| Constituent | Frequency | Type of Sample |
|---|---|---|
| Temperature | Hourly, 12 months per year | Continuous Sonde |
| Dissolved Oxygen | Hourly, 12 months per year | Continuous Sonde |
| pH | Hourly, 12 months per year | Continuous Sonde |
| Conductivity | Hourly, 12 months per year | Continuous Sonde |
| Turbidity | Hourly, 12 months per year | Continuous Sonde |
| Chemical Oxygen Demand | Monthly, daily during drawdown | Grab |
| Total Nitrogen | Monthly | Grab |
| Total Phosphorous | Monthly | Grab |
| Microcystis Cell Count | Monthly | Grab |

Other elements of the WQ Plan include:

- Sonde turbidity data will be collected as Nephelometric Turbidity Units (NTUs). However, impacts to aquatic resources from reservoir sediments have been quantified in milligrams per liter (mg/L) of Total Suspended Sediment (TSS). The KRRC plans to collect reservoir sediment samples in October 2017 and will conduct a series of laboratory tests to develop a TSS versus turbidity relationship for the reservoir sediments. This relationship will assist in making adaptive management decisions during and following dam removal and in understanding the impacts to aquatic resources. A laboratory protocol will be developed for the TSS/turbidity relationship analysis that identifies the accuracy and reliability of this relationship along with any uncertainties and specific field verification testing during dam decommissioning.
- Discrete grab samples will be collected during the winter of 2018 and 2019 during two to three storm events for TSS and dissolved oxygen. The KRRC anticipates collecting this data at Walker Bridge, Seiad, Orleans, and Klamath. TSS will be compared to turbidity to develop a relationship between these two parameters for storm derived turbidity events. This information will be compared to other planned KRRC fisheries monitoring activities and data collected over the same time to understand how fish (Chinook, Coho, and lamprey) naturally respond to avoid stressful water quality conditions (e.g. migration to tributaries).
- Sampling for blue-green algae derived microcystis during and following dam removal will be conducted to understand if microcystis has physically accumulated in reservoir sediments. If the KRRC can demonstrate that microcystis is not present in reservoir sediments this sampling will be discontinued.
- The KRRC will assess the need for acoustic monitoring technologies [i.e. submersible acoustic backscatter sediment sensors (LISST-ABS), Horizontal Acoustic Doppler Current Profilers (H-ADCP)] to monitor suspended sediment concentration and bedload transport.

These technologies could be used to augment or replace turbidity measurements collected by sondes.

#### 7.7.2.6 Sediment Toxicity

During the Secretarial Determination process, the USBR collected 75 five sediment cores from the three Project reservoirs and analyzed sediments for 501 anthropogenic and naturally occurring chemicals and compounds. USBR assessed whether significant risk existed for humans or aquatic biota via five contaminate exposure pathways. The data analysis was done in collaboration with the states of Oregon and California, as well as the EPA. The USBR concluded that no chemicals or compounds were detected in reservoir sediments at concentrations exceeding human health screening levels, and no other preclusions to releasing the reservoir sediments to the freshwater or marine environment were identified for human or aquatic biota exposure (USBR 2012d).

The above finding aside, the SWRCB has requested toxicity testing following dam removal in remaining reservoir sediments, downstream of reservoirs, and in the Klamath estuary. The KRRC does not have any data to indicate that further testing of reservoir sediments is necessary and would like to discuss this request further with the SWRCB to understand the rationale for this request. If additional testing is required, the KRRC would generally perform the following activities:

- Following dam removal, an estimated 10 samples will be collected in the footprint of the three reservoirs at randomly derived locations. Samples for each reservoir will be composited into a single sample at each reservoir for laboratory analysis.
- A composite sample will be collected at a location of deposition or aggradation in Klamath River between Seiad and Orleans (See Figure 7.7-1(C)). Sampling will occur prior to dam decommissioning to assess baseline conditions and will be repeated in the same location following dam decommissioning.
- Up to 10 samples will be collected in the Klamath River estuary at randomly derived locations. Samples will be composited into a single sample for laboratory analysis. Sampling will occur prior to dam decommissioning to assess baseline conditions and will be repeated following dam decommissioning.
- All sampling, analysis, and evaluation of sediments for the presence of toxic compounds will follow the procedures and protocols defined in the USACE Sediment Evaluation Framework for the Pacific Northwest, July 2016 (RSET 2016).

#### 7.7.2.7 Plan implementation

The KRRC will develop a separate Sampling Analysis Plan-Quality Assurance Plan (SAP-QAP) for each element of the WQ Plan. The SAP-QAPs will define:

- Field and laboratory quality assurance/quality control (QA/QC) practices and procedures
- Monitoring entities (i.e. Yurok and Karuk tribes, USGS, USBR etc.) and their specific roles
- Monitoring parameters, procedures, and frequency.
- Data management approach for continuous sonde data storage and discrete grab samples.

- Adaptive management measures and water quality trigger points to inform response actions defined in the Aquatic Resource Measures (Section 7.2).
- Regulatory, stakeholder, and public reporting of the collected data.

### 7.7.3 Groundwater Well Management Plan

The Detailed Plan proposed mitigation measure GW-1 that is intended to return the production rate of all affected domestic or irrigation groundwater wells to their pre-dam-removal condition by deepening or replacing the affected wells. GW-1 included a preconstruction well survey and interim actions to take prior to the completion of the modifications to the affected wells. The survey and related actions are now included in the Groundwater Well Management Plan described in this section and are, therefore, no longer included as a mitigation measure under the proposed Project.

#### 7.7.3.1 Introduction

The project has the potential to alter groundwater levels in the immediate vicinity of the reservoirs. The USBR performed a desktop review of wells located within a 2.5-mile radius of the three main reservoirs (Iron Gate, Copco, and J.C. Boyle) of the project and reported these well locations in the 2012 EIS/R for dam decommissioning (USBR and CDFW 2012). At the time, USBR identified 124 wells within the 2.5 mile range that had the potential to be impacted by reservoir drawdown (Figures 7.7-2 (C) and 7.7-3 (C)). USBR identified 15 of those wells as most likely to be impacted by reservoir drawdown. The USBR concluded that additional monitoring work would be required before, during, and following dam decommissioning to better understand reservoir removal effects on the surrounding groundwater wells.

**Figure 7.7-2 Identified Groundwater Wells within 2.5 Miles of J.C. Boyle Reservoir (Appendix C)**

**Figure 7.7-3 Identified Groundwater Wells within 2.5 Miles of Copco Lake and Iron Gate Reservoir (Appendix C)**

The Groundwater Well Mitigation Management Plan is intended to identify groundwater wells that may be adversely impacted following dam decommissioning and reservoir drawdown and provide sufficient monitoring to understand the effects, if any, on groundwater levels and quality. If groundwater wells are found to have been adversely impacted following dam decommissioning, the KRRC would undertake measures (e.g., well deepening) to return the production rate of any affected domestic or irrigation groundwater supply well to conditions prior to dam decommissioning. There are five steps in this plan:

1. Database Search and Agency Coordination
2. Outreach to land owners and residents
3. Installation of groundwater monitoring wells
4. Groundwater monitoring
5. Post-Dam removal outreach/notification of findings
6. Mitigation

#### 7.7.3.2 Database Search and Agency Coordination

The KRRC performed an initial review of USBR's database for the existing 124 wells located within a 2.5-mile radius of the project reservoirs. It could not be determined how USBR compiled the well location information, and the KRRC wanted to both verify the location of earlier documented wells and identify any new wells that might have been installed since 2012. To this end, the KRRC contacted Siskiyou County, the California Department of Water Resources (DWR), and Oregon Water Resources Department (OWRD) about the accessibility of their groundwater well data bases.

Siskiyou County was not able to provide any specific information on well locations or ownership due to insufficient staff resources. County staff stated that there are no shared water systems at the California reservoirs, so it can be assumed that all reservoir residents utilize groundwater for domestic use. (Rick Dean, personal communication, July 27, 2017). Siskiyou County recommended that the KRRC contact DWR to verify previously recorded well locations and to identify any potential new well records.

The KRRC contacted DWR and was told that DWR's policy does not allow the sharing of well ownership information (Benjamin Brezing, personal communication, August 8, 2017). DWR did provide well location information, but this data does not entirely match information reported by USBR in 2012, and there is uncertainty over whether new wells have been installed since 2012.

The KRRC contacted OWRD and was directed to use their public database to download well logs for those surrounding J.C. Boyle (Mary Grainey, personal communication, August 23, 2017). Of the 17 well logs that were identified and downloaded using the OWRD database search, only one provided a specific location. In ODEQ's August 24, 2017 request for additional information from the KRRC, they indicated that some wells within 2.5 miles of the JC Boyle Reservoir may have been installed prior to OWRD's registration requirements and consequently would not be included in the data base. Given the uncertainty of well locations and ownership around all reservoirs, the KRRC has proposed a broad land owner outreach program as described below.

#### 7.7.3.3 Outreach to Land Owners and Residents

Based on the limited new information that was collected from Siskiyou County, DWR, and OWRD, the locations reported by USBR in 2012 were retained for further analysis. To fully understand well location and ownership, the KRRC will undertake an outreach effort to all residents and landowners within 2.5 miles of the Project reservoirs to inquire about their groundwater wells.

The KRRC will develop and send an information and questionnaire mailer to property owners, residents, and businesses within 2.5 miles of each reservoir informing them that dam decommissioning and reservoir drawdown could result in groundwater level declines potentially affecting the functionality of their groundwater well. The mailer will include a request to monitor the well for water level prior to, during, and following dam decommissioning. The KRRC will also use its planned public meetings and meetings targeted at reservoir land owners to "spread-the-word" about the potential for impacts to well owners and the KRRC's need to identify wells for monitoring within 2.5 miles of the reservoirs. It is the KRRC's desire to identify as many willing well owners as possible to participate in the monitoring program to understand the effect of dam decommissioning on the groundwater aquifer system. Initial information requested by the questionnaire could include:

- Participation in the well monitoring program
- Property address and well location
- Current depth to groundwater
- Physical parameters of the well (casing size, well depth, screen interval, pump size)
- Historical groundwater well problems (quantity and quality)

#### 7.7.3.4 Installation of Groundwater Monitoring Wells

It is the KRRC's desire to identify a sufficient number of residential wells within the proximity of each reservoir to monitor the effects of reservoir drawdown on the groundwater aquifer (sentinel wells). Wells near the reservoirs (less than ¼ mile) are ideal as the groundwater recharge effect from the reservoir decreases with distance from the reservoir. If an insufficient number of well owners volunteer to participate in the groundwater monitoring activity, the KRRC will install a minimum of 10 sentinel monitoring wells around the three reservoirs. The monitoring wells would be installed ideally between residents and the reservoirs on PacifiCorp's Parcel B lands. Tentatively, up to four monitoring wells each would be installed at Iron Gate Reservoir and Copco Lake and two wells at J.C. Boyle Reservoir. Potential monitoring well locations are identified in Figures 7.7-2 (C) and 7.7-3 (C).

#### 7.7.3.5 Groundwater Monitoring

Sentinel wells belonging to participating landowners and any monitoring wells installed by the KRRC will be monitored pre- and post-dam decommissioning to identify seasonal fluctuations in groundwater levels and any groundwater level changes resulting from reservoir removal. Sentinel wells will also be monitored for general water quality parameters including pH, conductivity, and major anions and cations. To establish baseline conditions, the KRRC plans to monitor sentinel wells monthly for a minimum of one year prior to dam decommissioning. Following dam decommissioning, groundwater monitoring would be conducted monthly for up to one year or until such time that groundwater levels and general water quality parameters have stabilized (no discernable water level declines or changes in quality over a four-month period) or they mirror baseline conditions.

During the drawdown period, data loggers would be installed in the sentinel wells to continuously record groundwater levels and pH and conductivity. If changes to water levels or quality were identified that might indicate potential supply problems, the KRRC would take appropriate measures to provide temporary and long-term water supplies as defined below.

#### 7.7.3.6 Post-Dam Removal Outreach/ Notification of Findings

The KRRC will summarize the groundwater data collected prior to, during, and following dam decommissioning and identify any trends or changes in groundwater water levels and quality.

The KRRC will develop a report of findings and identify any areas where groundwater wells might be vulnerable to groundwater level declines resulting from reservoir removal. The KRRC will make the report available to all well owners in the study area. Well owners will have the opportunity to request an evaluation of their well for impacts resulting from dam decommissioning.

#### 7.7.3.7 Mitigation

If the data collected during or following dam decommissioning confirms an adverse impact (loss of supply due to water level declines or adverse effect on water quality) to any potable or irrigation well, the KRRC will act to return the water well owner's supply to pre-dam decommissioning conditions. These actions could include providing temporary water supplies until long-term measures such as motor replacement, well deepening, or full well replacement are identified and implemented.

### 7.7.4 Fire Management Plan

A fire management plan has been developed to include fire prevention and response methods including fire precaution, pre-suppression, and suppression measures consistent with the policies and standards in the affected jurisdictions and provisions that areas of construction and deconstruction work involving construction activities that could result in open sparks or flame be cleared of dried vegetation or wetted-down to prevent wildfires. The plan also requires fire suppression equipment be on-site at all times and emergency contact numbers be posted, in case of a fire. The elements proposed in this plan are included in the Fire Management Plan in Appendix J.

With the removal of the reservoirs as a source of water for fighting wildfires, the Fire Management Plan in Appendix J also provides measures for potential alternative sources of water for firefighting.

### 7.7.5 Hazardous Material Management Plan

All data used to construct this hazardous material plan was provided to the KRRC by PacifiCorp, EDR, or local agencies. Additional recommendations will be made following the planned Phase I-Environmental Site Assessment (ESA) visits and interviews and the following Phase II Site Investigation, if needed after the Phase I ESA.

The following structures have been reported on each of the four sites.

- J.C. Boyle Dam and Powerhouse: This facility consists of a reservoir, combination embankment and concrete dam, gated spillway, diversion culvert, water conveyance system, and powerhouse, completed in 1958. Current structures at the site include an office building (known as the Red Barn), a maintenance shop, a fire protection building, a communications building, two (2) occupied residences near the dam, and a large warehouse near the powerhouse.
- Copco No. 1 Dam and Powerhouse: This facility consists of a reservoir, concrete dam, gated spillway, diversion tunnel, intake structure, and powerhouse constructed between

1911 and 1922. Current structures at the site include an occupied residence with small garage, a vacant house, and a maintenance building.

- Copco No. 2 Dam and Powerhouse: This facility consists of a reservoir, concrete diversion dam, embankment section, gated spillway, water conveyance system, and powerhouse completed in 1925. Current structures at the site include a control center building, maintenance building, and oil and gas storage building.
- Iron Gate Dam and Powerhouse: This facility consists of a reservoir, embankment dam, ungated side-channel spillway, diversion tunnel, intake structures, and powerhouse completed in 1962. Current structures at the site include a communications building, restroom building, and two (2) occupied residences.

Asbestos Containing Material (ACM), lead based paint (LBP), and polychlorinated biphenyls (PCBs) may be present in building materials based on the year of construction of each of the four sites. All structures are expected to be removed will be sampled and tested for ACM, LBP, and PCBs. Any abated material with asbestos, lead, and or PCBs which exceed hazardous waste criteria levels will be handled and disposed of as hazardous waste at approved hazardous waste facilities in accordance with applicable federal and state regulations. Remaining materials will be disposed of as non-hazardous construction debris.

All hazardous materials removed from the sites (i.e., paints, oils, and welding gases) will be either returned to the vendor, recycled, or managed and disposed of as hazardous waste at an approved hazardous waste facility in accordance with applicable federal and state regulations. Transformer oils will be tested for PCBs if no data exists. Any tanks which contained hazardous materials will be decontaminated prior to disposal.

Universal hazardous waste (i.e., lighting ballasts, mercury switches, and batteries) will be handled per applicable federal and state universal waste regulations.

The types of hazardous materials that may be present are shown in Table 7.7-4 according to facility.

### Table 7.7-4 Anticipated Types of Hazardous Waste

| Type of Waste | J.C. Boyle | Copco No. 1 | Copco No. 2 | Iron Gate |
|---|---|---|---|---|
| Asbestos | X | X | X | X |
| Batteries | X | X | X | X |
| Bearing and hydraulic control system oils | X | X | X | X |
| Treated wood | X | X | X | X |
| Coatings containing heavy metals | X | X | X | X |
| Contaminated soils | ? | ? | ? | ? |
| PCBs | ? | ? | ? | ? |
| Oil and fuel tanks | X | X | X | X |
| Hazardous materials storage | X | | X | |
| Septic system | X | | X | X |

| Type of Waste | J.C. Boyle | Copco No. 1 | Copco No. 2 | Iron Gate |
|---|---|---|---|---|
| Gas cylinders | X | | | |
| Mercury containing fixtures | | ? | ? | |
| Creosote treated wood | | | X | |

Any additional hazardous materials noted during the Phase I site visits and Phase II investigations will be included in an updated hazardous materials management plan.

#### 7.7.5.1 J.C. Boyle

According to the Detailed Plan, 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 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. Table 7.7-5 lists the reported material and quantities for J.C Boyle from the Hazardous Materials Inventories provided by PacifiCorp.

**Table 7.7-5 Hazardous Materials Inventory – J.C. Boyle**

| Hazardous Class | Common Name | Quantities (Average daily) | Storage Container |
|---|---|---|---|
| Flammable and Combustible Liquids | Gasoline | 500 gallons | AST |
| Flammable and Combustible Liquids | Diesel Fuel No. 2 | 300 gallons | AST |
| Flammable Gases | Acetylene | 200 cubic feet | Cylinder |
| Nonflammable Gases | Argon, Liquid | 200 cubic feet | Cylinder |
| Flammable and Combustible Liquids | Gear Oil | 20 gallons | Plastic Drum |
| Flammable and Combustible Liquids | Hydraulic oil | 30 gallons | Plastic Drum |

| Hazardous Class | Common Name | Quantities (Average daily) | Storage Container |
|---|---|---|---|
| Corrosives (Liquids and Solids) | Lead Acid Batteries | 10,840 pounds | Glass bottle or Jug |
| Flammable and Combustible Liquids | Used Oil | 20 gallons | Steel Drum |
| Flammable and Combustible Liquids | Paint | 15 gallons | Cans |
| Nonflammable Gases | Nitrogen | 1,200 cubic feet | Cylinder |
| Flammable Gas | Propane | 300 gallon | AST |

#### 7.7.5.2 Copco No. 1

According to the Detailed Plan, 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. Table 7.7-6 lists the reported material and quantities for Copco No. 1 from the Hazardous Materials Inventories provided by PacifiCorp.

**Table 7.7-6 Hazardous Materials Inventory – Copco No. 1**

| Hazardous Class | Common Name | Quantities | Storage Container |
|---|---|---|---|
| Flammable Gas | Liquefied Petroleum Gas | 171 gallons | AST - Cylinder |
| Flammable and Combustible Liquids | Governor Oil (hydraulic oil) | 1,500 gallons | Tank inside building |
| Flammable and Combustible Liquids | Transformer Oil | 11,000 gallons | Tank inside building |
| Corrosives (Liquids and Solids) | Lead Acid Batteries | 66 gallons | Glass bottle or Jug |
| Nonflammable Gases | Nitrogen | 150 cubic feet | Cylinder |
| Flammable Gases | Liquefied Petroleum Gas | 499 gallons | Cylinder |

#### 7.7.5.3 Copco No. 2

According to the Detailed Plan, 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. 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. Table 7.7-7 lists the reported material and quantities for Copco No. 2 from the Hazardous Materials Inventories provided by PacifiCorp.

**Table 7.7-7 Hazardous Materials Inventory – Copco No. 2**

| Hazardous Class | Common Name | Quantities | Storage Container |
|---|---|---|---|
| Flammable and Combustible Liquids | Diesel Fuel No. 2 | 375 gallons | AST |
| Flammable Gas | Liquefied Petroleum Gas | 250 gallons | AST - Cylinder |
| Flammable and Combustible Liquids | Transformer Oil | 12,778 gallons | AST |
| Flammable and Combustible Liquids | Gasoline | 500 | AST |
| Nonflammable Gases | Oxygen | 500 cubic feet | Cylinder |
| Flammable and Combustible Liquids | Governor and Bearing Oil (hydraulic oil) | 3,600 gallons | Steel drum, Plastic/Non-metallic drum |
| Flammable Gases | Acetylene | 300 cubic feet | Cylinder |
| Nonflammable Gases | Nitrogen | 750 cubic feet | Cylinder |
| Nonflammable Gases | Argon, Liquid | 700 cubic feet | Cylinder |
| Flammable and Combustible Liquids | Oil base paint | 50 gallons | Cans |
| Corrosives (Liquids and Solids) | Lead Acid Batteries | 64 gallons | Glass bottle or Jug |

#### 7.7.5.4 Iron Gate

According to the Detailed Plan, 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. Table 7.7-8 lists the reported material and quantities for Iron Gate from the Hazardous Materials Inventories provided by PacifiCorp.

**Table 7.7-8 Hazardous Materials Inventory – Iron Gate**

| Hazardous Class | Common Name | Quantities | Storage Container |
|---|---|---|---|
| Nonflammable Gases | Nitrogen | 1,850 cubic feet | Cylinder |
| Flammable and Combustible Liquids | Governor and Bearing Oil (hydraulic oil) | 1,400 gallons | Tank Inside Building |
| Flammable and Combustible Liquids | Transformer Oil | 3,500 gallons | Other |
| Corrosives (Liquids and Solids) | Lead Acid Batteries | 102 gallons | Other |

### 7.7.6 Emergency Response Plan

The Detailed Plan proposed mitigation measure H-1 to develop and implement an Emergency Response Plan intended to provide adequate notification to agencies and the public of the potential changes in timing and magnitude of flooding below Iron Gate. An Emergency Response Plan has been included as part of the proposed project, as discussed in this section and is, therefore, no longer included as a mitigation measure.

The construction contractor will be required to develop a final Emergency Response Plan to document procedures to be put in place help prevent incidents, to assure preparedness in the event incidents occur, and to provide a systematic an orderly response to emergencies. This plan will be closely coordinated with the contractor's Health and Safety Plan, Spill Prevention and Response Plan and Fire Management Plan.

Procedures documented in the plan will apply to all personnel working on site. Prior to commencing construction activities, the contractor's Health and Safety lead will review emergency response procedures with all personnel assigned to the site to the extent necessary.

Applicable emergency scenarios include, but are not limited to, the following:

- Medical emergency
- Fire management
- Traffic incident
- Hazardous material spill management
- Downstream hydraulic change planning
- Dam or tunnel failure
- Catastrophic emergency (e.g. earthquake, high wind event, etc.)
- Security threat

Each type of emergency and its associated plan requirements are discussed in more detail below.

#### 7.7.6.1 General Requirements

The following is a list of general emergency requirements to be incorporated into the final plan.

1. Emergency service cards are to be posted in all offices on site and carried in all construction vehicles. Maps to clinics and hospitals will be posted by all land-line phones. Emergency service cards will list emergency phone numbers for local fire department, ambulance services, life flight medical helicopters, local police department, local medical clinic, nearest hospital, and KRRC construction manager.
2. Final Emergency Response Plan, as well as the steps to take in an emergency, will be posted and readily accessible at the site.
3. An adequate number of site personnel (minimum of one per dam site) will have current certification cards in First Aid and CPR.
4. Each dam site will be equipped with a First Aid cabinet, trauma kit, AED, and stretcher basket.
5. In the event of an emergency, all personnel will clear the radio for "Emergency Use Only" by calling "May-Day, May-Day, please clear the radio for emergency use."
6. Should an offsite emergency response team be required, contractor's supervisor or the KRRC construction manager will designate an on-site employee to meet and escort the response team to the injury or emergency location.
7. Medical personnel/facilities on site: This will be specifically determined before the start of construction.
8. Emergency response plan procedures and documentation are subject to annual KRRC audits and shall be reviewed and/or updated annually.

#### 7.7.6.2 Medical Emergency

In the event of an onsite medical emergency, the onsite contractor supervisor and KRRC construction manager shall be notified immediately with details concerning the location, name of injured person(s) and a brief description of the situation. Initiate immediate first aid action as necessary through the use of trained first aid providers. The injured shall not be left unless absolutely necessary to quickly notify the jobsite office and then return. Injured person(s) shall not be moved unless they are in immediate danger of further injury. The final emergency response plan shall outline detailed procedures for medical emergency procedures and shall include standard reporting forms to document the emergency.

The following hospitals are located within the vicinity of the Project site:

1. Sky Lakes Medical Center
   2865 Daggett Ave, Klamath Falls, OR 97601
   (541) 882-6311
2. Fairchild Medical Center
   444 Bruce St, Yreka, CA 96097
   (530) 842-4121
3. Asante Ashland Community Hospital
   280 Maple St, Ashland, OR 97520
   (541) 201-4000

#### 7.7.6.3 Fire Management

Refer to the Fire Management Plan in Section 7.7.4 for procedures and contacts related to managing fire emergencies.

#### 7.7.6.4 Traffic Incident or Emergency

In the event of traffic incident or emergency onsite, or along construction access routes currently in use (by the contractor), the onsite contractor supervisor and KRRC construction manager shall be notified immediately with details concerning the location, name of injured person(s) and a brief description of the situation. If medical attention is required, protocols outlined for “Medical Emergencies” shall be followed. The local authorities, as defined in this plan, shall be contacted by the onsite supervisor.

#### 7.7.6.5 Hazardous Material Spill Management

The contractor shall develop a separate Spill Prevention and Response Plan, which shall comply with all governmental approvals and applicable local, state and federal laws and regulations. In the event of an onsite hazardous material spill, the onsite contractor supervisor and KRRC construction manager shall be notified immediately with details concerning the location, type of material and a brief description of the situation. The Spill Prevention and Response Plan shall include detailed procedures and documentation forms to prevent and respond to spills. Topics or requirements to be provided in the final plan include, but are not limited to, the following:

1. Identification and location of staging and material stockpiles in areas that will prevent spills from entering the river channel
2. All hazardous materials shall be stored in a clearly identified and protected area, and all hazardous materials brought onsite will have a Material Safety Data Sheet (MSDS), which will be provided to the contractor’s Health and Safety lead.

3. Vehicles or equipment operated adjacent to the stream shall be checked and maintained daily to prevent leaks of materials. If a leak is discovered, the equipment will be removed from the project for repair.
4. Required equipment/vehicle maintenance, refueling and lubrication will be performed at the pre-determined, protected location. If this is not possible, the activity will be completed at least 100' from any water body.
5. All aboveground storage tanks containing fuel or oil stored onsite in excess of 1,320 gallons will require a site-specific Spill Prevention Control and Countermeasures (SPCC) Plan.
6. All project workers will receive training on the CRRDR Project Spill Response and Reporting Procedures

Attempts to handle the emergency shall only be attempted if doing so presents no exposure or risk to danger or contamination to personnel. If possible, cleanup of all spills will commence as soon as possible following any spill. The MSDS will be referenced to identify safe handling and cleanup procedures. If a spill requires a hazardous waste cleanup operation and specially trained crew, the contractor's Health and Safety lead will be notified to ensure properly trained personnel any conduct cleanup and remediation. This is not anticipated for cleanup of spills of common construction materials.

#### 7.7.6.6 Downstream Hydraulic Change Planning

Prior to dam removal, the KRRC will inform the National Weather Service River Forecast Center of any 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.

Contact Information for California Nevada River Forecast Center:

US Dept. of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
California Nevada River Forecast Center
3310 El Camino Avenue, Room 227
Sacramento, CA 95821-6373
916-979-3056
Webmaster Email: cnrfc.webmaster@noaa.gov

The KRRC will also inform FEMA of a planned major hydraulic change to the Klamath River that could affect the 100-year flood plain. This will be done through a conditional letter of map revision (CLOMR) report, submitted to FEMA during the detailed design phase. Through this process, and the subsequent letter of map revision (LOMR) submittal to FEMA, the KRRC 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 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.

#### 7.7.6.7 Dam or Tunnel Failure

In the event of a tunnel failure during construction or drawdown, the immediate area shall be evacuated and the onsite contractor supervisor and KRRC construction manager shall be notified immediately. Tunnel failure resulting in partial or full blockage of flow, could results in reservoir drawdown occurring outside of the proposed window, or being delayed indefinitely. Should this occur, the applicable regulatory agencies shall be notified, and the KRRC shall develop a plan to mitigate any associated impacts. The plan shall be developed within five (5) calendar days of the tunnel failure, and shall be sent to the applicable regulatory agencies for review and approval.

In the event of a dam failure, or an imminent dam failure, during construction or drawdown, the immediate area shall be evacuated and the onsite contractor supervisor and KRRC construction manager shall be notified immediately. The onsite supervisor shall contact 911, local law enforcement, local fire departments, the Klamath and Siskiyou County emergency services, and the California Division of Safety of Dams (DSOD) immediately.

County Emergency Services and DSOD contact information is provided below:

1. Siskiyou County Office of Emergency Services
   806 South Main Street
   Yreka, CA 96097
   530-841-2155
2. Klamath County Emergency Management
   2543 Shasta Way
   Klamath Falls, OR 97601
   541-851-3741
3. DSOD: Specific contact and phone numbers for working and non-working hours shall be coordinated with DSOD prior to finalization of Emergency Action Plan by the contractor. The current project contact at DSOD is Nekane Hollister at 916-227-4627.

In Klamath County, Oregon, there is an Emergency Operations Plan (EOP) that outlines procedures to ensure protection of life and property during a dam failure. The government and private agencies involved as well as their roles and responsibilities in response to a dam failure are defined. Flood inundation maps are available in the office of the Klamath County Emergency Manager.

Prior to finalization of the contractor's Emergency Action Plan, the contractor shall request and review PacifiCorp's Emergency Action Plans for each dam. These plans will contain useful information on emergency contacts and protocol.

#### 7.7.6.8 Catastrophic emergency (e.g., earthquake, extreme weather event, etc.)

The contractor's final Emergency Response Plan shall clearly identify procedures and documentation forms to manage the response associated with a catastrophic emergency. In the event of a catastrophic emergency, the onsite contractor supervisor and KRRC construction manager shall be notified immediately with details concerning the location, name of any injured person(s) and a brief description of the situation at any damaged structure or facility. It is imperative that each employee is accounted for. The designated supervisor will perform a physical headcount of all on-site personnel as soon as possible.

When evacuation is determined necessary, the following procedures shall be followed:

1. Employees will leave any buildings and the site area or as advised and report to the designated emergency staging area. The emergency staging area for the various project sites will be clearly identified in the final Emergency Response Plan. When evacuating, employees should walk, remain quiet, and follow all other emergency instructions.
2. When evacuating work areas, employees should close doors behind them, but do not lock unless otherwise instructed.
3. Employees working with electrically operated machines or equipment should switch the equipment off or unplug it prior to leaving the work area.
4. After evacuation is completed, police and other emergency personnel will prevent entrance to this effected site area.
5. When emergency is over, the contractor's project manager or KRRC construction manager, in conjunction with site Health and Safety personnel, will advise employees when it is safe to return to the site.

#### 7.7.6.9 Security Threat

Security threats to any facility within the Project site will be immediately communicated to the onsite contractor supervisor and KRRC construction manager. Based on the information or type of threat received, a response will be initiated by the supervisor that may include any of the following:

1. Cessation of all work activity and mustering of site personnel
2. Notification of local law enforcement agencies
3. Notification of the Federal Bureau of Investigation

### 7.7.7 Noise and Vibration Control Plan

The purpose of the Noise and Vibration Control Plan (NVCP) is to address and reduce increases in day and night time noise levels resulting from Project construction activities. The final NVCP developed by the contractor would document noise and vibration objectives based on regulatory and industry guidelines, discuss contractor staff roles and responsibilities for noise and vibration control, define noise intensive activities and timing, clearly identify sensitive receptors, evaluate construction noise levels, and outline the monitoring program for noise and vibration.

The following measures will be incorporated into the contractor's final NVCP to reduce effects to sensitive receptors associated with noise and vibration. Measures include, but are not limited to, the following:

- Contractor shall maintain equipment to comply with federal, state and local noise standards (e.g., exhaust mufflers, acoustically attenuating shields, shrouds, or enclosures)
- Contractor shall schedule truck loading, unloading, and hauling operations to reduce daytime and nighttime noise impacts to the extent feasible
- Construction activities will be conducted or phased so that noise generated during construction would not exceed thresholds or durations identified by the appropriate regulatory authorities
- Contractor shall employ appropriate blasting techniques to minimize noise and vibration to the extent feasible
- Equipment and trucks used for the Project shall employ the best available noise control techniques to the extent feasible
- Stationary sources shall be located as far from adjacent noise-sensitive receptors as reasonably possible and shall be enclosed if feasible
- Where feasible, temporary portable sound barriers would be deployed where construction noise would cause noise levels at sensitive receptor locations to be in excess of an applicable criteria threshold
- The KRRC or contractor shall notify nearby residents of hours and duration of construction activities
- At least two weeks prior to the anticipated start of construction at a particular location, the KRRC or its contractor will notify all property owners within 1,000 feet of that location that construction activities are about to commence
- The contractor shall have a complaint hotline for local residents, and shall promptly address noise and vibration complaints

# 8. Mitigation Measures

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

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

## 8.1 Surface Water Hydrology

### 8.1.1 H-2: Flood proofing structures

H-2 requires coordination with willing landowners to move or relocate permanent, legally-established, habitable structures that are in place before dam removal. The KRRC 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 USBR 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 8.1-1 below, based on estimates of sediment deposition.

### Table 8.1-1 Changes in River Stage with Dam Removal

| River Reach | Average WSE (feet) |
|---|---|
| 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 with dams, as determined by USBR
2. Within the altered 100-year floodplain without dams, as determined by USBR
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 193.1) and Humbug Creek (RM 174) were categorized. This is because the tributaries below Iron Gate increasingly dominate the flood discharges as one travels downstream from Iron Gate, and the impact of dam removal on the 100-yr flood is less than 0.5 foot below Humbug Creek.

An estimated 6 or fewer additional structures would be subject to flooding following dam removal when compared to the existing floodplain. A total of 53 structures would be located within the altered 100-year floodplain between Iron Gate Dam and Humbug Creek following dam removal with an additional 10 structures located near the altered floodplain. Final determination of the future 100-year floodplain after dam removal will be made by FEMA, and KRRC is coordinating with FEMA to initiate the map revision process.

An estimated three river crossings in this downstream reach could also be affected by the increase in flood depths: two pedestrian bridges and the Central Oregon and Pacific Railroad Bridge. Both pedestrian bridges are below the existing 100-year flood elevation, and there is a potential increase in scour depth at the railroad bridge. Pedestrian Bridge #1 is dilapidated and is not structurally safe. Pedestrian Bridge #2 and the railroad bridge are in good condition. The KRRC will meet with bridge owners to determine the need for any improvements at these structures. Pedestrian Bridge #1 will likely need to be removed, but who is responsible for removal needs to be determined. Pedestrian Bridge #2 could be raised or removed. The railroad bridge could have sufficient footing and foundation depths to accommodate the increased scour potential, or it could require additional scour protection. The following sections provide additional information on these crossings.

#### 8.1.1.1 Pedestrian Bridge #1

Pedestrian Bridge #1 spans the Klamath River just upstream of it confluence with Cedar Gulch. The bridge is a cable suspension structure of unknown origin, with no connection to any approach roads. The bridge is in very poor condition. The bottom chord of the bridge is not high enough to pass the anticipated 100 year flood following the removal of the dams.

**Figure 8.1-1 Pedestrian Bridge #1**

#### 8.1.1.2 Pedestrian Bridge #2

Pedestrian Bridge #2 is a cable suspension bridge that spans the Klamath River next to the Klamath River County Estates (KRCE). The structure is on the KRCE Campground property on the north bank of the river. The structure is understood to have been built by the previous owners of the campground and is maintained by the campground. The structure is in good condition and appears to be well maintained.

**Figure 8.1-2 Pedestrian Bridge in Campground**

The bottom chord of the bridge is not high enough to pass the anticipated 100 year flood after the removal of the dams. An evaluation of the structure will be performed during the detailed design phase to determine whether removal or replacement will be required.

#### 8.1.1.3 Central Oregon and Pacific Railroad (CORP) Bridge

The CORP Railroad Bridge is a 7 span ballasted concrete bridge that spans the Klamath River between the Ager Road Bridge and Cottonwood Creek. The structure is supported on stone masonry seat type abutments and the bents are composed of steel H-pile extensions with reinforced concrete caps. No information is available at this time regarding foundation type.

The Detailed Plan estimated the Project to result in 1.2 feet of scour at the bridge. This is considered unlikely to affect the structural integrity of the bridge; however, a more detailed assessment would be performed at detailed design to confirm this.

Figure 8.1-3 Rail Road Bridge

## 8.2 Water Supply

### 8.2.1 WRWS-1: Protection for downstream water intakes

WRWS-1 would provide protection for downstream water intakes during passage of the eroded sediment within the Klamath River by identifying legal points of diversion on the Klamath River and performing pre-dam removal assessments at each corresponding pump or intake location. Points of diversion that could be affected by the passage of the sediment load associated with reservoir drawdown would be identified during detailed design through an investigation of the records provided in the Electronic Water Rights Information Management System (eWRIMS) for the river reach in California and through an information request to OWRD for the reach of river in Oregon below JC Boyle Dam. The identified water rights holders would be notified about the proposed project and asked to provide information to illustrate the existing conditions of the intake (i.e., typical diversion patterns and diversion mechanism). The KRRC does not anticipate impacts to agricultural diversions during the drawdown period because this will occur prior to the irrigation season and turbid water applied to crops will not have an adverse effect. Although there are no known potable river diversions on the Klamath River below Iron Gate Dam, if any are identified during the eWRIMS assessment, the KRRC will provide temporary facilities (e.g. settling basins or groundwater wells) to remove silt and sediment prior to the diverter's primary treatment process. Following dam removal, any intake would be investigated at the request of a water right holder. If the investigation confirms an adverse impact has occurred as a result of dam removal, modifications would be completed to the intake as necessary to reduce effects and allow the water right holder to divert water in the same manner (amounts and timing) as before dam removal.

## 8.3 Air Quality

### 8.3.1 AQ-1: Off-road construction equipment

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.

### 8.3.2 AQ-2: On-road construction equipment

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.

### 8.3.3 AQ-3: Trucks used to transport materials

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.

### 8.3.4 AQ-4: Dust control measures

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.

## 8.4 Greenhouse Gases/Global Climate Change

### 8.4.1 CC-1: Use the market mechanism under development as part of AB 32

Use the market mechanism under development as part of AB 32 development when feasible to mitigate greenhouse gas emissions impacts.

### 8.4.2 CC-2: Establish an energy audit program

In April PacifiCorp issued its 2017 Integrated Resource Plan (IRP) that identifies the company's preferred power generation portfolio that "reflects a cost-conscious transition to a cleaner energy future" over the next 20 years. The IRP shows that PacifiCorp plans to meet new energy resource needs primarily through new renewable resources and demand management (e.g. energy efficiency measures) over the 20-year (2017-2036) planning horizon by adding approximately 4,000 MW of wind and solar resources and 2,100 MW though energy efficiency and load control. The IRP includes the anticipated loss of Lower Klamath Project (LKP) hydroelectric generation beginning in 2020. The preferred portfolio also identified a reduction in coal capacity of 3,650 MW through the end of 2036. PacifiCorp projects that between 2017 and 2036 its average annual CO2 emissions will be reduced by of 24.5 percent falling from 43.8 million tons in 2017 to 33.1 million tons in 2036 representing an annual average reduction in CO2 emissions of 10.7 million tons. (PacifiCorp 2017)

Mitigation Measure CC-2 is removed from consideration because PacifiCorp has already developed a plan to reduce CO2 emissions that includes improving inefficient processes, systems, and equipment.

### 8.4.3 CC-3: Establish an energy conservation plan

In April PacifiCorp issued its 2017 Integrated Resource Plan (IRP) that identifies the company's preferred power generation portfolio that "reflects a cost-conscious transition to a cleaner energy future" over the next 20 years. The IRP shows that PacifiCorp plans to meet new energy resource needs primarily through new renewable resources and demand management (e.g. energy efficiency measures) over the 20-year (2017 - 2036) planning horizon by adding approximately 4,000 MW of wind and solar resources and 2,500 MW though energy efficiency and load control management. The IRP includes the anticipated loss of LKP hydroelectric generation beginning in 2020. The preferred portfolio also identified a reduction in coal capacity of 3,650 MW through the end of 2036. PacifiCorp projects that between 2017 and 2036 its average annual CO2 emissions will be reduced by of 24.5 percent falling from 43.8 million tons in 2017 to 33.1 million tons in 2036 representing an annual average reduction in CO2 emissions of 10.7 million tons. (PacifiCorp 2017)

Mitigation Measure CC-3 is removed from consideration because PacifiCorp has already developed a plan to reduce CO2 emissions that includes conservation through demand side demand management.

## 8.5 Geology, Soils, Geologic Hazards

### 8.5.1 GEO-1: Geotechnical analysis of the proposed construction sites

A geotechnical assessment would be conducted by a qualified geologist for new features built in the former reservoir area post-dam removal as part of the Project or its mitigation (e.g., new recreation facilities). The analysis would determine the suitability and potential limitations of the development and construction on the sediment at the site. Should the geotechnical analysis indicate the sediment is not suitable for the proposed activities, the site should be avoided or a sediment removal or treatment plan should be developed prior to beginning construction activities.

## 8.6 Cultural and Historic Resources

Proposed mitigation measures to resolve adverse effects/significant impacts to cultural and historic resources are based on the Detailed Plan prepared by the USBR for the Klamath River Dam Removal Project. The Detailed Plan identified four broad measures, designated Cultural and Historic Resources (CHR) 1 through CHR-4, as well as specific subtasks for each measure. These measures and subtasks are detailed below. Additional mitigation measures may be identified through the ongoing Section 106 consultation process for the Lower Klamath Project, which may supplement or replace one or more of the measures identified in the Detailed Plan.

In addition to these four measures, the Detailed Plan also noted additional tasks associated with general mitigation plans. These subtasks included conduct of cultural resources surveys in potential impact areas, including drawdown zones at J.C. Boyle, Copco No.1 and No. 2, and Iron Gate reservoirs; raised river corridor areas within the 100-year floodplain zone; and haul routes and disposal sites.

### 8.6.1 CHR-1: Resolve adverse effects/significant impacts on four hydroelectric facilities and on the Klamath Hydroelectric Historic District (KHHD)

- Update the Klamath Hydroelectric Project Request for Determination of Eligibility to include Iron Gate Dam and to identify contributing elements to the Klamath Hydroelectric Historic District (KHHD)
- Continue consultation under Section 106 of the National Historic Preservation Act (NHPA) with the Advisory Council on Historic Preservation (ACHP), California and Oregon SHPOs, and interested parties to reach consensus on the eligibility of hydroelectric facilities
- Prepare a Section 106 agreement document (Memorandum of Agreement [MOA]or Programmatic Agreement [PA]) in consultation with the ACHP, SHPOs, and interested parties to identify additional mitigation measures designed to address impacts to eligible properties, inclusive of an educational or outreach component
- Document the four dams and associated structures to Historic American Building Survey, Historic American Engineering Record, and Historic American Landscape Survey (HABS/HAER/HALS) standards or equivalent

### 8.6.2 CHR-2: Resolve adverse effects/significant impacts from dam removal on significant prehistoric and historic archaeological properties and historical resources

- Continue Section 106 consultation with ACHP, SHPOs, Indian tribes, and other interested parties to identify and evaluate cultural resources per NRHP and California Historic Register (CHR) eligibility criteria
- Continue identification and evaluation of historic properties and historical resources for unevaluated cultural resources, unsurveyed areas, and inundation zones. 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

- Continue Section 106 consultation 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 (MOA or PA) 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)

### 8.6.3 CHR-3: Resolve adverse effects/significant impacts from dam removal on TCPs and cultural landscapes

- 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 NRHP and/or CHR
- 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)

### 8.6.4 CHR-4: Resolve the impacts of dam removal on Native American burials

- 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 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

## 8.7 Public Health and Safety

### 8.7.1 PHS-1: Public Safety Management Plan

A Public Safety Management Plan would be developed to address and maintain public safety during the proposed construction and demolition. This plan would include, but is not limited to, the following elements: public notification of the location and duration of construction and demolition activities, pedestrian/bicycle path and trail closures, and restrictions on reservoir use (i.e., boating, water skiing, fishing, swimming); verification with local jurisdictions to ensure compliance with existing emergency evacuation plans and minimize the potential interference with emergency response times; and installation of signage and fencing near construction zones and temporary walkways, and detours.

### 8.7.2 PHS-3: Cattle exclusion fencing

PHS-3 would provide cattle exclusion fencing at the reservoir sites, as applicable, 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. The fencing would likely 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. However, further investigation will be made during detailed design to identify specifically where cattle fencing is needed at all reservoirs.

## 8.8 Scenic Quality

### 8.8.1 SQ-1: Scenic quality enhancement measures

Scenic quality enhancement measures would be included for all permanent structural, landform, and vegetation-altering components, where practical, to minimize scenery disturbances to either achieve the Visual Resource Management Classes assigned by BLM or achieve the most natural appearing scenic quality possible while meeting other Project objectives. These measures would include one or more of the following:

- Identification of the most aesthetically beneficial location and configuration of constructed facilities to reduce visual disturbance
- Development of scenically harmonious design components into constructed facilities such as edges, borders, and surface textures that blend with surrounding topography and landscape
- Coloration of constructed facilities, such as colored concrete that mimics as closely as practical the adjacent native soil, bedrock, or vegetation
- Screening of constructed facilities, or portions thereof, from sensitive viewpoints through the planting of native riparian or upland vegetation

### 8.8.2 SQ-2: Reduce nighttime light and glare

SQ-2 would require the use of reflectors, shields, directional lighting, or other appropriate methods to reduce nighttime light and glare on surrounding residences during construction.

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 also be used for temporary lighting, where feasible.

## 8.9 Recreation

### 8.9.1 REC-1: Recreation facilities

At least 1 year before starting dam removal activities, the KRRC 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 will be developed in coordination with appropriate state and federal agencies (e.g., BLM and CDFW), counties, tribes, and stakeholder groups and would include an implementation schedule for construction of recreation facilities and river access areas. Examples of recreation facilities and features that could be constructed as part of project mitigation include:

- New non-motorized trails to provide fishing access along the river bank between J.C. Boyle dam site and Iron Gate fish hatchery
- Expansion and upgrade of Jenny Creek Campground to accommodate additional camping sites with parking, shade structures, picnic tables, fire grates and restrooms
- 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 could be reconstructed. Additional security fencing for the City of Yreka’s water supply facilities located in the vicinity of the Fall Creek trail may be required.
- Redesign and reorientation of Topsy Campground to accommodate a river versus reservoir environment. This could include either replacement or redesign of the existing boat ramp and more extensive revegetation efforts in the vicinity of the campground to hasten stabilization of the newly exposed riverbank in areas of concentrated human activity.
- Trail routes could be provided on each side of the river to provide public recreation access to the river
- 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
- 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

Input from the states (as the future landowners), the counties (as providing law enforcement and emergency response), tribes (as having sensitive resources in the project area and vicinity), and other stakeholders will be critical to the final form of the recreation plan and which features are included. Impacts to wetlands, sensitive habitats, and sensitive species associated with new recreation facility construction will be included in the applicable permit applications for the project.

## 8.10 Iron Gate Fish Hatchery

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

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

### 8.10.1 Existing Facility and Operations

The IGH spawning/trapping facility was constructed in 1962 with additional facilities added in 1966 where it is located approximately ½ mile downstream of Iron Gate Dam, adjacent to the Bogus Creek tributary. The main hatchery complex includes an office, incubator building, rearing/raceway ponds, fish ladder with trap, settling ponds, visitor information center, and four employee residences (see Figure 8.10-1). The collection facility is located at the dam and includes a fish ladder consisting of 20 ten-foot weir-pools that terminates in a trap, a spawning building and six 30-foot circular holding ponds.

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

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

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

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


**Figure 8.10-1 Iron Gate Hatchery**

### 8.10.2 Impacts to IGH Facility

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

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

### 8.10.3 Project Description

The Project intends to allow for continued operation of the Iron Gate Hatchery to maintain a level of production during drawdown and throughout Project construction, as appropriate to limit the Project effect. Improvements to the collection facility and water supply will be required. Three options for providing water supply are discussed in more detail below. Additional coordination will be required with PacifiCorp and CDFW to confirm final hatchery operational requirements and feasible solutions. KRRC is working with CDFW to determine fish production targets and anticipates providing an update by the end of October 2017.

Along with any of the measures discussed below, it may be appropriate to consider reducing production or taking the hatchery facility offline temporarily during the reservoir drawdown period (2 to 2.5 months) to limit impacts associated with high suspended sediment concentrations within the Klamath River (assuming long-term water supply location draws directly from the river).

#### 8.10.3.1 Collection Facility

Since the existing collection system will be demolished, it will be necessary to replace the function of this facility. An auxiliary trap and ladder system is currently located at the main IGH facility, and could be utilized as the primary capture facility post-drawdown with some improvements such as additional flow and structural modifications to enhance the flow characteristics. Additional collection methods may include seining, gaffing or gill netting at specific locations within the Klamath River. An existing raceway at the IGH used for juveniles could be used as a holding facility.

#### 8.10.3.2 Water Supply

Required water supply to the IGH could be on the order of 20 cfs or more. Options to replace the existing water supply are summarized below. Depending on production goals, one or more of the following water supply options may be selected. The KRRC is refining our understanding of the water supply potential associated with the options below, and anticipates providing an update by the end of October 2017.

1. **New Klamath River Intake:** Construct a new water supply intake facility adjacent to the Klamath River, in the vicinity of the existing IGH facility. A Ranney-type collector water well may be appropriate as it draws water from the shallow aquifer connected to the river and typically can be designed with capacities up to 40 cfs. Ranney collectors typically include a large central well with horizontal wells radiating from and feeding the central well. Ranney wells are utilized where there is shallow ground water in direct connection with a surface water source like a river or lake. Since the water is drawn from the subsurface as groundwater, it can have better quality from the filtering effect provided by sediments separating the surface water source and the radial wells.
    h. The capacity of a Ranney collector and the quality of water it produces would need to be confirmed through a geologic assessment of the soil and rock conditions adjacent to and beneath the river.
    i. Due to the close connection to the river, inflow quality may be impacted during drawdown, potentially requiring treatment or augmentation. If treatment is required during drawdown, a clarifier system could be designed and installed to reduce turbidity below 30 parts per million. Depending on the number of units required, the clarifier system could require up to 0.5 acres. A sludge management system would also be required for sludge collection, loading and hauling to an onsite disposal site. The disposal site identified for placement of the Iron Gate Dam embankment material could likely accommodate the sludge (processing and final placement). Other risks associated with this type of facility operating during drawdown include facility clogging (the intake itself, or the treatment system if suspended sediment concentrations are greater than the design).

2. **Local Well Field for Water Supply:** If it is determined through coordination with PacifiCorp, CDFW and other aquatic resource agencies that the IGH can function with a lower water supply capacity (on the order of 5 to 10 cfs), a local well field could be investigated to provide a reliable water source with ideal temperature and water quality. The capacity of a local well field would need to be confirmed through a geologic assessment, installation of test wells and pump testing.
3. **Use Fall Creek Water Supply and Pipeline**: Utilize existing PacifiCorp diversion facilities (or connect into diversion infrastructure closer to the powerhouse) on Fall Creek and construct a pipeline along Copco Road to transfer supply water to the IGH. Additional diversion options could include the City of Yreka's Fall Creek diversion facility, or a new facility on Fall Creek. Available capacity from any of these locations would need to be confirmed in addition to a water right change in the point of use. The pipeline alignment would run along Copco Road, and the distance would be approximately 10 miles crossing the river at the IGH bridge.

# 9. References

Bilby 1984. Bilby, R. E. Removal of woody debris may affect stream channel stability. *Journal of Forestry*. 82:609–613. 1984.

Bilby and Ward 1989. Bilby, R. E., and J. W. Ward. Changes in characteristics and function of woody debris with increasing size of streams in western Washington. *Transactions of the American Fisheries Society*. 118:368–378. 1989.

Black and Veatch, 1998. J.C. Boyle Development Klamath River Hydroelectric Project FERC Project No. 2082, Safety Inspection Report.

Bryant and Sedell 1995. Riparian forests, wood in the water, and fish habitat complexity. In *Condition of the world's aquatic habitats*. *Proceedings of the World Fisheries Congress, Theme*. Vol. 1, pp. 202-224.

Buffington 1995. *Effects of hydraulic roughness and sediment supply on surface textures of gravel-bedded rivers*. Master's thesis, University of Washington.

Buffington and Montgomery 1999. Buffington, J. M., and D. R. Montgomery. Effects of hydraulic roughness on surface textures of gravel-bed rivers. *Water Resources Research*. 35:3507–3522. 1999.

California Department of Fish and Wildlife (CDFW) 2017. Keith Pomeroy. Iron Gate Hatchery Production 2001 to 2017 spreadsheet and summary.

California Oregon Power Company, 1960a. Specifications for the Construction of the Iron Gate Earth Fill Regulating Dam.

California Oregon Power Company, 1960b. Report on Investigation of Locally Available Materials for the Construction of Iron Gate Earth Fill Regulating Dam.

Cross, S.P., H. Lauchstedt, M. Blankenship. 1998. *Numerical status of Townsend's Big-eared Bats at Salt Caves in the Klamath River Canyon and other selected sites in Southern Oregon, 1997*. Southern Oregon University, Ashland, Oregon.

Eilers and Gubala 2003. *Bathymetry and Sediment Classification of the Klamath Hydropower Project Impoundments*. Prepared for PacifiCorp by J.M. Eilers and C. P. Gubala, JC Headwaters, Inc. April 2003.

Ferro and Porto 2011. Ferro, V, and P. Porto. Predicting the equilibrium bed slope in natural streams using a stochastic model for incipient sediment motion. *Earth Surface Processes and Landforms*. Vol 36., pp.1007-1022.

Hayner, S. 2017. Unpublished Bald and Golden Eagle Nesting Data. Sent from Stephen Hayner, BLM to Jennifer Jones, CDM Smith by email on August 24, 2017.

Holmquist-Johnson and Milhous 2010. Holmquist-Johnson, C.L. and Milhous, R.T. *Channel maintenance and flushing flows for the Klamath River, California*. U.S. Geological Survey Open File Report 2010-1086, 31 p.

PacifiCorp 2004. *Terrestrial Resources Final Technical Report Klamath Hydroelectric Project*. FERC No. 2082. February 2004.

DOI and NMFS 2013. Department of the Interior and Department of Commerce, National Marine Fisheries Service. *Klamath Dam Removal Overview Report for the Secretary of the Interior – An Assessment of Science and Technical Information* (a.k.a. the Secretarial Determination of Record (SDOR)). Version 1.1. March 2013.

Geo-Studio 2016. SEEP/W computer program.

Hammond 1983. Hammond, P.E. Volcanic formations along the Klamath River near Copco Lake. *California Geology*. V. 36, no. 5, p. 99-109. 1983.

Mussman 2008. E.K. Mussman, D. Zabowski, and S. A. Acker. *Predicting Secondary Reservoir Sediment Erosion and Stabilization Following Dam Removal*. 2008.

NRCS 2007. Natural Resources Conservation Service. National Engineering Handbook, Part 654. 2007. Stream Restoration Design. Technical Supplement 14B Scour Calculations.

NMFS and USFWS 2013. National Marine Fisheries Service and United States Fish and Wildlife Service. Biological Opinions on the Effects of Proposed Klamath Project Operations from May 31, 2013, through March 31, 2023, on Five Federally Listed Threatened and Endangered Species. NMFS file number: SWR-2012-9372; FWS file number: 08EKLA00-2013-F-0014. May 2013.

PanGEO 2006. Technical Memorandum - Preliminary Assessment of Slope Stability, Iron Gate and Copco Dams and Reservoirs, Under Rapid Drawdown. To Dennis Gathard, River Resources. Prepared by Stephen H. Evans, L.E.G. Project No. 06-201. November 27, 2006.

PanGEO 2008. *Geotechnical Report – Klamath River Dam Removal Project – California and Oregon*. Project No. 07-153. Prepared for Philip Williams & Associates, Ltd. and California State Coastal Conservancy. August 2008.

Porto and Gessler 1999. Porto, P. and J. Gessler. Ultimate Bed Slope in Calabrian Streams upstream of Check Dams: Field Study. American Society of Civil Engineers, *Journal of Hydraulic Engineering*. December.

RSET (Northwest Regional Sediment Evaluation Team). 2016. Sediment Evaluation Framework for the Pacific Northwest. July.

Sedell and Froggatt 1984. Sedell, J. R., and J. L. Froggatt. Importance of streamside forests to large rivers: the isolation of the Willamette River, Oregon, U.S.A., from its floodplain by snagging and streamside forest removal. *Verhandlungen-Internationale Vereinigung für Theoretifche und Angewandte Limnologie*. 22:1828–1834. 1984.

USACE 2003. U.S. Army Corps of Engineers. Slope Stability – Engineer Manual. EM-110-2-1902. October 31, 2003.

USBR 2011a. U.S. Bureau of Reclamation. *Final Biological Assessment and Final Essential Fish Habitat Determination for the Preferred Alternative of the Klamath Facilities Removal EIS/EIR*. U.S. Bureau of Reclamation, October.

USBR 2011b. U.S. Bureau of Reclamation. *Reservoir Area Management Plan for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration Klamath River, Oregon and California*. Technical Report No. SRH-2011-19. Mid-Pacific Region. June 2011.

USBR 2012a. U.S. Bureau of Reclamation. Compiled Well Logs for Wells Identified Within 2.5 Miles of Dams from J.C. Boyle to Iron Gate.

USBR 2012b. U.S. Bureau of Reclamation. *Detailed Plan for Dam Removal – Klamath River Dams – Klamath Hydroelectric Project – FERC License No. 2082 – Oregon-California*. July 2012.

USBR 2012c. U.S. Bureau of Reclamation. *Hydrology, Hydraulics, and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration Klamath River, Oregon and California*. Technical Report No. SRH-2011-02. Mid-Pacific Region. January 2012.

USBR 2012d. U.S. Bureau of Reclamation. Secretarial Determination Overview Report (SDOR) – Klamath Dam Removal Overview Report for the Secretary of the Interior- An Assessment of Science and Technical Information. Prepared by the U.S. Department of the Interior, U.S. Department of Commerce, National Marine Fisheries Service. August.

USBR and CDFW 2012. U.S. Bureau of Reclamation and California Department of Fish and Wildlife. *Klamath Facilities Removal – Final Environmental Impact Statement/Environmental Impact Report* (EIS/R). December.

USFWS-NMFS 2012. National Marine Fisheries Service Southwest Region and U.S. Fish and Wildlife Service Region 8. *Joint Preliminary Biological Opinion on the Proposed Removal of Four Dams on the Klamath River*. November.

USGS 1982. U.S. Geological Survey, Interagency Advisory Committee on Water Data. Guidelines for Determining Flood Flow Frequency – Bulletin #17B of the

Hydrology Subcommittee. Revised September 1981, editorial corrections March 1982.

Whisenant 1999. S.G. Whisenant. *Repairing Damaged Wildlands: A Process-Oriented, Landscape-Scale Approach*. Cambridge University Press. 1st edition. November 28, 1999.

Williams 1949. Williams, H. *Geology of the Macdoel Quadrangle*. California Division of Mines Bulletin 151, scale 1:125,000. 1949.

Willy, E. 2017. Unpublished Bald and Golden Eagle Nesting Data. Sent from Elizabeth Willy, USFWS to Jennifer Jones, CDM Smith by email on June 29, 2017.

Wray, Simon. Wildlife Biologist, ODFW. Personal communication with Jennifer Jones, KRRC, June 22, 2017.

# Appendix A Additional Information Request Letters from SWRCB and ODEQ

**State Water Resources Control Board**

AUG 24 2017

Mr. Michael Carrier, President
Klamath River Renewal Corporation
423 Washington Street, 3rd Floor
San Francisco, CA 94111

Dear Mr. Carrier:

REQUEST FOR ADDITIONAL INFORMATION TO PROCESS WATER QUALITY CERTIFICATION FOR LOWER KLAMATH PROJECT, FEDERAL ENERGY REGULATORY COMMISSION PROJECT NO. 14803, SISKIYOU COUNTY

On September 23, 2016, the State Water Resources Control Board (State Water Board) received from the Klamath River Renewal Corporation's (KRRC) water quality certification (certification) application for the Lower Klamath Project (LKP). On October 21, 2016, the State Water Board determined the KRRC's certification application with attachments[1] met the filing requirements specified in California Code of Regulations, title 23, section 3856. As noted in the October 2016 letter, though the certification application is considered complete, the State Water Board maintains the ability to request additional information to clarify, amplify, correct, or otherwise supplement the contents of the certification application.

Following acceptance of the KRRC's certification application, the State Water Board has proceeded with processing the certification application, including conducting public and agency scoping under the California Environmental Quality Act (CEQA). State Water Board staff has reviewed information submitted by the KRRC in support of its certification application and has developed an initial list of information that is needed to process the certification application and inform the associated CEQA process.

On March 20, 2017, State Water Board staff met with KRRC technical representatives to discuss preliminary information needs identified by State Water Board staff based on review of the certification application, specifically the Detailed Plan that currently serves as the KRRC's LKP description. Information needs were also discussed at a subsequent meeting which occurred on April 10, 2017. On May 4, 2017, State Water Board staff attended a portion of the KRRC Board meeting and provided the KRRC Board with a draft information request.

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[1] This includes the KRRC's Federal Energy Regulatory Commission license surrender application, and supplemental submittals.

Attachment A of this letter details the specific information State Water Board staff has identified as needed, at this time, to process the certification application. Information requested in Attachment A is consistent with the information needs discussed at previous meetings, with minor additions or clarifications.

The State Water Board appreciates the KRRC's willingness to collaboratively work with State Water Board staff and other interested parties to address the identified information needs. We encourage the KRRC to continue collaboration with interested parties in development of the requested information. It is State Water Board staff's understanding from previous conversations that the KRRC intends to provide all requested information by September 30, 2017, and that some information may be submitted earlier. Please note, late or inadequate responses may result in associated delays in the certification process.

State Water Board staff looks forward to working with KRRC representatives and other interested parties on the LKP. If you have questions regarding this letter or Attachment A, please contact me by email at parker.thaler@waterboards.ca.gov or by phone at (916) 341-5321. Written correspondence should be addressed as follows:

State Water Resources Control Board
Division of Water Rights – Water Quality Certification Program
Attn: Parker Thaler
P.O. Box 2000
Sacramento, CA 95812-2000

Sincerely,

Parker Thaler, Senior Environmental Scientist – Specialist
Water Quality Certification Program
Division of Water Rights

Enclosure: Attachment A: Information Request for Lower Klamath Project

cc (on next page)

AUG 24 2017

cc: Mr. Chris Stine
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165 East Seventh Avenue, Suite 100
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ATTACHMENT A:
INFORMATION REQUEST FOR LOWER KLAMATH PROJECT
FEDERAL ENERGY REGULATORY COMMISSION PROJECT NO. 14803

Below is a list of information needs identified by State Water Resources Control Board (State Water Board) staff for the Lower Klamath Project (LKP), Federal Energy Regulatory Commission (FERC) Project No. 14803. The information is needed for the State Water Board's water quality certification process, which includes compliance with the California Environmental Quality Act (CEQA).

General Comments:

1. State Water Board staff understands the Klamath River Renewal Corporation (KRRC) is collecting additional data to inform aspects of the LKP. Studies are planned for summer 2017, which include but are not limited to: verification of reservoir drawdown rates; selection of disposal sites for inert waste materials; and environmental resource surveys. Within 10 days of the date of this letter, please provide a list of all studies being conducted by the KRRC and its affiliates. In addition, include a schedule for completion of all studies.

2. KRRC technical representatives have confirmed that the KRRC intends to apply to the United States Army Corps of Engineers (ACOE) for a Clean Water Act (CWA) section 404 permit for the LKP. Please confirm whether the project description the KRRC will submit to ACOE is the same project description submitted to FERC and inform the State Water Board which agency will be the National Environmental Policy Act lead agency. In addition, please provide an estimated timeline for when the ACOE CWA section 404 permit application and associated State Water Board CWA section 401 water quality certification application will be submitted.

3. During CEQA scoping, several commenters expressed concern with a hot spring located on Shovel Creek above Copco reservoir being too hot to allow for fish passage. In July 2017, State Water Board staff visited the hot spring area and gained a better understanding of its location. State Water Board staff requests the KRRC collect preliminary water temperature data above and below the hot spring's confluence with Shovel Creek to determine whether further inquiry into the hot spring's influence on water temperature is required. State Water Board staff further requests the KRRC measure flow of Shovel Creek and the hot springs during temperature data collection.

Comments related to 2012 Detailed Plan:

State Water Board staff understands that the 2012 Detailed Plan submitted by the KRRC, as part of its September 23, 2017 certification application, currently serves as the LKP description. The 2012 Detailed Plan will be superseded by the Definite Plan, which the KRRC plans to submit to the Federal Energy Regulatory Commission (FERC) by December 2017. The Definite Plan will have additional information related to proposed LKP.

On June 1, 2017, State Water Board staff received additional clarification regarding the LKP description. Specifically, that the KRRC's proposed project is the full removal alternative listed in Chapters 4, 6, 7, and 8 of the Detailed Plan.

ATTACHMENT A:
INFORMATION REQUEST FOR LOWER KLAMATH PROJECT
FEDERAL ENERGY REGULATORY COMMISSION PROJECT NO. 14803

In reviewing the 2012 Detailed Plan, State Water Board staff requests the following information:

1. **Iron Gate Hatchery:** Please confirm whether the Iron Gate Hatchery is part of the LKP, and if so, please provide:

    - A description of Iron Gate Hatchery's current operations.
    - A description of the proposed operations for Iron Gate Hatchery both during and following LKP dam removal activities.

    Regardless of whether the hatchery is part of the LKP, please provide:

    - Measures to locate/supply an alternative water source of sufficient quality and quantity to the Iron Gate Hatchery for any continued operations.
    - Measures that will be implemented to address the large sediment releases associated with the LKP dam removal's impact on the Iron Gate Hatchery operations during and following removal of the dams.

2. **Copco No. 1 Dam Removal Elevation:** Page 47 of the Detailed Plan states: "*Copco No.1 Dam is located within a narrow canyon on the Klamath River at RM [River Mile] 198.6. Minimum requirements for a free-flowing condition and for volitional fish passage on the Klamath River through the Copco No. 1 dam site 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 2467, 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.*"

    Please clarify the depth to which Copco No. 1 dam extends below the existing streambed elevation. In addition, please describe monitoring being proposed to ensure no fish barrier forms at the Copco No. 1 dam site following dam removal and any adaptive management practices being proposed to resolve potential fish barrier formations.

3. **Reservoir Slope Stability and Drawdown Rates:** Page 49 of the Detailed Plan states, "*The drawdown of Copco Reservoir should be controlled to the extent necessary to prevent problems with slope stability around the reservoir rim that could result in property damage, including the loss or damage of residential homes. Although there do not appear to be any potential 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.*"

    In addition to slope stability issues potentially impacting residential homes within the vicinity of Copco reservoir, slope stability issues could negatively impact tribal cultural resources located within Copco and Iron Gate reservoirs. As suggested above, please indicate what further studies, if any, are or will be conducted to assess and ensure slope stability at Copco and Iron Gate reservoirs during and following dam removal.

Should an area of potential slope instability be identified at any of the LKP reservoirs, maps indicating these areas should be presented in the Reservoir Drawdown and Streamflow Diversion Plan (detailed below). Measures and monitoring to address slope instability should also be included in this plan.

4. **Copco No. 2 Dam Development:** In relation to Table 4-5 of the Detailed Plan, please describe how remaining facilities located at Copco No. 2 dam development will be managed or disposed (e.g., cookhouse, bunkhouse, storage buildings, etc.).

5. **Mitigation Measures:** Detailed Plan Section 9.7 includes mitigation measures along with estimated implementation costs. KRRC representatives have indicated that the KRRC is analyzing which of these measures to propose, and whether to identify different measures. Please identify which mitigation measures are included in the KRRC's proposed project to reduce impacts to environmental resources.

   - For identified mitigation measures that require additional studies, surveys, or plan development, please provide a timeline for completing the additional work items.

   - For mitigation measures not selected, please provide rationale for not including them along with any new mitigation measures that the KRRC proposes to address impacts.

6. **Project Plans:** The plans listed below represent the plans and related information State Water Board staff has identified, at this point, as necessary to continue processing the water quality certification application. The plans listed below are not a comprehensive list of all plans that may be needed to evaluate LKP dam removal impacts to environmental resources. The KRRC may provide the requested information in a different plan, if appropriate.

   a. Reservoir Drawdown and Streamflow Diversion Plan for all LKP reservoirs that includes:

      - For each reservoir, the total anticipated discharge in cubic feet per second (cfs) associated with reservoir drawdown operations.
      - Description of structures (i.e., gates, diversion tunnels, etc.) used for reservoir drawdown operations including the flow (cfs) releases anticipated for each structure during drawdown operations.
      - For notching, a description of where notches would be located and the dimensions of each notch.
      - Proposed duration and timing of reservoir drawdown operations.
      - For each reservoir, proposed reservoir elevation change per day.
      - Description of any measures or actions that would be implemented if dam or tunnel failure occurs (may require an Emergency Action Plan).
      - Additional information on the diversion tunnels including: tunnel safety; measures/actions needed to retrofit the diversion tunnels; operation constraints of the remote gates (i.e., full open/close or allow for varying degrees of water releases); and post-reservoir drawdown actions to ensure tunnels are adequately sealed and do not pose an environmental or public safety hazard.

- Slope-stability monitoring during and after reservoir drawdown.
- Measures to implement if slope stability issues are identified.
- Measures to implement in and downstream of LKP reservoirs if tribal cultural resources and/or human remains are found during draw down activities (may include reference to a Tribal Resources Management Plan or similar plan).
- Measures to implement in and downstream of LKP reservoirs to reduce impacts on aquatic species listed under the federal Endangered Species Act (ESA) and California ESA, including candidate-listed species.
- References to studies conducted to verify reservoir drawdown rates are protective of slope stability and potential flooding downstream of LKP reservoirs.

b. Reservoir Area Restoration Plan for all portions of the Lower Klamath River and surrounding areas impacted by the LKP that includes:

- Measures to manage remaining sediment following reservoir drawdown in a manner that is protective of water quality, slope stability, aesthetics, air quality, and tribal cultural resources.
- Monitoring of remaining sediments and adaptive management measures to ensure identified measures are effective at reducing impacts associated with the LKP.
- Measures to restore the Klamath River within LKP reservoirs following dam removal and drawdown activities.
- Quantification of the number of wetlands (in acres) impacted by the LKP along with a description of wetlands created during reservoir restoration activities.

c. Water Quality Monitoring Plan for all portions of the LKP and downstream, as appropriate, that monitors water quality before, during, and after dam removal. The Water Quality Monitoring Plan should adequately monitor for impacts associated with LKP dam removal activities and should contain adaptive management measures to appropriately mitigate LKP dam removal impacts.

As appropriate, prior to LKP dam removal activities, the Water Quality Monitoring Plan should include:

- General water quality parameters (dissolved oxygen, temperature, turbidity, suspended sediment, nutrients, etc.)

During and following LKP dam removal activities, the Water Quality Monitoring Plan should include:

- General water quality parameters (dissolved oxygen, temperature, turbidity, suspended sediment, nutrients, etc.)
- Blue-green algae (microcystis cell count and associated toxins)
- Sediment toxicity samples of remaining sediments in LKP reservoirs, downstream of LKP reservoirs, and the Klamath estuary

Where possible, use of Interim Measure 15 water quality monitoring stations should be used in the Water Quality Monitoring Plan.

d. Waste Disposal Plan for all portions of the LKP that includes:
   - Location and size of disposal sites.
   - Description and results of resource assessment surveys conducted for proposed disposal sites. Such assessments should include federal and state ESAs, tribal cultural resources, special status plants, migratory bird nesting and foraging areas, and bat roosts.
   - Description of materials (quantity and type) being buried at each disposal site.
   - Measures and monitoring to ensure disposal sites do not contribute to erosion following dam removal.
   - Description of material (quantity and type) that will be disposed of at local landfills including an estimated number of truck trips (including distance traveled) and associated greenhouse gas emissions.
   - Description of material (quantity and type) that will be recycled.
   - Description of hazardous material (quantity and type) that may be encountered during LKP dam removal, and plans for safe handling and disposal thereof (may reference a Hazardous Materials Plan).

e. Groundwater Well Management Plan for groundwater use potentially impacted by LKP that includes:
   - Identification of known groundwater wells that may be impacted by the LKP.
   - Identification of a potential zone of impact to groundwater wells surrounding LKP reservoirs.
   - Description of surveys and assessments conducted to assess potential impacts to groundwater wells surrounding LKP reservoirs.
   - Monitoring and measures to address water quality and supply impacts during LKP dam removal activities.
   - Measures to mitigate water supply impacts to groundwater well users following LKP dam removal activities.

f. City of Yreka Water Supply Plan that describes measures to ensure the City of Yreka maintains an adequate water supply during and following LKP dam removal activities.

g. Habitat Restoration Plan Outside of Reservoir Areas that describes measures to restore LKP affected areas outside of the LKP reservoir footprints.

h. Road Management Plan for all portions of the LKP area that includes:

   - Maps of temporary staging roads, disposal sites, access roads, etc.
   - Description of upgrades needed to bridge crossings and access roads prior to LKP dam removal activities.
   - Measures following LKP dam removal activities to restore any degraded road conditions to pre-LKP conditions.

i. Fire Management Plan that includes:

- Fire prevention and management measures during LKP dam removal activities.
- Water supply assessment for fire management post-dam removal, with identification of additional water sources or other measures as appropriate.

j. Recreation Facilities Removal and Management Plan

k. Eagle and Other Migratory Bird Conservation Plan

l. Traffic Management Plan

m. Hazardous Materials Management Plan

n. Emergency Response Plan

o. Noise and Vibration Control Plan

Oregon

Kate Brown, Governor

Department of Environmental Quality
Western Region Eugene Office
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Eugene, OR 97401
(541) 686-7838
FAX (541) 686-7551
TTY 711

July 19, 2017

Mark Bransom, Executive Director
Klamath River Renewal Corporation
2001 Addison St., Suite 317
Berkeley, CA 94704

RE: Comments on Detailed Plan for Removal of the Klamath Hydroelectric Project

Dear Mr. Bransom:

In September 2016, the Klamath River Renewal Corporation and PacifiCorp Energy jointly filed an application with the Federal Energy Regulatory Commission to designate the lower four dams and generation facilities of the Klamath Hydroelectric Project (FERC No. 2082) as a new project ("Lower Klamath Project", FERC No. 14803) and transfer license of the LKP to the KRRC.

Concurrent with this application, KRRC filed an application for license surrender and removal of project works and applications to Oregon and California for water quality certification pursuant to Section 401 of the Clean Water Act. Procedures for removal of the project works are described in the Detailed Plan for Dam Removal – Klamath River Dams ("Detailed Plan"; Reclamation, 2012). In correspondence dated June 1, 2017, the KRRC confirmed the scope of the proposed action includes the Full Removal alternative described in Sections 4, 6, 7, and 8 of the Detailed Plan. Mitigation Measures, described in Section 9.7, are presently being refined in consultation with appropriate resource agencies.

The Oregon Department of Environmental Quality may issue a water quality certification if it has reasonable assurance the proposed action will comply with Oregon water quality standards and other requirements of state law. To assist with our review, DEQ requests KRRC provide the additional information presented in Attachment A to this correspondence by September 30, 2017.

If you have any questions or would like to discuss this request, please contact me directly at (541) 686-7810 or via email at stine.chris@deq.state.or.us.

Sincerely,

Christopher Stine, PE
Water Quality Engineer

cc: Michael Carrier, Klamath River Renewal Corporation
Peter Okurowski, California Environmental Associates
Parker Thaler, California State Water Resources Control Board

encl.: Attachment A – Detailed Plan: DEQ Comments and Additional Information Request

# Attachment A

# Detailed Plan: DEQ Comments and Additional Information Request

Regulatory Requirements

a. Section 401 water quality certification:
   Section 401 of the Clean Water Act prohibits federal agencies from authorizing actions which may result in a discharge to waters of the state without first receiving state certification confirming the activity will comply with state water quality standards and other relevant portions of state law. Because the proposed activity will require federal authorization and will result in a discharge, KRRC concurrently applied to DEQ for CWA Section 401 certification. DEQ may issue a water quality certification if it has reasonable assurance the proposed action will comply with Oregon water quality standards and other requirements of state law.

b. Army Corps 404 Permit:
   DEQ expects the activity will also require a federal removal-fill permit issued by the US Army Corps of Engineers pursuant to CWA Section 404. Please confirm whether and when KRRC expects to apply to the Corps for a CWA 404 permit. Please also confirm if the project description which may be proposed to the Corps is the same as the activity proposed to FERC as described in the Detailed Plan.

c. NPDES 1200C Construction Stormwater Permit
   DEQ requires a NPDES 1200C permit to manage potential stormwater discharge from construction sites which disturb one acre or more. DEQ expects the KRRC to apply for and obtain coverage under NPDES 1200C prior to undertaking activities that disturb more than one acre.

JC Boyle Dam and Facilities Removal

d. Emergency Spillway Restoration Plan:
   Use of the JC Boyle emergency spillway has caused extensive erosion of the canyon wall below the forebay. DEQ requests KRRC develop a restoration plan to reduce sediment inputs to the river. The plan should describe finished restoration objectives; engineering design criteria to meet slope-stability requirements; and sources for material which meet the restoration design criteria. The plan should also identify appropriate cover material, vegetative mix for stabilization, and a schedule for post-placement monitoring to ensure restoration objectives are met and maintained.

e. Waste Disposal Plan:
   DEQ requests the KRRC develop a waste disposal plan to address the permanent placement of inert deconstruction material. The use of the two borrow pits near the right abutment has initially been suggested. Aerial photos show these areas have partially filled with water and may currently support wetland habitat. KRRC should determine the suitability of these areas, provide volumetric estimates of the borrow pits and all displaced material, and propose alternative locations for material which may exceed capacity. The waste disposal plan should address restoration methods (e.g., minimum cover, vegetative restoration, etc.), identify current ownership and consistency with local land use planning requirements, post-construction monitoring, and other requirements needed to ensure compatible long-term placement.

f. Removal Limits :
In correspondence dated June 1, 2017, KRRC confirmed the scope of the proposed project is the Full Removal alternative as described in the Detailed Plan. KRRC should clarify the description of the following proposed actions.

Power Canal: The 2.2-mile J.C. Boyle power canal consists of reinforced concrete slab walls and floor with shotcrete slope protection. The extent to which the J.C. Boyle power canal will be removed is unclear from the description in Section 4.1.1 of the Detailed Plan. Please present a comprehensive description of KRRC's proposed activity to decommission the power canal and roadway. Please also identify how the linear canal excavation and roadway will be stabilized and restored to reduce the potential for future erosion.

Powerhouse Tailrace: The tailrace below the J.C. Boyle powerhouse consists of a short excavated channel near a bend in the Klamath River. KRRC should describe plans to fill and restore this portion of the project consistent with pre-development river dimensions. KRRC should identify the source material and restoration methods for this activity and a schedule for completing this in-water work.

<u>Reservoir Drawdown</u>

g. Reservoir Drawdown Plan:
DEQ requests KRRC develop a Reservoir Drawdown Plan to describe reservoir management during reservoir drawdown. Because reservoir drawdown procedures affect all dams of the Lower Klamath Project, DEQ requests the KRRC develop this Plan in conjunction with concerns which the California State Water Resources Control Board may have regarding the cumulative effects which these actions may have on related removal actions in California. The Plan should include the following:

- Schedule and sequence for drawdown of all Lower Klamath Project dams;
- Adaptive strategy for adjusting schedule based on interruptions in drawdown sequence;
- Physical modifications to the dam to facilitate drawdown (e.g., notches, valves, etc.);
- Strategies for managing drawdown under low, medium, and high flow conditions;
- The Detailed Plan expresses reservoir drawdown in ft/day of surface elevation. Because reservoir volume varies irregularly with depth, and because water quality modeling was performed in terms of volumetric flow, discharge below the dams during drawdown should also be expressed in cubic feet per second;
- Reconnaissance plan to inspect areas of expected inundation prior to initiating drawdown;
- Measures to ensure drawdown rates do not adversely affect slope-stability of structures (e.g., Highway 66 bridge abutment, Topsy Grade Road) or reservoir embankments.

h. The Detailed Plan indicates that drawdown rates faster than 3 feet per day "could result in some pore pressure development and slope instability." Nevertheless, the proposed streamflow diversion plan could result in short-duration rapid reservoir drawdown in the range of 8 to 10 feet within a 24 hour period. The Detailed Plan further states that slope-stability studies will be performed to confirm the suitability of these drawdown rates. Please describe the work and field schedule needed to determine the suitability of the proposed rapid reservoir drawdown rates. Identify an alternate release schedule if a reservoir surface drawdown of 8 to 10 feet per day if the degree of embankment instability is determined to be unacceptable.

i. Section 4.1.2.1 of the Detailed Plan states that power canal releases after decommissioning the JC Boyle powerhouse would be directed over the forebay emergency spillway. The scour hole beneath this spillway is the subject of proposed restoration efforts. To prevent further erosion at this location, KRRC should consider sequencing construction activities and reservoir drawdown methods which reduce or eliminate reliance on the use of the spillway. For example, KRRC may consider delaying powerhouse decommissioning to allow canal discharge through the powerhouse penstock rather than the spillway until drawdown has been completed.

<u>Reservoir and Riparian Restoration</u>

j. Sediment Estimate:
The volume of sediment impounded by JC Boyle Dam is estimated at 990,000 (+/- 300,000) cubic yards. It is estimated that 36% to 57% of impounded sediment will be mobilized depending on the magnitude of streamflow in the water year following dam removal. KRRC should undertake pre-removal bathymetric and post-removal topographic surveys of reservoir areas to estimate the volume of sediment mobilized in response to facilities removal. Results of the survey will also be applicable to restoration efforts.

<u>Reservoir Management Plan</u> (Section 7.0)

k. The Detailed Plan Table 7-1 establishes the goals, objectives and projects for managing reservoir of the reservoir management envisions monitoring post-removal revegetation projects during short-term (1-5 years), mid-term (5-10 years), and long-term (10-50 years). Describe how KRRC expects to ensure the objectives described in these schedules will be met.

l. The Detailed Plan calls for hydro-seeding embankment areas after drawdown. Common hydro-seeding applications rely on a slurry of seed blends with fertilizer, lime, biostimulants, moisture retention polymers, tackifiers, and other additives for mechanical application over a broad area. The hydroelectric reach of the Klamath River in Oregon is impaired for chlorophyll-a which is an indicator for elevated levels of nutrients including nitrogen. Activities which result in additional nitrogen loading are prohibited. KRRC should describe hydro-seeding methods which will reduce or prevent the introduction of nutrients into the river during restoration efforts.

m. Sediment deposits in project reservoirs represent extensively reworked soils transported from upstream sources and may not share soil characteristics with local native soils. To ensure revegetation objectives are met KRRC may need to select planting varieties according to existing sediment/soil characteristics.

<u>Hazardous Materials Management Plan</u>

n. Many construction materials may include hazardous substances, liquids, coatings, or other materials which are regulated by DEQ. DEQ requests that KRRC prepare a comprehensive plan to address hazardous materials management. The plan should include: detection; removal; cleanup; and disposal of hazardous materials including:

- Asbestos Containing Material (ACM) in buildings scheduled for removal; testing and abatement procedures.
- Hazardous materials. Include methods to identify and manage hazardous materials including paints and coatings containing heavy metals; PAHs; mercury switches; fluorescent fixtures; ballasts; etc.
- Transformer oil removal and disposal. Oils in older transformers may contain PCBs.
- Regulated motor fuel storage tanks at the J.C. Boyle maintenance facility.
- Volume of oil at JCB may require a Spill Prevention Control and Countermeasure Plan. SPCCs are federally required and may be applicable to oil management at all four dams.

Water Quality Monitoring Plan

o. KRRC must prepare a water quality monitoring plan that describes data collection procedures before, during, and after facilities removal. The plan should provide sufficient scope and resolution to reliably evaluate the effect of the proposed activity on Oregon water quality standards.

Mitigation Measures

p. In correspondence dated June 1, 2017, KRRC confirmed the scope of the proposed action is as described in Sections 4, 6, 7, and 8 of the Detailed Plan. KRRC further notes that mitigation measures described in Section 9.7 of the Detailed Plan are being reviewed and, if necessary, revised in consultation with appropriate resource agencies and stakeholders. The KRRC should identify which mitigation measures will be included as part of the proposed action. KRRC also should identify the scope and schedule of additional studies which may be required to inform the revision of the mitigation measures.

DEQ offers the following brief comments on the mitigation measures presented in the Detailed Plan.

q. Aquatic Resources
The Detailed Plan proposes mitigation plans intended to protect aquatic resources from the short-term effects of dam removal. Certain measures propose capture and/or relocation of individuals. These include:

- AR-1: Protection of mainstem spawning fish through capture and relocation;
- AR-2: Protection of outmigrant juveniles through capture and relocation
- AR-5: Pacific Lamprey capture and relocation
- AR-6: Sucker rescue and relocation
- AR-7: Freshwater mussel relocation

At the May 23, 2017 resource meeting in Yreka stakeholders and relevant resource agencies generally opposed measures which relied on the capture and relocation of individuals. KRRC should redevelop plans to protect aquatic resources which achieve resource protection objectives and stakeholder concerns.

r. TER-5: Terrestrial Resource
- Removal of reservoirs will result in unavoidable impacts to 245 acres of wetland habitat at all four reservoir locations. Plan should specify how wetland acreage is distributed throughout project.
- Does wetland acreage include upland borrow pits which sourced JC Boyle embankment material?
- TER-5 expects a Compensatory Mitigation Plan will be required under 404 permit to offset losses. Please confirm whether surveys developed for the 2012 Detailed Plan remain valid for 404 permitting requirements.
- TER-5 proposed performance standards require monitoring required for minimum of five years. Further, a maintenance plan is proposed to ensure wetland habitat functions as proposed "in perpetuity". How will KRRC implement this requirement?

s. GW-1: Groundwater
This mitigation measure provides for deepening or replacement of wells whose production is affected by removal of reservoirs. Survey includes all wells within 2.5 miles of reservoirs.
- Four wells were identified in Oregon, all belonging to PacifiCorp which are scheduled for abandonment.

- Indicate if the survey includes only those Oregon wells with logs on file with OWRD. Because many operating wells predate OWRD registration requirements, this measure should indicate how unregistered wells within 2.5 miles of JC Boyle Reservoir will be identified.

t. WRWS-1: Water Supply/Water Rights

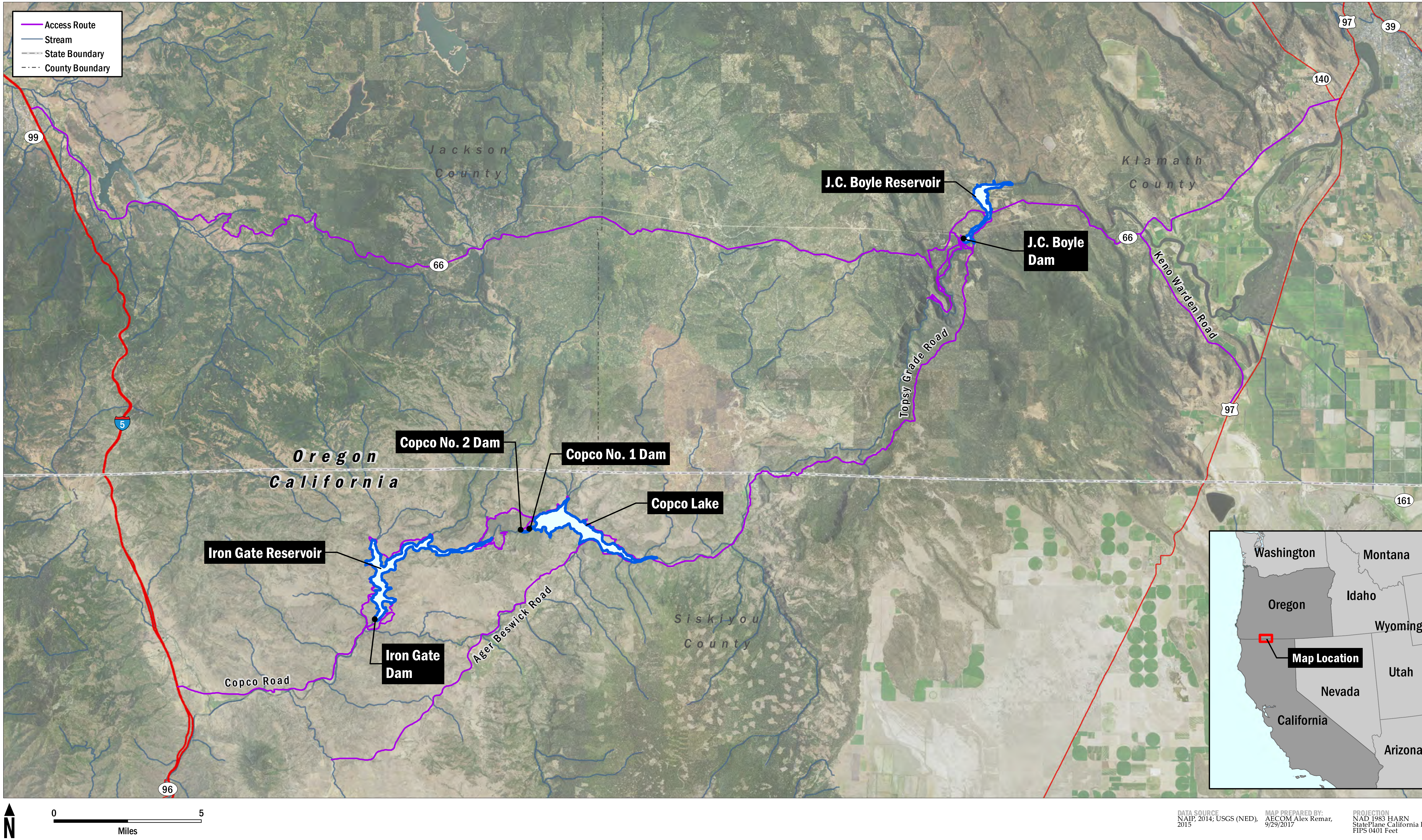
This measure protects downstream water intakes from sediment load following dam removal.

- WRWS-1 proposes to assess all "legitimate" points of diversion. What efforts will be made to identify all users potentially affected by removal?
- Intakes would be investigated at request of water user after dam removal. If negative effects are confirmed, this measure requires modifications (e.g., removal of sediment bars impeding diversion). What preventive measures will be undertaken prior to dam removal to ensure water users are protected from immediate effects of dam removal?

# Appendix B Figures – CEII (not included in submittal)

# Appendix C Figures – non-CEII

AECOM Oakland CA 9/29/2017 USER latha.chandrasekaran PATH L:\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_1_2-2_ProjectVicinityAndAccess.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

AECOM
**Klamath River Renewal Corporation**
*Klamath River Renewal Project*

**FIGURE 1.2-2**
*Project Vicinity and Access*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_2_1-1__JCB_ExistingFeatures_Overview.mxd


DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
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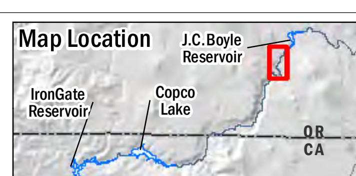
AECOM
**Klamath River Renewal Corporation**
*Klamath River Renewal Project*




# FIGURE 2.1-1

*J.C. Boyle Dam Existing Features Overview Sheet*

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DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
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AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*

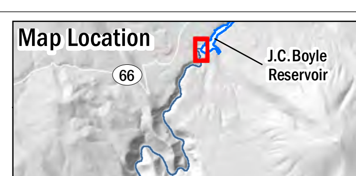



**FIGURE 2.1-1**
*J.C. Boyle Dam Existing Features*
*Sheet 1 of 2*

## 2A - FOREBAY AND SPILLWAY


## 2B - PENSTOCKS AND POWERHOUSE

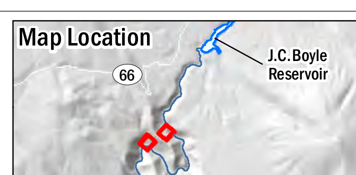

0 150
Feet

DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

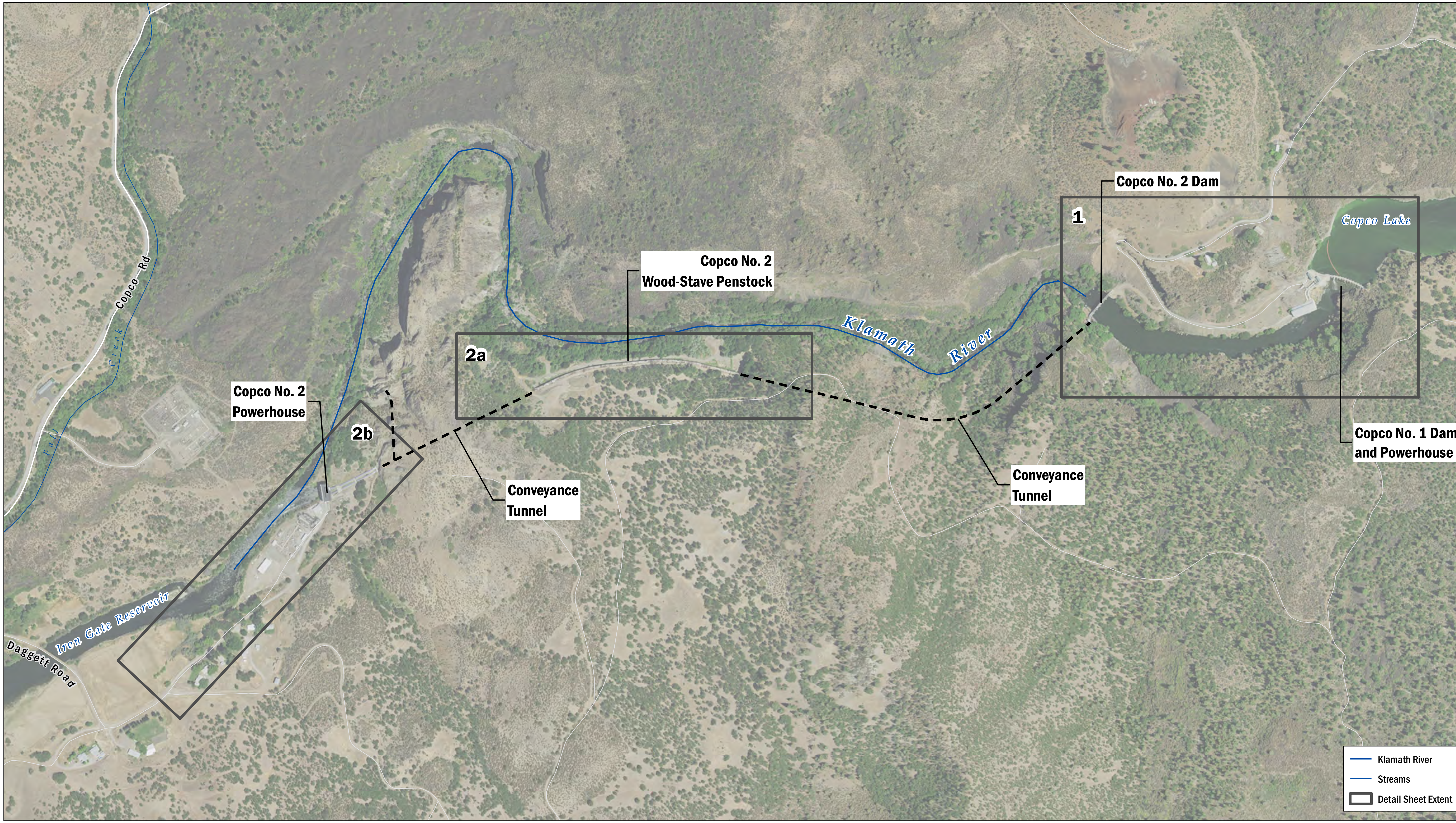
AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*




# FIGURE 2.1-1

*J.C. Boyle Dam Existing Features*
*Sheet 2 of 2*

AECOM Oakland CA 9/29/2017 USER latha.chandrasekaran PATH L:\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_2_2-1__Copco_ExistingFeatures_Overview.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN
StatePlane California I
FIPS 0401 Feet

AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*

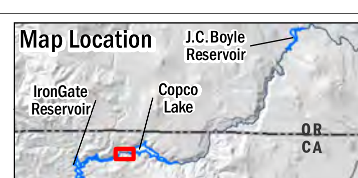



**FIGURE 2.2-1**

*Copco No. 1 and Copco No. 2 Dams Existing Features*
*Overview Sheet*

AECOM Oakland CA 9/29/2017 USER latha.chandrasekaran PATH L:\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_2_2-1__Copco_ExistingFeatures_Sheet1.mxd


N

0 150
Feet

DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
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PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*

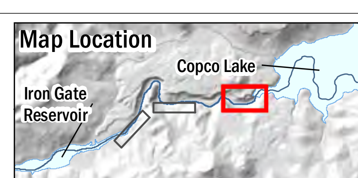


**FIGURE 2.2-1**

*Copco No. 1 and Copco No. 2 Dams Existing Features*
*Sheet 1 of 2*


DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
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PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*

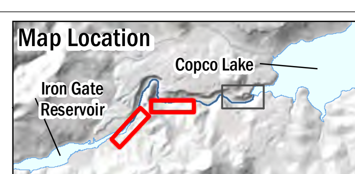
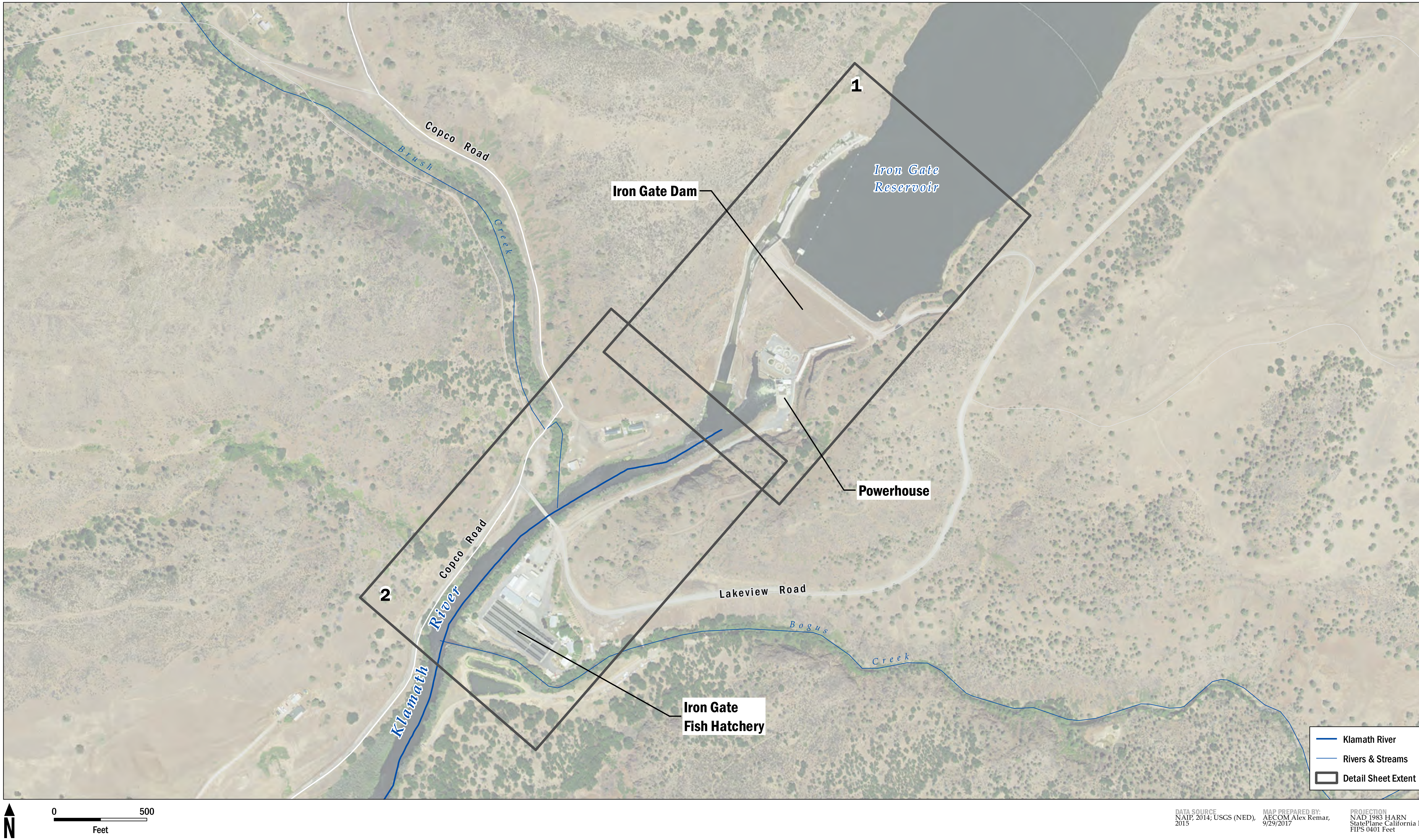



**FIGURE 2.2-1**

*Copco No. 1 and Copco No. 2 Dams Existing Features*
*Sheet 2 of 2*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_2_4-1__IG_ExistingFeatures_Overview.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
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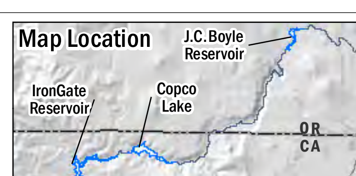
PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

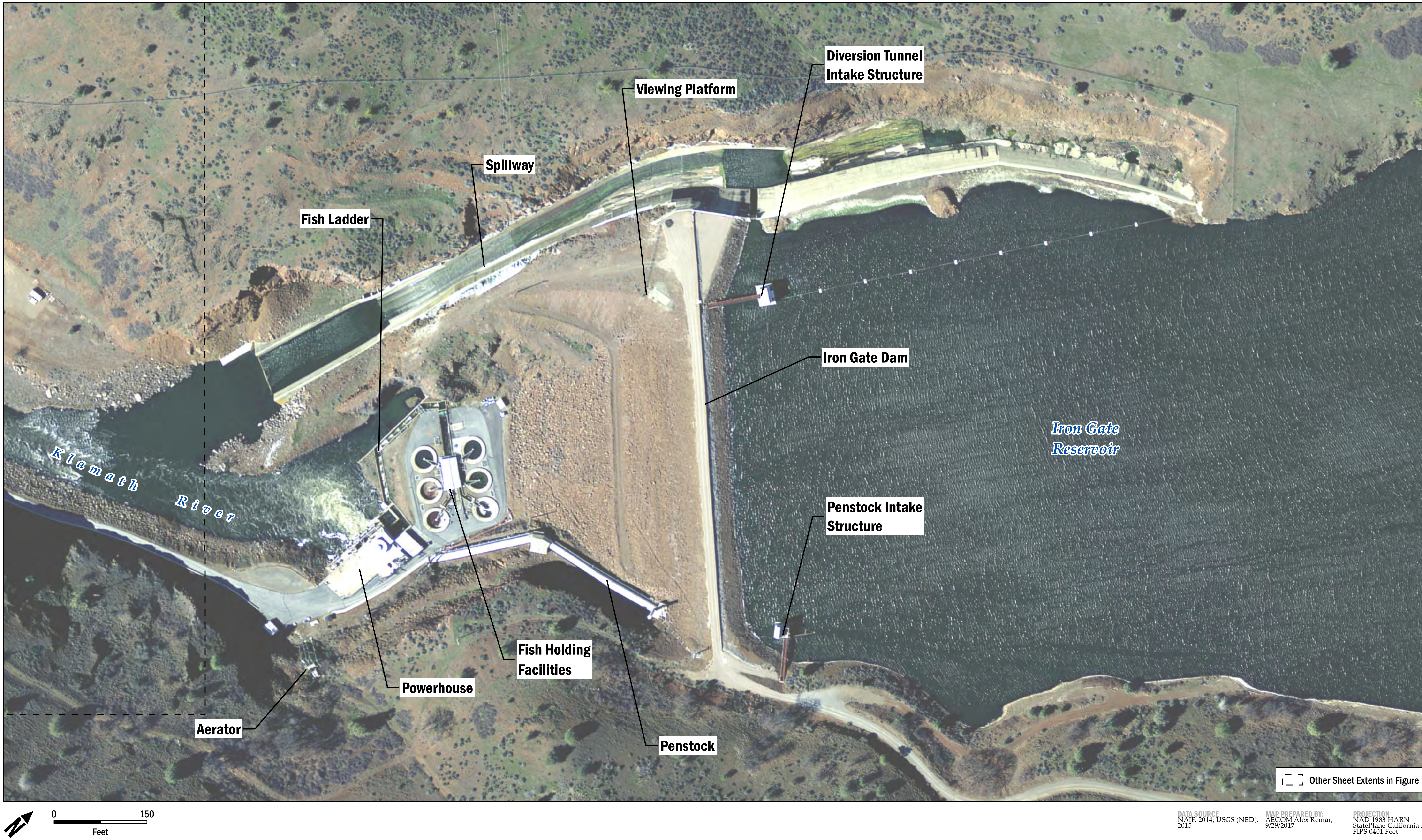
AECOM
**Klamath River Renewal Corporation**
*Klamath River Renewal Project*




# FIGURE 2.4-1

*Iron Gate Dam Existing Features Overview Sheet*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_2_4-1__IG_ExistingFeatures_Sheet1.mxd

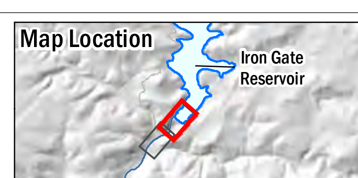



DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN
StatePlane California I
FIPS 0401 Feet

AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*




# FIGURE 2.4-1

*Iron Gate Dam Existing Features*
*Sheet 1 of 2*


DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
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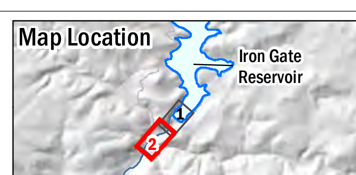
PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

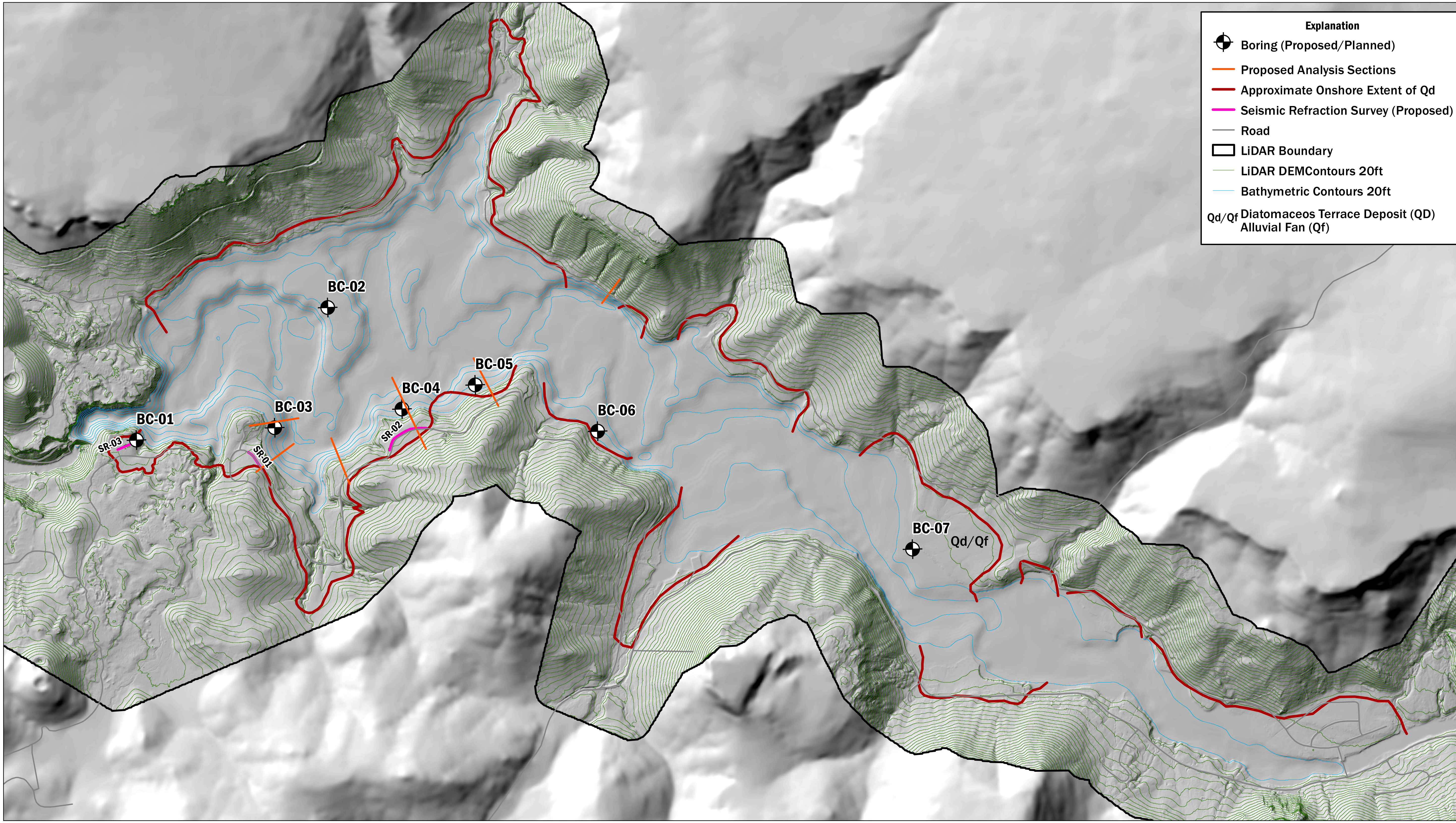
AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*




# FIGURE 2.4-1

*Iron Gate Dam Existing Features*
*Sheet 2 of 2*

AECOM Oakland CA 9/15/2017 USER Benjamin.kozlowicz PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_3_1-1c_Copco_RimStability.mxd

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Feet

DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
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PROJECTION
NAD 1983 HARN
StatePlane California I
FIPS 0401 Feet

AECOM

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*Klamath River Renewal Project*

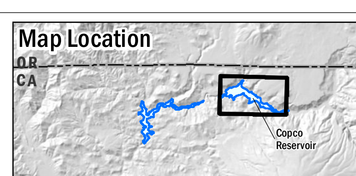
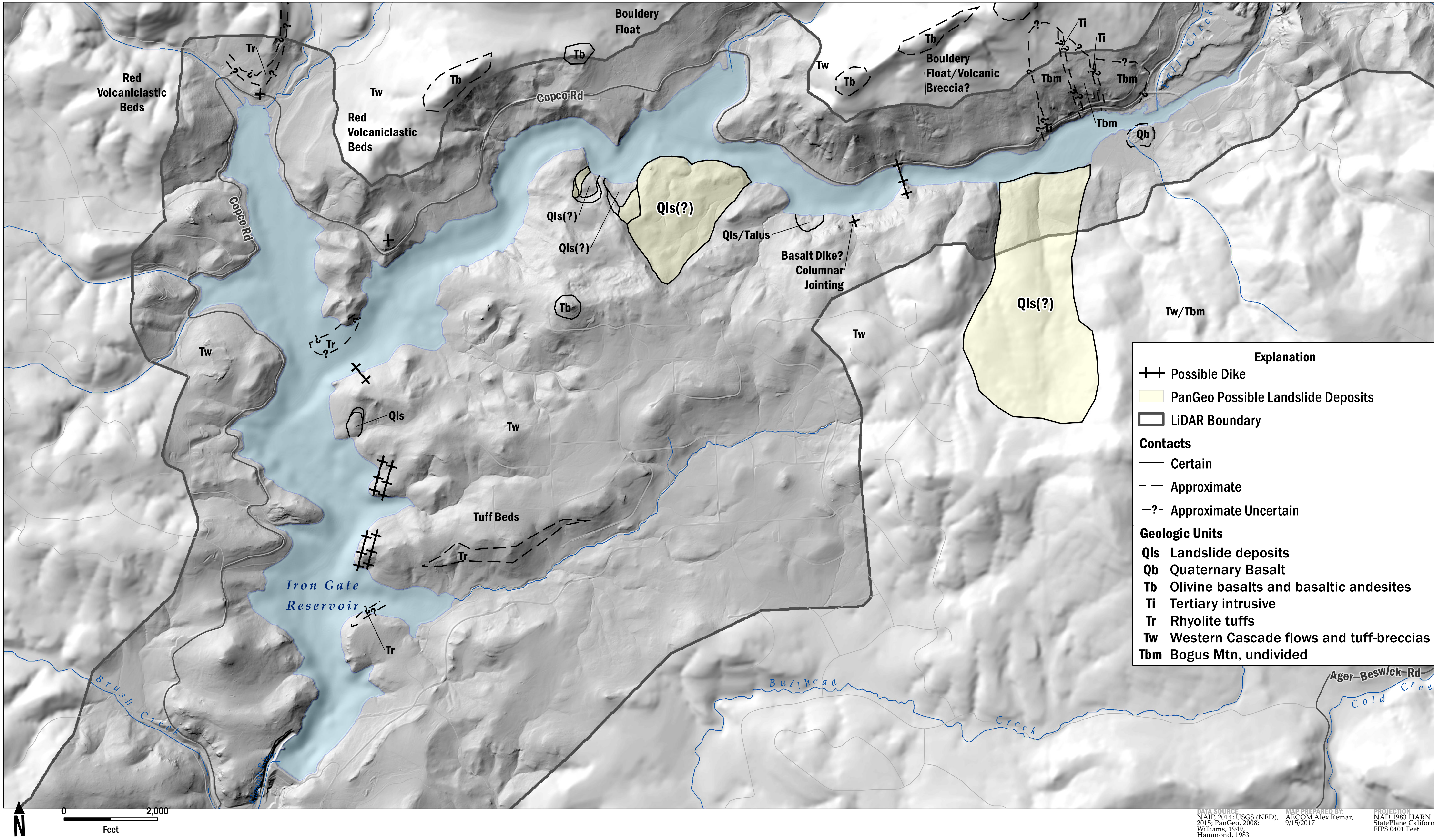



**FIGURE 3.1-**

*Copco Rim Stability & Exploration Plan*




DATA SOURCE
NAIP, 2014; USGS (NED), 2015; PanGeo, 2008; Williams, 1949, Hammond, 1983

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PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

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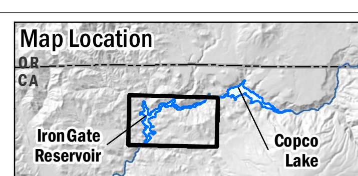
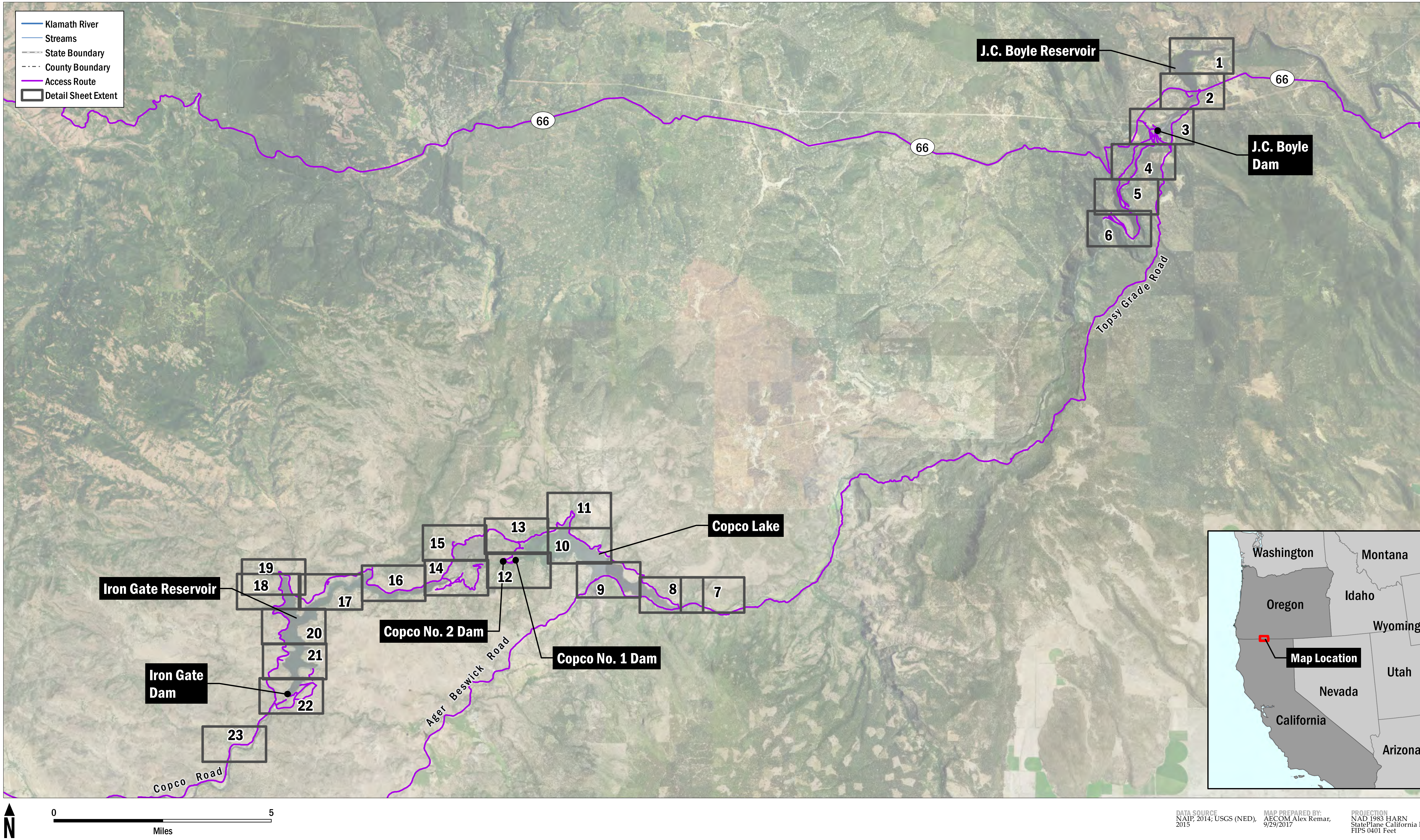



**FIGURE 3.1-2**

*Iron Gate Rim Stability*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_1-1_ProjectLimitsOfWorkAndAccess_Overview.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
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PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

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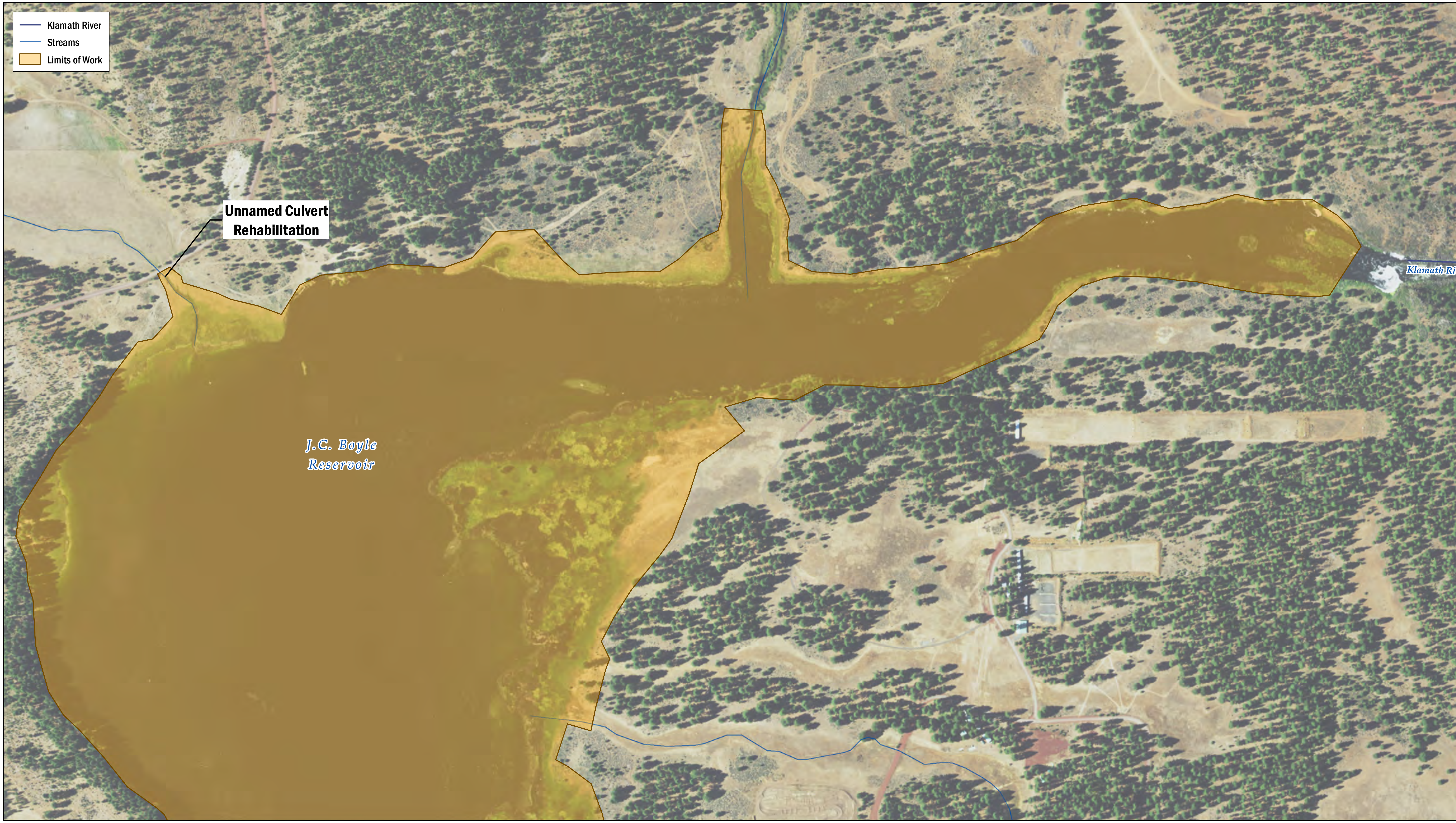
# FIGURE 5.1-1
*Project Limits of Work and Access Overview Sheet*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_1-1_ProjectLimitsOfWorkAndAccess_Sheets.mxd

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Feet

DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
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PROJECTION
NAD 1983 HARN
StatePlane California I
FIPS 0401 Feet

AECOM
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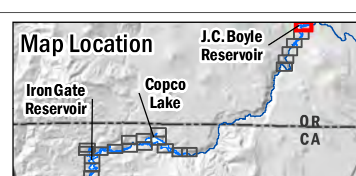
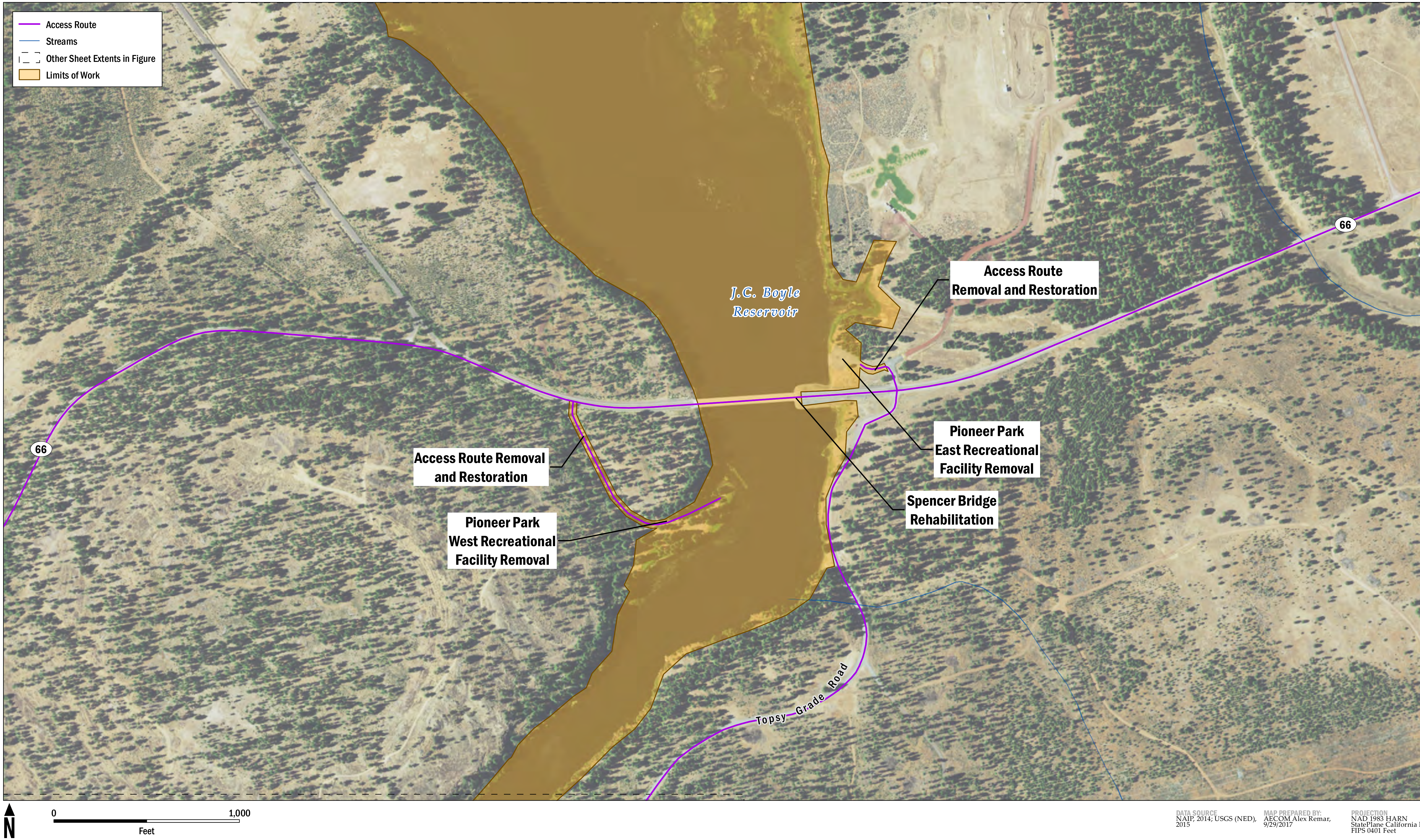
*Klamath River Renewal Project*




# FIGURE 5.1-1

*Project Limits of Work and Access*
*Sheet 1 of 23*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_1-1_ProjectLimitsOfWorkAndAccess_Sheets.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
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PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

AECOM
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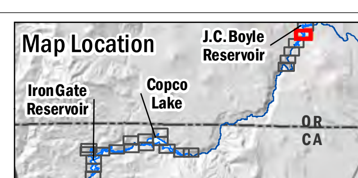
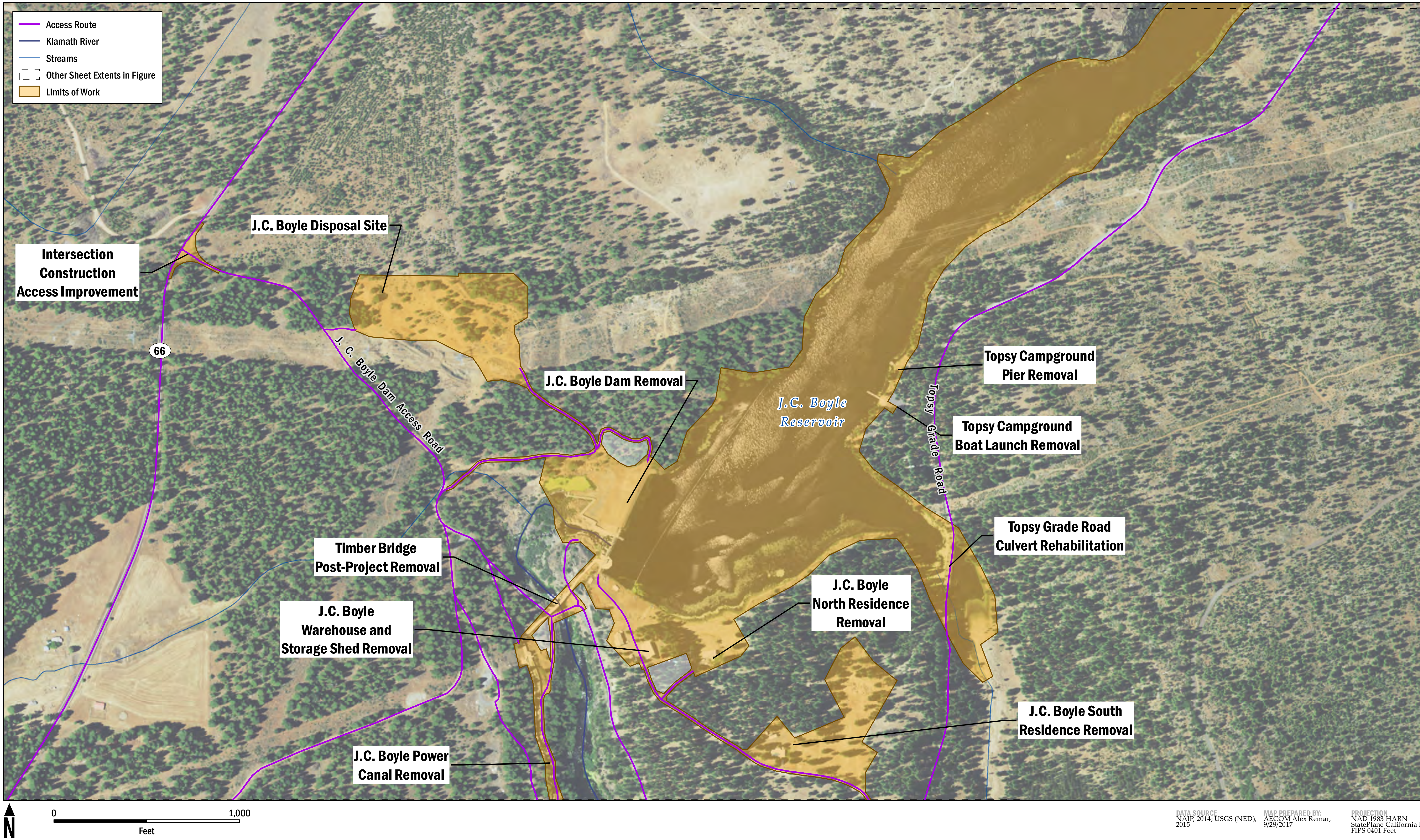
*Klamath River Renewal Project*




# FIGURE 5.1-1

*Project Limits of Work and Access*
*Sheet 2 of 23*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_1-1_ProjectLimitsOfWorkAndAccess_Sheets.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
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PROJECTION
NAD 1983 HARN
StatePlane California I
FIPS 0401 Feet

AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*

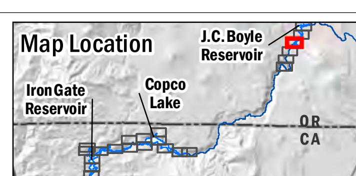
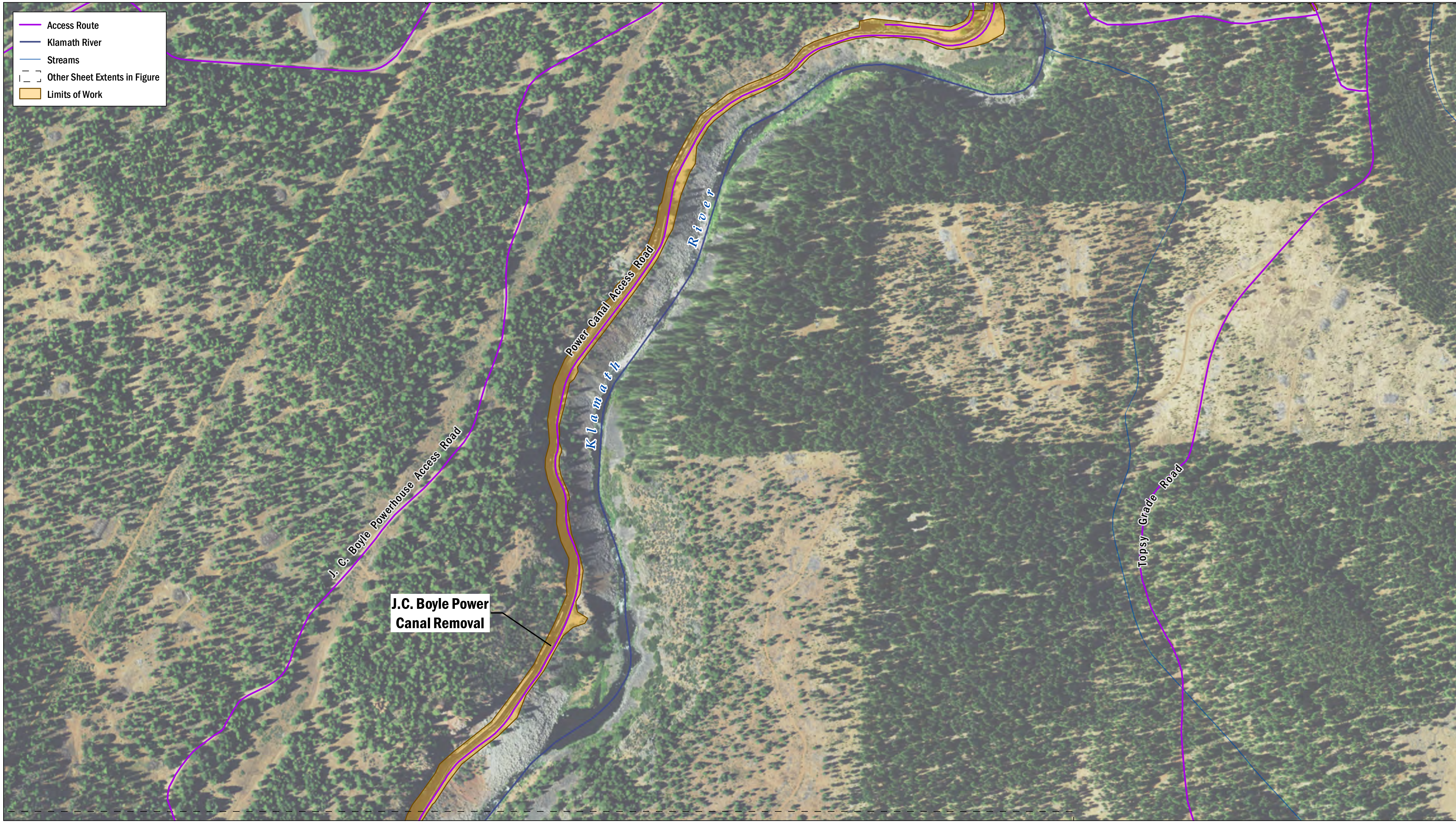



**FIGURE 5.1-1**

*Project Limits of Work and Access*
*Sheet 3 of 23*




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

AECOM
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*Klamath River Renewal Project*

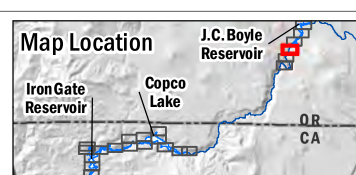
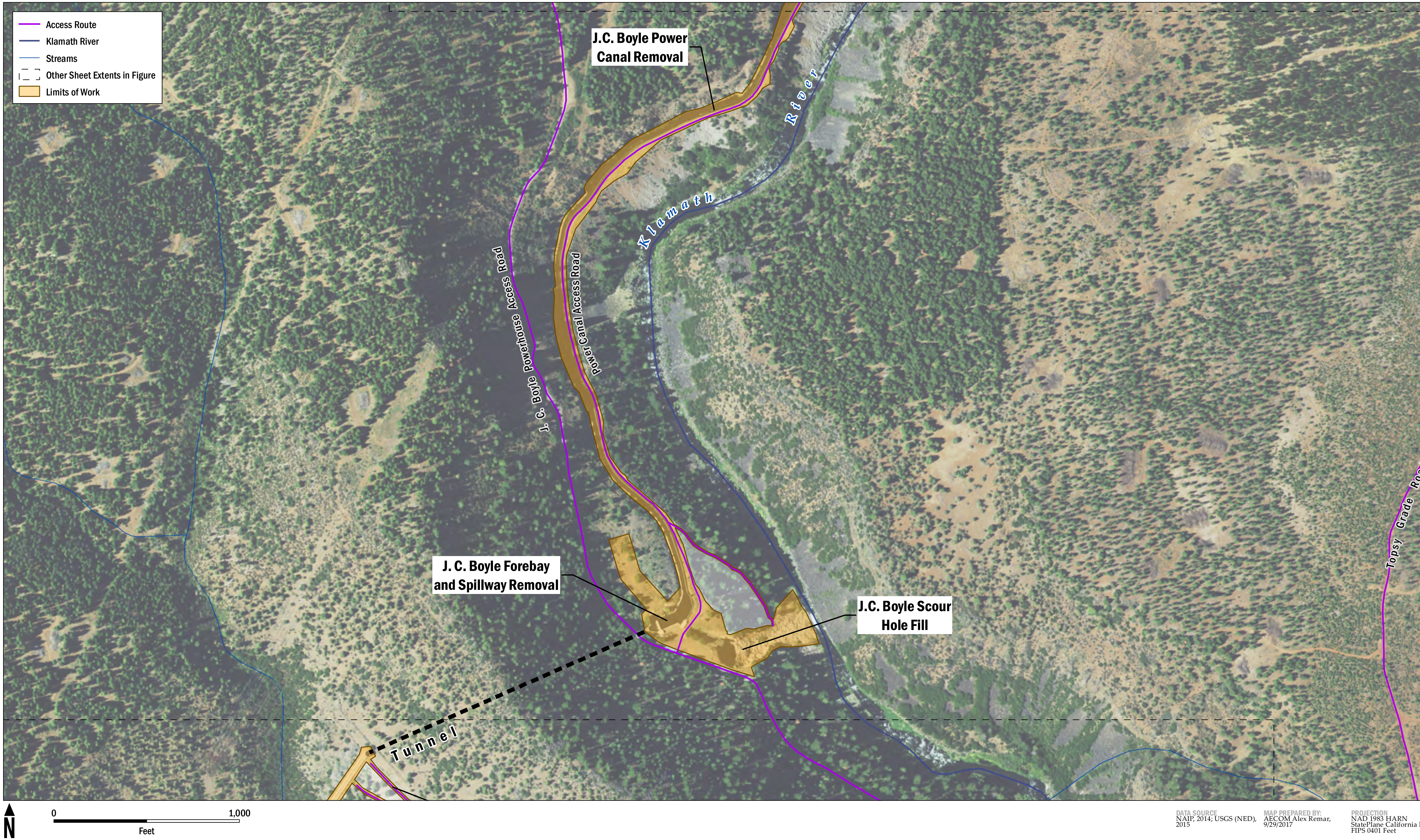



**FIGURE 5.1-1**

*Project Limits of Work and Access*

*Sheet 4 of 23*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_1-1_ProjectLimitsOfWorkAndAccess_Sheets.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*

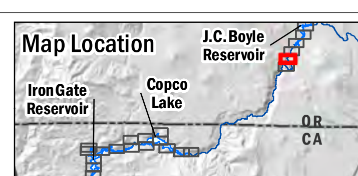
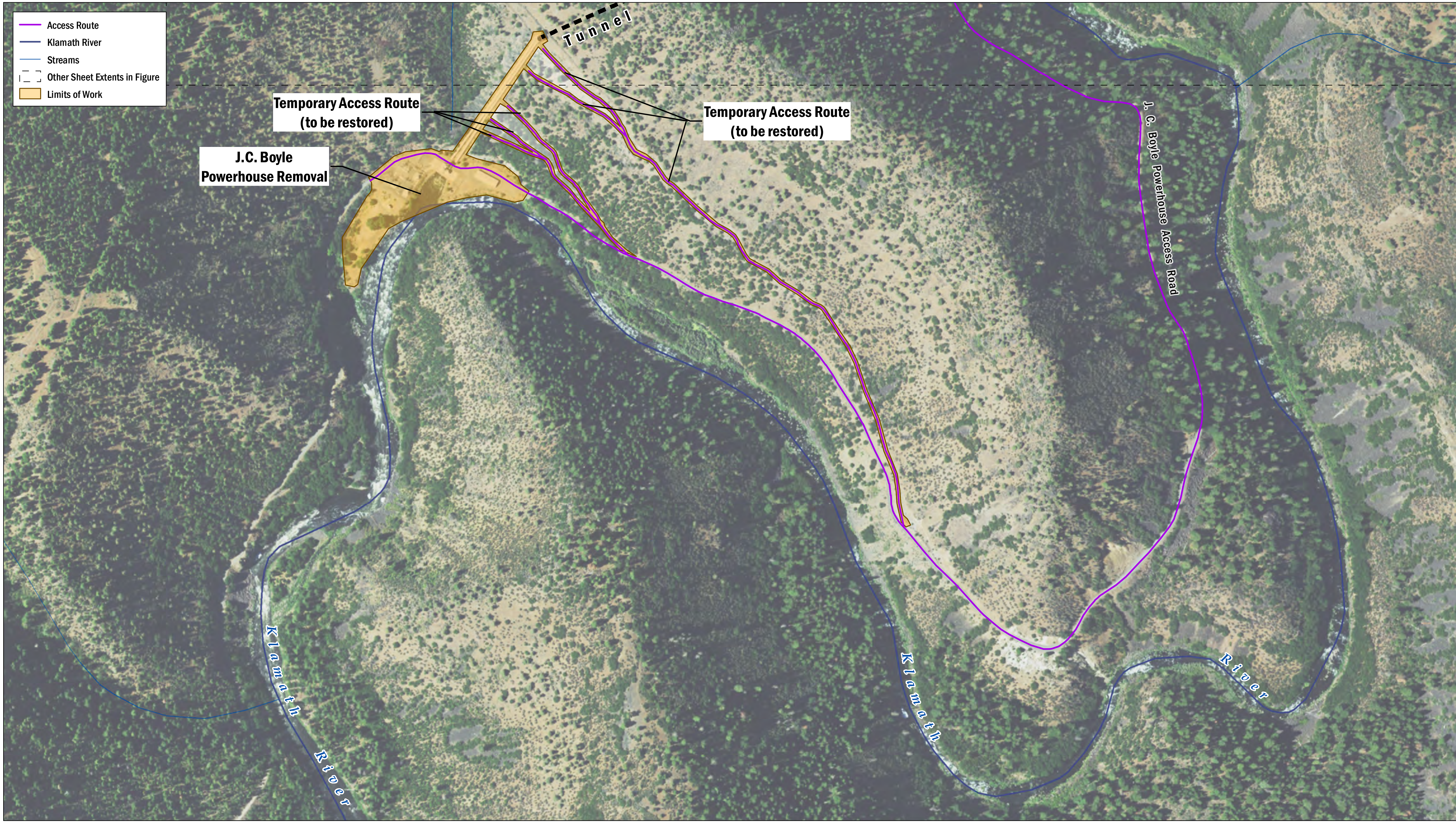



**FIGURE 5.1-1**

*Project Limits of Work and Access*
*Sheet 5 of 23*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_1-1_ProjectLimitsOfWorkAndAccess_Sheets.mxd

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DATA SOURCE
NAIP, 2014; USGS (NED), 2015

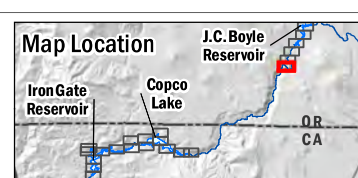
MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

AECOM

Klamath River Renewal Corporation

*Klamath River Renewal Project*




# FIGURE 5.1-1

*Project Limits of Work and Access*

*Sheet 6 of 23*


DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
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PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*

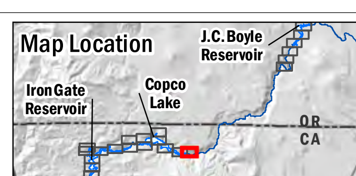
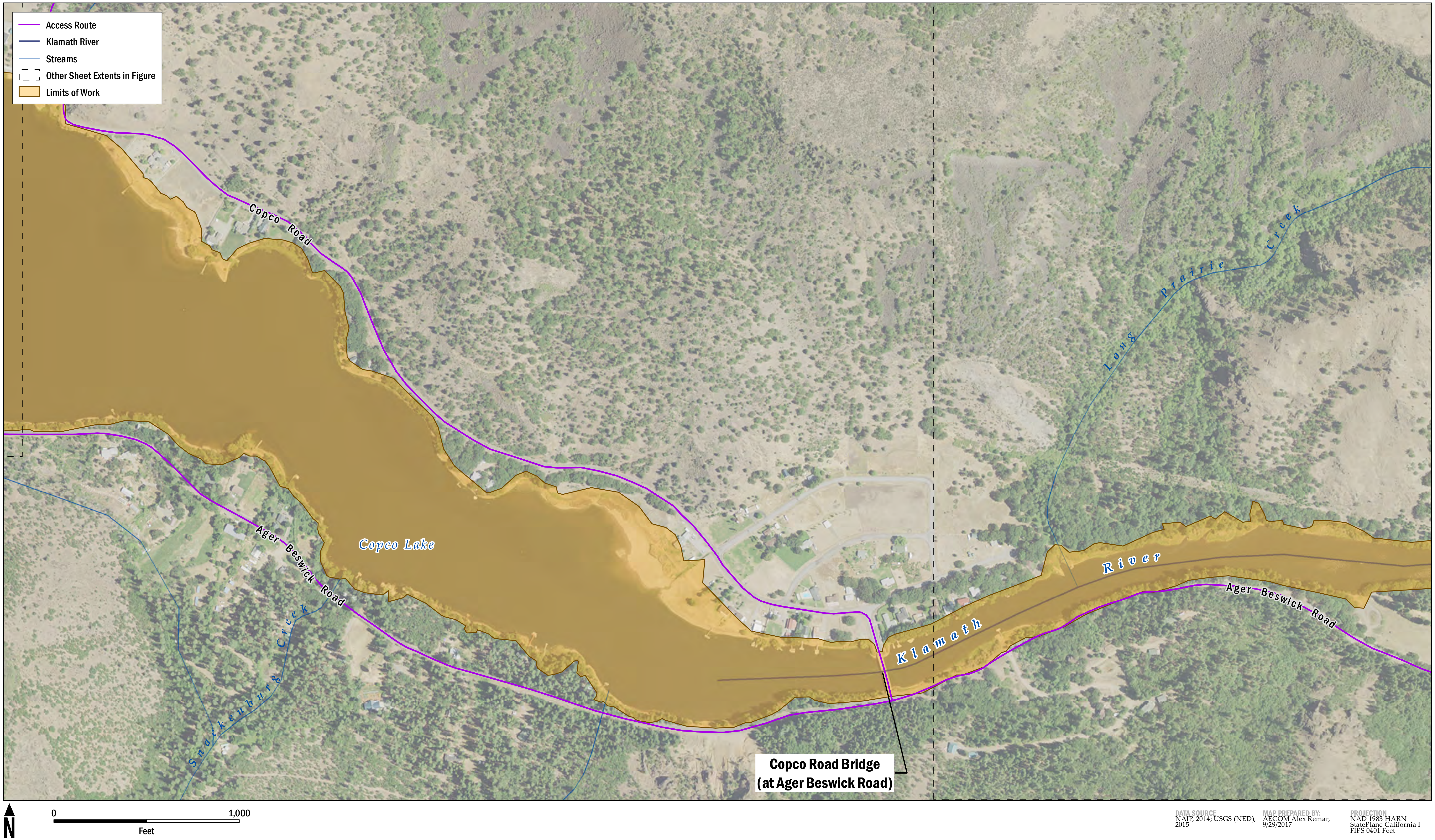



**FIGURE 5.1-1**
*Project Limits of Work and Access*
*Sheet 7 of 23*




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*

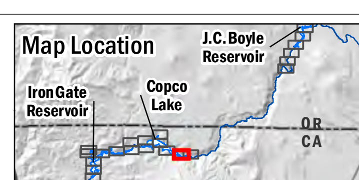
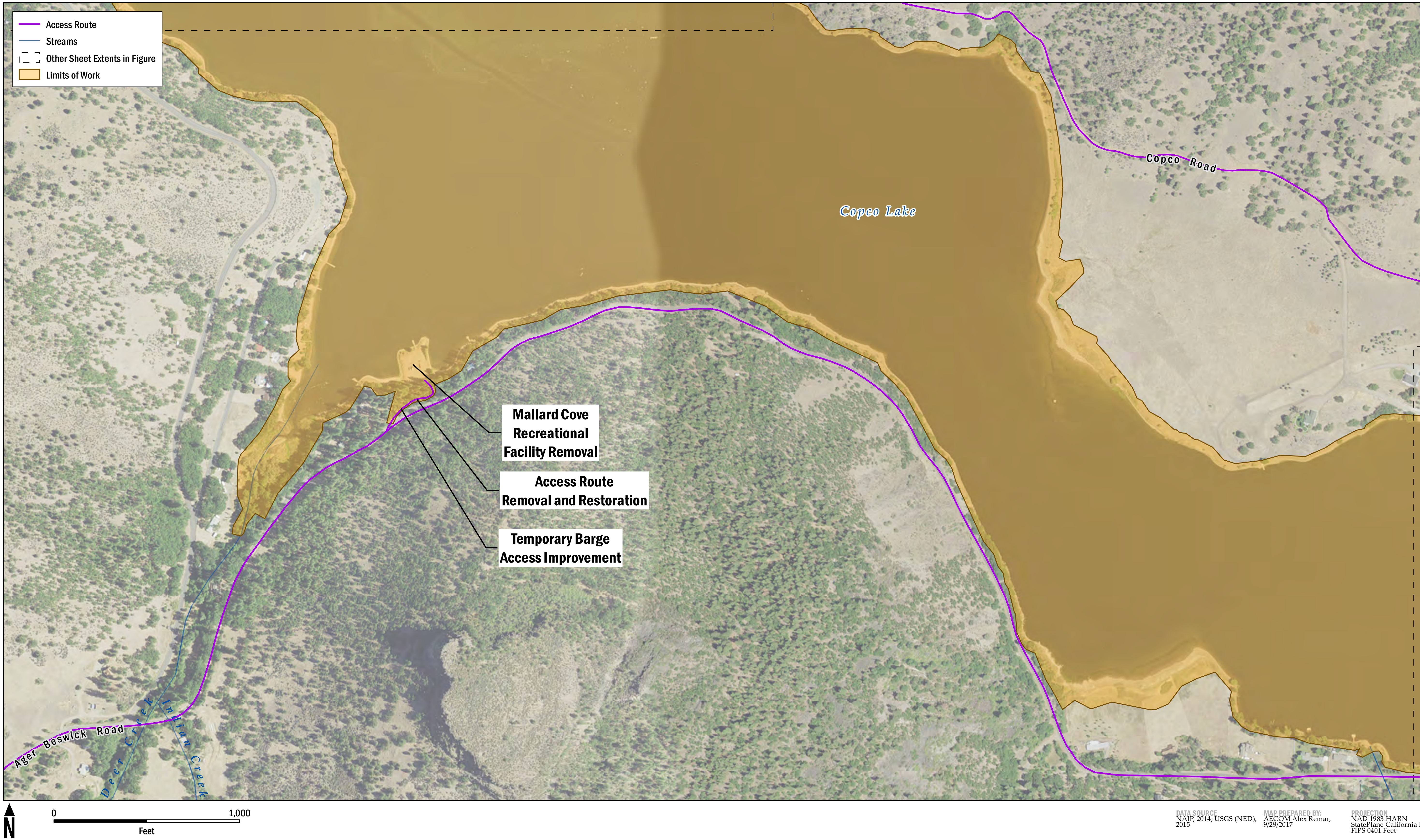



**FIGURE 5.1-1**
*Project Limits of Work and Access*
*Sheet 8 of 23*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_1-1_ProjectLimitsOfWorkAndAccess_Sheets.mxd

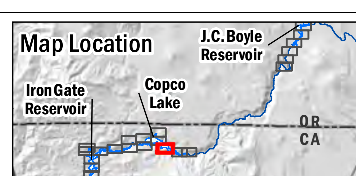



DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

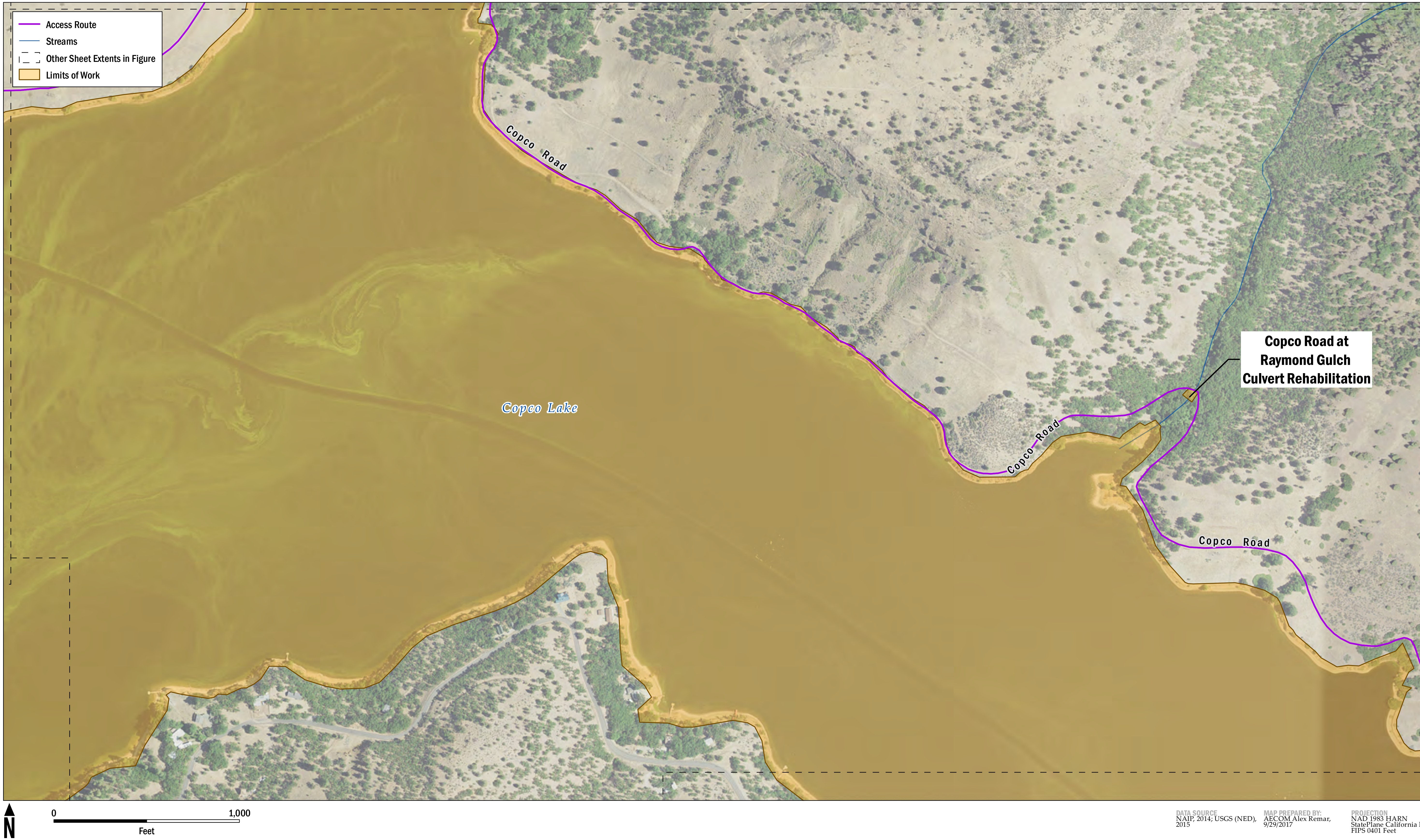
PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*




# FIGURE 5.1-1

*Project Limits of Work and Access*
*Sheet 9 of 23*




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
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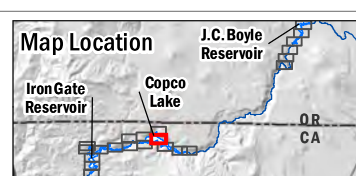
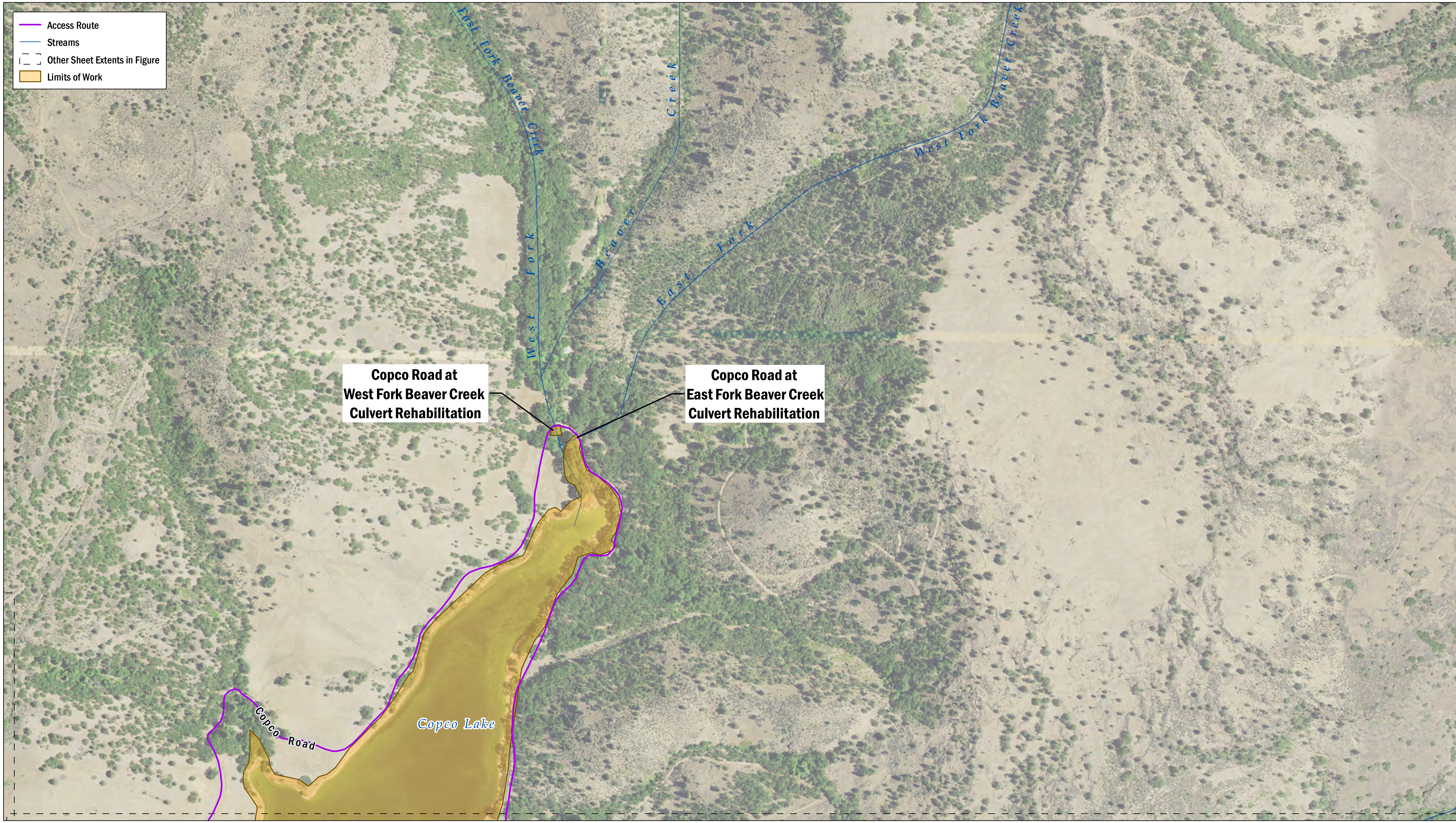
PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*




# FIGURE 5.1-1

*Project Limits of Work and Access*
*Sheet 10 of 23*




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN
StatePlane California I
FIPS 0401 Feet

AECOM
**Klamath River Renewal Corporation**
*Klamath River Renewal Project*

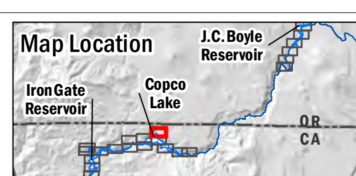
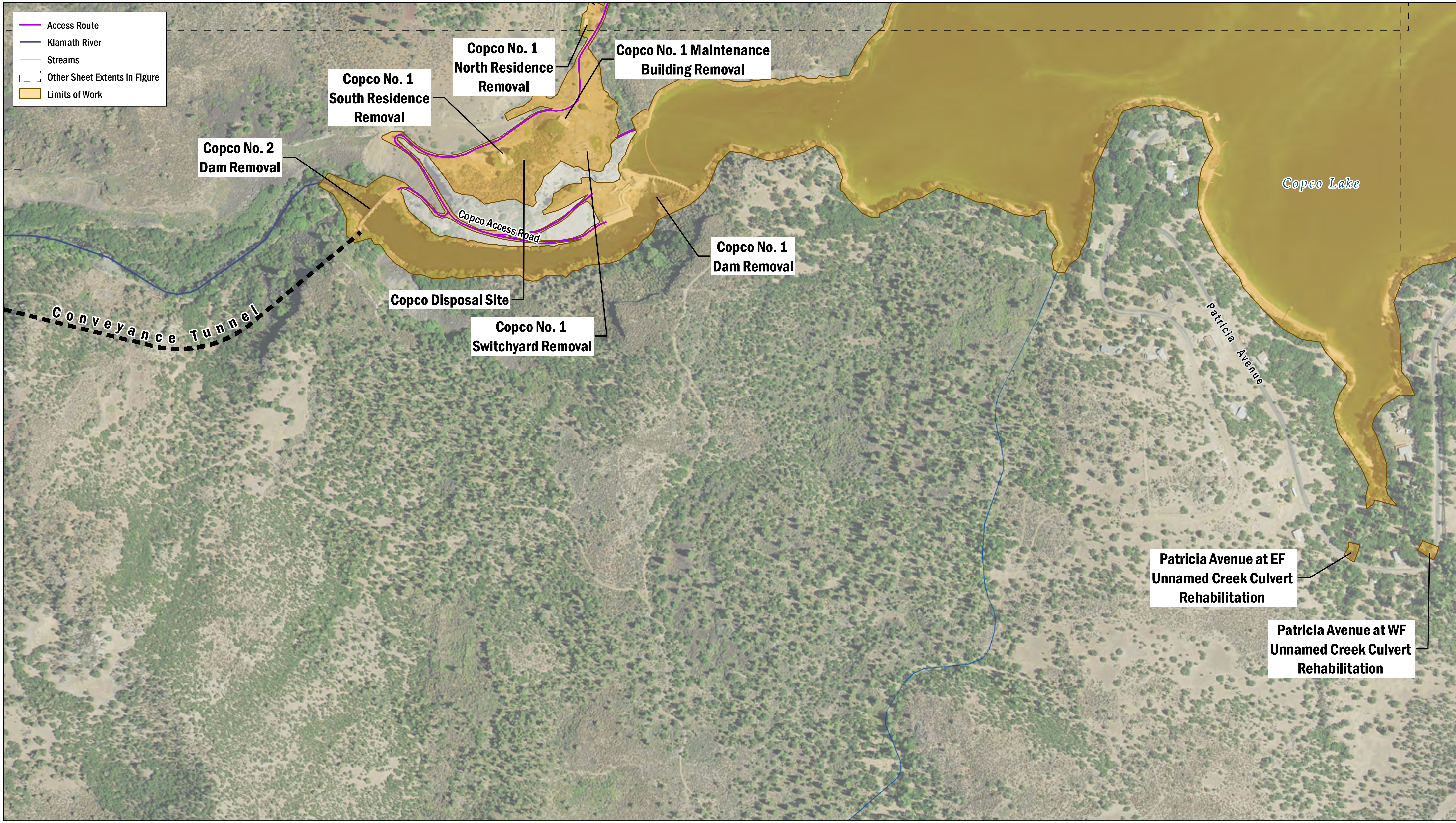



**FIGURE 5.1-1**
*Project Limits of Work and Access*
*Sheet 11 of 23*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_1-1_ProjectLimitsOfWorkAndAccess_Sheets.mxd

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DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*

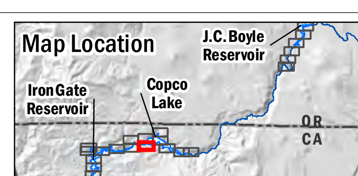
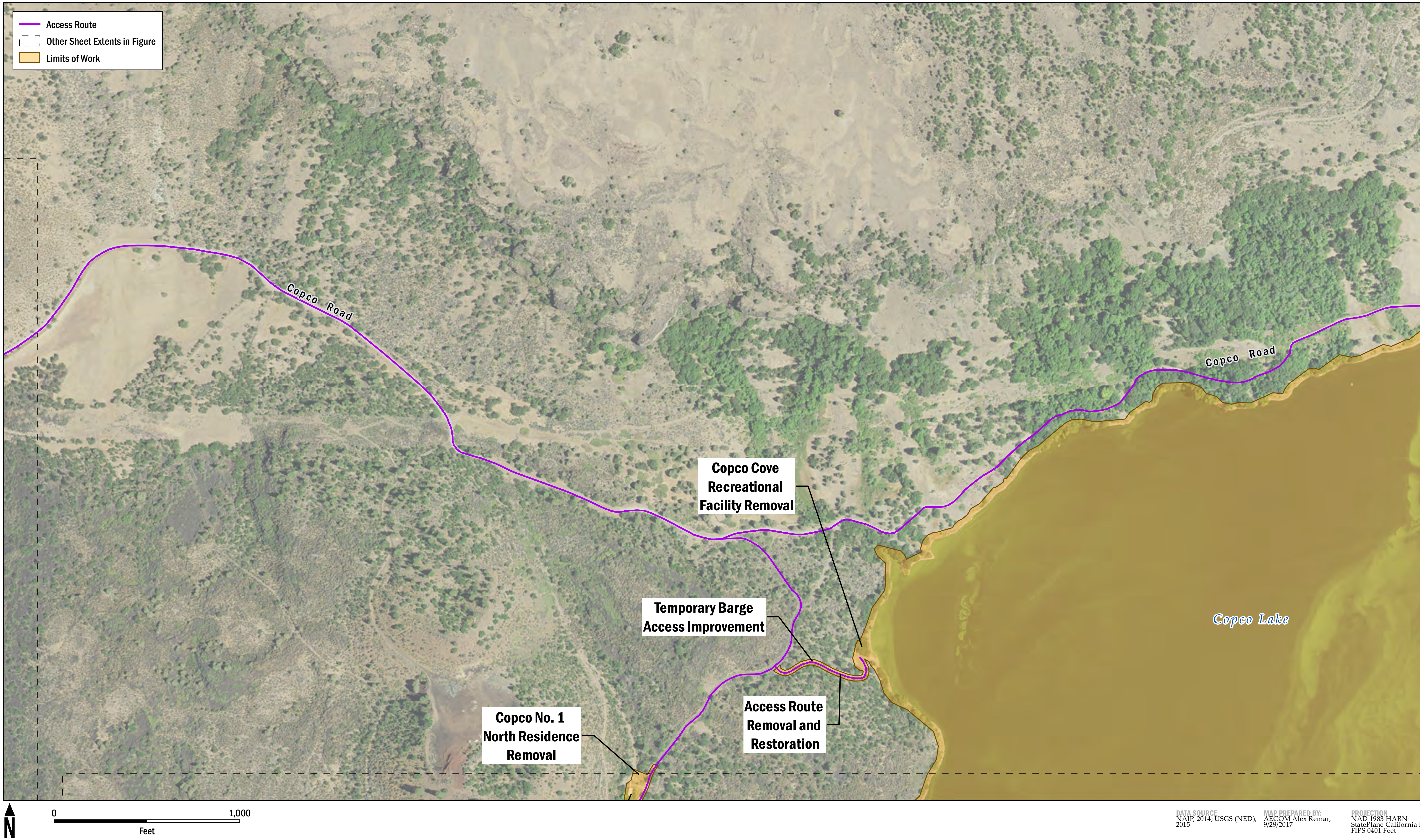



**FIGURE 5.1-1**
*Project Limits of Work and Access*
*Sheet 12 of 23*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_1-1_ProjectLimitsOfWorkAndAccess_Sheets.mxd

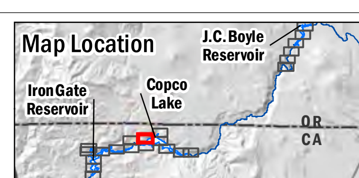



DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN
StatePlane California I
FIPS 0401 Feet

AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*

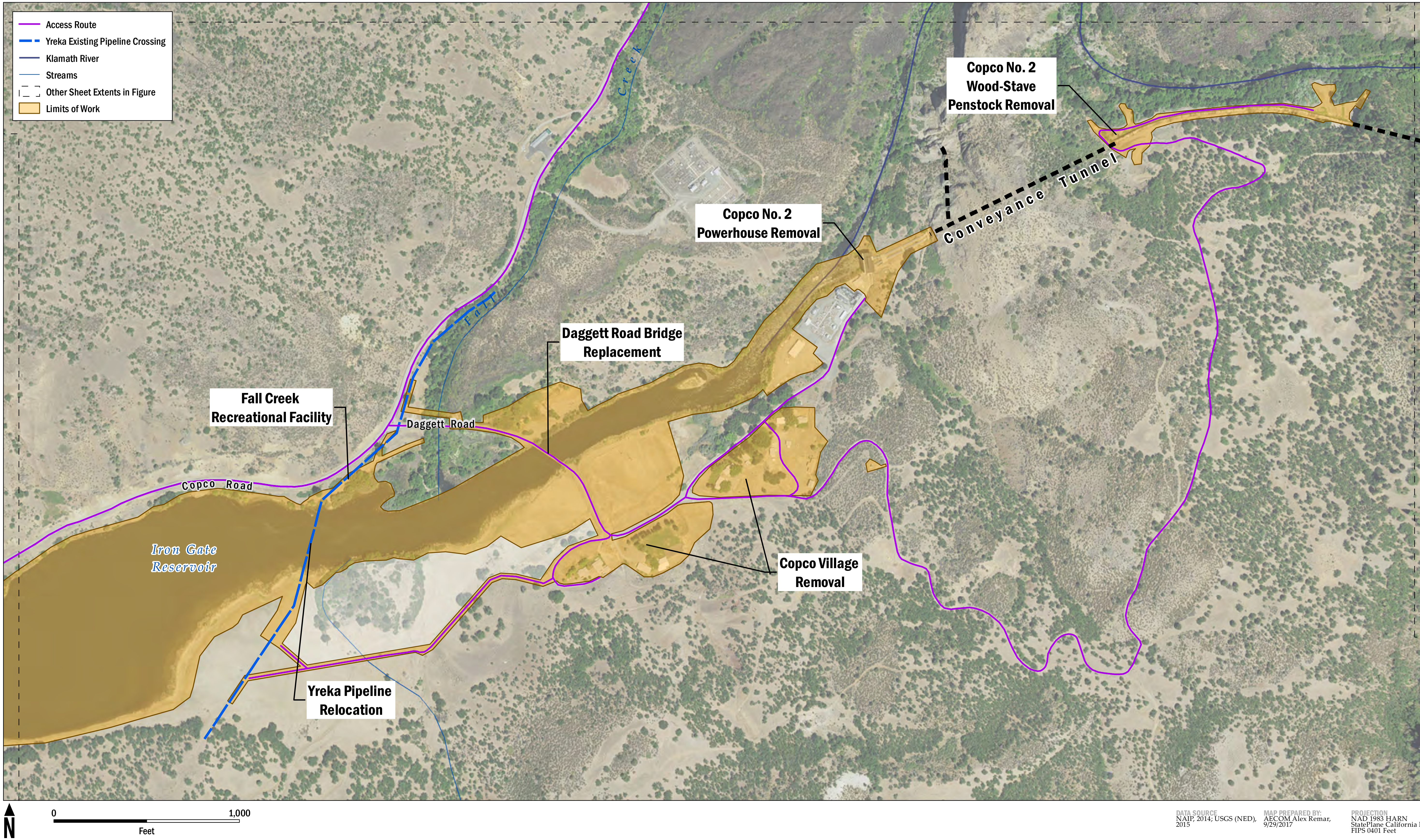



# FIGURE 5.1-1

*Project Limits of Work and Access*

*Sheet 13 of 23*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_1-1_ProjectLimitsOfWorkAndAccess_Sheets.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN
StatePlane California I
FIPS 0401 Feet

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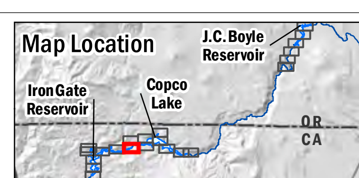
Klamath River Renewal Corporation
*Klamath River Renewal Project*

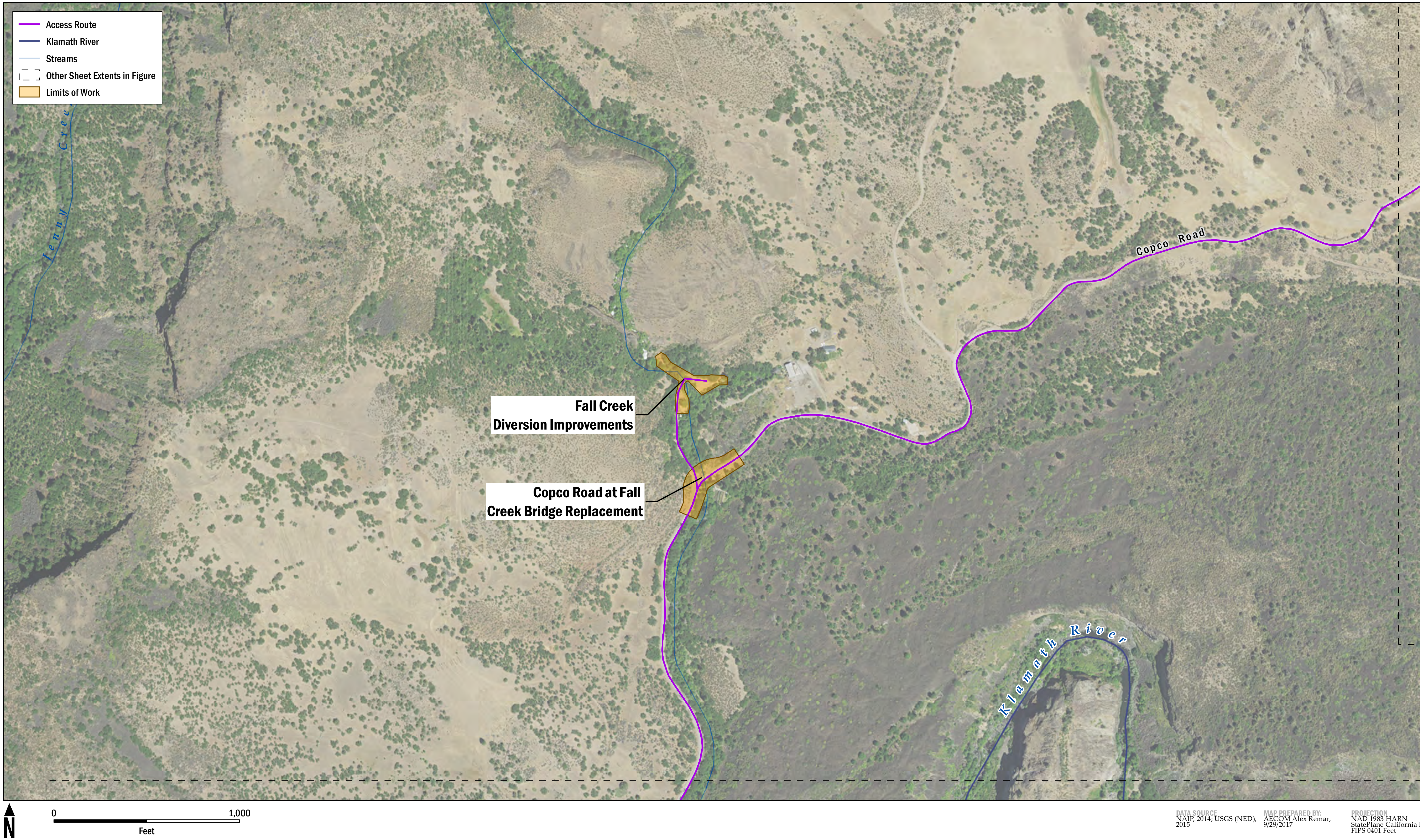



# FIGURE 5.1-1

*Project Limits of Work and Access*

*Sheet 14 of 23*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_1-1_ProjectLimitsOfWorkAndAccess_Sheets.mxd

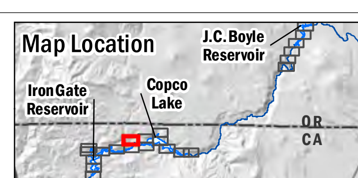



DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

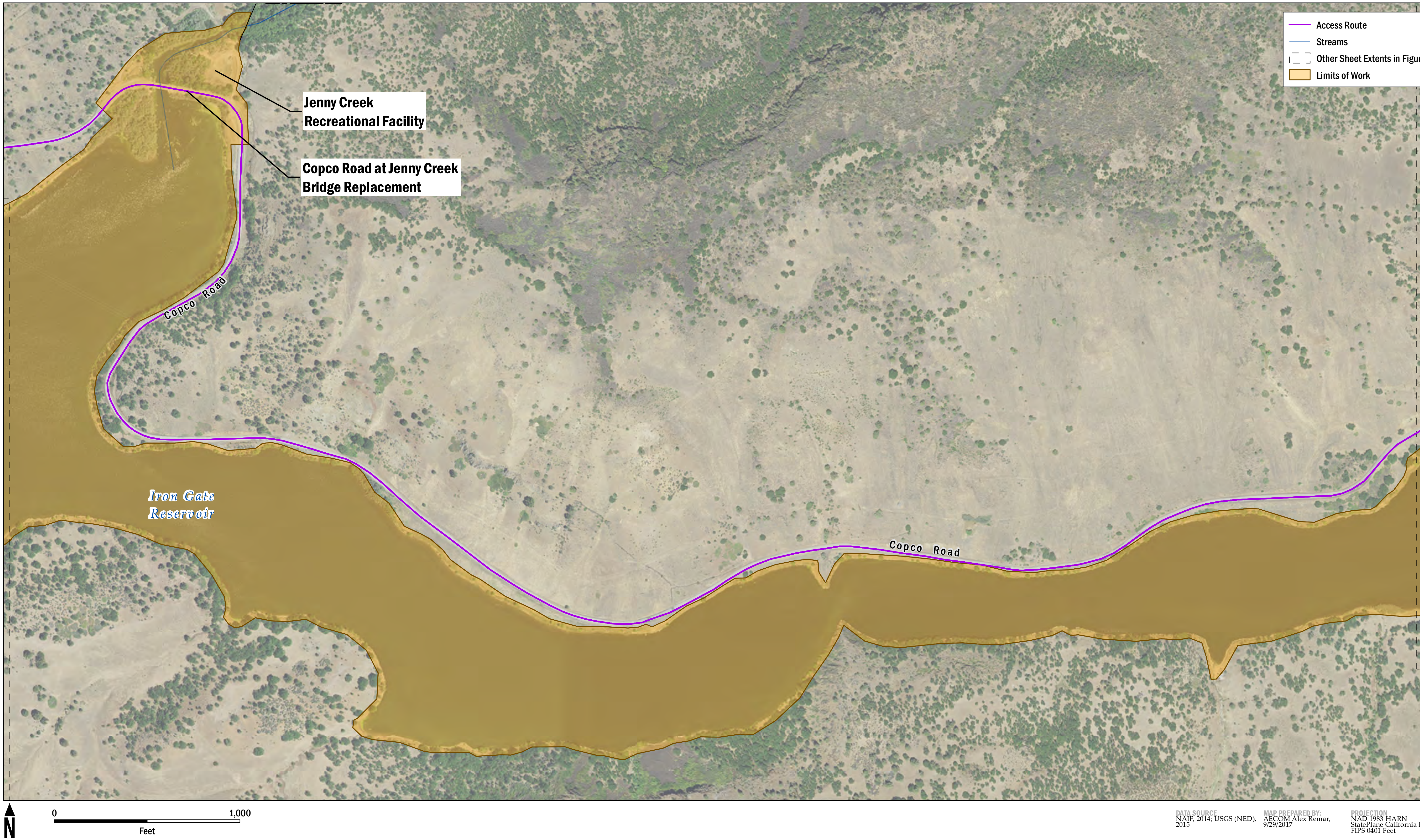
AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*




# FIGURE 5.1-1

*Project Limits of Work and Access*
*Sheet 15 of 23*

AECOM Oakland CA 9/29/2017 USER latha.chandrasekaran PATH L:\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_1-1_ProjectLimitsOfWorkAndAccess_Sheets.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
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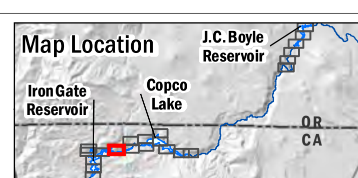
PROJECTION
NAD 1983 HARN
StatePlane California I
FIPS 0401 Feet

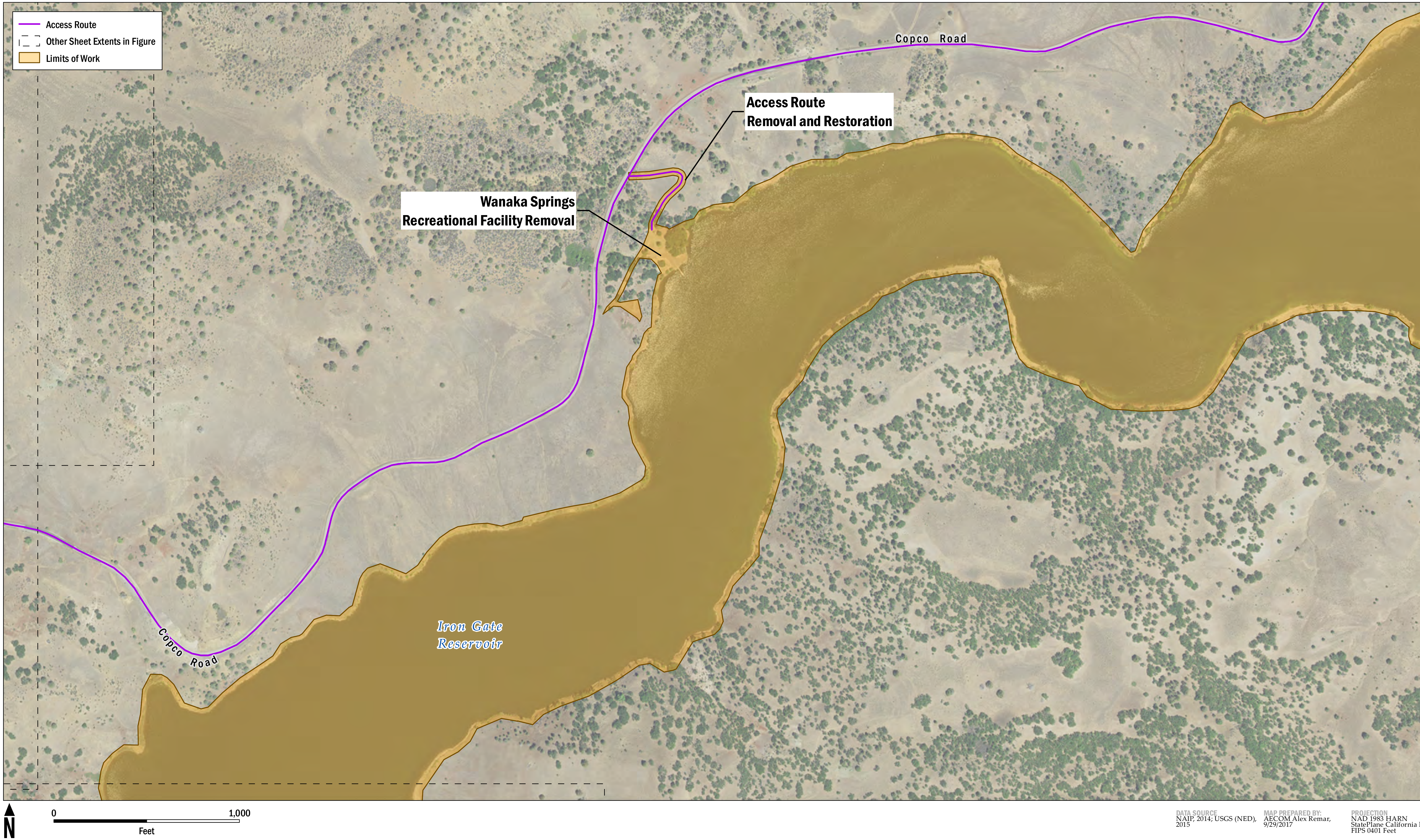
AECOM
**Klamath River Renewal Corporation**
*Klamath River Renewal Project*




# FIGURE 5.1-1

*Project Limits of Work and Access*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_1-1_ProjectLimitsOfWorkAndAccess_Sheets.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
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AECOM
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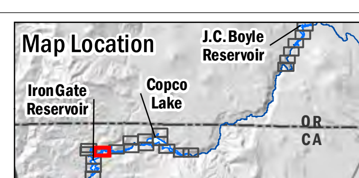
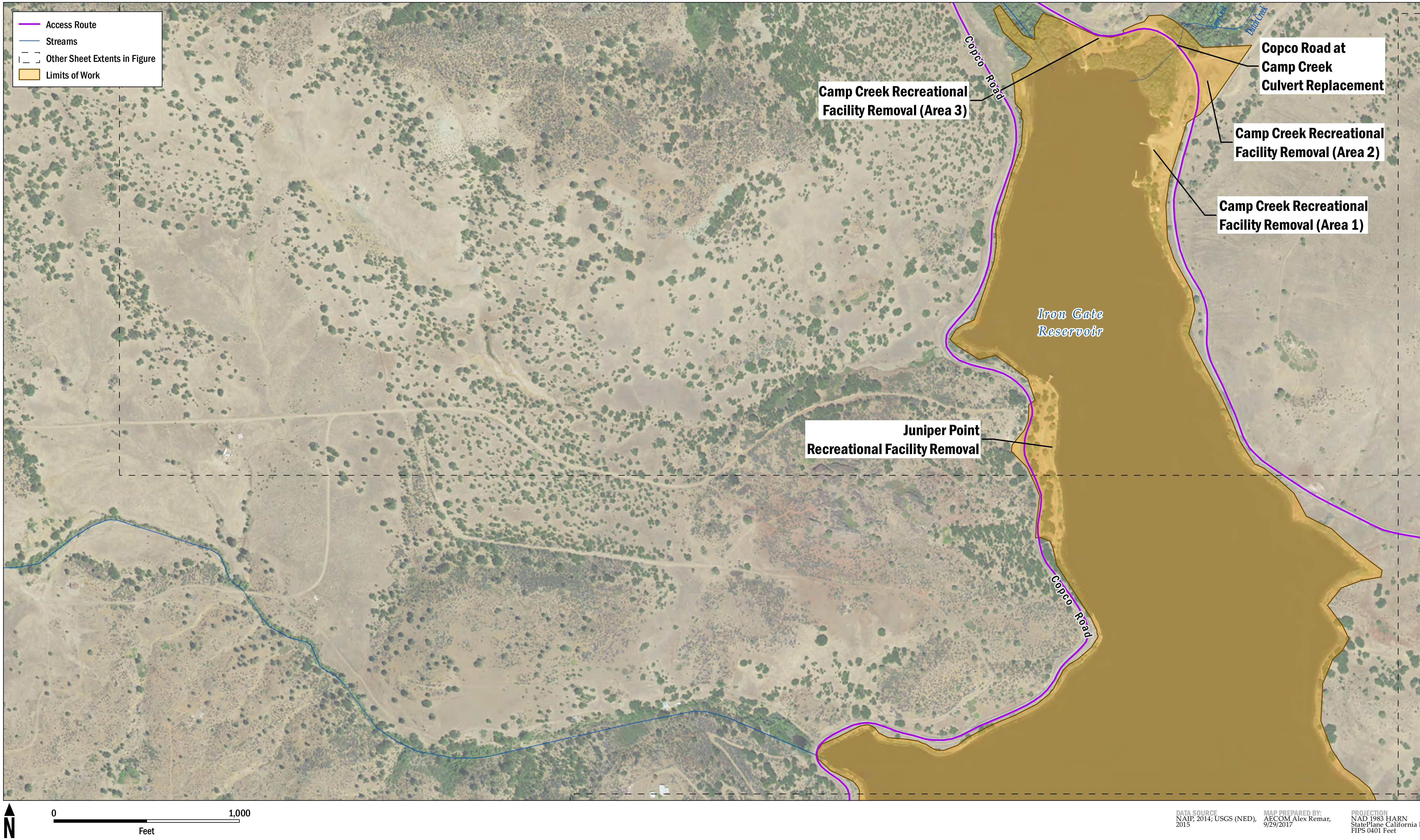



# FIGURE 5.1-1

*Project Limits of Work and Access*
*Sheet 17 of 23*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_1-1_ProjectLimitsOfWorkAndAccess_Sheets.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN
StatePlane California I
FIPS 0401 Feet

AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*

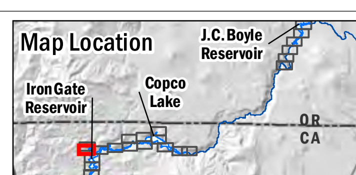
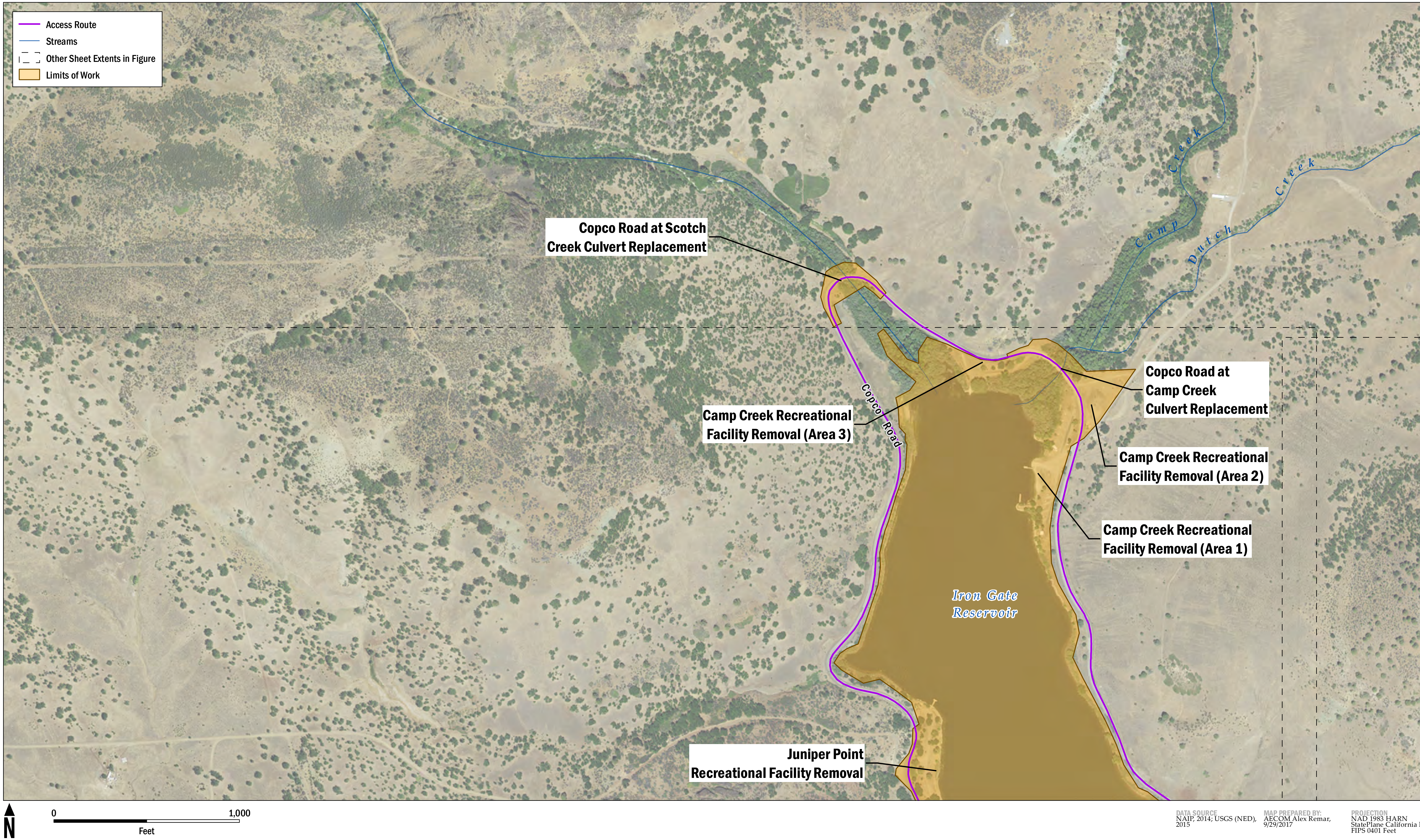



**FIGURE 5.1-1**

*Project Limits of Work and Access*

*Sheet 18 of 23*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_1-1_ProjectLimitsOfWorkAndAccess_Sheets.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

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PROJECTION
NAD 1983 HARN
StatePlane California I
FIPS 0401 Feet

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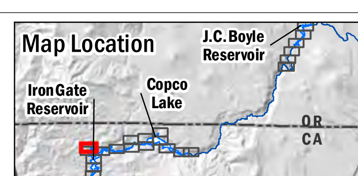
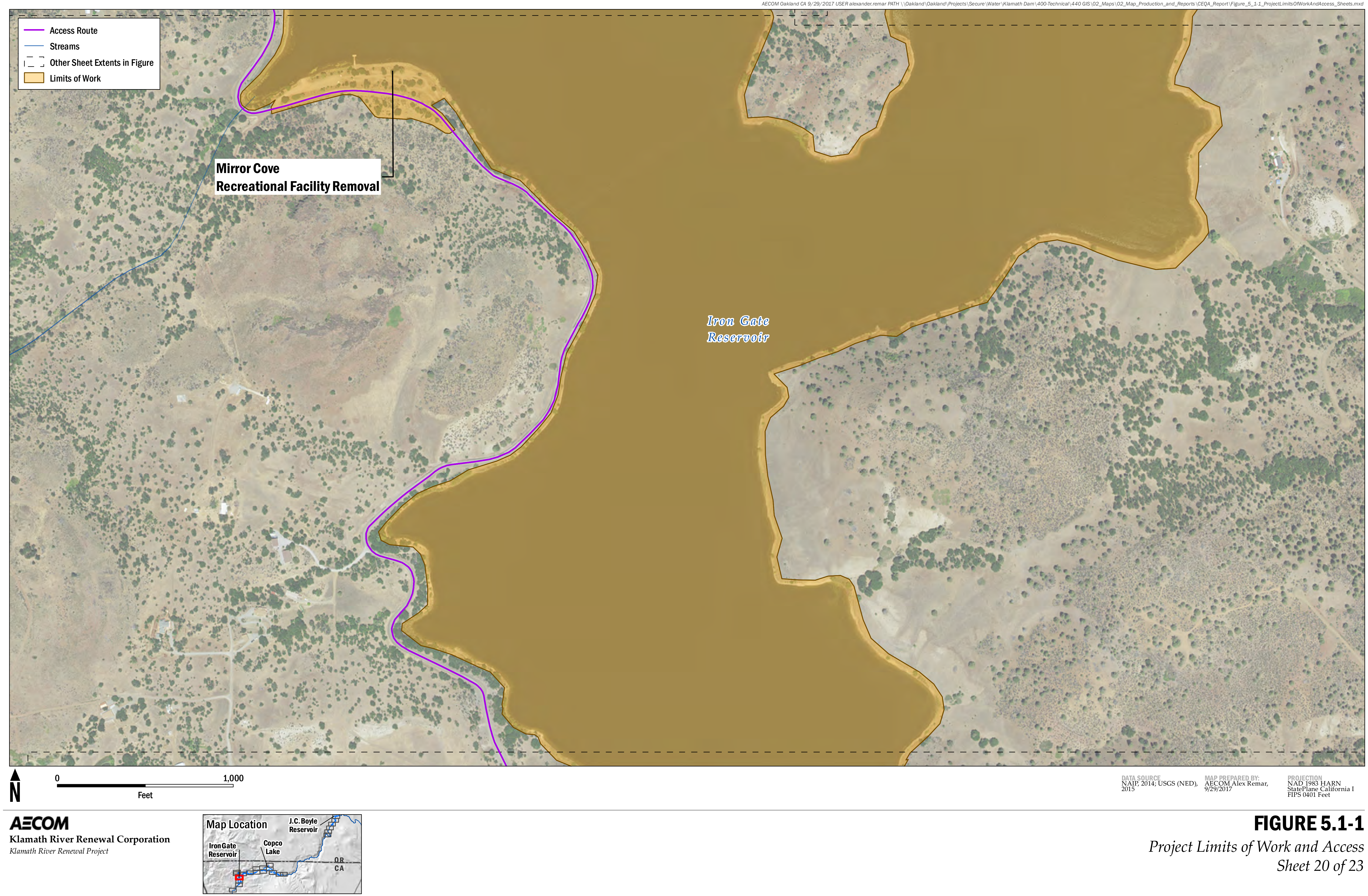



**FIGURE 5.1-1**

*Project Limits of Work and Access*

*Sheet 19 of 23*

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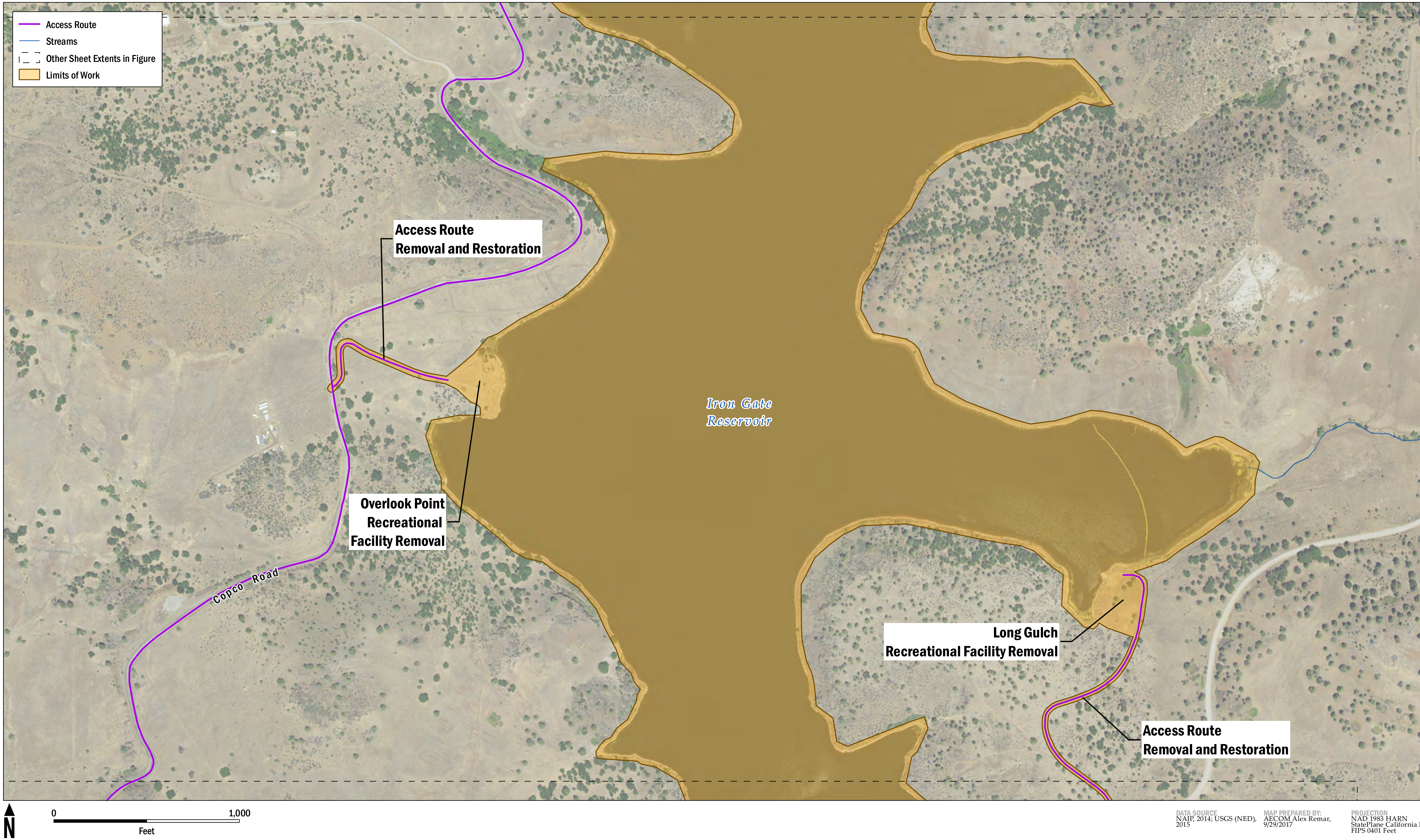
*Klamath River Renewal Project*

# FIGURE 5.1-1
*Project Limits of Work and Access*
*Sheet 20 of 23*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_1-1_ProjectLimitsOfWorkAndAccess_Sheets.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*

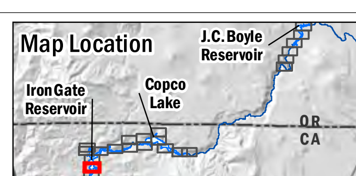
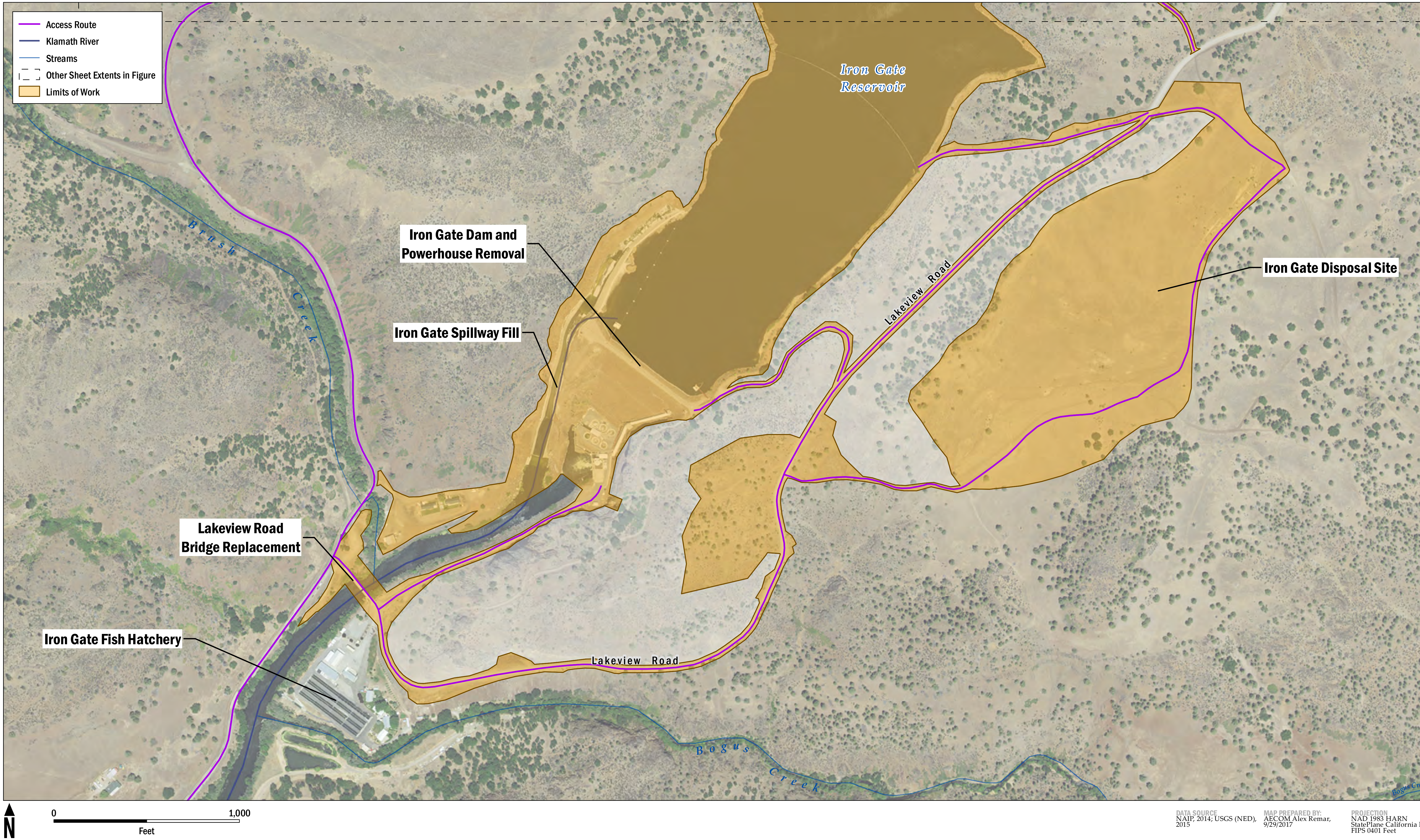



**FIGURE 5.1-1**

*Project Limits of Work and Access*

*Sheet 21 of 23*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_1-1_ProjectLimitsOfWorkAndAccess_Sheets.mxd

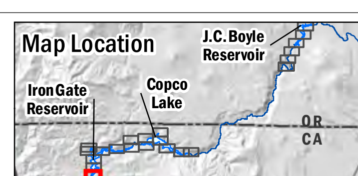



DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN
StatePlane California I
FIPS 0401 Feet

AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*




# FIGURE 5.1-1

*Project Limits of Work and Access*
*Sheet 22 of 23*


DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
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PROJECTION
NAD 1983 HARN
StatePlane California I
FIPS 0401 Feet

AECOM
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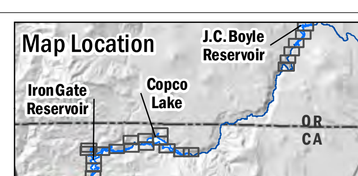
*Klamath River Renewal Project*

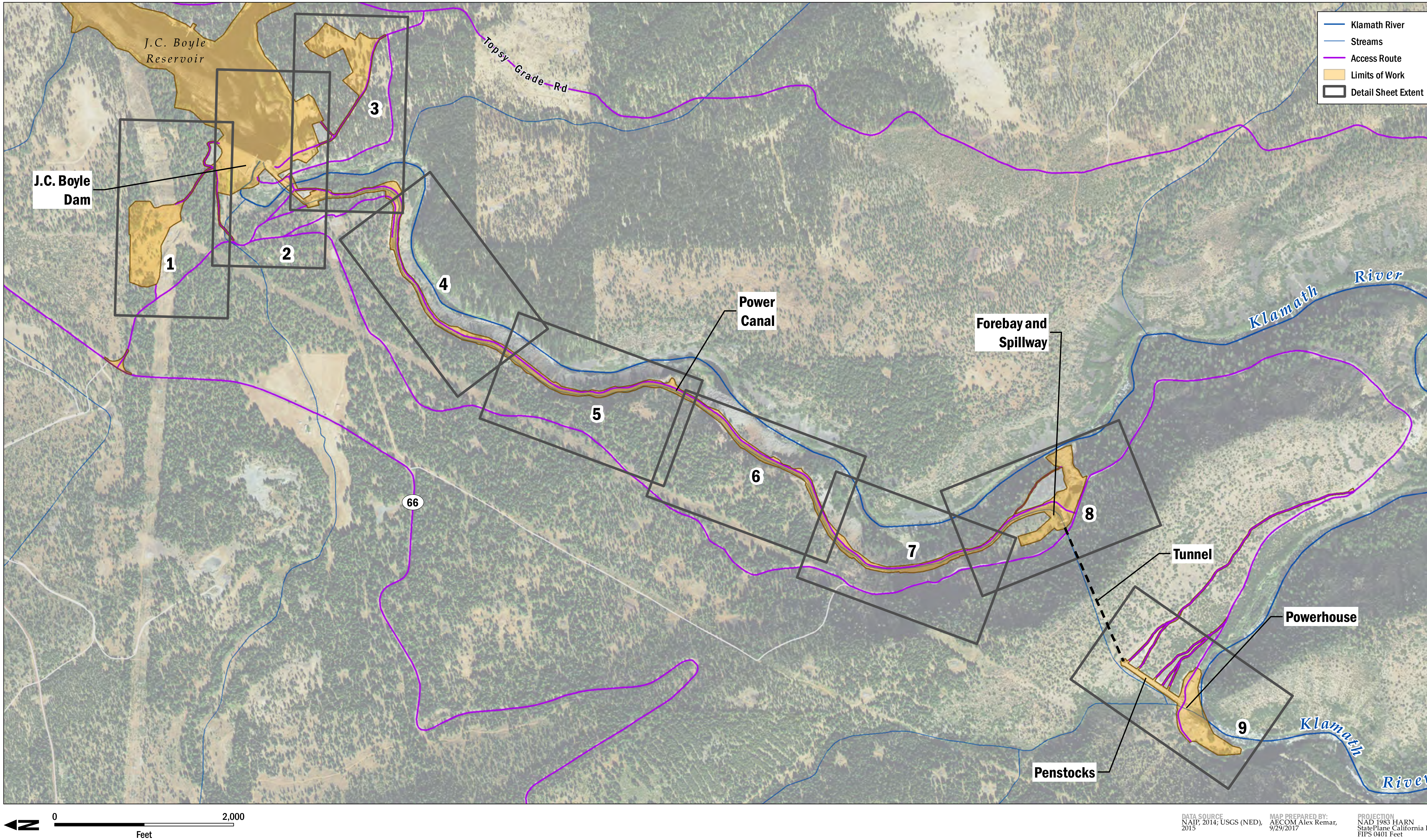



# FIGURE 5.1-1

*Project Limits of Work and Access*

*Sheet 23 of 23*

AECOM Oakland CA 9/29/2017 USER latha.chandrasekaran PATH L:\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_2-1_JCB_RemovalFeatureAndLimits_Overview.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015

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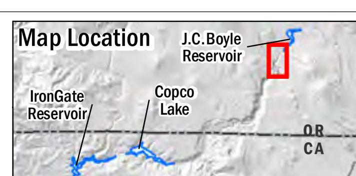
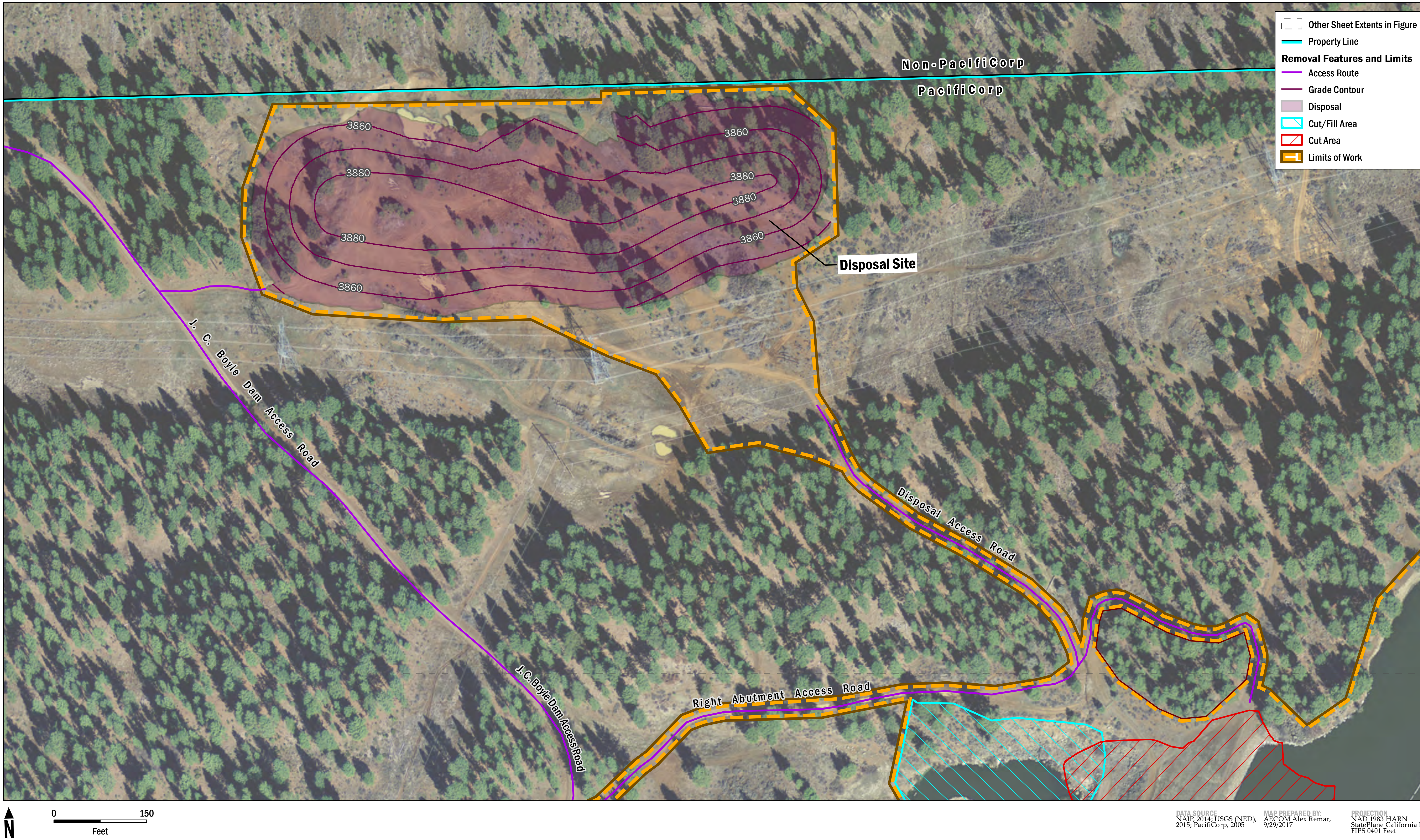
PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*




# FIGURE 5.2-1
*J.C. Boyle Dam Removal Features and Limits Overview Sheet*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_2-1_JCB_RemovalFeatureAndLimits_Sheets.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015; PacifiCorp, 2005

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PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

AECOM
Klamath River Renewal Corporation
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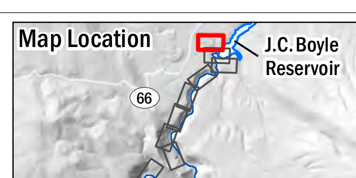
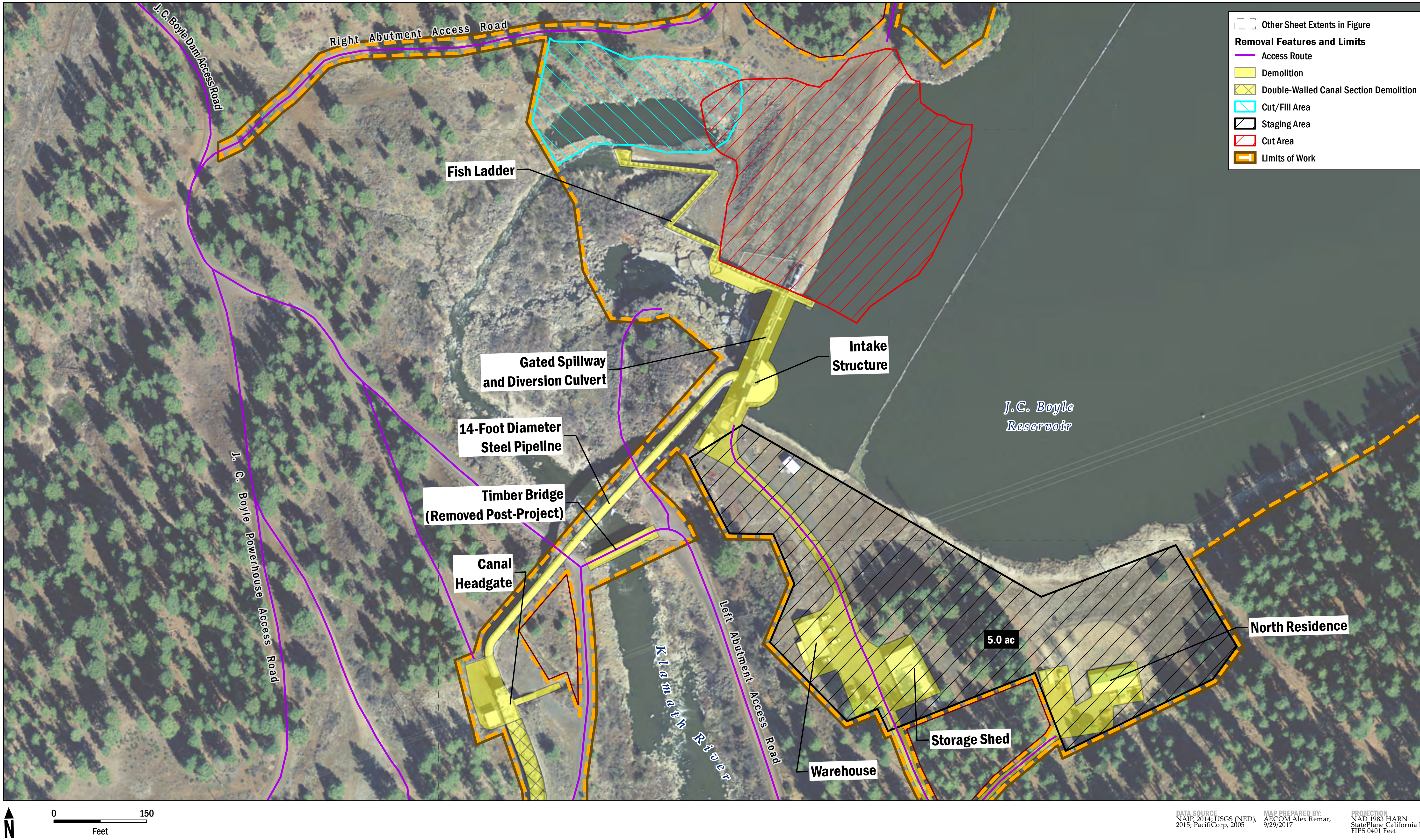



# FIGURE 5.2-1

*J.C. Boyle Dam Removal Features and Limits*

*Sheet 1 of 9*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_2-1_JCB_RemovalFeatureAndLimits_Sheets.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015; PacifiCorp, 2005

MAP PREPARED BY:
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PROJECTION
NAD 1983 HARN
StatePlane California I
FIPS 0401 Feet

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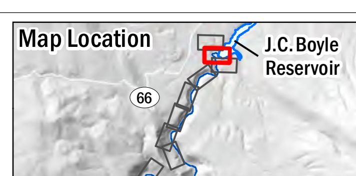
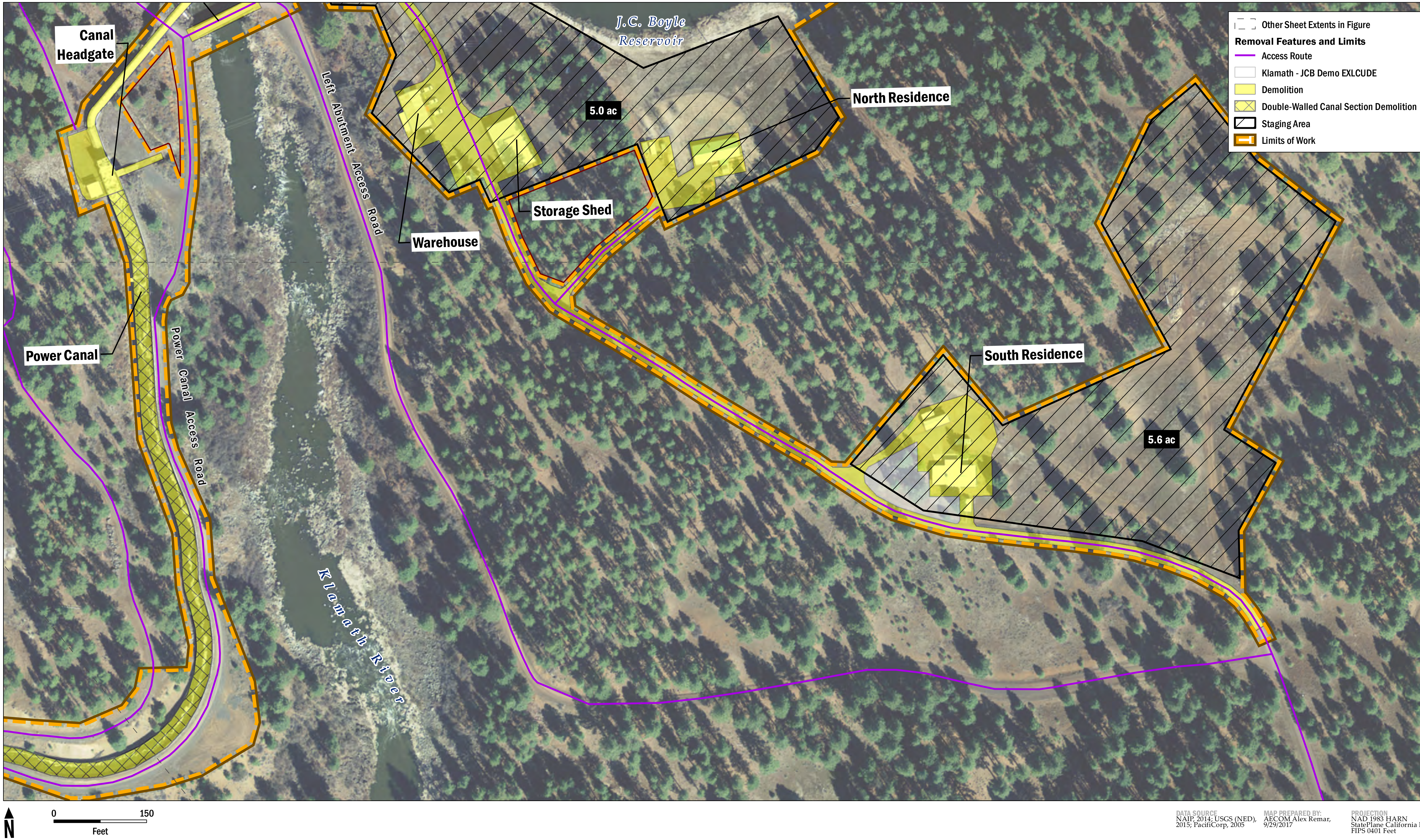
Klamath River Renewal Corporation
*Klamath River Renewal Project*




# FIGURE 5.2-1

*J.C. Boyle Dam Removal Features and Limits*
*Sheet 2 of 9*




DATA SOURCE
NAIP, 2014; USGS (NED), 2015; PacifiCorp, 2005

MAP PREPARED BY:
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PROJECTION
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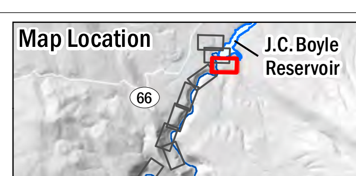
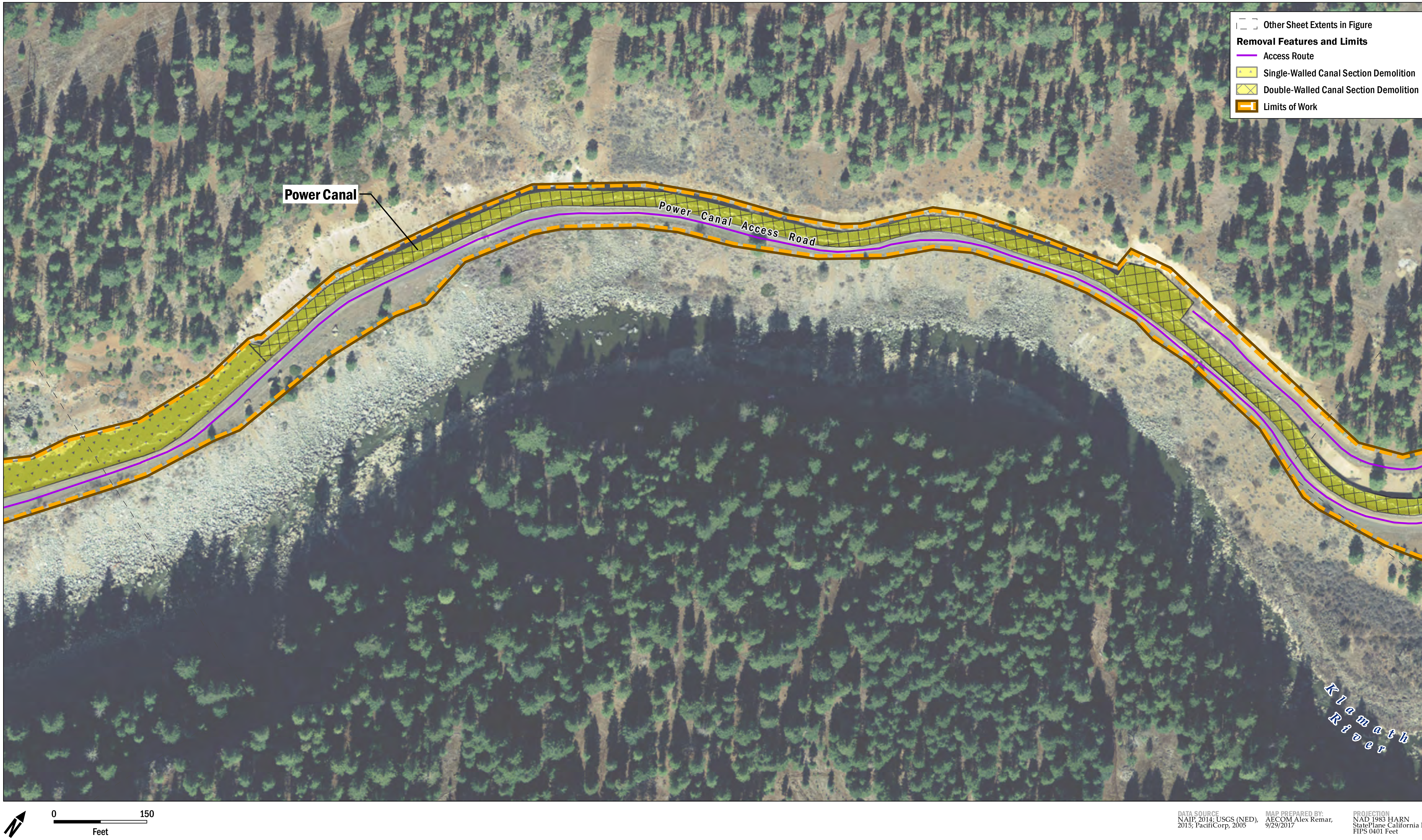
AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*




# FIGURE 5.2-1

*J.C. Boyle Dam Removal Features and Limits*
*Sheet 3 of 9*




DATA SOURCE
NAIP, 2014; USGS (NED), 2015; PacifiCorp, 2005

MAP PREPARED BY:
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PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

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Klamath River Renewal Corporation
*Klamath River Renewal Project*

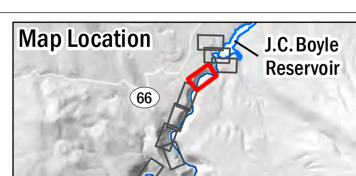
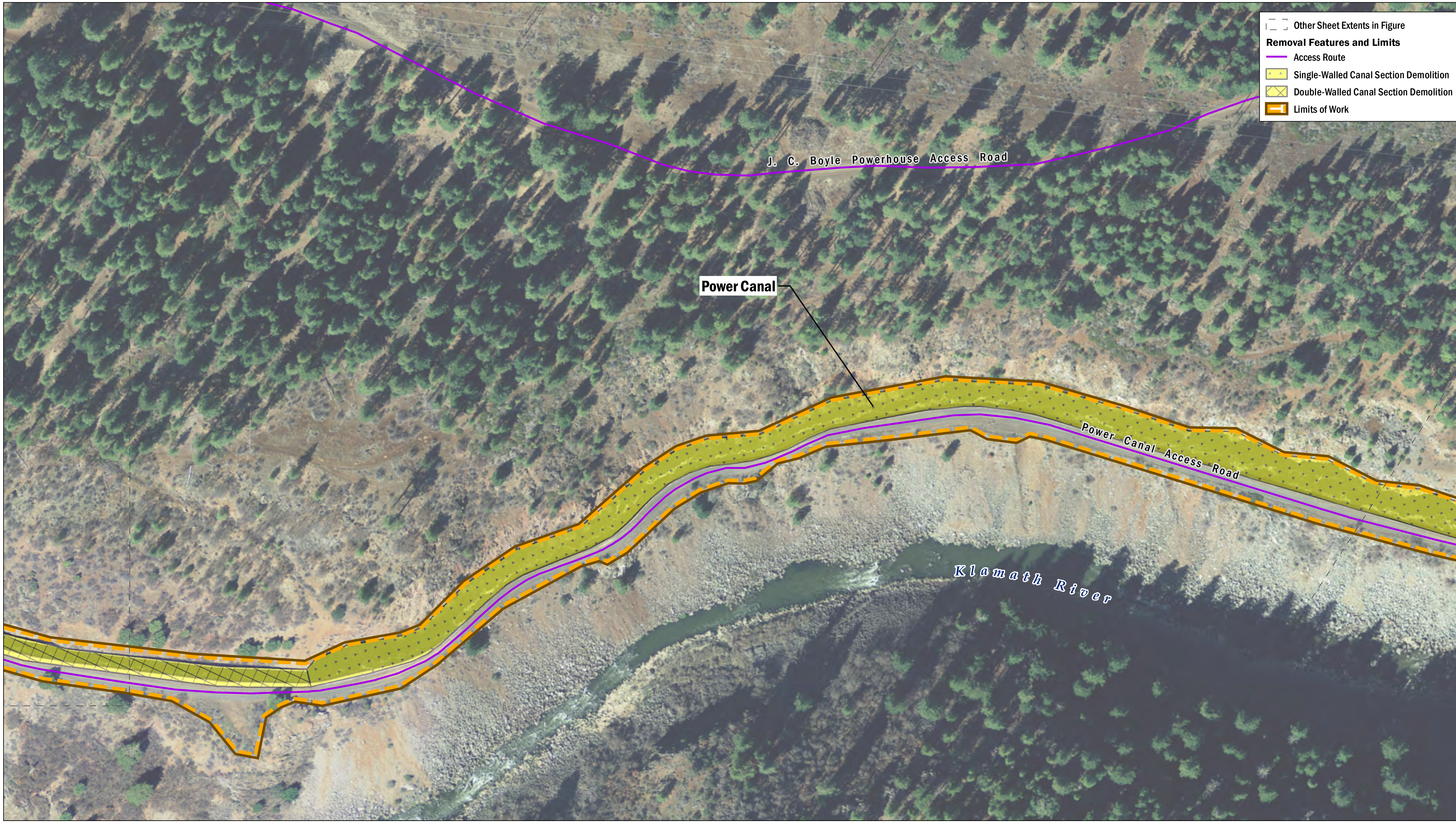



**FIGURE 5.2-1**

*J.C. Boyle Dam Removal Features and Limits*

*Sheet 4 of 9*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_2-1_JCB_RemovalFeatureAndLimits_Sheets.mxd




0 150
Feet

DATA SOURCE
NAIP, 2014; USGS (NED), 2015; PacifiCorp, 2005

MAP PREPARED BY:
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PROJECTION
NAD 1983 HARN
StatePlane California I
FIPS 0401 Feet

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*Klamath River Renewal Project*

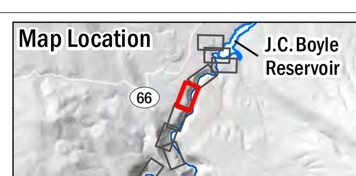
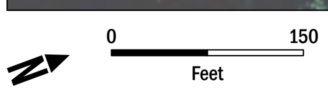



**FIGURE 5.2-1**

*J.C. Boyle Dam Removal Features and Limits*

*Sheet 5 of 9*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_2-1_JCB_RemovalFeatureAndLimits_Sheets.mxd


DATA SOURCE
NAIP, 2014; USGS (NED), 2015; PacifiCorp, 2005

MAP PREPARED BY:
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PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

AECOM

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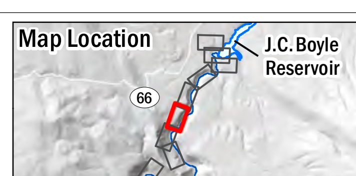
*Klamath River Renewal Project*




# FIGURE 5.2-1

*J.C. Boyle Dam Removal Features and Limits*

*Sheet 6 of 9*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_2-1_JCB_RemovalFeatureAndLimits_Sheets.mxd


0 150
Feet

DATA SOURCE
NAIP, 2014; USGS (NED), 2015; PacifiCorp, 2005

MAP PREPARED BY:
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PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

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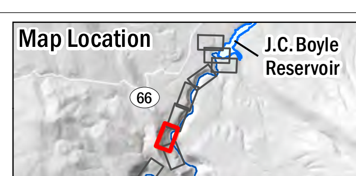
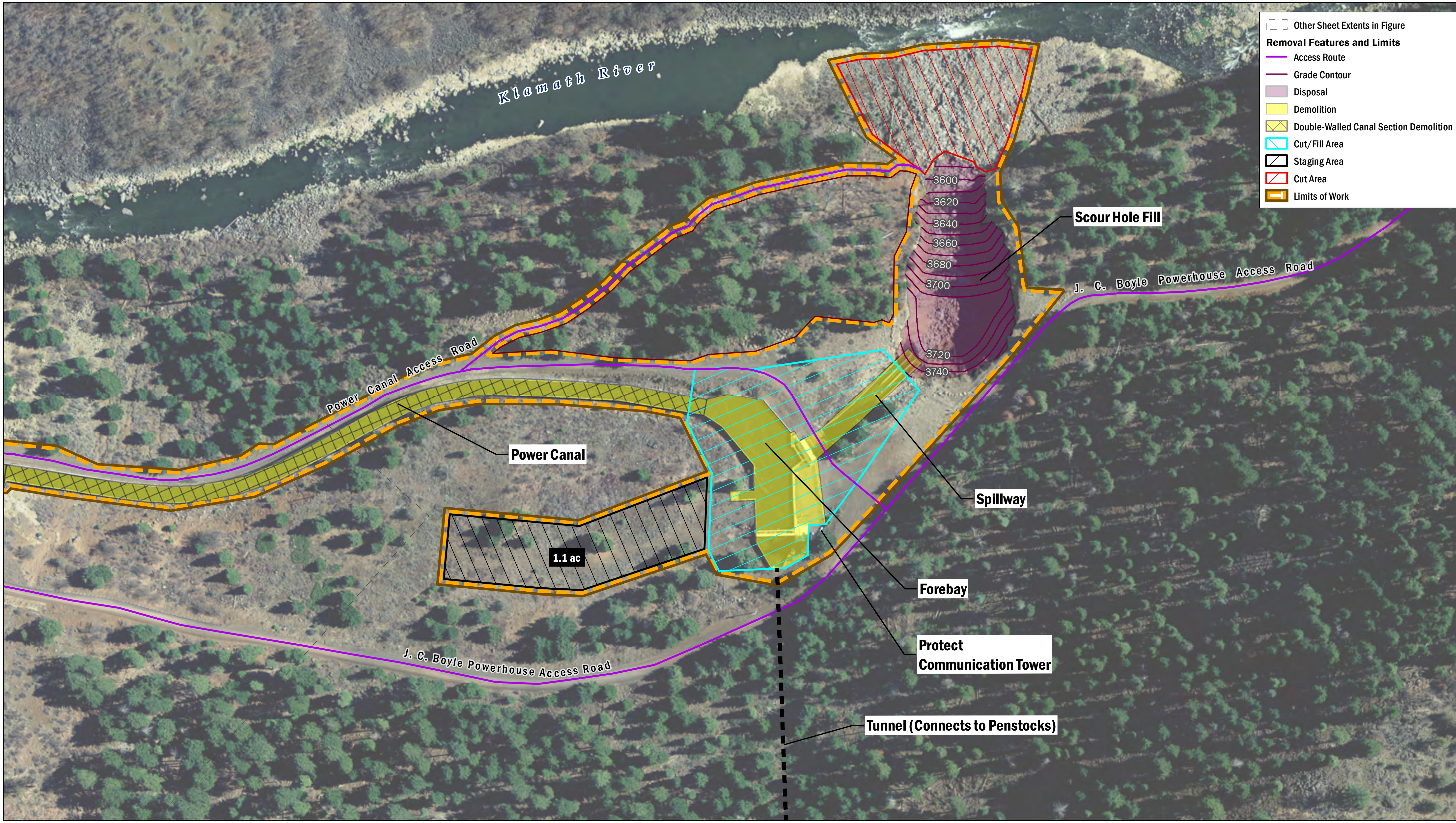
Klamath River Renewal Corporation
*Klamath River Renewal Project*




# FIGURE 5.2-1

*J.C. Boyle Dam Removal Features and Limits*
*Sheet 7 of 9*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_2-1_JCB_RemovalFeatureAndLimits_Sheets.mxd




0 150
Feet

DATA SOURCE
NAIP, 2014; USGS (NED), 2015; PacifiCorp, 2005

MAP PREPARED BY:
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PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

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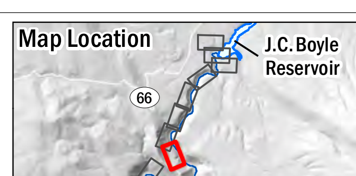
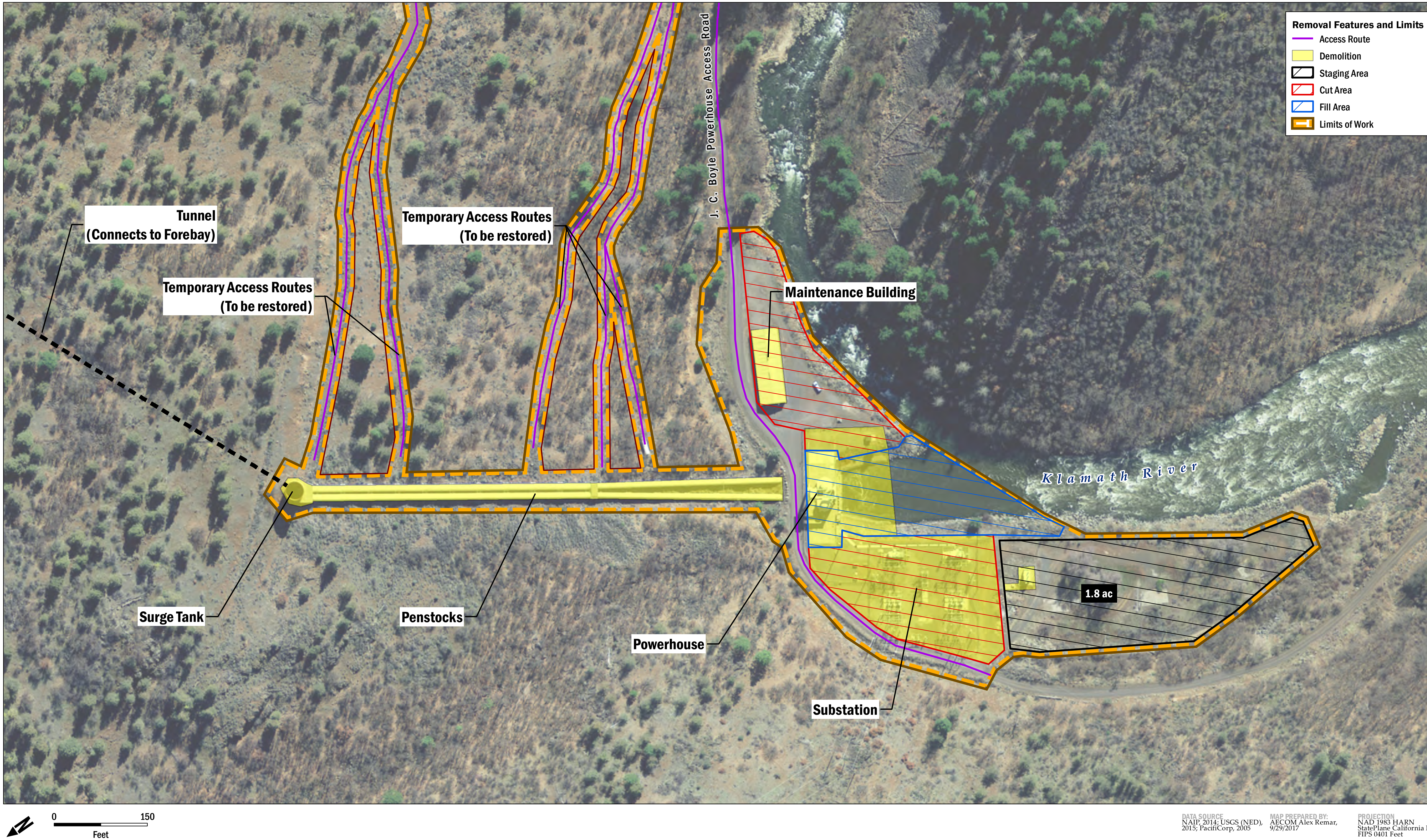


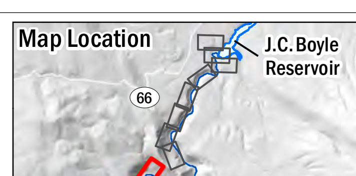

# FIGURE 5.2-1

*J.C. Boyle Dam Removal Features and Limits*

*Sheet 8 of 9*

AECOM Oakland CA 9/29/2017 USER alexander.remar PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_2-1_JCB_RemovalFeatureAndLimits_Sheets.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015; PacifiCorp, 2005

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

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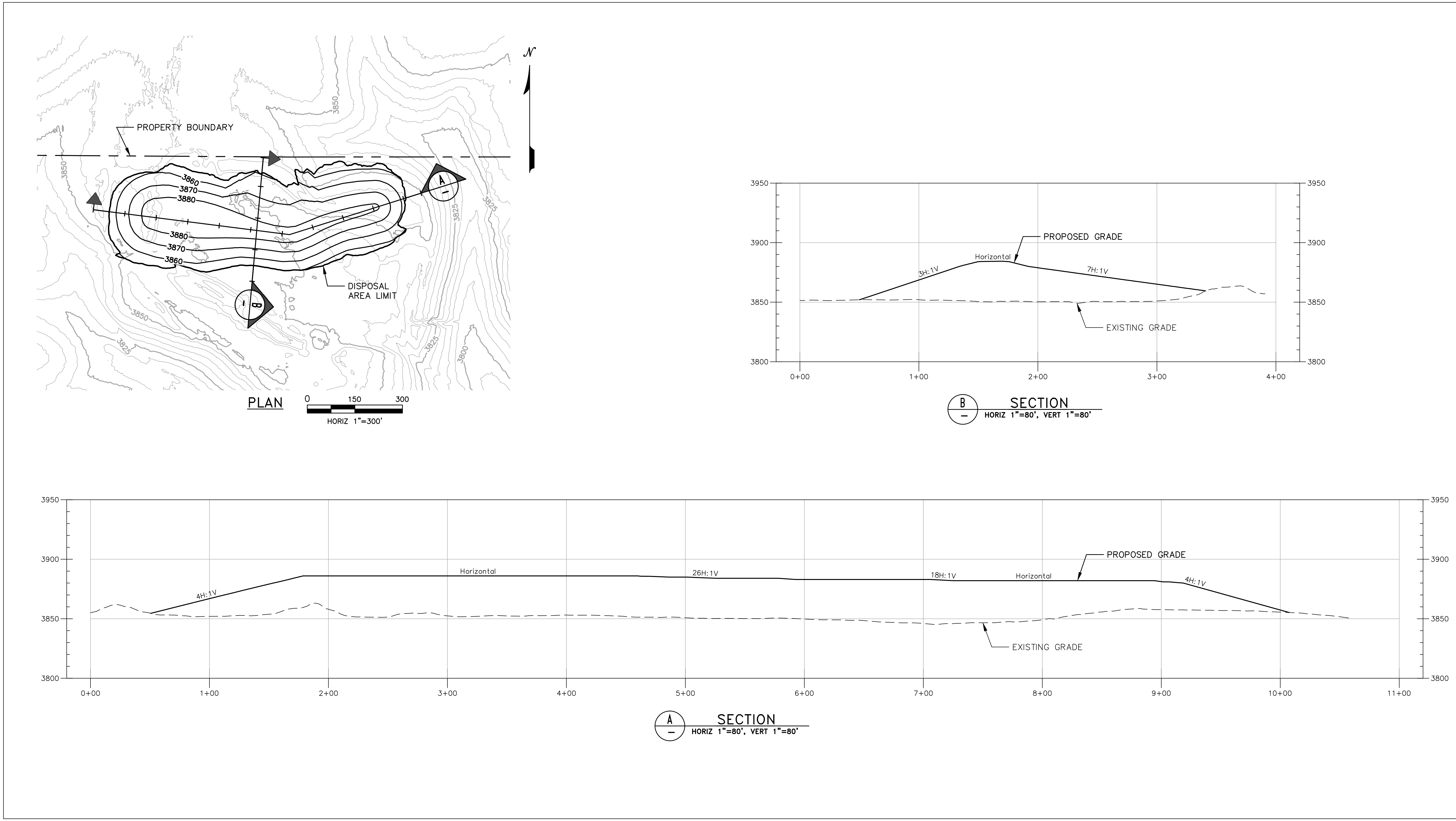
Klamath River Renewal Corporation
*Klamath River Renewal Project*

**FIGURE 5.2-1**

*J.C. Boyle Dam Removal Features and Limits*

*Sheet 9 of 9*




AECOM

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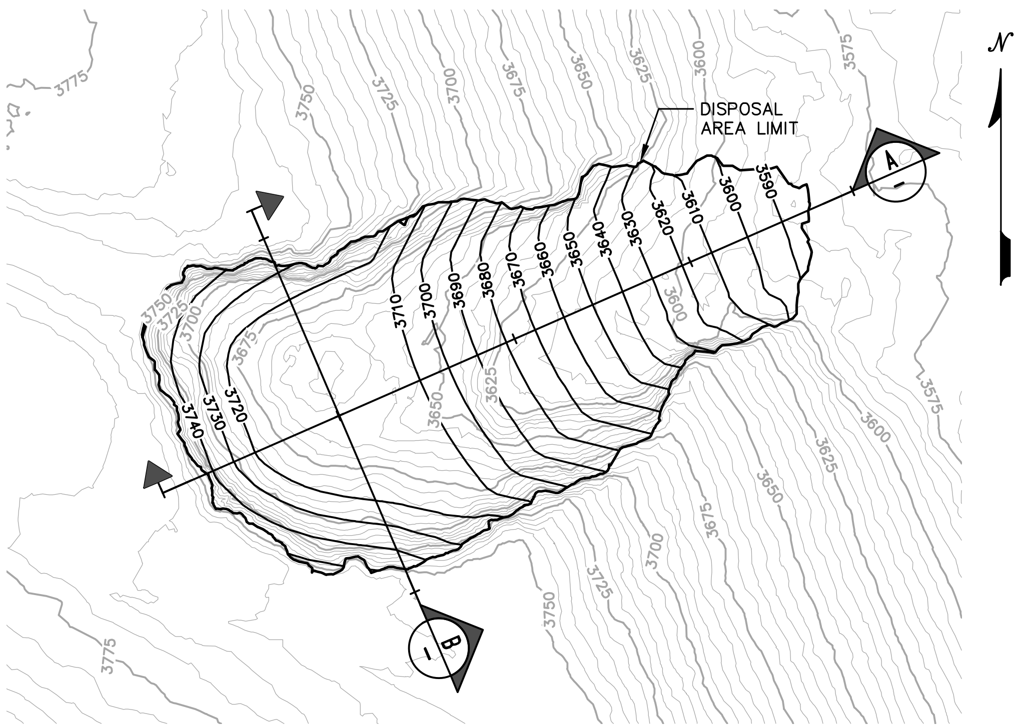
*Klamath River Renewal Project*

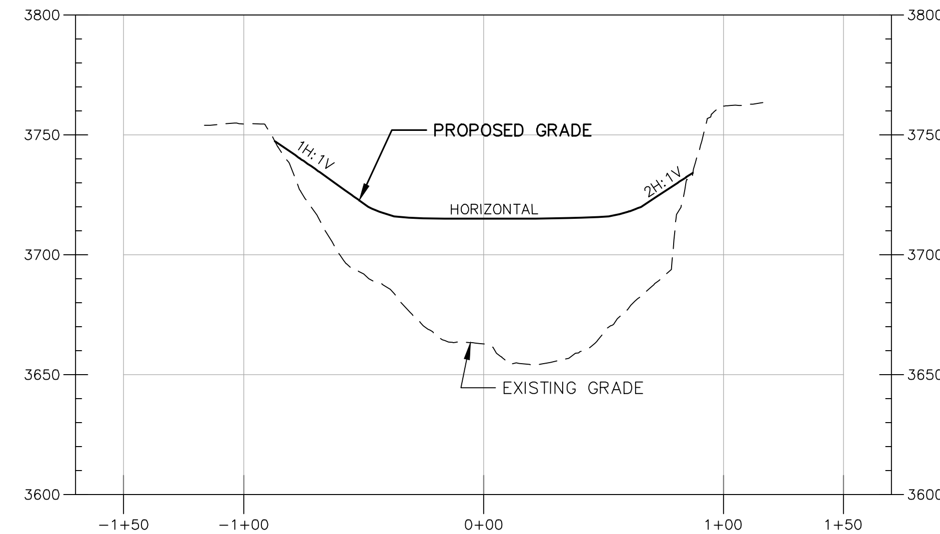
**FIGURE 5.2-8**

*J.C. Boyle Right Abutment Disposal Site Plan & Sections*

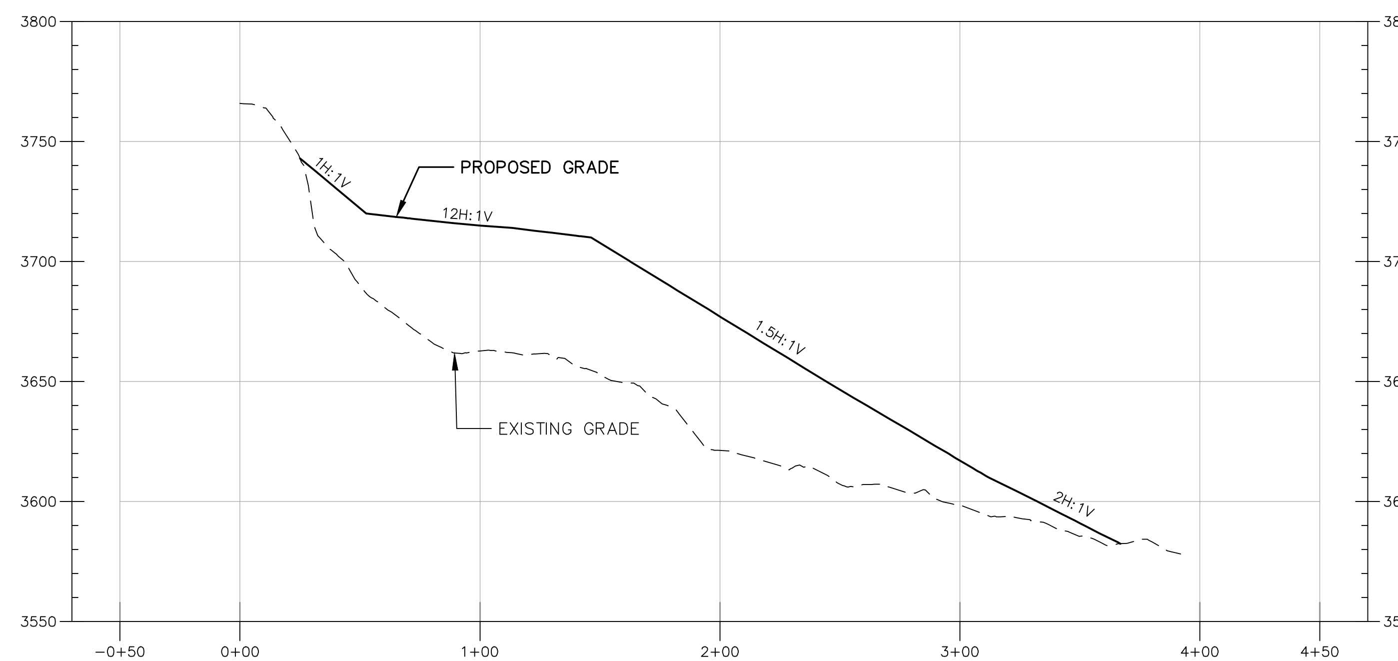



PLAN

0 50 100
HORIZ 1"=100'




B SECTION
HORIZ 1"=80', VERT 1"=80'

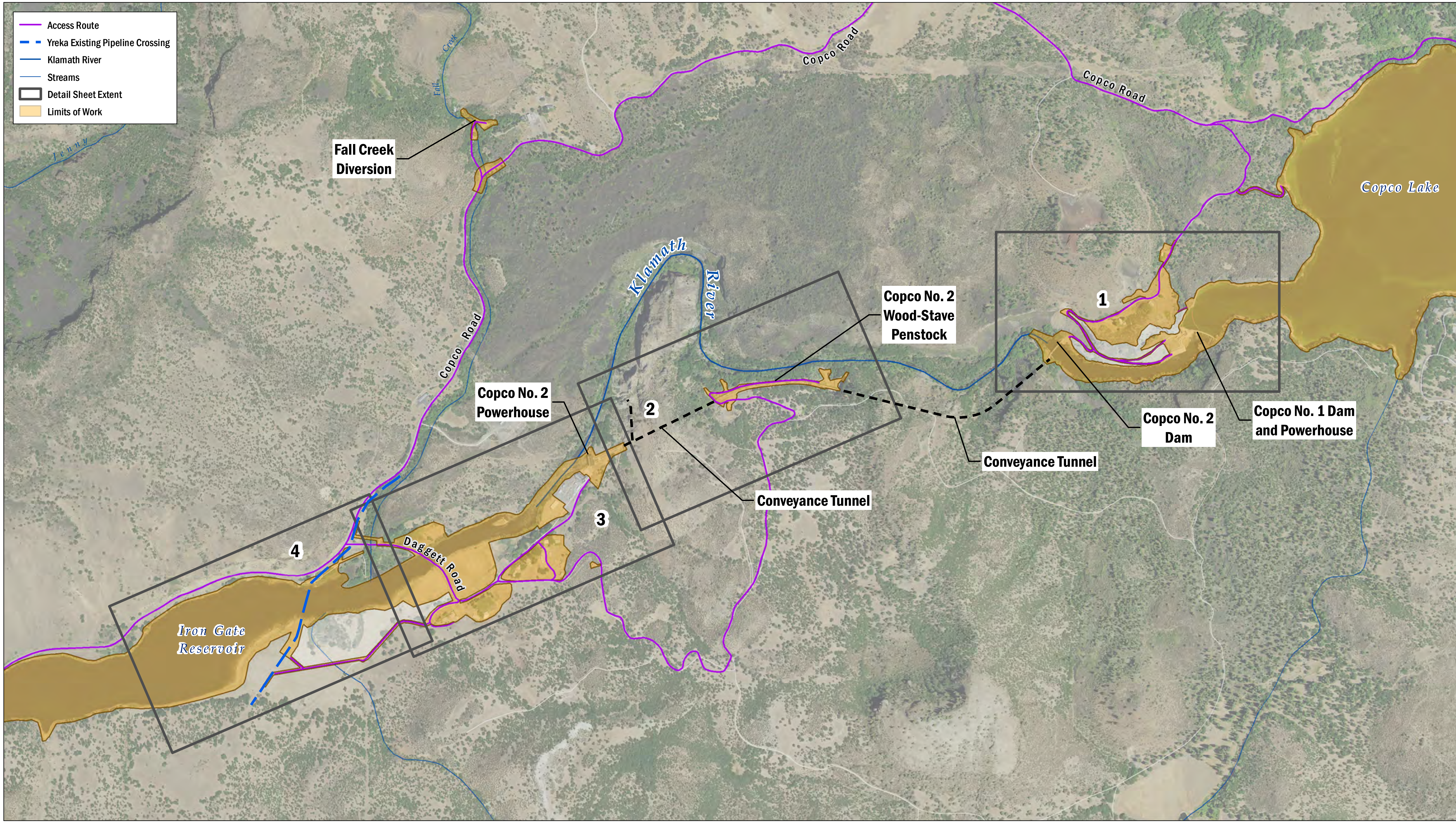



A SECTION
HORIZ 1"=80', VERT 1"=80'



**FIGURE 5.2-9**
*J.C. Boyle Forebay Spillway Scour Hole Backfill Plan & Sections*

AECOM Oakland CA 9/29/2017 USER latha.chandrasekaran PATH L:\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_3-1_Copco_RemovalFeatureAndLimits_Overview.mxd

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DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

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Klamath River Renewal Corporation
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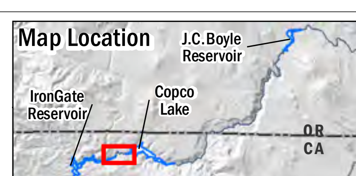
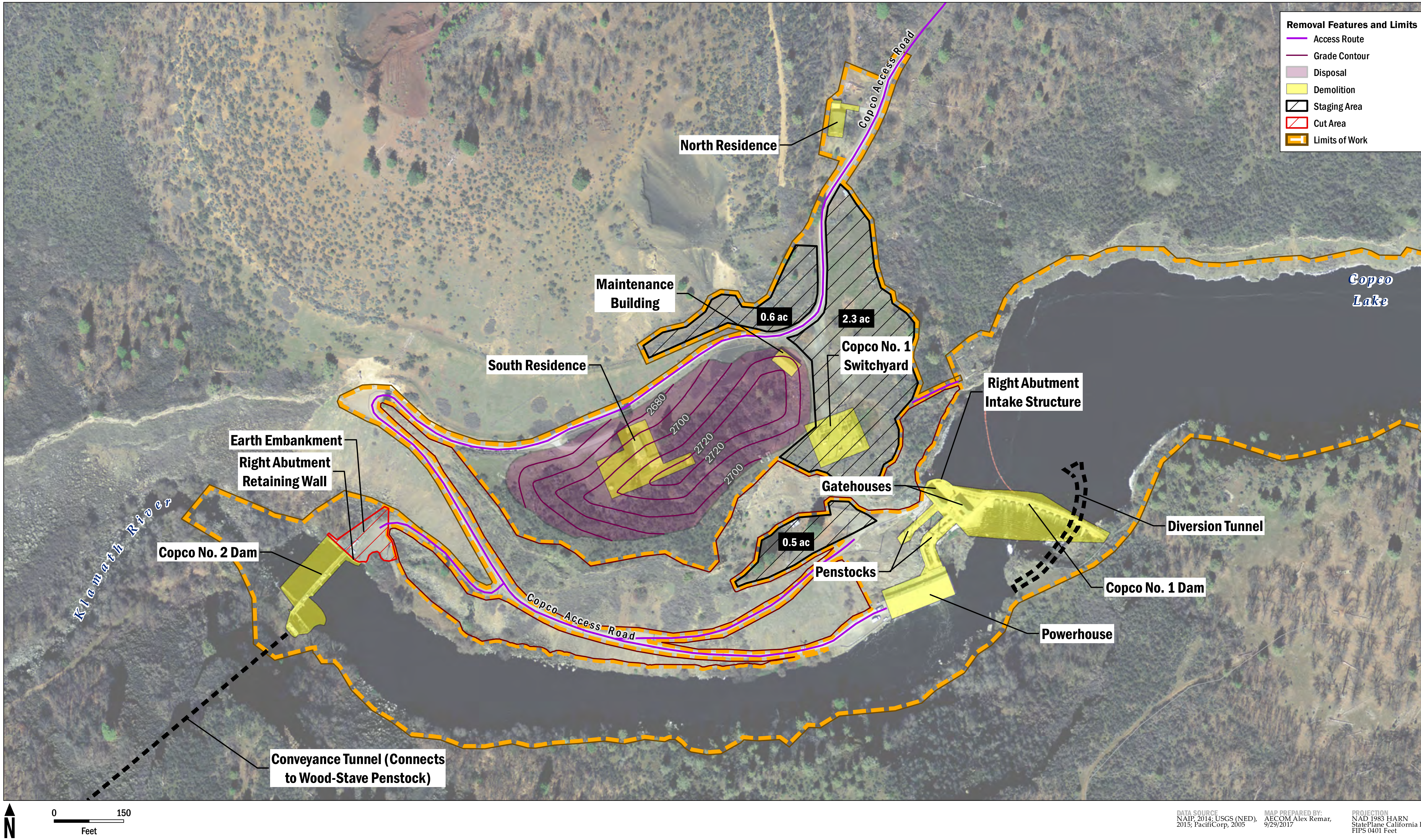



**FIGURE 5.3-1**

*Copco No. 1 and Copco No. 2 Dams Removal Features and Limits Overview Sheet*

AECOM Oakland CA 9/29/2017 USER latha.chandrasekaran PATH L:\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_5_3-1_Copco_RemovalFeatureAndLimits_Sheet1.mxd




DATA SOURCE
NAIP, 2014; USGS (NED), 2015; PacifiCorp, 2005

MAP PREPARED BY:
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PROJECTION
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Klamath River Renewal Corporation
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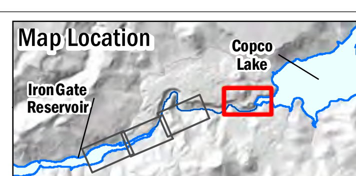


# FIGURE 5.3-1

*Copco No. 1 and Copco No. 2 Dams Removal Features and Limits*
*Sheet 1 of 4*

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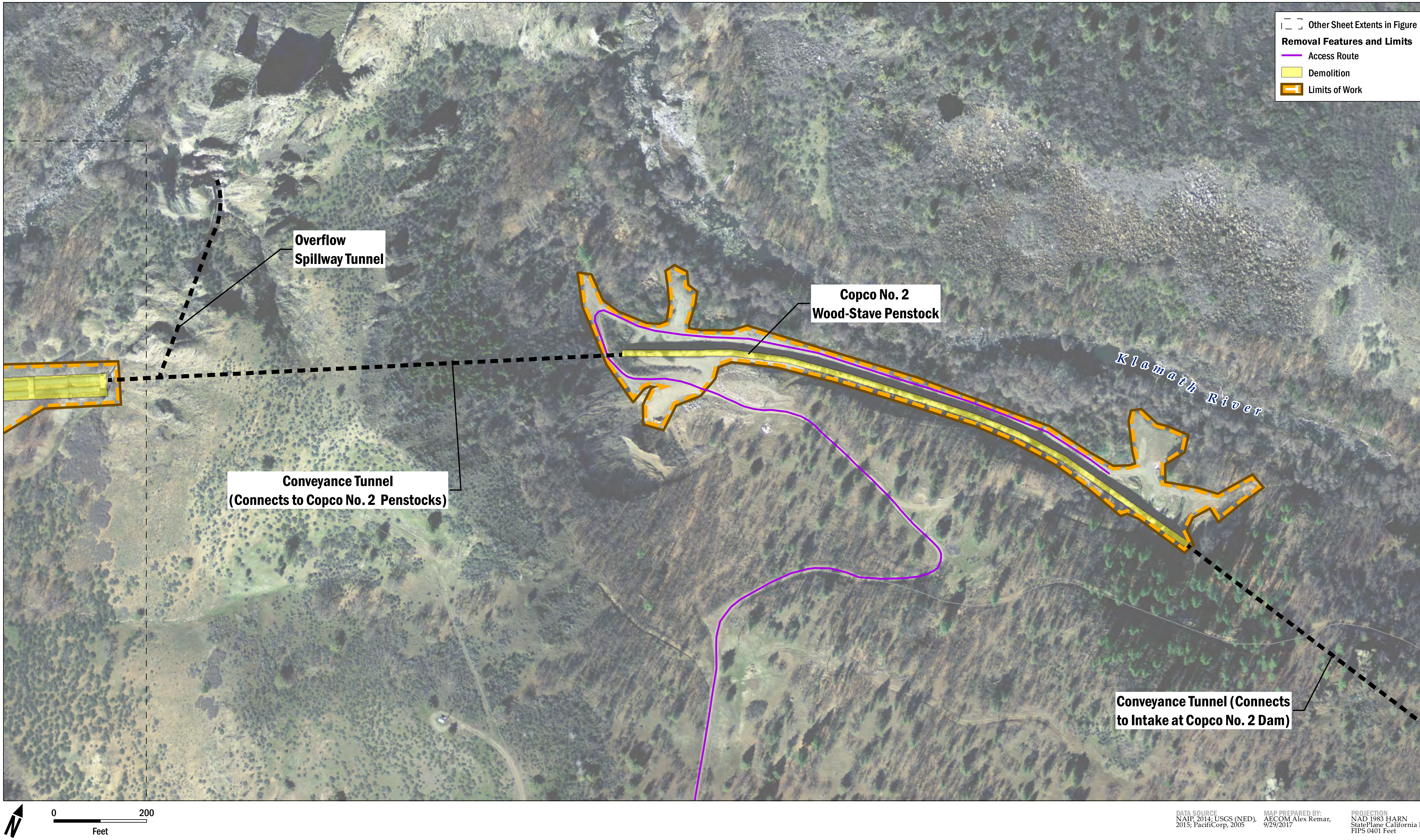


DATA SOURCE
NAIP, 2014; USGS (NED), 2015; PacifiCorp, 2005

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

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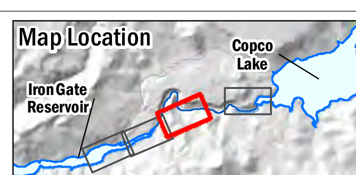
Klamath River Renewal Corporation
*Klamath River Renewal Project*




# FIGURE 5.3-1

*Copco No. 1 and Copco No. 2 Dams Removal Features and Limits*
*Sheet 2 of 4*

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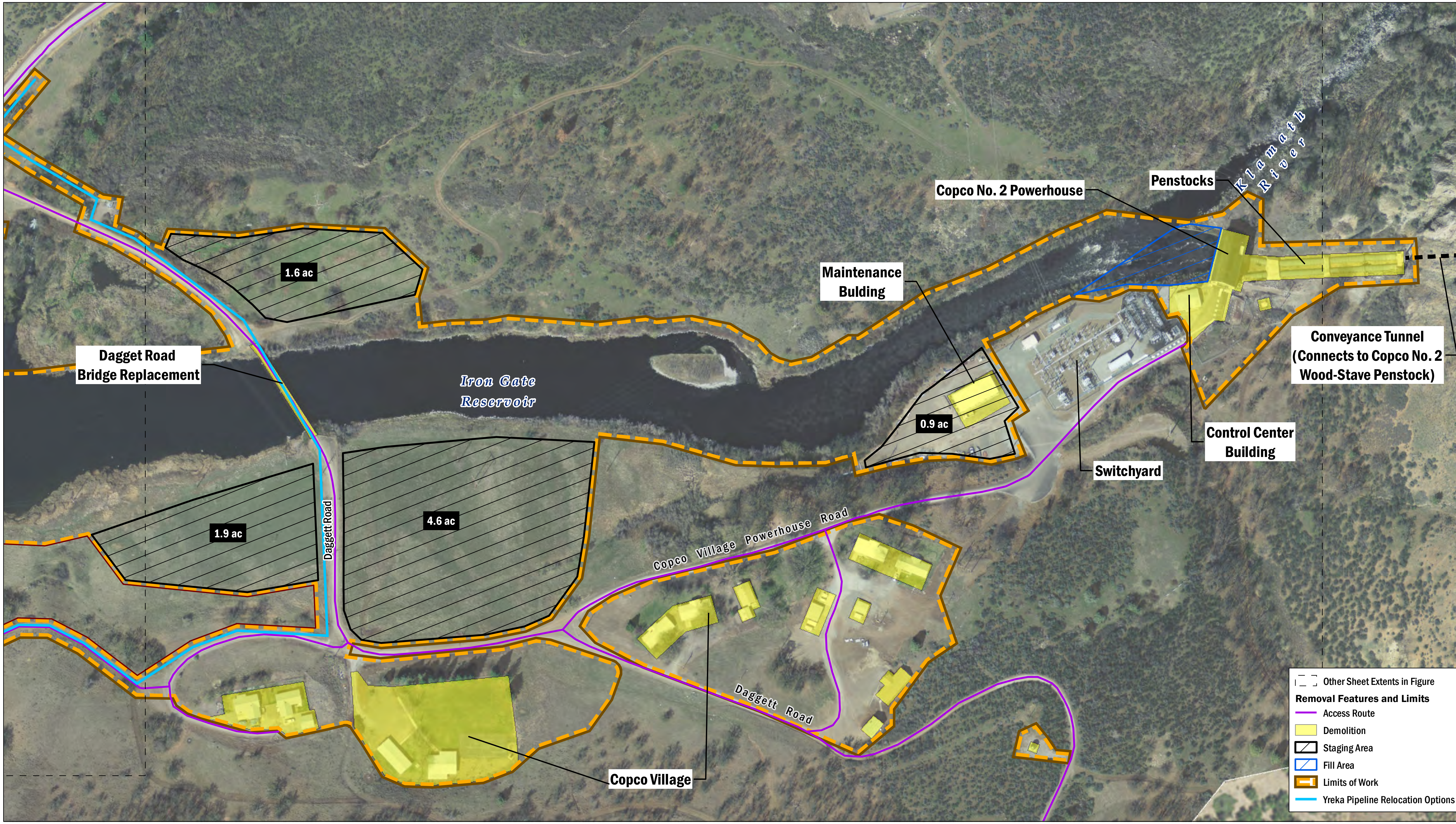


DATA SOURCE
NAIP, 2014; USGS (NED), 2015; PacifiCorp, 2005

MAP PREPARED BY:
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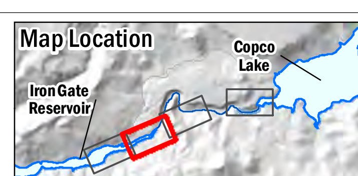


# FIGURE 5.3-1

*Copco No. 1 and Copco No. 2 Dams Removal Features and Limits*
*Sheet 3 of 4*

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DATA SOURCE
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PROJECTION
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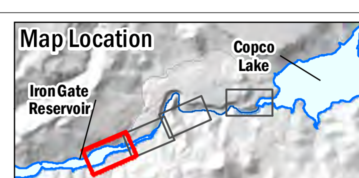
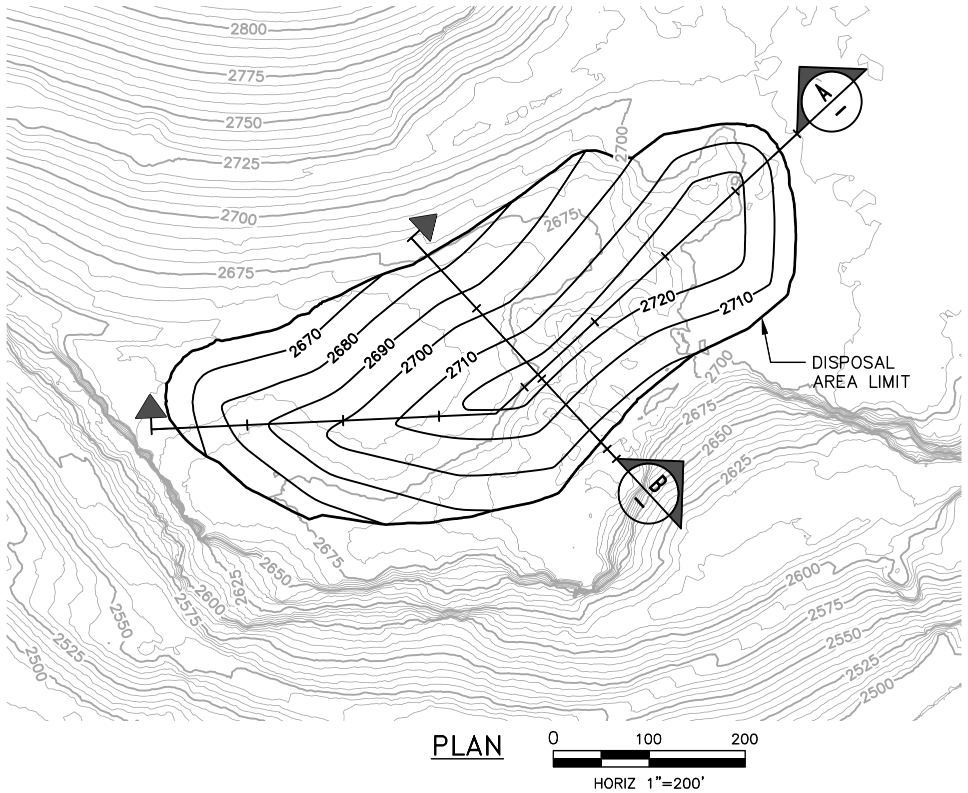
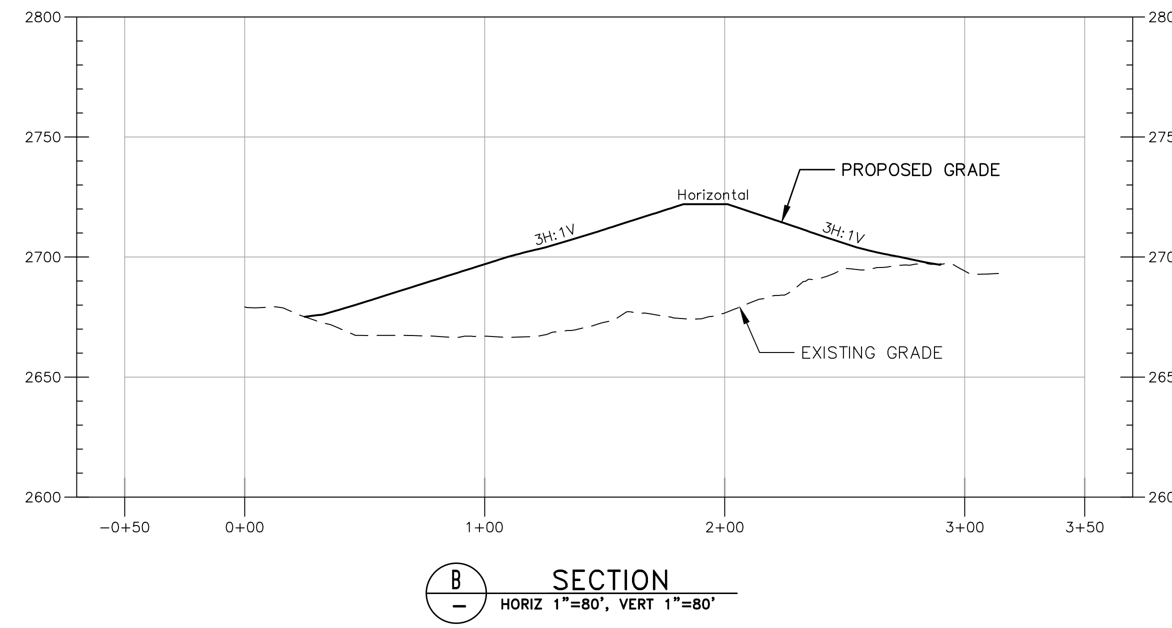



# FIGURE 5.3-1

*Copco No. 1 and Copco No. 2 Dams Removal Features and Limits*
*Sheet 4 of 4*



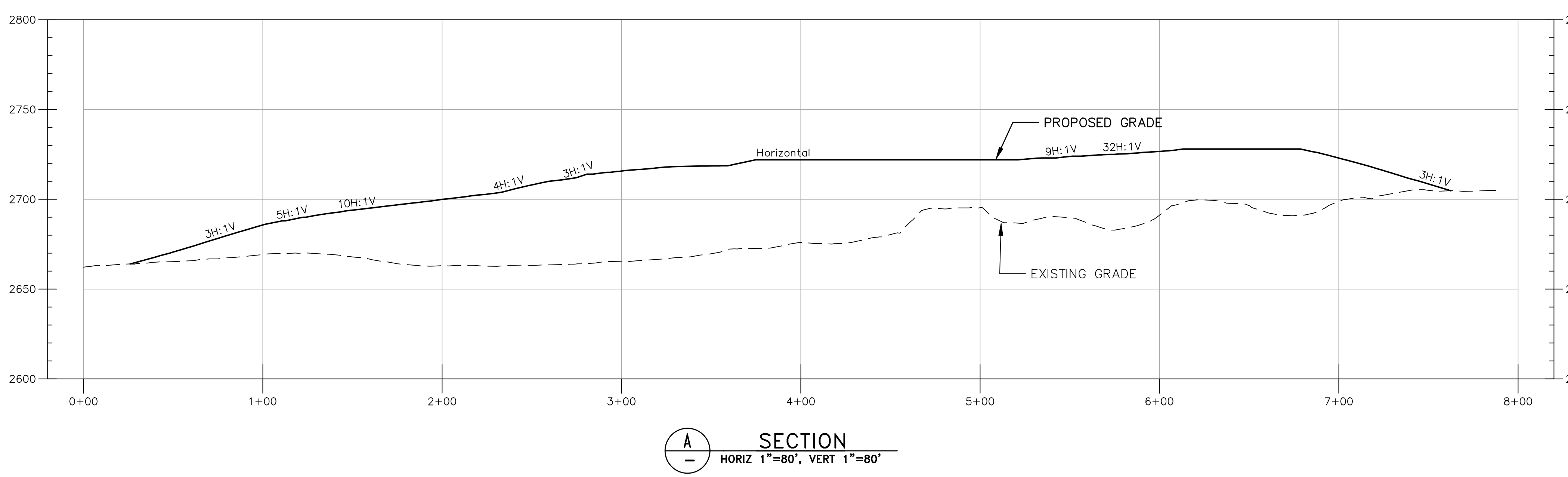






**FIGURE 5.3-8**

*Copco No. 1 & Copco No. 2 Disposal Site Plan & Sections*

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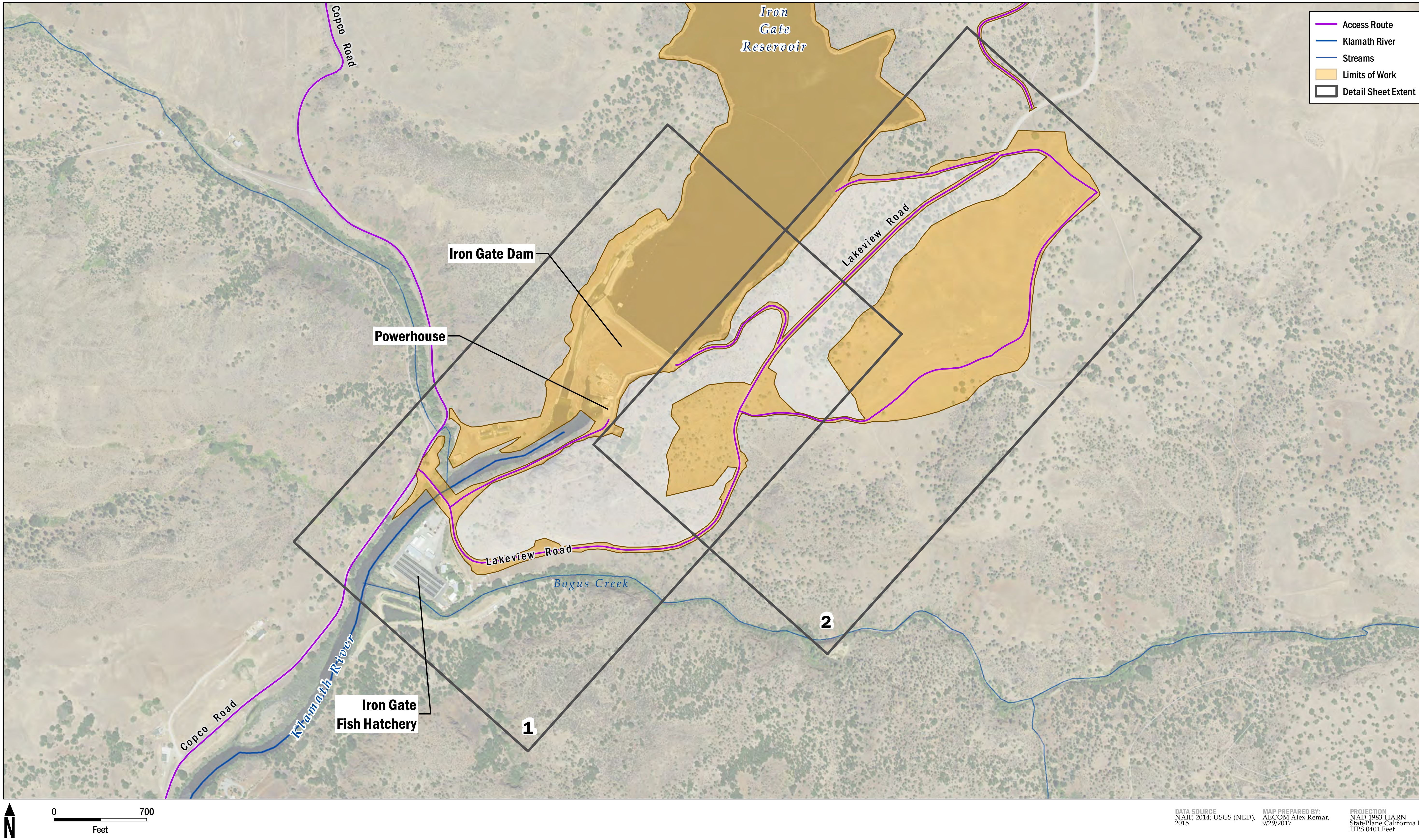


DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
NAD 1983 HARN StatePlane California I FIPS 0401 Feet

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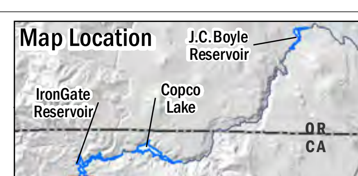


# FIGURE 5.5-1

*Iron Gate Dam Removal Features and Limits Overview Sheet*

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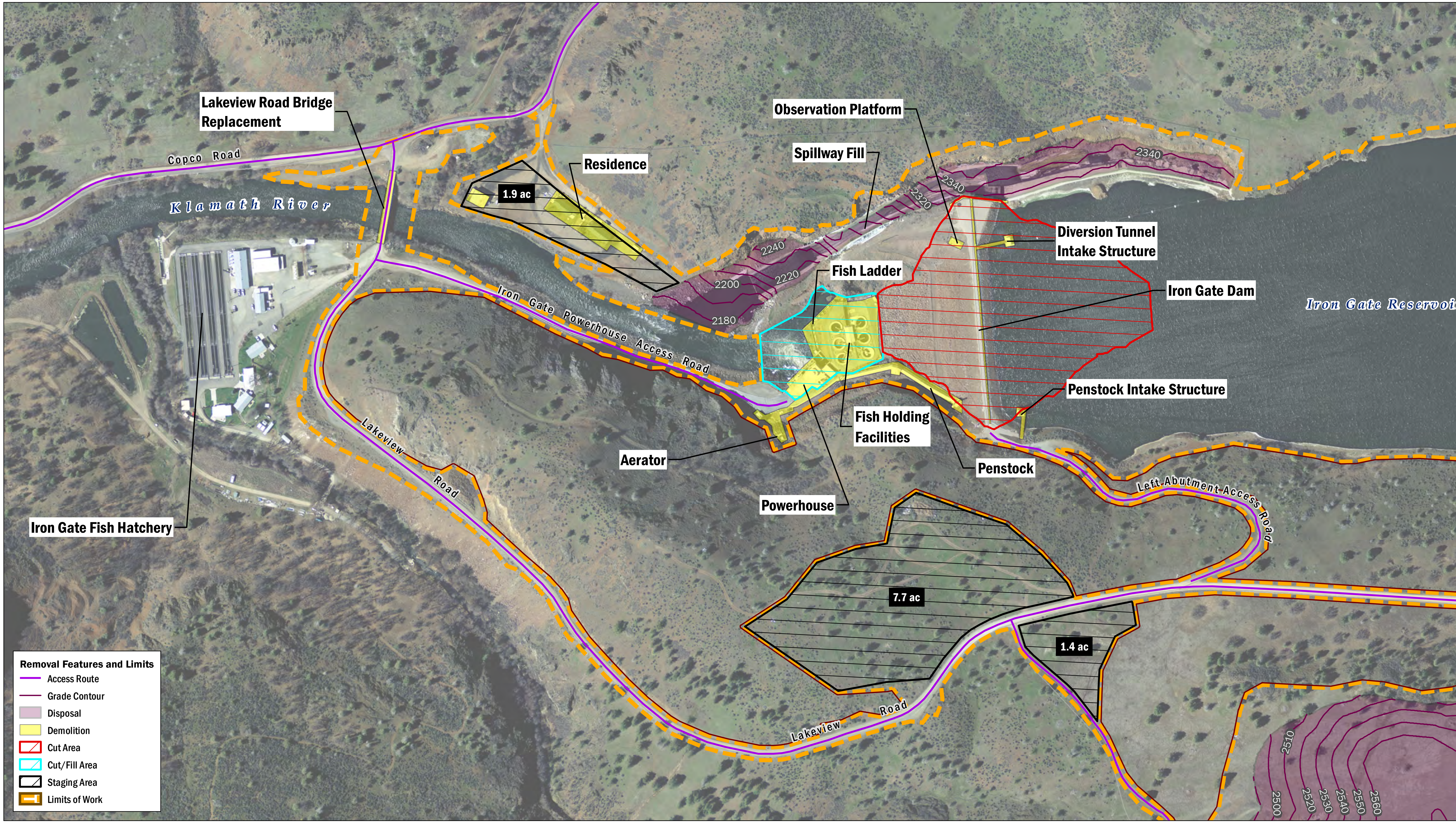


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DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
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PROJECTION
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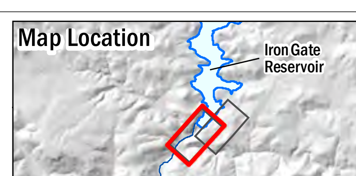


# FIGURE 5.5-1

*Iron Gate Dam Removal Features and Limits*
*Sheet 1 of 2*

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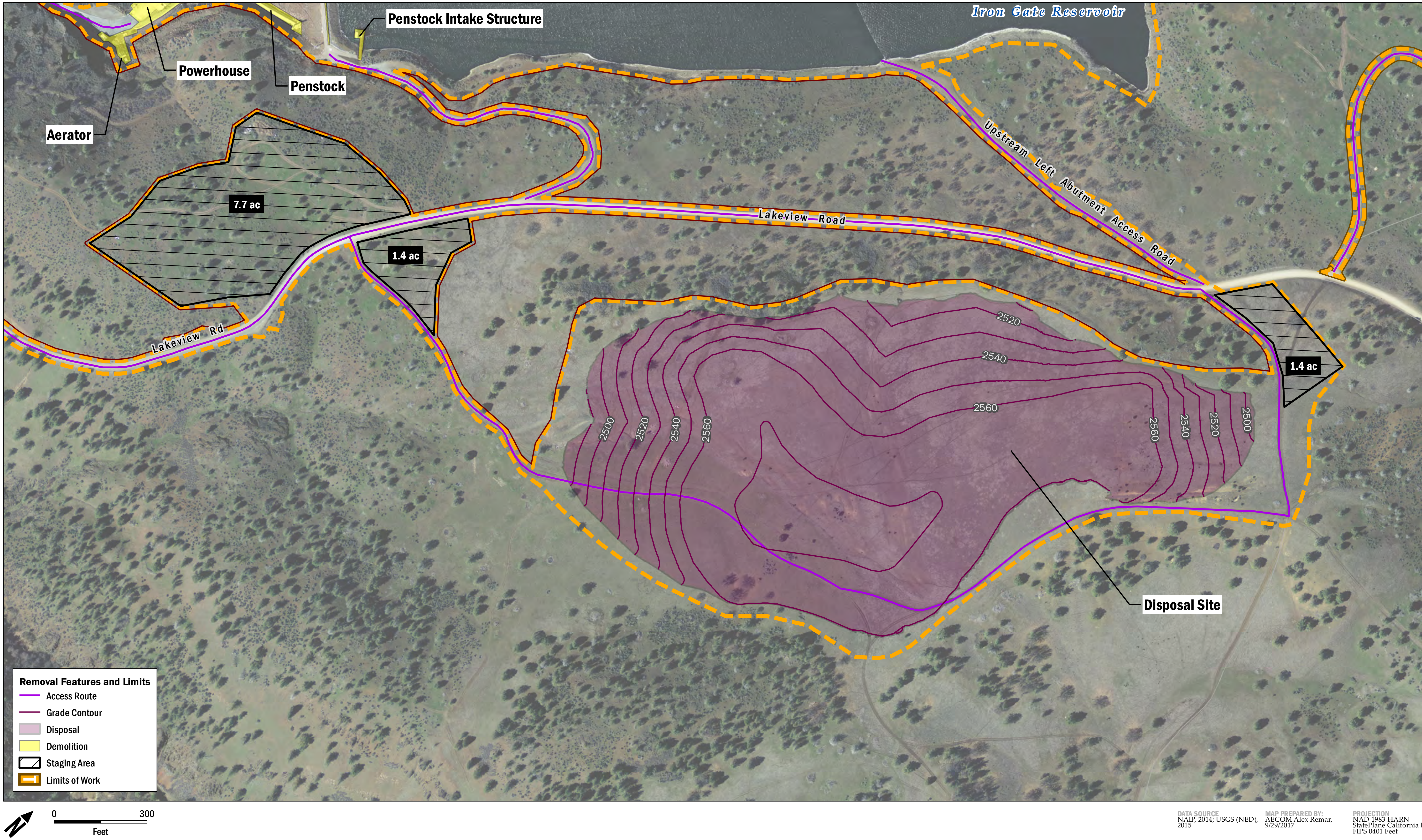


DATA SOURCE
NAIP, 2014; USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/29/2017

PROJECTION
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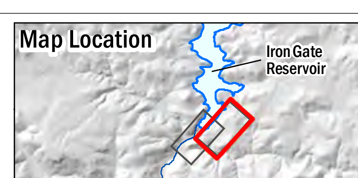


# FIGURE 5.5-1

*Iron Gate Dam Removal Features and Limits*
*Sheet 2 of 2*

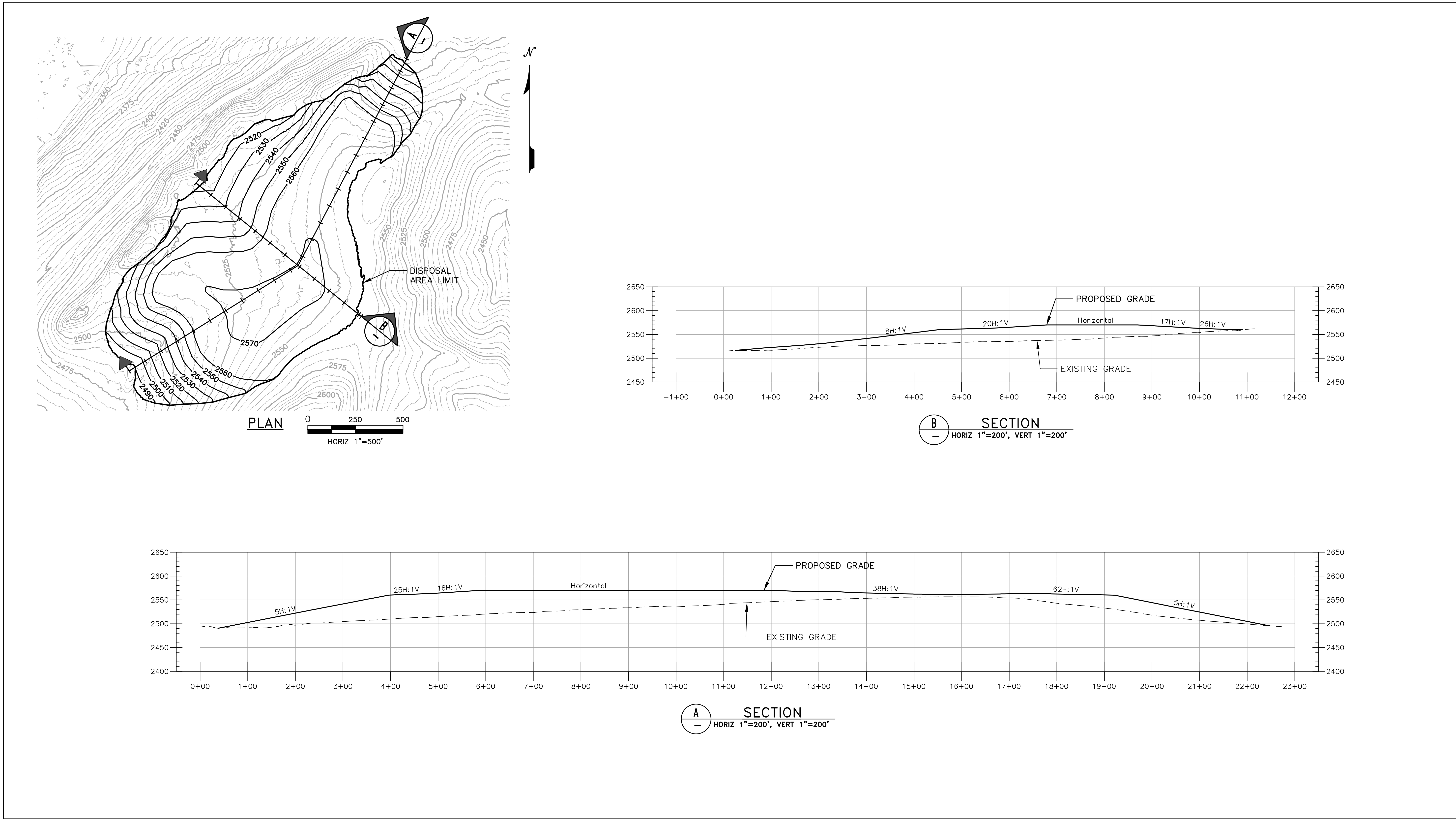


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**FIGURE 5.5-4**
*Iron Gate Disposal Site Plan & Sections*

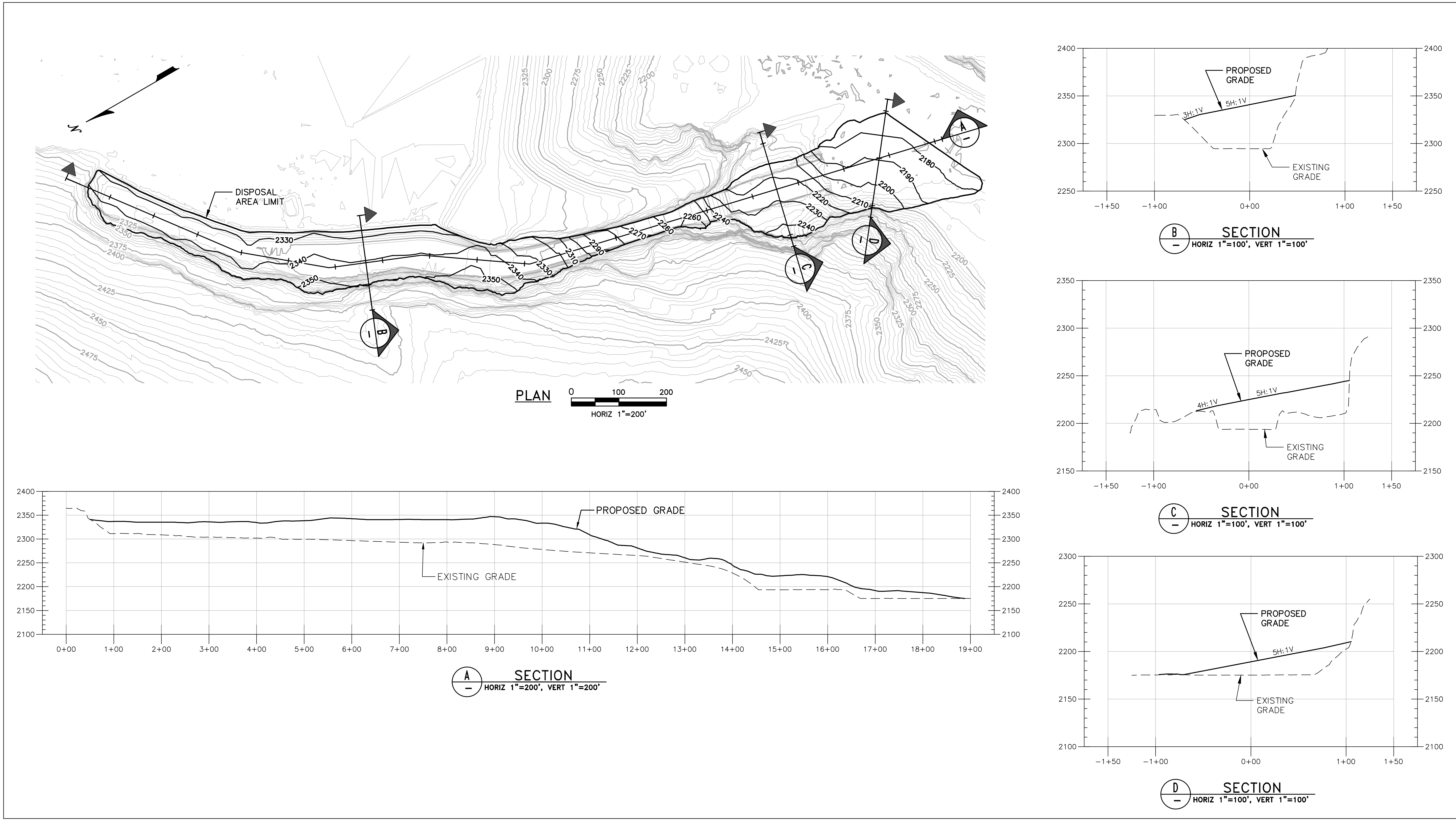




**FIGURE 5.5-5**

*Iron Gate Spillway Backfill Plan & Sections*

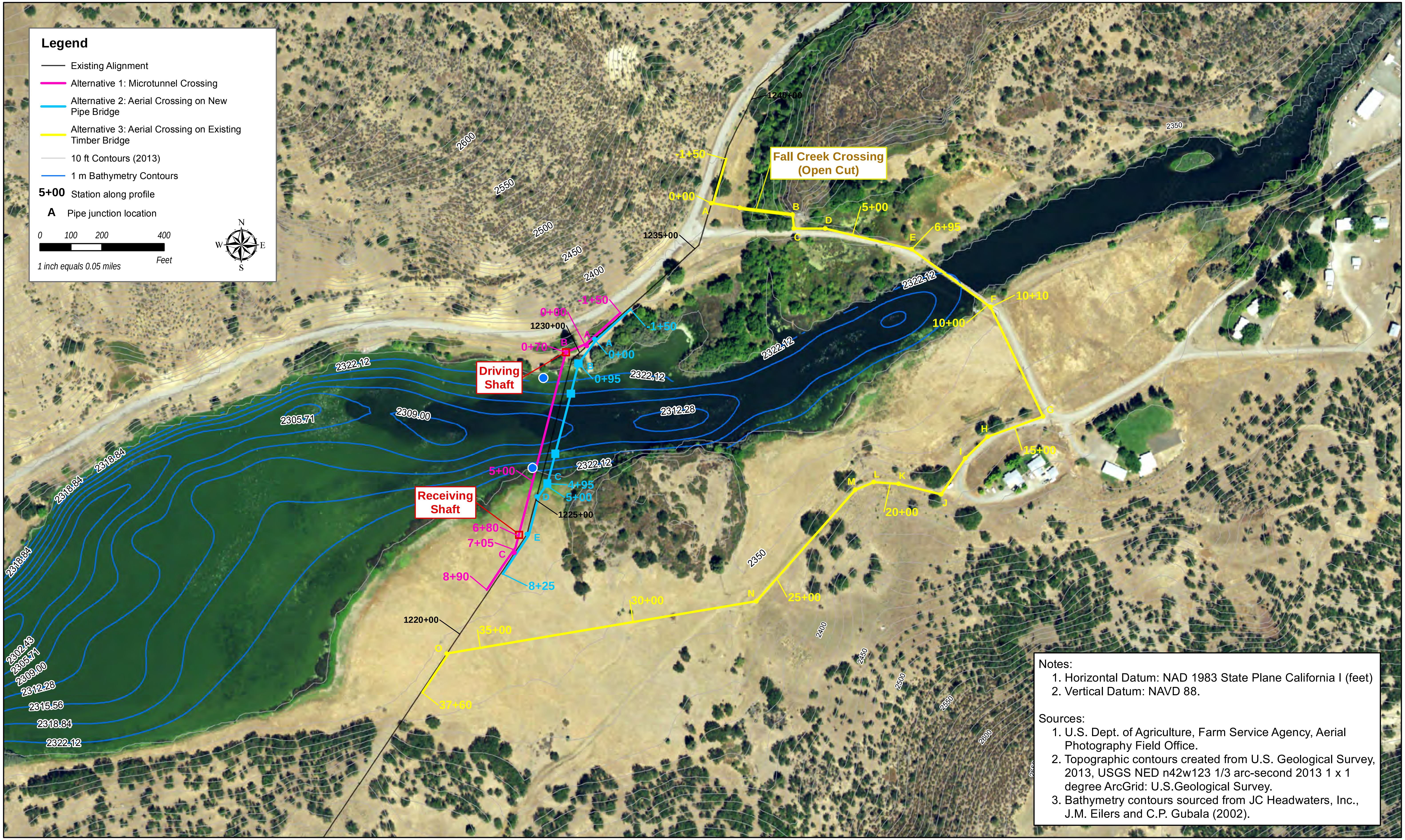


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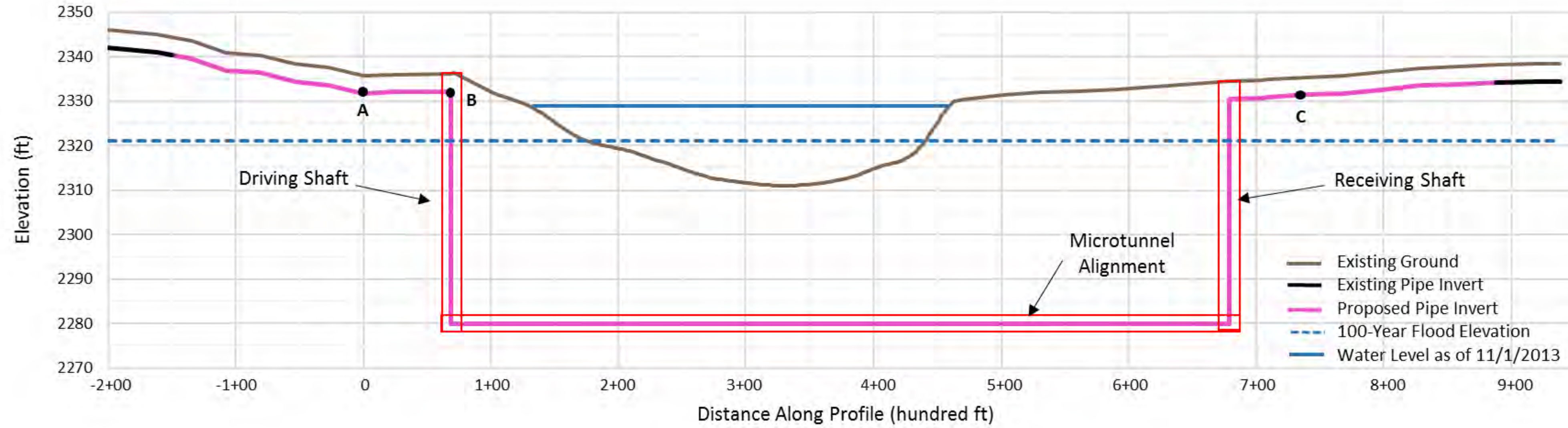
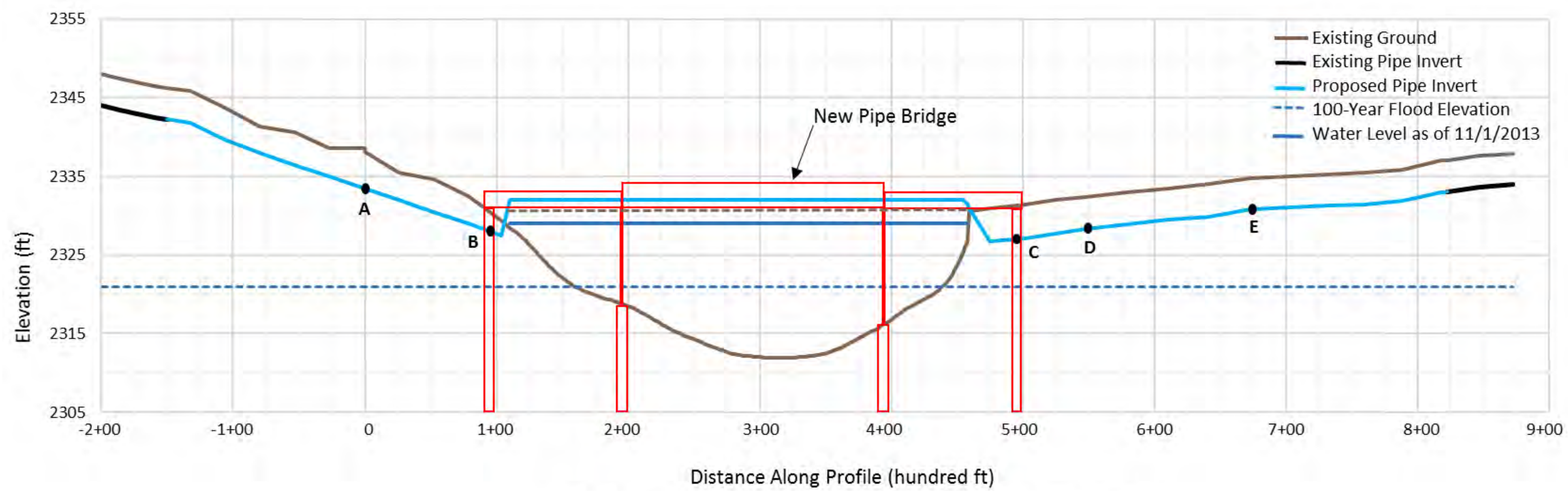
**FIGURE 7.5-2: ALIGNMENTS FOR KLAMATH RIVER CROSSING CONCEPTUAL ALTERNATIVES**

Klamath Dams Removal Project – Yreka Waterline Replacement

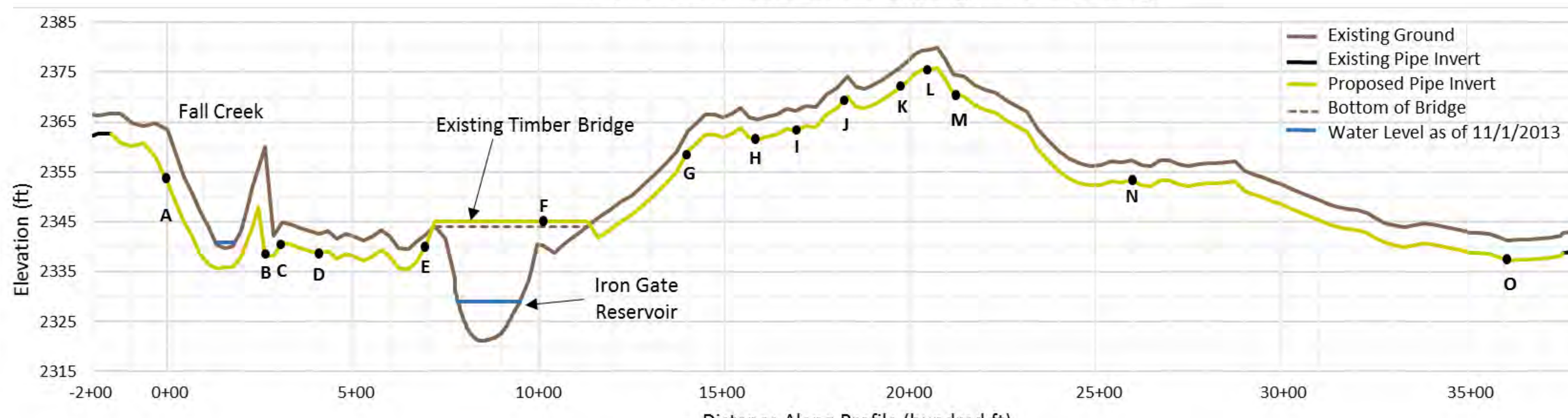
September 14, 2017




Profile for Alternative 1: Microtunnel



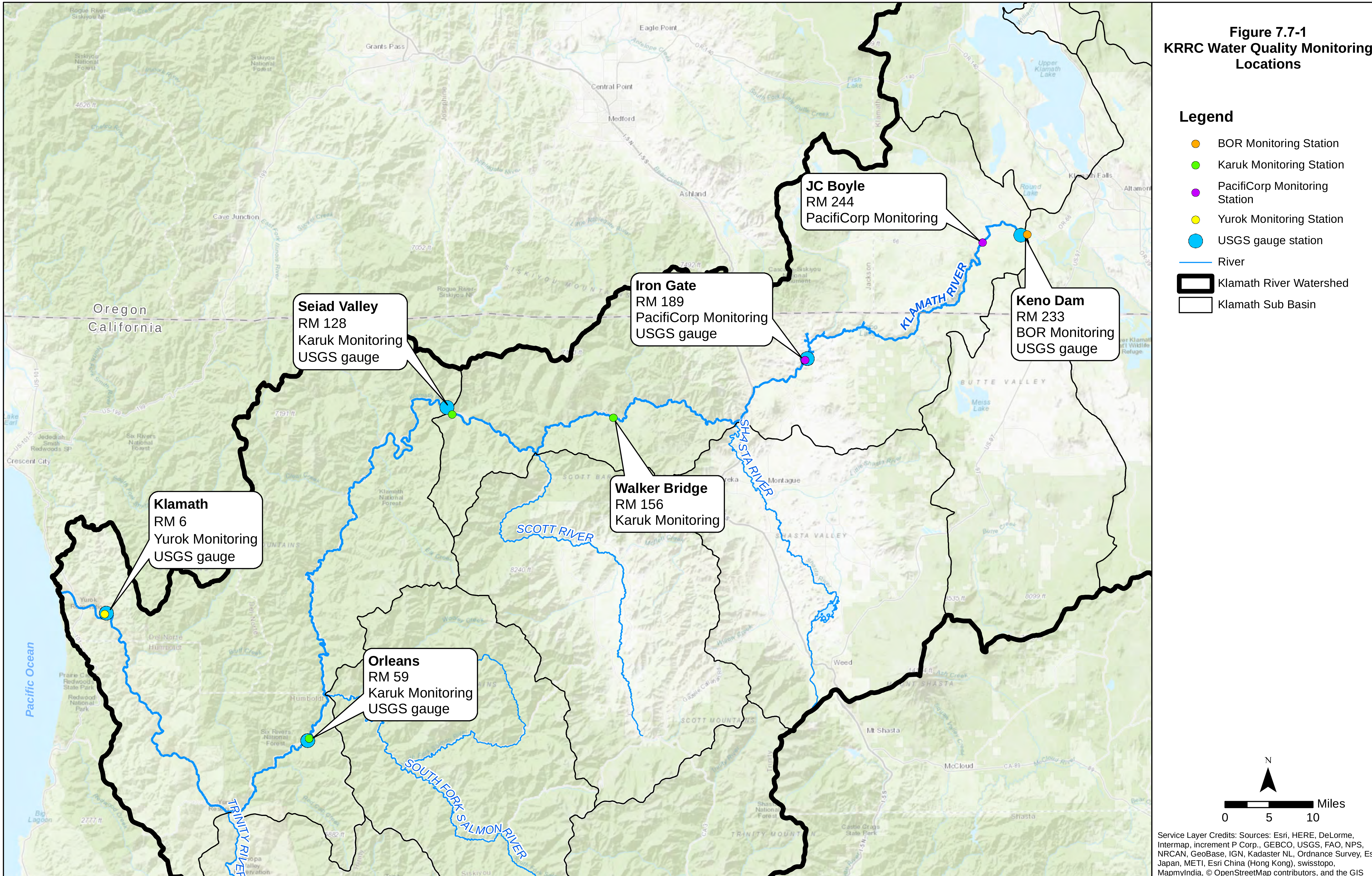

Profile for Alternative 2: Aerial Crossing on New Pipe Bridge




Profile for Alternative 3: Aerial Crossing on Existing Timber Bridge

**FIGURE 7.5-3: PROFILES FOR KLAMATH RIVER CROSSING CONCEPTUAL ALTERNATIVES**
Klamath Dams Removal Project – Yreka Waterline Replacement
September 14, 2017

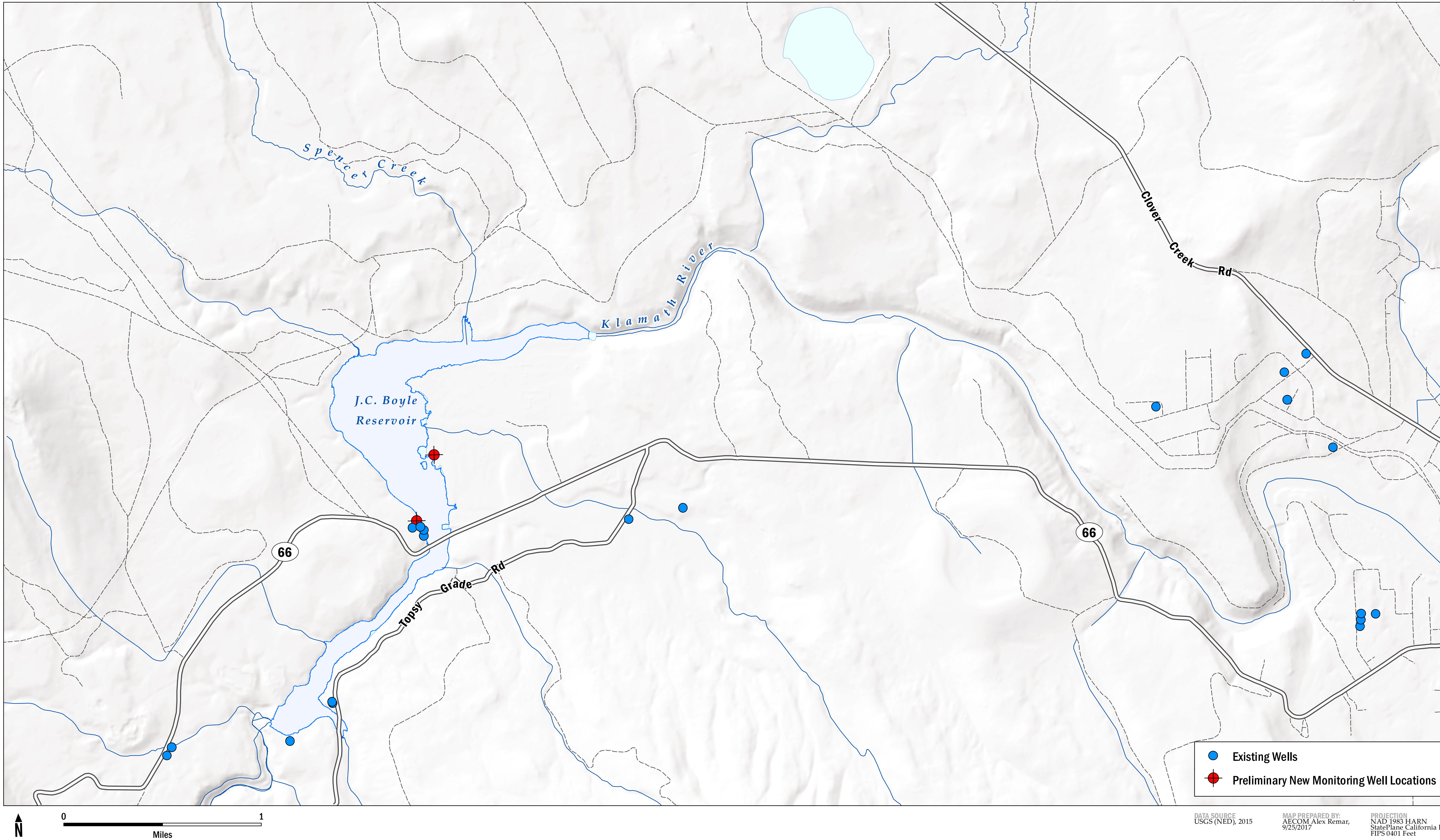
**Figure 7.7-1**
**KRRC Water Quality Monitoring Locations**




Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS

Document Path: J:\109070-KlamathRiver\Klamath River\mxd\Water_Quality_Monitoring.mxd WAGNERA

AECOM Oakland CA 9/25/2017 USER jessica.parteno PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\CEQA_Report\Figure_7_7-2c_JCB_GoundWaterWells.mxd




DATA SOURCE
USGS (NED), 2015

MAP PREPARED BY:
AECOM Alex Remar, 9/25/2017

PROJECTION
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FIPS 0401 Feet

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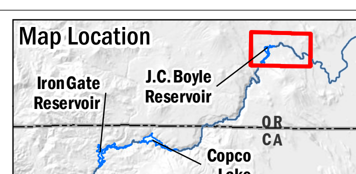
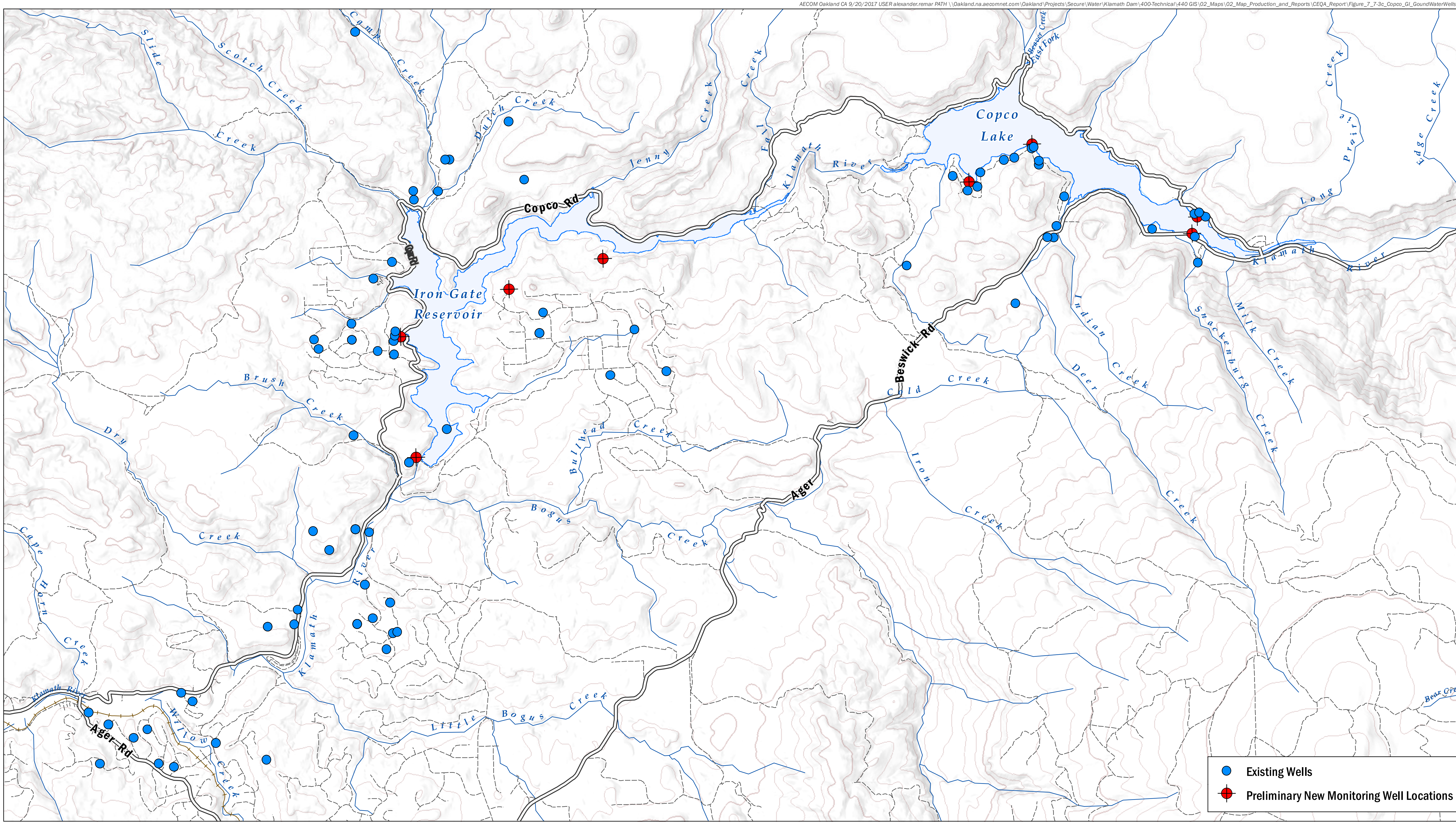



# FIGURE 7.7-2

*Identified Groundwater Wells within 2.5 Miles of J.C. Boyle Reservoir (Appendix C)*

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DATA SOURCE
USGS (NED), 2015

MAP PREPARED BY:
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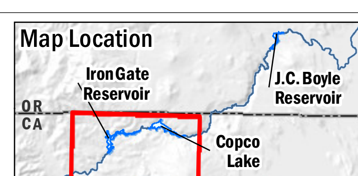



# FIGURE 7.7-3

*Identified Groundwater Wells within 2.5 Miles of Copco Lake and Iron Gate Reservoir (Appendix C)*

# Appendix D Dam Stability Analyses

AECOM
300 Lakeside Drive, Suite 400, Oakland, CA 94612
USA
aecom.com

**Project name:**
Klamath Dam Removal

**Project ref:**
60537920

**From:**
John Roadifer, Kanax Kanagalingam, Benjamin Choy

**Date:**
September 18, 2017

**To: Klamath River Renewal Coporation**

**CC:**

# Memo

**Subject:** Klamath River Dam Removal Project
Analysis of Stability of J.C. Boyle and Iron Gate Dams During Reservoir Drawdown

## INTRODUCTION

AECOM prepared this technical memorandum in support of the design for the removal of the Iron Gate Dam and J.C. Boyle Dam, which are located on the Klamath River in northern California and southern Oregon, respectively. The purpose of this technical memorandum is to review existing geotechnical data related to the Iron Gate and J.C. Boyle embankments, characterize the materials in the embankments, and evaluate the stability of the upstream slopes of the embankments under various conditions of rapid drawdown of the reservoirs prior to dam removal.

Iron Gate Dam is a 189-foot high zoned earthfill embankment, as measured from the crest to the rock foundation. The crest of the dam is at El. 2343[1] feet. The crest of the dam is 20 feet wide, and the dam is approximately 740 feet long. The embankment upstream slopes are 2:1 (H:V) above El. 2328 feet, 2.5:1 from El. 2328 feet to 2300 feet, and 3H:1V below El. 2300 feet. The downstream slopes are 1.75:1 above El. 2323 feet and 2:1 below El. 2323 feet. The dam also features a 29-foot wide bench and a 10-foot wide bench at El. 2275 feet on the upstream side and downstream side, respectively. The dam consists of a central impervious clay core, an upstream and a downstream compacted pervious shell with filter zones and a downstream drain. A 10-foot thick layer of riprap protects the upstream slope of the dam against erosion. A 5-foot thick riprap layer is present on the downstream slope. In 2003, the dam crest was raised 5 feet from El. 2338 feet to 2343 feet by over-steepening the upstream and downstream slopes. To provide additional freeboard, a sheet pile was installed upstream of the dam centerline that extends five (5) feet above the dam crest to an El. of 2348 feet. A cross section of the Iron Gate Dam is shown on Figure 1.

J.C. Boyle Dam consists of two portions: an earthfill embankment on the right side and a concrete spillway and gravity section on the left side. This technical memorandum evaluates the earthfill embankment portion of the dam. The earthfill embankment is a 68-foot high zoned earthfill embankment. The crest of the dam is at El. 3800 feet. The crest of the embankment is 15 feet wide and approximately 413 feet long. The upstream slopes are 2.5:1 (H:V) above El. 3780 feet and 3H:1V below El. 3780 feet. The downstream slopes are 2.5:1. The downstream slope also includes a 16-foot wide bench at El. 3768 feet. The internal zoning of the dam consists of a central impervious clay core, an upstream and a downstream compacted pervious shell consisting of sand and gravels. A filter blanket underlies the downstream shell. Erosion protection of the upstream slope is provided by a 3-foot thick riprap layer above El. 3680 feet. A 2-foot thick riprap layer below El. 3768 feet protects the downstream slope against erosion due to elevated tailwater. A cross section of the J.C. Boyle Dam is shown on Figure 2.

[1] All elevations in this memorandum are in the original datum unless otherwise indicated.

**EXISITNG DATA REVIEW**

A review of existing available pertinent information for Iron Gate Dam and J.C. Boyle Dam were performed as part of this study to judge whether additional geotechnical investigation would have to be conducted for evaluating the dams for the rapid drawdown conditions. The reviewed information included design drawings, laboratory testing data for the borrow source materials, construction history, specifications, previous stability analyses, and post construction subsurface investigation. The results from the review indicate the followings:

- Representative analysis cross sections can be developed at the maximum section using the design drawings for both the Iron Gate Dam and the J.C. Boyle Dam.
- A reasonable material characterization of embankment materials, in particular the core and shell materials, can be developed using the information in the construction history, drawings, and specifications for the two dams. The source of materials, loose lift thickness and compaction efforts were discussed in those documents (California Oregon Power Company, 1960a and Unknown Publisher, Unknown Date). The results from a post-construction subsurface investigation conducted for J.C. Boyle Dam in 1994 (Black and Veatch, 1998) provide additional information for shell material characterization.
- Material properties necessary for performing slope stability and seepage analyses can be reasonably developed using the reviewed information. The reviewed information included laboratory shear strength and permeability tests conducted on the borrow source materials (California Oregon Power Company, 1960b and Unknown Date) and previous rapid drawdown analyses performed by others (Bechtel, 1968, Department of Water Resources, 1986, Black and Veatch, 1998, and PanGEO, 1998) .

The existing information for both dams are deemed sufficient to perform rapid drawdown analyses with targeted sensitivity analysis to address uncertainties associated with material properties as discussed later in this memorandum.

**MATERIAL CHARACTERIZATION**

***Iron Gate Dam***

Iron Gate Dam, which was built in 1961, is a zoned earth and rock fill dam. The dam consists of six (6) main zones (see Figure 1): an upstream pervious shell (Zone I), a downstream pervious shell (Zone II), a central impervious core (Zone III), a transition (Zone IA) upstream of the core, a downstream chimney two-stage filter (Zone IV and Zone IVA) and drain (Zone V), and a downstream blanket filter (Zone IV) and drain (Zone V). The analysis section for rapid drawdown stability is the maximum cross section as shown on Figure 3.

The shell materials mainly consist of locally borrowed, pervious talus rock and gravel placed in 3-foot loose lifts, moisture conditioned, and compacted with four (4) passes of 72-inch vibratory roller (PanGEO, 2006). The weight of the roller was not indicated in the documents reviewed. The impervious core mainly consists of high plasticity clay from a local borrow source. The core material was placed in 8-inch loose lifts and compacted to not less than 95% of the maximum dry density as determined by ASTM D698 (California Oregon Power Company , 1960a and PanGEO, 2006). The upstream transition zone consists of graded talus rock and is approximately 20 feet in thickness. The downstream chimney and blanket filters consist of fine sand to gravel and were constructed in three (3) vertical layers (California Oregon Power Company, 1960a). Based on the design drawings, the thicknesses of the chimney and blanket filters are 20 feet and 5 feet, respectively. The downstream chimney and blanket drains consist of selected talus, gravel, or other excavations that is essentially free of materials smaller than the #100 sieve (California Oregon Power Company, 1960a). The dam was founded on basalt that is generally hard, blocky, heavily jointed, and moderately weathered (DSOD, 1986).

***Iron Gate Dam Material Properties***

The shear strength parameters of shell and core are very important for the rapid drawdown analysis. Shear strength parameters for the core material were developed mainly based on results from isotropic consolidated undrained triaxial tests (TX-ICU) conducted on samples obtained from borrow sources during borrow source evaluation (California Oregon Power Company, 1960b). The results of the triaxial tests are included in Appendix A. However, no laboratory shear strength tests are available for the shell and other embankment materials. Therefore, shear strength parameters for these materials were selected based on available information such as the type of construction, parameters used in previous analyses, and published data (NAVFAC, 1986 and EPRI, 1990). As mentioned above, the shell materials consist of talus rock and gravel, which were compacted during placement. Based on the published data, the effective friction angle for compacted gravelly materials would be greater than 37 degrees. For this rapid drawdown analysis, the shell materials were conservatively assigned an effective friction angle of 35 degrees. In addition, transition zone, chimney filter and drain, and blanket filter and drain were compacted during placement. Therefore, these materials were also assigned an effective friction angle of 35 degrees. The bedrock is modeled as impenetrable in the slope stability model. Table 1 summarizes these engineering parameters (best estimate parameters) used in the slope stability analyses.

The unit weights for different embankment zones were selected based on the laboratory tests conducted on the samples collected from proposed borrow areas, compaction test results on samples collected during dam construction, previous analyses (DWR, 1986 and PanGEO, 2006), and published data (NAVFAC, 1986 and EPRI, 1990).

The permeability values for the core and shell materials were selected based on the results from the falling head permeability tests performed on samples from the core and shell material borrow sources during borrow source evaluation. The results of the falling head permeability tests are included in Appendix B. Permeability values of the filter, chimney drain, the blanket drain, the riprap, and the random fill were estimated based on the characteristics of the materials, published data, and engineering judgment. The permeability parameters were selected conservatively based on typical ranges (Holtz and Kovacs, 1981), which is included in Appendix C. Table 1 summarizes permeability parameters used in the seepage analysis.

Anistropic ratios ($k_h/k_v$) typically range from 1 to 4 for uniform soil deposits without significant interbedding or stratification but can be higher for soil deposits with significant stratification. An anisotropic ratio of 10 for the core is selected considering the nature of the materials and its placement method. For the shell and random fill, an anisotropic ratio of 2 was selected as typical anisotropic ratios for similar materials range from 1 to 2. Anisotropic ratio for the filter/drain and riprap is selected to be 1 as the materials are expected to drain freely in both directions.

Table 1. Material Properties Used for the Analyses of Iron Gate Dam

| Material | Unit Weight (pcf) | Effective Stress | | Total Stress | | Horizontal Permeability, $k_h$ (cm/s)[1,3] | $k_h/k_v$ |
|---|---|---|---|---|---|---|---|
| | | Cohesion, c' (psf) | Friction Angle, ϕ' (°)[1,2] | Cohesion, c (psf) | Friction Angle, ϕ (°) | | |
| Core | 130 | 0 | 22 | 300 | 16 | 1.00E-07 | 10 |
| Shell | 135 | 0 | 35 | - | - | 8.00E-03 | 2 |
| Filter/ Drain/ Transition Zones | 135 | 0 | 35 | - | - | 1.00E-02 | 1 |
| Riprap | 135 | 0 | 35 | - | - | 1.00E-02 | 1 |
| Random Fill | 135 | 0 | 25 | - | - | 8.00E-03 | 2 |

Note:
1. The parameter that was used for sensitivity analyses is provided in parenthesis.
2. For compacted sand and gravel materials, the friction angles are typically greater than 34 degrees (NAVFAC, 1986 and EPRI, 1990).
3. For clean coarse materials, permeability ranges from $10^{-3}$ cm/s to 1 cm/s per Holtz and Kovacs (1981).

***J.C. Boyle Dam***

The earthfill embankment of the J.C. Boyle Dam is a zoned earth fill dam built in 1958. The dam consists of two (2) major zones: a central impervious clay core (Zone 1) and the upstream and downstream pervious shells (Zone 2). A filter blanket with thickness of 12 inches was placed between the Zone 2 materials and its foundation for the whole downstream area. An 18-inch thick gravel drain zone was also installed over part of the downstream foundation. A waste rock fill was placed at the downstream toe of the dam. Ripraps are placed on both the upstream and downstream sides of the dam. For analysis purpose, the gravel drain is modeled as part of the filter blanket. The rapid drawdown analyses were performed on maximum cross section of J.C. Boyle Dam, which is shown on Figure 4.

The impervious clay core is constructed of selected clay materials, which are described as rust colored sandy clay with some pea gravel. The shell materials were constructed of a mixture of well graded gravel with sand and well graded sand. Based on the specifications, the embankment materials were to be constructed in 8-inch loose lift and compacted with a minimum of twelve (12) passes of sheepfoot rollers to obtain a minimum of 95% of the dry density which correspond to the optimum moisture content of the materials placed The filter blanket is approximately 12 inches thick and consists of well graded sandy gravel. The waste rock fill was constructed of gravel placed under water without compaction. Specific information regarding size and compaction effort is not available for the upstream and downstream ripraps and the gravel drain. The dam is mostly founded on basalt with the exception of the right abutment, which is founded on satisfactory overburden (Bechtel, 1968).

***J.C. Boyle Dam Material Properties***

The effective shear strength parameters for the core material are developed based on the results of direct shear tests performed on samples from  core borrow sources during borrow source evaluation.  The results show that the effective friction angle is greater than that of Iron Gate Dam's core. This is consistent with the material descriptions which suggest that the core in J.C. Boyle Dam consists of lower plasticity clay and pea gravel. The results of the direct shear test are included in Appendix D. The total stress shear strength parameters are not available from the direct shear tests. For the purpose of rapid drawdown slope stability analysis, those parameters were conservatively assumed the same as those of the Iron Gate Dam core. No laboratory shear strength data are available for the other embankment materials. Previous slope stability analyses performed by others selected the shear strength parameters based on the SPT blow count data (Black and Veatch, 1998). Review of available data suggests that the shell materials consist of up to 50% of gravel. The shear strength parameters that were previously selected did not account for the presence of high gravel percentage in the shell material. Considering the high gravel content, the borrow source, and how the shell material was placed and compacted, for the purpose of the rapid drawdown analysis a friction angle of 34 degrees (the previous analysis used a friction angle of 37 degrees) was assumed. The strength parameters of the riprap are conservatively assumed to be the same as the shell materials as the anticipated effect from the riprap on the overall stability performance is not significant due to its relative thickness to the shell. The bedrock is modeled as impenetrable in the slope stability model. Table 2 summarizes the best estimate engineering parameters used in slope stability analyses.

As no total strength parameters are available for the core materials, a sensitivity analysis is performed on the strength parameters for the core materials. Total cohesion of 100 psf and total friction angle of 12 degrees were conservatively selected considering very soft soil conditions for this sensitivity analysis. This sensitivity analysis also considers a lower effective friction angle of 19.4 degrees for the core materials, which was selected based on the lowest values from the direct shear tests.  As the core is relatively thin compared to the shell, it is anticipated that reducing the strength parameters for the core materials will not significantly impact the analysis results. Table 2 includes the engineering parameters used in the sensitivity analysis in parenthesis.

Compaction tests performed on the samples from the core and shell borrow sources during borrow source evaluation were used as the basis for unit weight of the materials. The results of the compaction tests are included in Appendix E. The selection of the unit weight used in the rapid drawdown analysis is based on the compaction test results, published data (NAVFAC, 1986 and EPRI, 1990), and previous analyses. Table 2 summarizes the unit weights used in the slope stability analysis.

Falling head permeability tests performed on samples from the core borrow sources during borrow source evaluation were used as the basis for permeability values of the core material. The results of the permeability test are included in Appendix F. Permeability values for the shell materials and filter blankets are estimated based on results of the grain size analysis using the Kozemy-Carmen permeability correlations, characteristics of the materials, published data, and engineering judgement. The permeability of the riprap is assumed to be the same as the shell materials, whereas the permeability of the wasterock fill is assumed to be the same as the shell. Table 2 summarizes the best estimate engineering properties used in the seepage analyses.

Similar to Iron Gate Dam, anisotropic ratios of 10 and 2 are selected for the core and shell materials with the exception of riprap, respectively. An anisotropic ratio of 1 is selected for the ripraps.

In addition, a set of sensitivity analysis was performed based on typical permeability ranges for gravel and sand materials (Holtz and Kovacs, 1981). This set of sensitivity analysis conservatively assumes the lower permeability values within the typical ranges for the shell, riprap, filter blanket, and waste rock fill. Table 2 includes the engineering parameters used in the sensitivity analysis in parenthesis.

Table 2. Material Properties Used for the Analyses of J.C. Boyle Dam

| Material | Unit Weight (pcf) | Effective Stress | | Total Stress | | Horizontal Permeability, $k_h$ (cm/s)[1,3] | $k_h/k_v$ |
|---|---|---|---|---|---|---|---|
| | | Cohesion, c' (psf) | Friction Angle, ϕ' (°)[1,2] | Cohesion, c (psf)[1] | Friction Angle, ϕ (°)[1] | | |
| Core | 120 | 0 | 27 (19) | 300 (100) | 16 (12) | 1.71E-04 | 10 |
| Shell | 130 | 0 | 34 | - | - | 6.62E-01 (4.00E-03) | 2 |
| Upstream Riprap | 140 | 0 | 34 | - | - | 1.04E-00 (4.00E-03) | 1 |
| Downstream Riprap | 140 | 0 | 34 | - | - | 1.04E-00 (4.00E-03) | 1 |
| Filter Blanket | 125 | 0 | 35 | - | - | 1.04E-00 (4.00E-03) | 2 |
| Waste Rock Fill | 145 | 0 | 40 | - | - | 6.62E-01 (4.00E-03) | 2 |

Note:
1. The parameter that was used for sensitivity analyses is provided in parenthesis.
2. For compacted sand and gravel materials, the friction angles are typically greater than 34 degrees (NAVFAC, 1986 and EPRI, 1990).
3. For clean coarse materials, permeability ranges from $10^{-3}$ cm/s to 1 cm/s per Holtz and Kovacs (1981).

## PREVIOUS SLOPE STABILITY ANALYSIS PERFORMED BY OTHERS

### *Iron Gate Dam*

After the construction of the Iron Gate dam, stability analyses of the dam were originally performed by the Division of Safety of Dams (DSOD) in 1962 (DWR, 1986). The slope stability analyses were performed for static, rapid drawdown, and pseudo-static loading conditions with assumed effective friction angles of 30 and 17 degrees with no cohesion for the shell and core, respectively. A minimum factor of safety of 1.67 was calculated for the rapid drawdown conditions. Bechtel Corporation analyzed stability of the embankment in 1968 using effective friction angles of 35 degrees for the shell and 22 degrees for the core. The rapid drawdown analysis performed as part of Bechtel's analyses calculated a minimum factor of safety of 1.99 (DWR, 1986). In 1986, DSOD reanalyzed the dam by assigning an effective friction angle of 35 degrees for the shell zones and drained zones, and calculated a minimum factor of safety of 2.00 for rapid drawdown. These stability evaluations were then updated in 1995 and 2004 to account for the then planned dam raises (Section 8 of STID, 2015). The existing dam incorporates the sheet-pile raised crest, and has an effective crest elevation of 2348.0 feet.

As the latest stability analysis, PanGEO performed the preliminary assessment of the stability of upstream slope under rapid drawdown conditions and presented the results in a technical memorandum (PanGEO, 2008).

### *J.C. Boyle Dam*

Based on available information, two (2) rapid drawdown analyses were performed in 1968 and 1996 (Bechtel, 1968 and Black and Veatch, 1996). The 1968 analysis assumed a very conservative strength for the shell materials, in which the shear strength of the shell materials was assumed to be the same as the shear strength of the core materials (effective friction angle of 26 degrees). The phreatic surface used in the analysis was derived by a flow net analysis, which considered partial pore dissipation within the shell materials. The rapid drawdown analysis resulted in a factor of safety of 1.03. In 1994, three (3) borings were drilled on the downstream side of the dam to collect additional subsurface information for better material characterization for the shell materials. Based on the results of this subsurface investigation, the 1996 analysis assumed a higher shear strength for the shell material (effective friction angle of 37 degrees). No additional seepage analysis was performed, and the phreatic surface from the 1968 analysis was assumed in the 1996 analysis. The rapid drawdown analysis resulted in a factor of 1.88.

**CURRENT RAPID DRAWDOWN ANALYSIS**

Sudden or rapid drawdown is the most critical condition controlling the lowering of the reservoir prior to dam removal because deep slides in the upstream slope of the dam during the drawdown could lead to dam failure. Rapid drawdown reduces the total stress on the upstream face and lowers the head driving seepage through the embankment. The shear stresses within the upstream slope increase which may lead to instability. In principle, the stability of the upstream slope can be evaluated using either total stress (undrained) or effective stress (drained) strength parameters. The rapid drawdown analysis approach used for this project involves the following steps:

1. Develop analysis sections and material properties,
2. Establish a base case by performing conventional rapid drawdown stability analysis under instantaneous drawdown for two scenarios that provide the upper and lower bound for stability of the dams during rapid drawdown:
    a. The first scenario (least conservative bound) assumes full pore pressure dissipation within the pervious shell after drawdown from the steady state condition.
    b. The second scenario (most conservative bound) assumes no pore pressure dissipation within the pervious shell from after drawdown from the steady state condition.
3. Perform transient drawdown analysis for various drawdown rates:
    a. Seepage analysis to determine the location of the phreatic surface at different time steps during reservoir drawdown
    b. Slope stability analysis for each corresponding phreatic surface during reservoir drawdown.
4. Additional sensitivity analyses, if needed.

SEEP/W (Geo-Studio, 2016) presents a method for using uncoupled transient seepage analysis along with limit equilibrium to evaluate the stability of slopes affected by changing hydraulic boundary conditions such as the conditions during rapid drawdown. The latest version of the USBR Embankment Dam design standards (2011) recommends using the effective stress approach with pore pressures from uncoupled transient seepage analysis to analyze stability following rapid drawdown. For these reasons, a transient analysis was considered as listed above. Because the shells of the dams are constructed of pervious materials rapid drawdown of the reservoir level behind the dams will result in concurrent (but slower) lowering of the phreatic surface (groundwater level) in the upstream shell of the dams. To account for this, transient seepage analyses are required. The computer programs SEEP/W and SLOPE/W (Geo-Studio, 2016) were utilized for the seepage and slope stability. SEEP/W is a two-dimensional, finite element analysis software program that has the capability to analyze both steady-state and transient seepage conditions. Slope/W is used to perform limit equilibrium slope stability analyses. Slope/W uses the phreatic surface developed in SEEP/W as input to the stability analysis. The limit equilibrium slope stability calculations use Spencer's method, which satisfies both moment and force equilibrium simultaneously.

**Acceptance Criterion**

According to the Engineering Manual (EM-110-2-1902) of United States Army Corps of Engineers (USACE), the factor of safety for the rapid drawdown analyses of the upstream slope of the dam should be greater than the range of 1.1 to 1.3. Given, the importance of safety to both workers on site and the public downstream of the dams, the minimum rapid drawdown factor of safety for transient seepage analyses is selected to be 1.3.

**Analysis Results**

Rapid drawdown slope stability analyses were performed to calculate the minimum factors of safety for the following five (5) scenarios as described below:

1. Instantaneous drawdown from steady state condition with full pore pressure dissipation in the shell materials (least conservative bound).
2. Instantaneous drawdown from steady state condition with no pore pressure dissipation in the shell materials (most conservative bound).
3. Slow drawdown rate (3 ft/day for Iron Gate Dam and 2 ft/day for J.C. Boyle Dam)
4. Intermediate drawdown rate (6 ft/day for Iron Gate Dam and 5 ft/day for J.C. Boyle Dam)
5. Rapid drawdown rate (10 ft/day for Iron Gate Dam and 10 ft/day for J.C. Boyle Dam)

For Iron Gate Dam, the reservoir was drawn down from El. 2328 feet to El. 2202 feet. For J.C. Boyle Dam, the reservoir was drawn down from El. 3793 feet to El. 3762 feet. The results of the rapid drawdown slope stability analyses for Iron Gate Dam are summarized in Table 3. Table 3 also includes the results of the sensitivity analyses, which consider the potential lower bound strength for the shell materials. The results of rapid drawdown slope stability analyses for J.C. Boyle Dam are summarized in Table 4. Table 4 also includes the results of the sensitivity analyses, which consider the lower bounds for both the core strength and the shell permeability. The analysis results for the best estimate parameters are also shown on Figures 5 through 9 for Iron Gate Dam, and on Figures 10 through 14 for J.C. Boyle Dam. It should be noted that the plotted phreatic surfaces shown on the figures for the transient rapid drawdown analyses correspond to the phreatic surfaces at the specific time when the calculated factors of safety are minimum.

Table 3. Rapid Drawdown Slope Stability Analysis Results for Iron Gate Dam

| Scenario | Factors of Safety for Best Estimate Parameters | |
|---|---|---|
| | Mid-Slope | Full-Slope |
| 1. Instantaneous drawdown, full pore pressure dissipation | 1.91 | 2.02 |
| 2. Instantaneous drawdown, no pore pressure dissipation within upstream shell | 1.42 | 1.46 |
| 3. Slow drawdown rate (3 ft/day) | 1.51 | 1.77 |
| 4. Intermediate drawdown rate (6 ft/day) | 1.49 | 1.74 |
| 5. Rapid drawdown rate (10 ft/day) | 1.48 | 1.70 |

Table 4. Rapid Drawdown Slope Stability Analysis Results for J.C. Boyle Dam

| Scenario | Factor of Safety for Best Estimate for Core Strength | | Factor of Safety from Sensitivity Analyses Using Potential Lower Bound Strength for Core | |
|---|---|---|---|---|
| | Mid-Slope | Full-Slope | Mid-Slope | Full-Slope |
| 1. Instantaneous drawdown, full pore pressure dissipation | 2.06 (2.06) | 1.86 (1.86) | 1.97 (1.97) | 1.85 (1.85) |
| 2. Instantaneous drawdown, no pore pressure dissipation within upstream shell | 1.11 (1.12) | 1.18 (1.18) | 1.10 (1.10) | 1.18 (1.18) |
| 3. Slow drawdown rate (2 ft/day) | 1.77 (1.76) | 1.84 (1.74) | 1.70 (1.70) | 1.83 (1.73) |
| 4. Intermediate drawdown rate (5 ft/day) | 1.78 (1.76) | 1.85 (1.66) | 1.70 (1.69) | 1.83 (1.66) |

| | | | | |
|---|---|---|---|---|
| 5. Rapid drawdown rate (10 ft/day) | 1.78<br>(1.72) | 1.85<br>(1.61) | 1.75<br>(1.69) | 1.82<br>(1.61) |

Note: The values in parenthesis refer to the results of the sensitivity analysis using the lower permeability for the shell materials.

## Conclusions

Rapid drawdown analysis results for the Iron Gate Dam and J.C. Boyle Dam indicate that the calculated factors of safety are greater than the selected minimum factor of safety of 1.3 for all cases analyzed except some cases instantaneous drawdown without any pore pressure dissipations for the J.C. Boyle Dam. However, in these cases, the minimum factors of safety are still within the range recommended by USACE. In addition, it should be noted that these cases conservatively assume no pore pressure dissipation within the upstream shell. Based on the analyses, reservoir drawdown could be as high as 10 feet/day. However, we recommend that reservoir drawdown be 5 feet/day, except as noted for J,C. Boyle Dam below.

It is our understanding that the demolition of J.C. Boyle Dam includes removal of concrete stoplogs within two diversion culverts. The removal of the concrete stoplogs (likely by blasting) will result in drawdown of approximately 10 feet for the first culvert and 8 feet for the second culvert within less than 24 hours. Although we conclude that the J.C. Boyle Dam will perform satisfactorily under these rapid drawdown conditions, we recommend a hold period of one week be implemented between removal of the stoplogs from the first culvert until the stoplogs from the second culvert are removed to allow for pore pressure dissipation.

The analysis results indicated that no slope instability would result during reservoir drawdown. However, there is a potential for shallow slumping along the upstream embankment slopes due to the potential strength loss of surficial materials during the drawdown. Therefore, we recommend frequent visual inspection during the reservoir drawdown process. If any shallow slumping is observed, riprap can be placed to provide additional resistance.

It is recommended that instrumentation should be installed to monitor the upstream slopes during reservoir drawdown for dam removal. The types of recommended instrumentation include survey monuments, inclinometers, and piezometers. Daily readings are recommended to closely monitor if there are any unanticipated slope movements or pore pressure accumulation. It is also recommended that the instrumentation be installed the year prior to reservoir drawdown. The piezometers would be monitored during reservoir drawdown to confirm that the transient phreatic surfacewithin the upstream shell of the dam falls as the reservoir elevation drops.

## Limitations

AECOM represents that our services were conducted in a manner consistent with the standard of care ordinarily applied as the state of practice in the profession within the limits prescribed by our client. No other warranties, either expressed or implied, are included or intended in this technical memorandum.

Background information and other data have been furnished to AECOM by Pacific Corp and/or third parties, which AECOM has used in preparing this technical memorandum. AECOM has relied on this information as furnished, and is neither responsible for nor has confirmed the accuracy of this information.

The analyses and results presented in this report are for the current study only and should not be extended or used for any other purposes.

## References

Bechtel Corporation, 1968a. Dam Safety Investigations, Iron Gate Dam Report.

Bechtel Corporation, 1968b. Dam Safety Investigations, J.C. Boyle Dam Report.

Black and Veatch, 1998. J.C. Boyle Development Klamath River Hydroelectric Project FERC Project No. 2082, Safety Inspection Report.

California Oregon Power Company, 1960a. Specifications for the Construction of the Iron Gate Earth Fill Regulating Dam.

California Oregon Power Company, 1960b. Report on Investigation of Locally Available Materials for the Construction of Iron Gate Earth Fill Regulating Dam.

California Oregon Power Company, Unknown. Big Bend Dam Earthwork Specifications.

Department of Navy, 1986. Foundation and Earth Structures. Design Manual 7.02. Naval Facilities Engineering Command.

Department of Water Resources (DWR), 1986. Iron Gate Dam 91-3 Safety Review Report.

Geo-Slope International Ltd., 2016. Geostudio 2016 Software. Version 8.16.1.13452

Holtz and Kovacs, 1981. An Introduction to Geotechnical Engineering.

Kulhawy and Mayne, 1990. Manual on Estimating Soil Properties for Foundation Design.

PacifiCorp Energy, 2015. J.C. Boyle Development Klamath River Project Supporting Technical Information Document.

PacifiCorp Energy, 2015. Iron Gate Development Klamath River Project Supporting Technical Information Document.

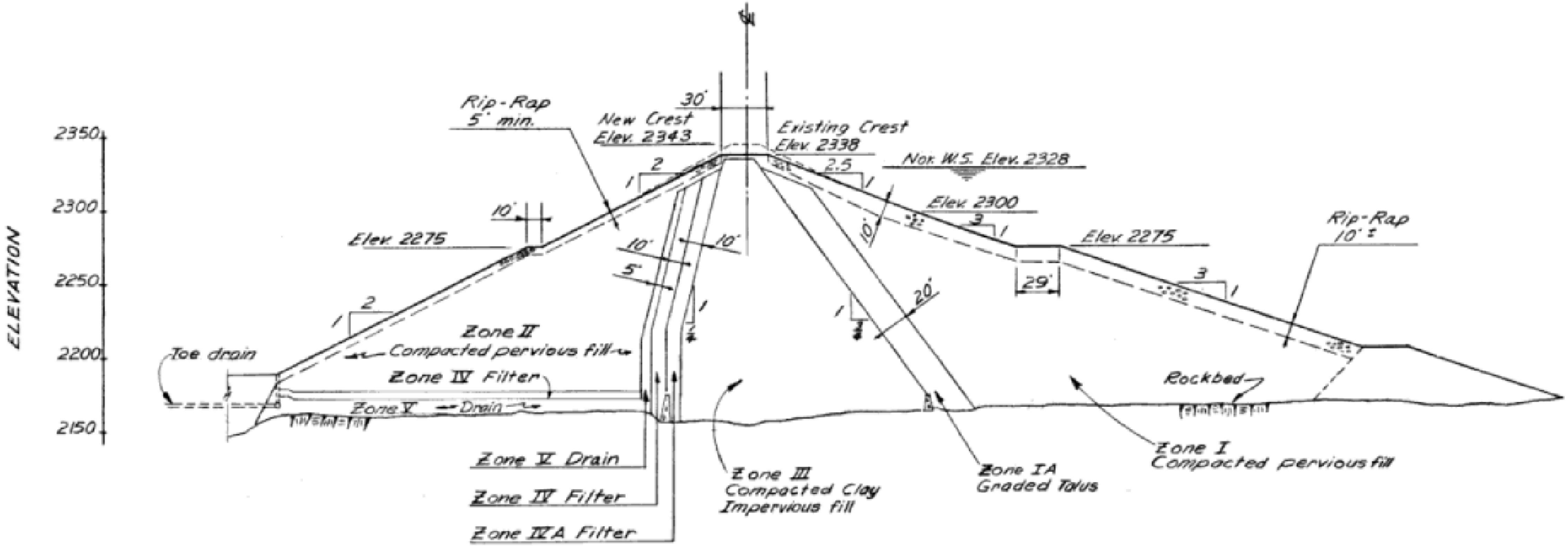
PanGEO, 2006. Preliminary Assessment of Slope Stability, Iron Gate and Copco Dams and Reservoir, Under Rapid Drawdown.

PanGEO, 2008. Geotechnical Report Klamath River Dam Removal Project.

United States Army Corps of Engineers (USACE), 2003. Engineeing and Design Slope Stability. Engineer Manual 1110-2-1902.

United States Department of the Interior, 2012. Detailed Plan for Dam Removal – Klamath River Dams.

Unknown Publisher, Unknown Date. Report on Investigation of Locally Available Materials for Construction of Big Bend Earth Fill Diversion Dam by Unknown

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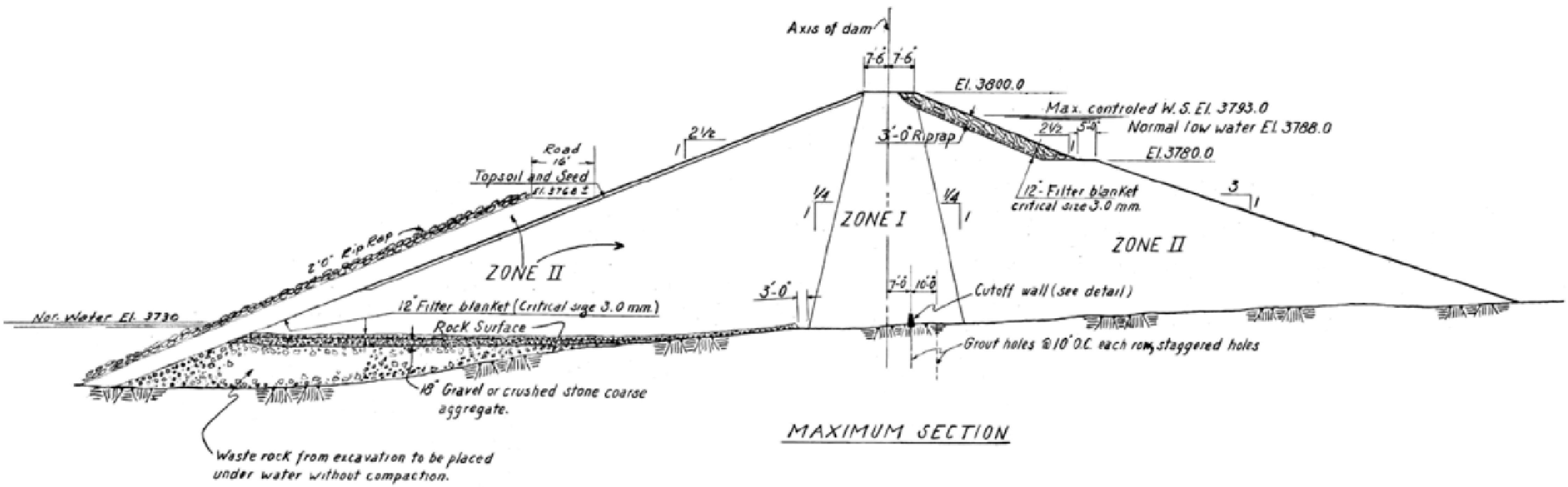


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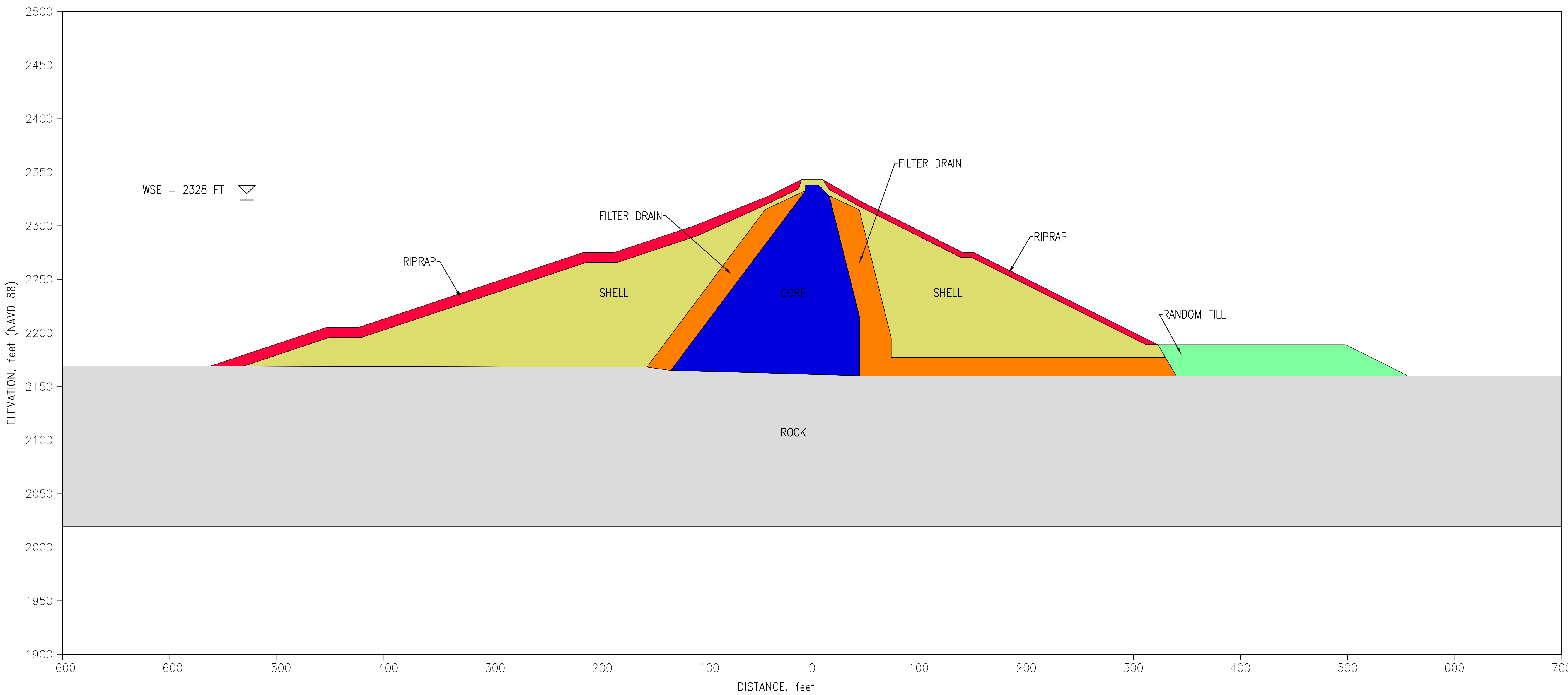




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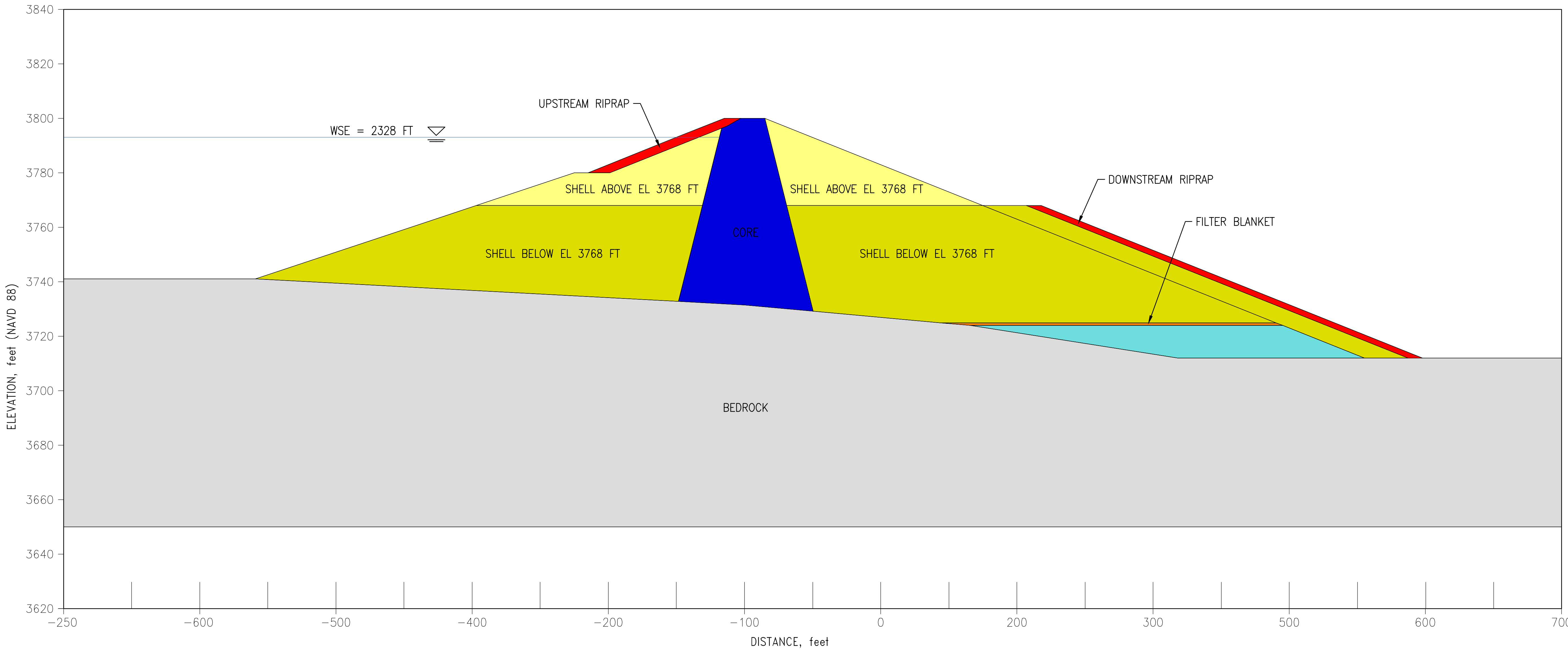


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ANALYSIS MODEL GEOMETRY
JC BOYLE DAM

FIGURE
4

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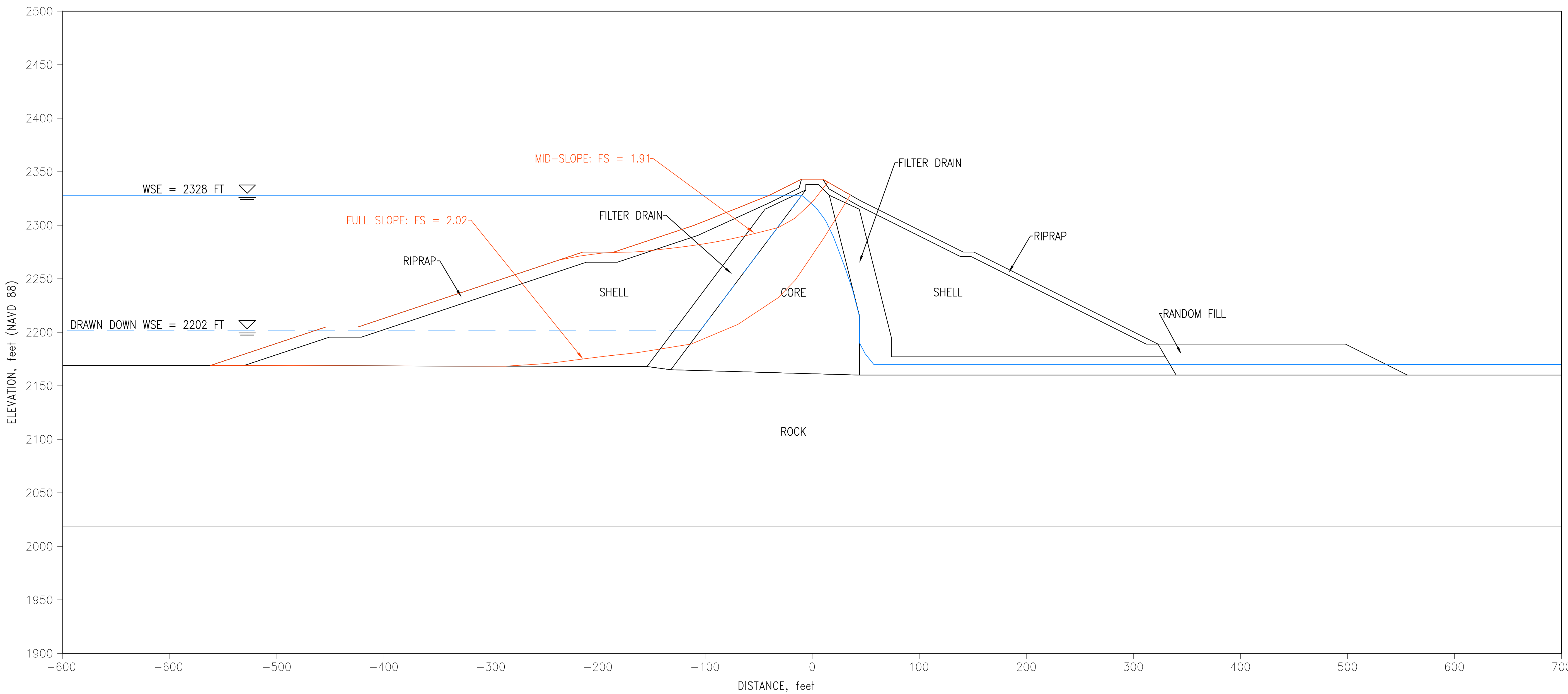


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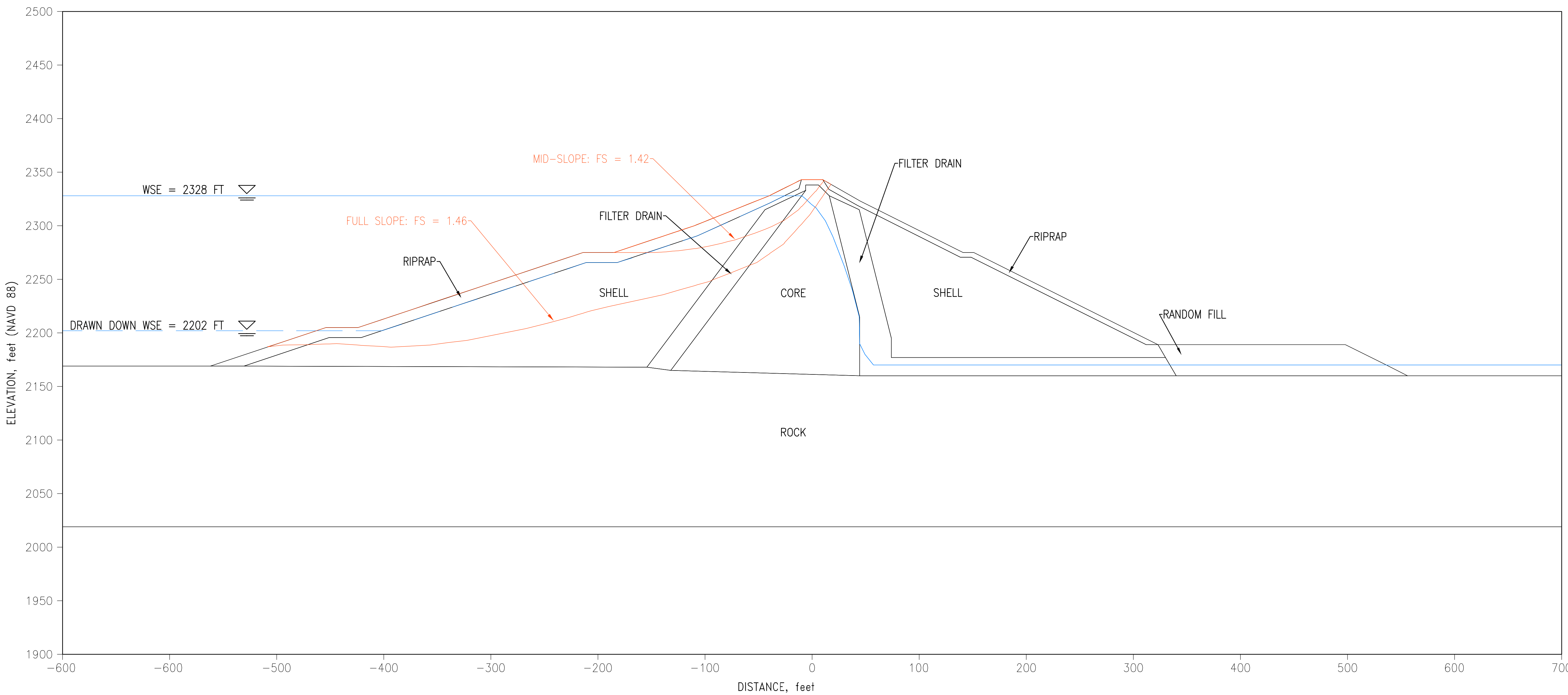


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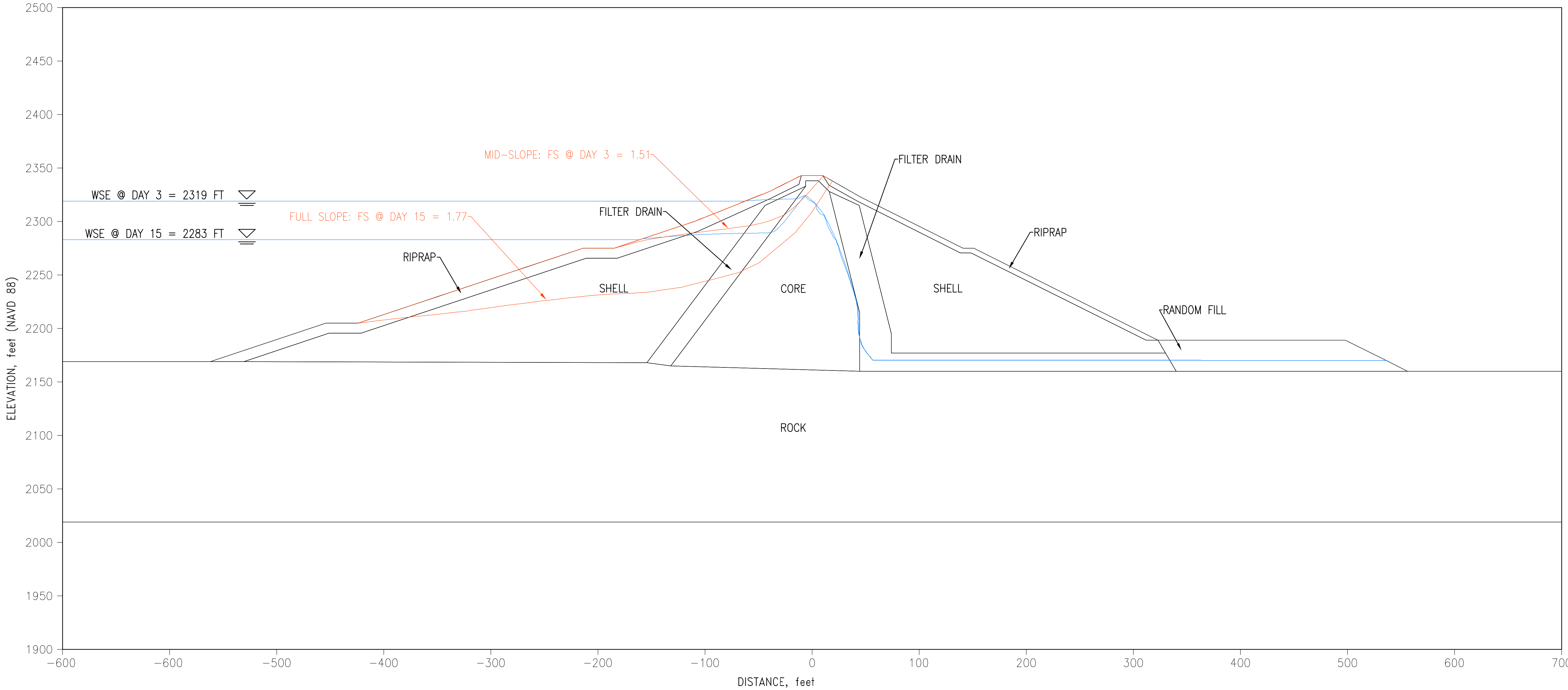


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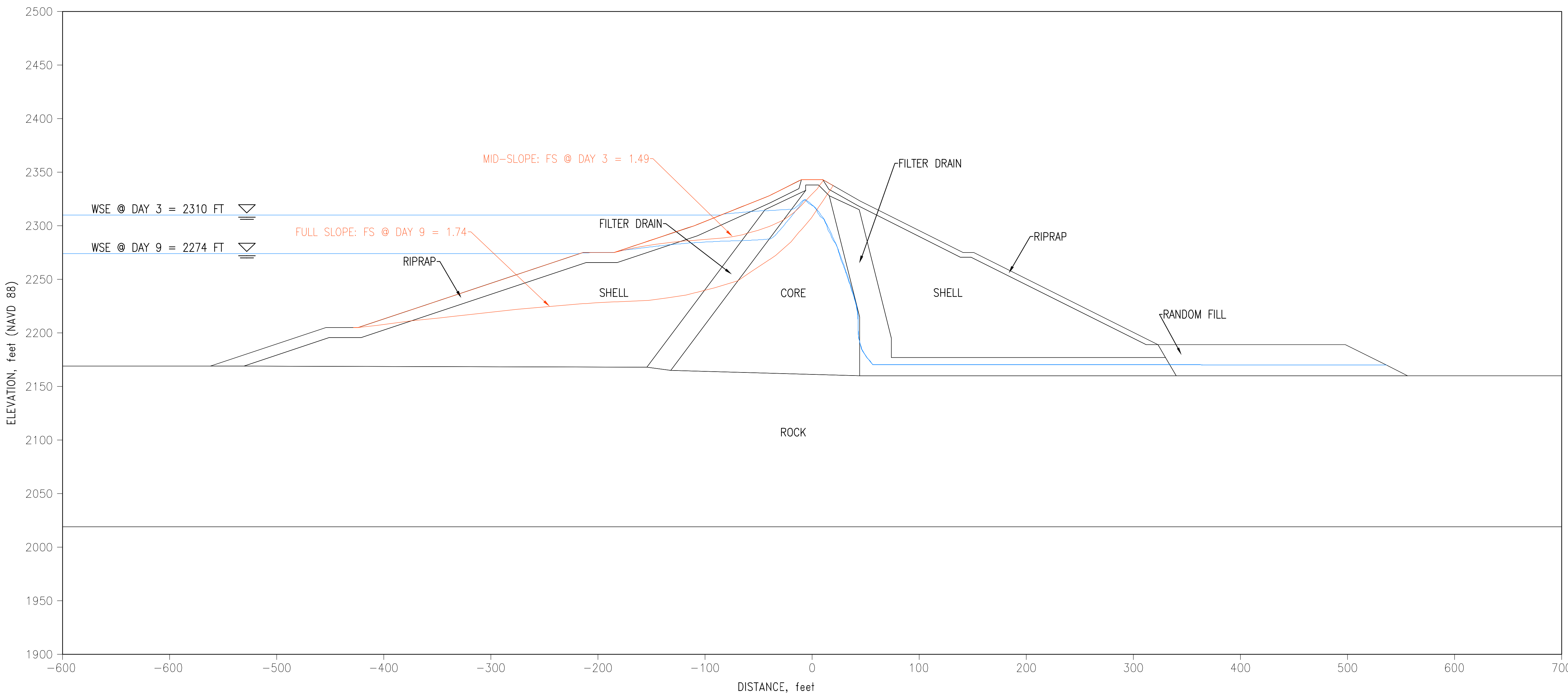


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KANAX KANAGALINGAM

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KLAMATH RIVER DAM REMOVAL

RAPID DRAWDOWN STABILITY ANALYSIS
IRON GATE DAM
SLOW DRAWDOWN SCENARIO
6 FT/DAY DRAWDOWN RATE

FIGURE
8

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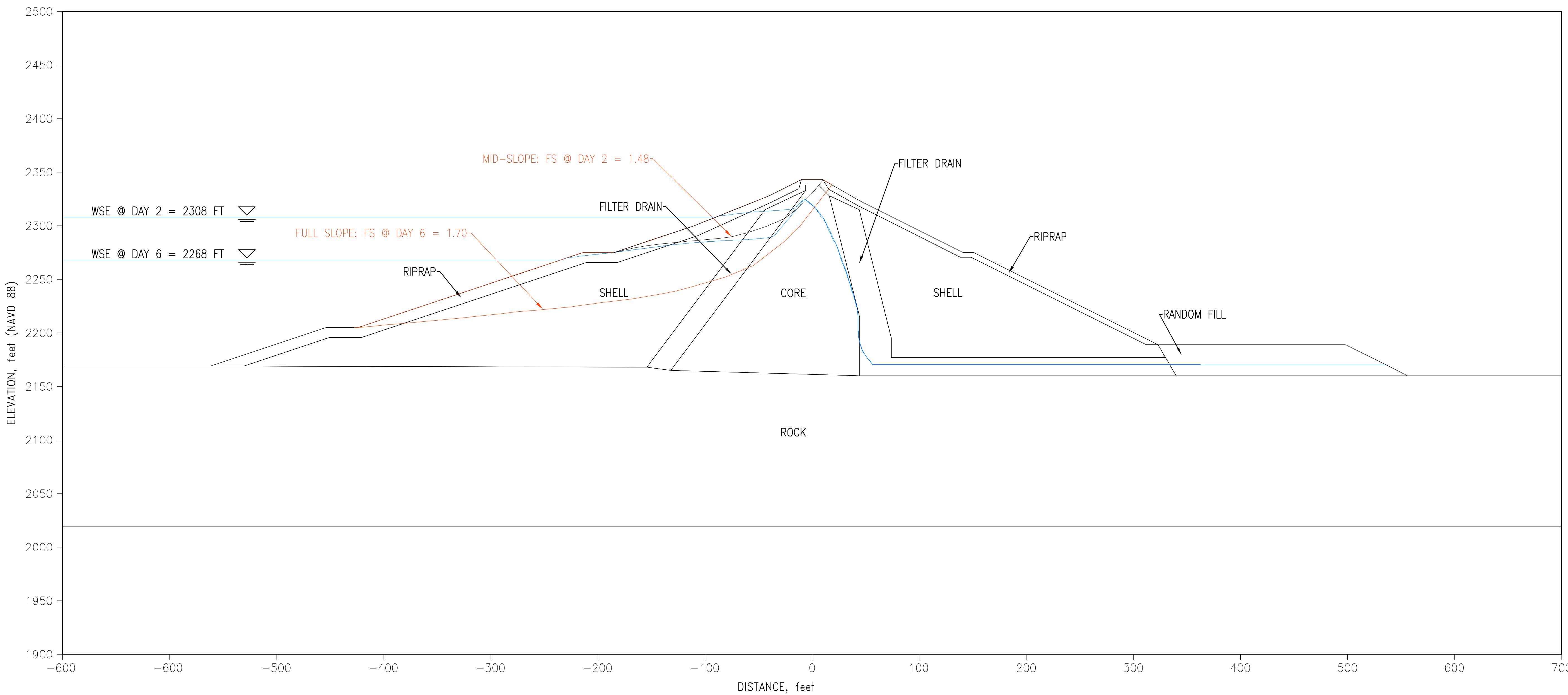


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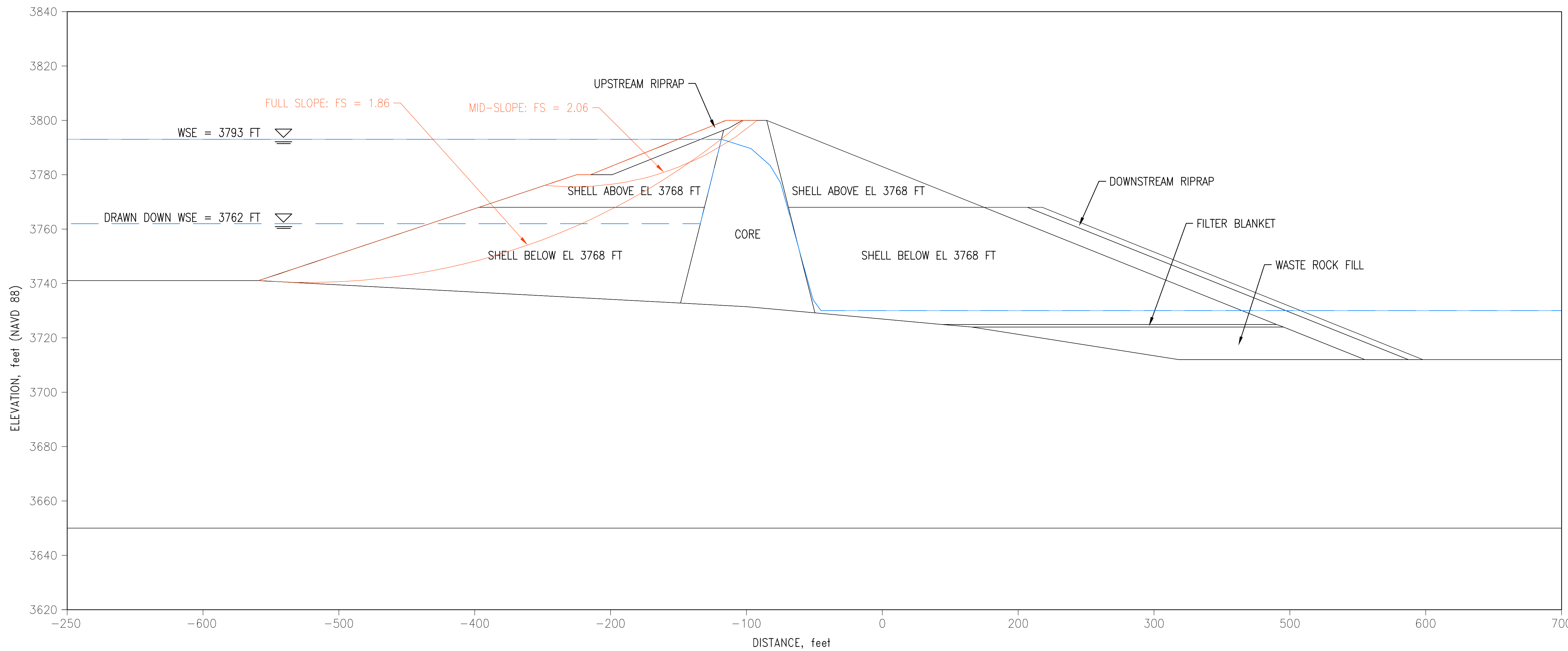


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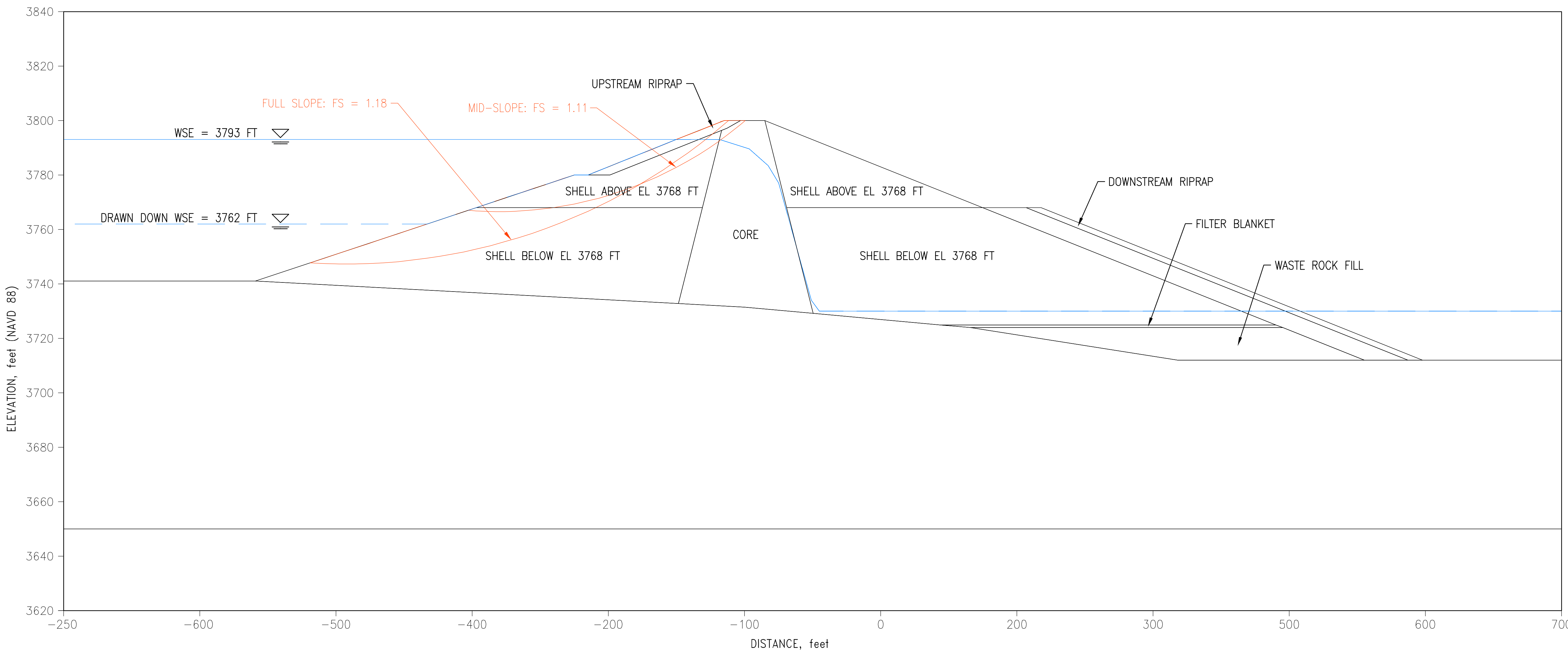


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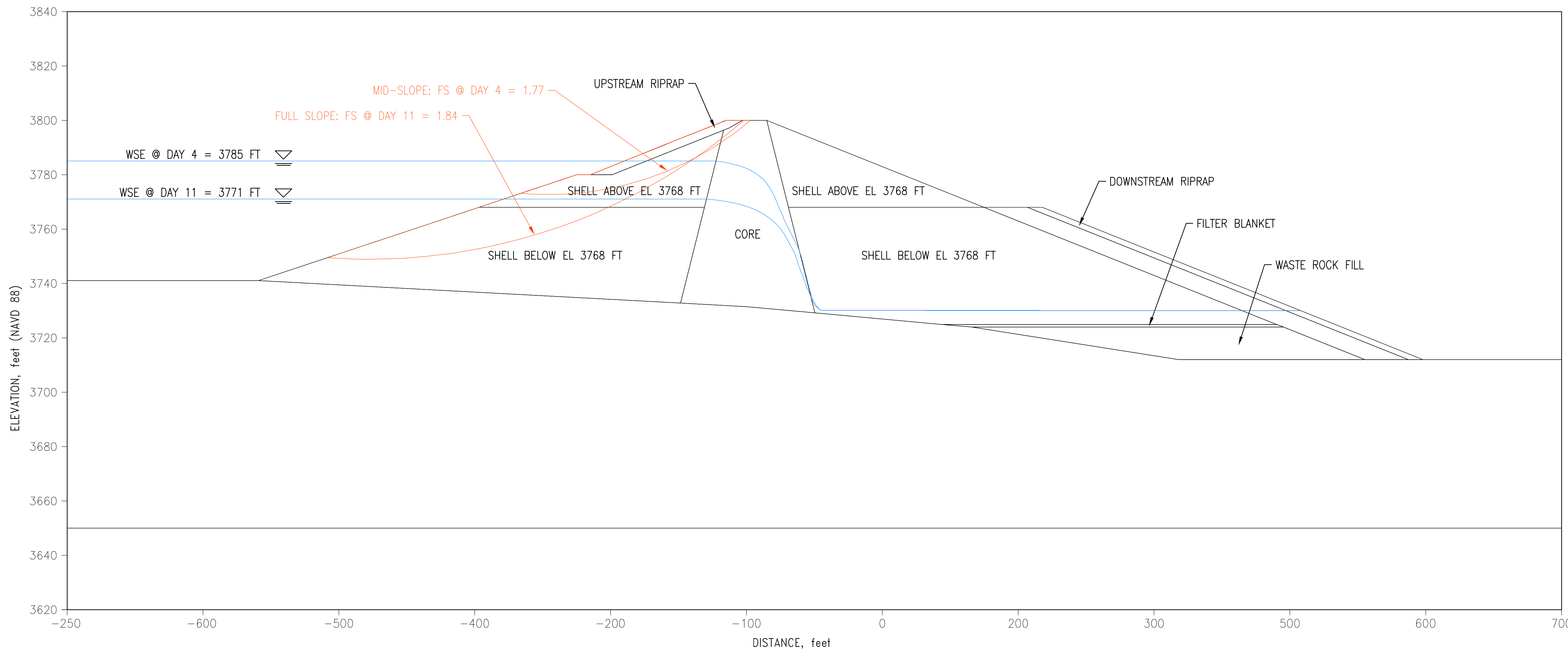
| 0 | KANAX KANAGALINGAM |

KLAMATH RIVER DAM REMOVAL

RAPID DRAWDOWN STABILITY ANALYSIS
JC BOYLE DAM
INSTANTANEOUS DRAWDOWN SCENARIO
NO PORE PRESSURE DISSIPATION

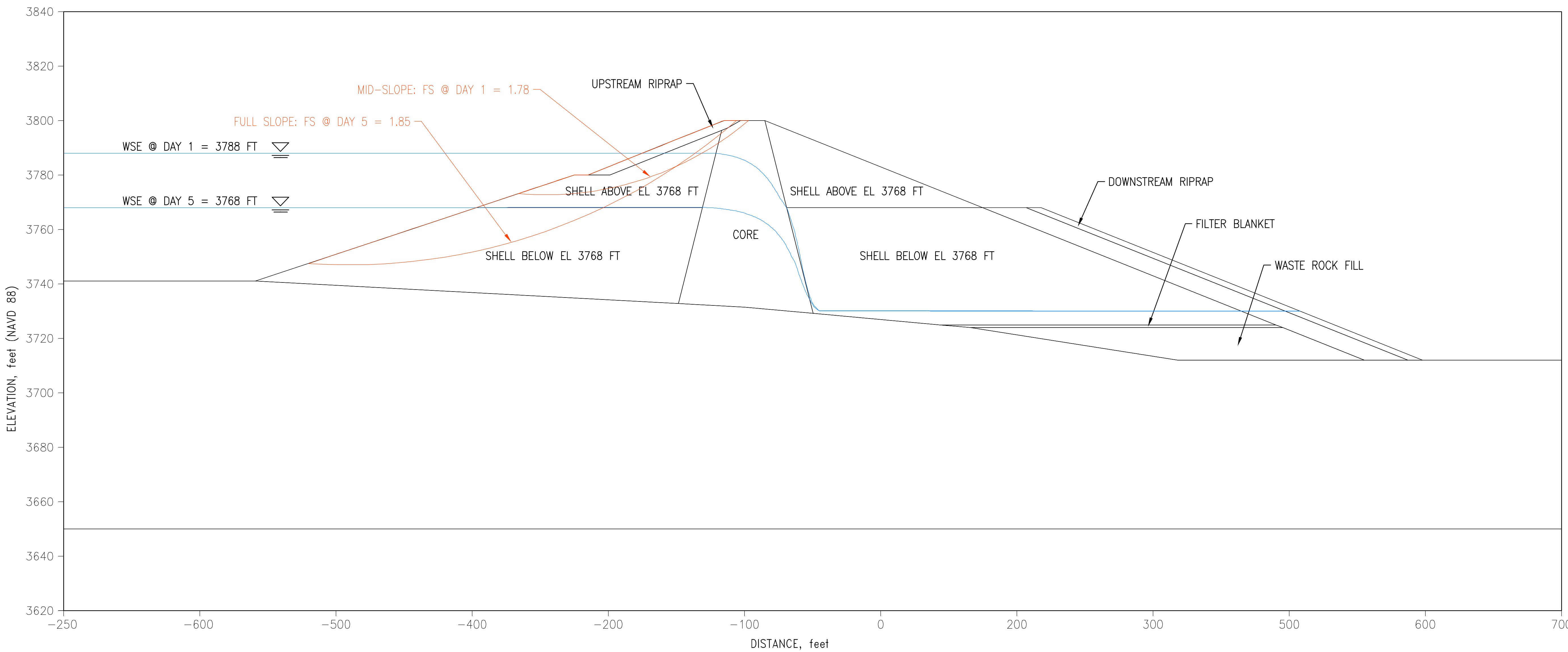
FIGURE
11

PLOT BY: BENJAMIN.CHOY – Sep 12, 2017 – 4:29:57pm
DRAWING: K:\400-Technical\430 Engineering\3.2 Tech Assess\5. Embank Stability\JC Boyle\Figures\Figure 11.dwg



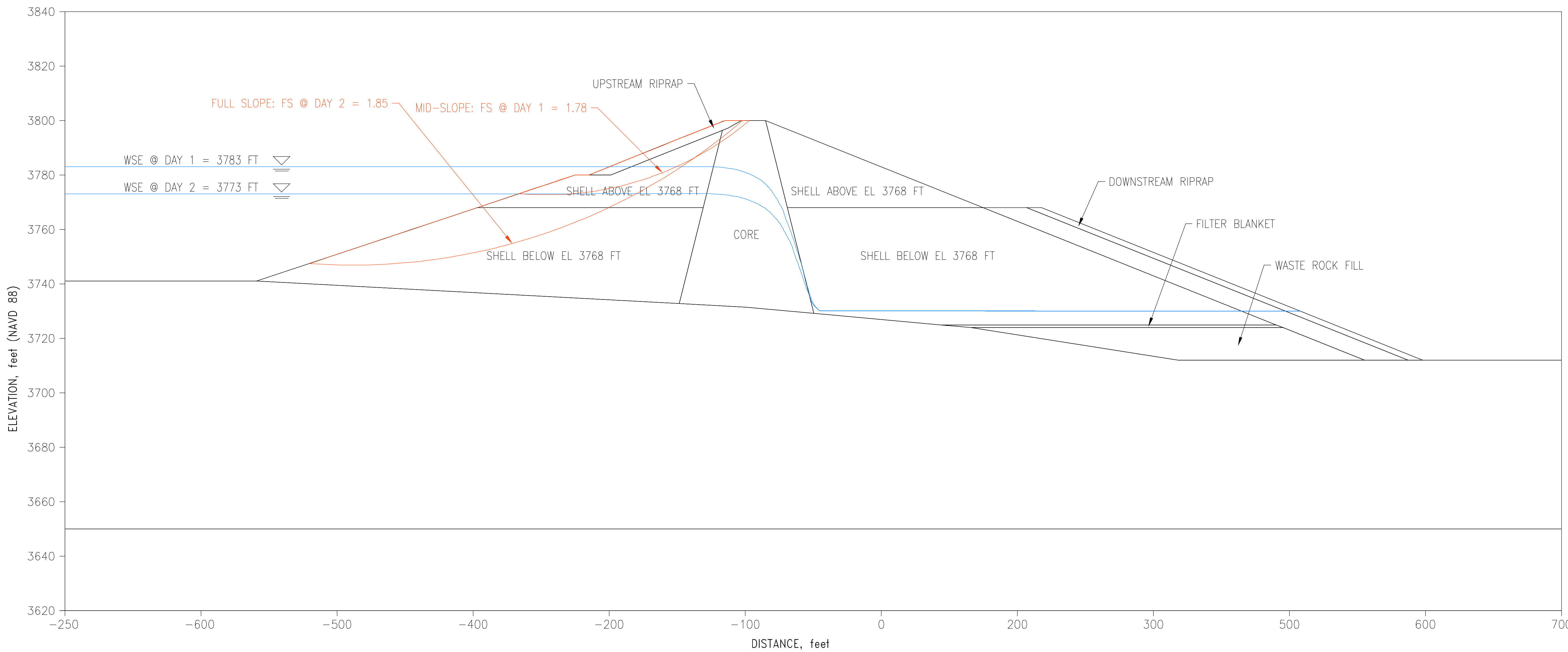

PLOT BY: BENJAMIN.CHOY – Sep 11, 2017 – 10:47:21am
DRAWING: K:\400-Technical\430 Engineering\3.2 Tech Assess\5. Embank Stability\JC Boyle\Figures\Figure 12.dwg

| | | | | |
|---|---|---|---|---|
| PROJECT NUMBER<br>60537920 | PREPARED BY<br>BENJAMIN CHOY | KLAMATH RIVER DAM REMOVAL | RAPID DRAWDOWN STABILITY ANALYSIS<br>JC BOYLE DAM<br>SLOW DRAWDOWN SCENARIO<br>2 FT/DAY DRAWDOWN RATE | FIGURE<br>12 |
| REVISION<br>0 | CHECKED BY<br>KANAX KANAGALINGAM | | | |




PLOT BY: BENJAMIN.CHOY – Sep 11, 2017 – 10:53:07am
DRAWING: K:\400-Technical\430 Engineering\3.2 Tech Assess\5. Embank Stability\JC Boyle\Figures\Figure 13.dwg

| | | | | |
|---|---|---|---|---|
| PROJECT NUMBER<br>60537920 | PREPARED BY<br>BENJAMIN CHOY | KLAMATH RIVER DAM REMOVAL | RAPID DRAWDOWN STABILITY ANALYSIS<br>JC BOYLE DAM<br>SLOW DRAWDOWN SCENARIO<br>5 FT/DAY DRAWDOWN RATE | FIGURE<br>13 |
| REVISION<br>0 | CHECKED BY<br>KANAX KANAGALINGAM | | | |




PLOT BY: BENJAMIN.CHOY – Sep 11, 2017 – 10:59:18am
DRAWING: K:\400-Technical\430 Engineering\3.2 Tech Assess\5. Embank Stability\JC Boyle\Figures\Figure 14.dwg

| PROJECT NUMBER | PREPARED BY | | | |
|---|---|---|---|---|
| 60537920 | BENJAMIN CHOY | KLAMATH RIVER DAM REMOVAL | RAPID DRAWDOWN STABILITY ANALYSIS<br>JC BOYLE DAM<br>SLOW DRAWDOWN SCENARIO<br>10 FT/DAY DRAWDOWN RATE | FIGURE<br>14 |
| REVISION | CHECKED BY | | | |
| 0 | KANAX KANAGALINGAM | | | |

Appendix A - Iron Gate Dam Triaxial Tests

CABLE, HANX

ABBOT A. HANKS, INC.
ESTABLISHED 1866
1300 SANSOME STREET · SAN FRANCISCO 11, CALIFORNIA · EXBROOK 7-2464

Engineers
Assayers
Chemists
Metallurgists
Spectrographers
Soils and Foundations
Consulting · Testing · Inspecting

File No. 1732.1
Lab. No. 46938

May 11, 1960

Mr. W. L. Warren
Assistant Chief Engineer
The California Oregon Power Company
216 West Main Street
Medford, Oregon

Re: Iron Gate Dam
Soil Samples

Dear Sir:

Enclosed are the findings from tests performed on soil samples marked Hole No. 1, which is the only sample for which all tests are complete. Tests of remaining samples are in various stages of completion.

As you may recall from your recent visit, there appeared to be a possibility that samples from Holes 2 and 3 had been mislabelled. It now appears that all samples marked Holes 2 and 3 are nearly identical, and we are performing further tests to distinguish between them. It is quite possible that these soils are exceptionally sensitive to seasoning period, owing to the porous nature of the parent rock, and that test results, particularly optimum moisture content, are influenced by the length of seasoning period. We have completed triaxial shear and consolidation tests on the sample labelled Hole No. 2, but are not yet certain that the samples were compacted at optimum moisture content and maximum density.

We shall advise you of results of our identification tests, and shall forward sets of test data as they are completed.

Very truly yours,

ABBOT A. HANKS, INC.

L. O. Long

L. O. Long

LOL:hms
Encls.
Reports to:
3-The California Oregon Power Company

Iron Gate Dam
Klamath River
File No. 1732.1

Abbot A. Hanks, Inc.
Lab. No. 46938
May 10, 1960

## TEST RESULTS

Hole No. 1.
Specific Gravity: 2.77.

### Triaxial Shear Test

| | Sample A | Sample B | Sample C |
|---|---|---|---|
| Chamber Pressure, psi | 15 | 50 | 80 |
| Unit Dry Weight at Compaction, $lb/ft^3$ | 103.3 | 103.6 | 104.3 |
| Moisture Content at Compaction, % | 21.3 | 22.1 | 20.8 |
| Unit Dry Weight at Test, $lb/ft^3$ | 103.0 | 108.6 | 110.5 |
| Moisture Content at Test, % | 23.7 | 21.6 | 20.4 |
| Degree of Saturation at Test, % | 97 | 100+ | 100 |
| Maximum Deviator Stress, psi | 36 | 60 | 77 |
| Pore Pressure at Max. Deviator Stress, psi | 4 | 9 | 23 |

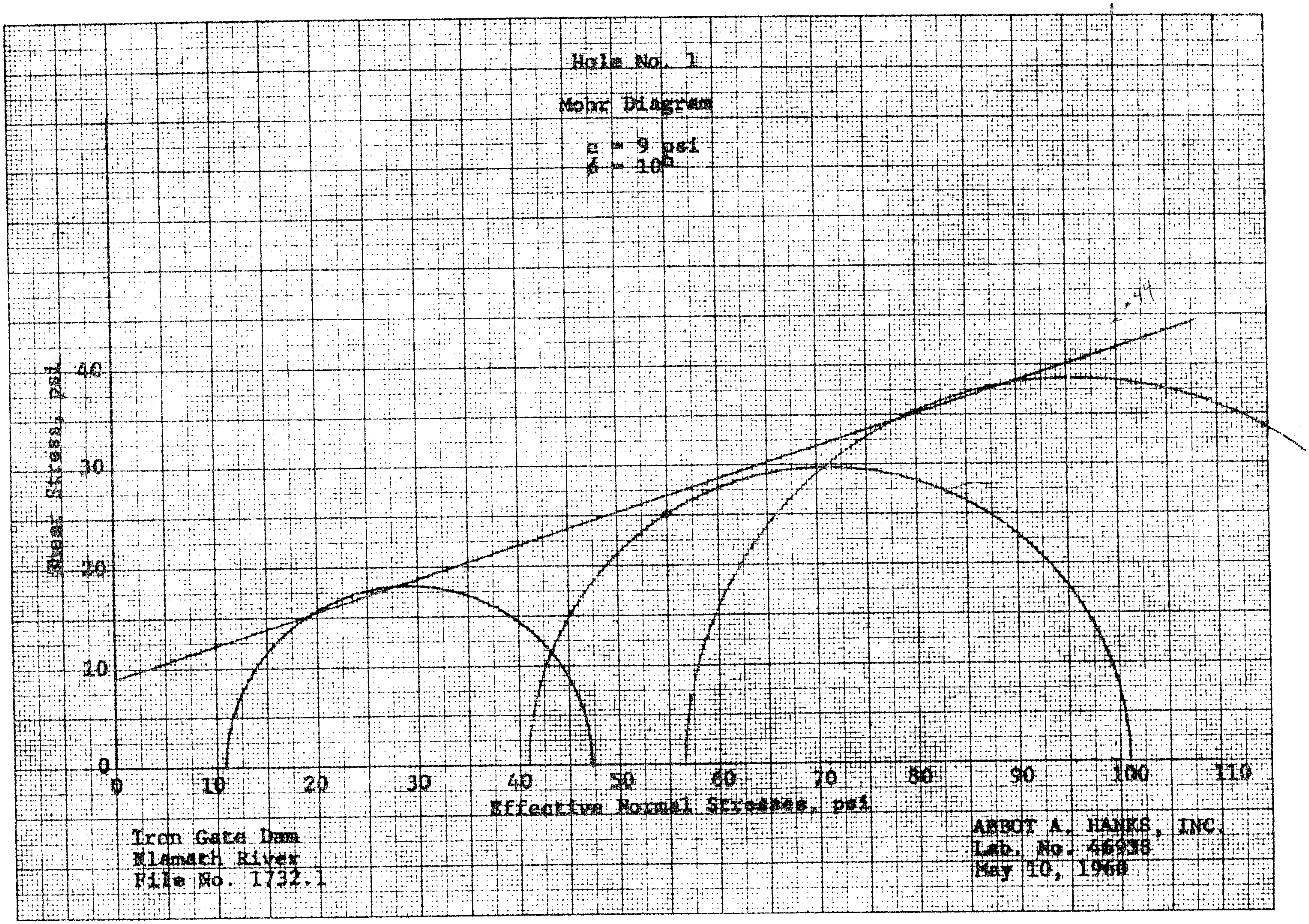
### Permeability Test
(Constant Head Test)

| | |
|---|---|
| Unit Dry Weight at Compaction, lb/ft | 100.6 |
| Moisture Content at Compaction, % | 23.6 |
| Moisture Content at Test, % | 24.4 |
| Degree of Saturation at Test, % | 95 |
| Permeability coefficient, ft per yr | Less than .01 |
| " " , cm/sec | Less than $10^{-8}$ |

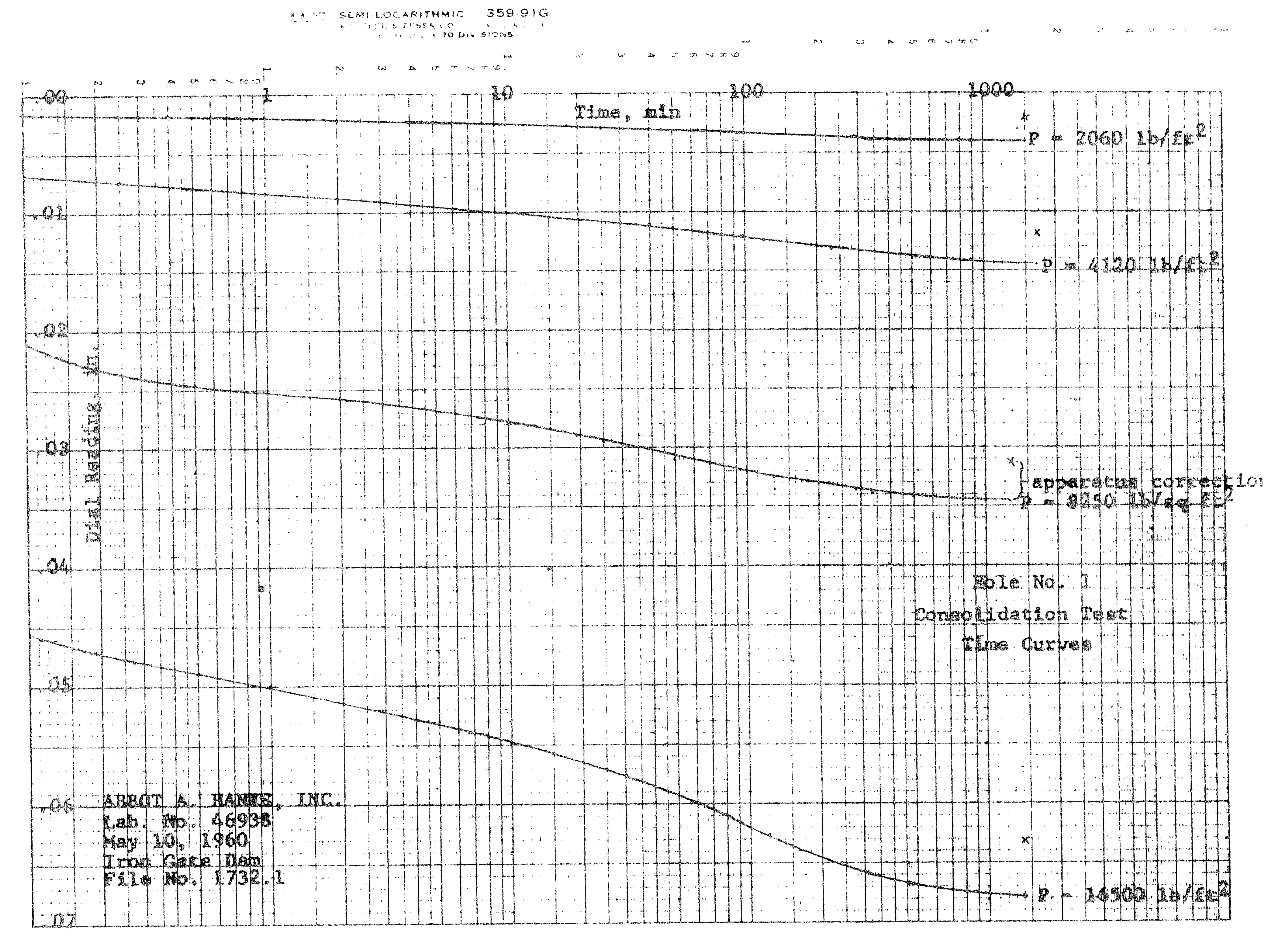
~~Perfect~~ ~~Settle~~

~~optimum moisture — 22% — 22.7~~

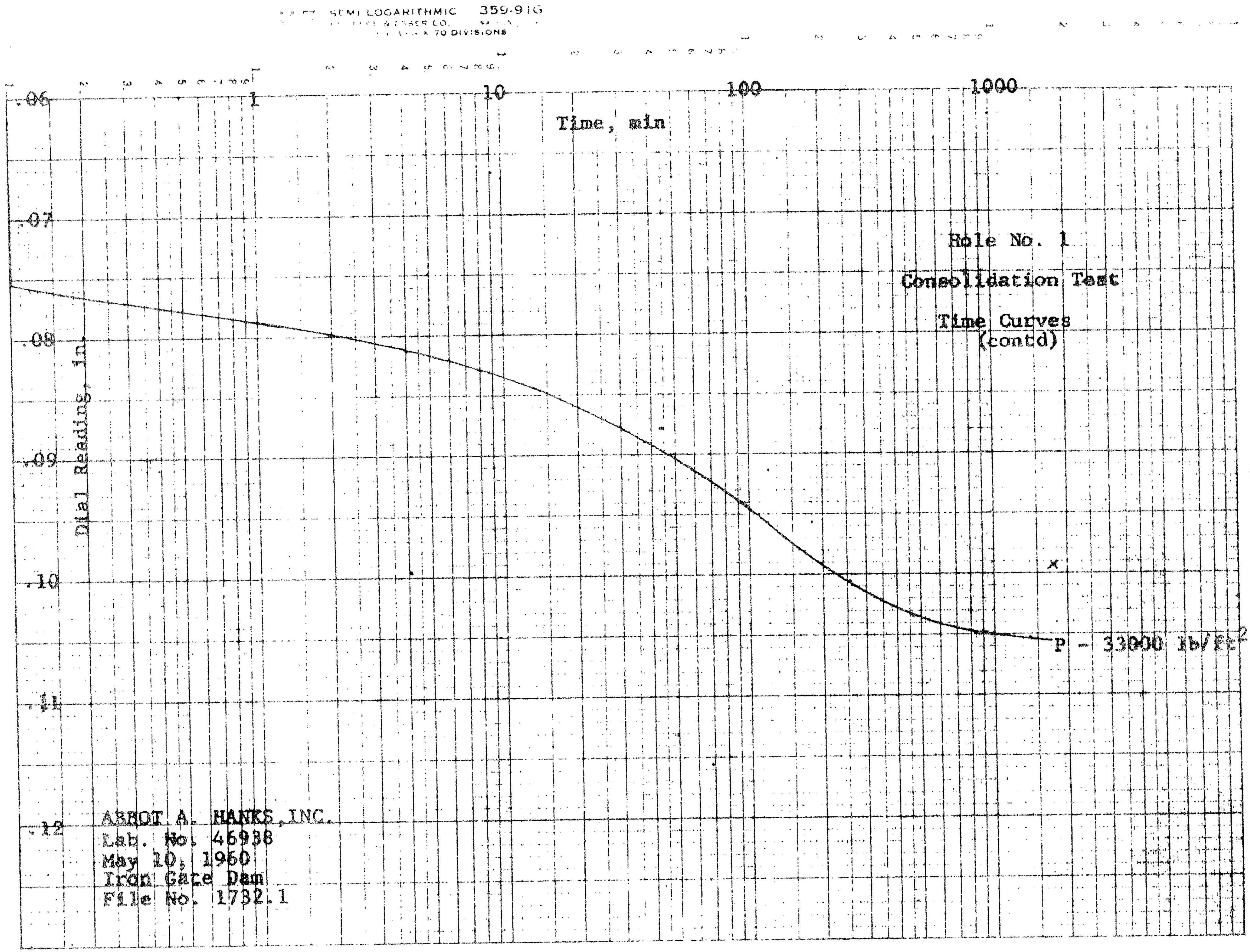
~~max dry density — 102.8 lb/cu ft. — 103~~



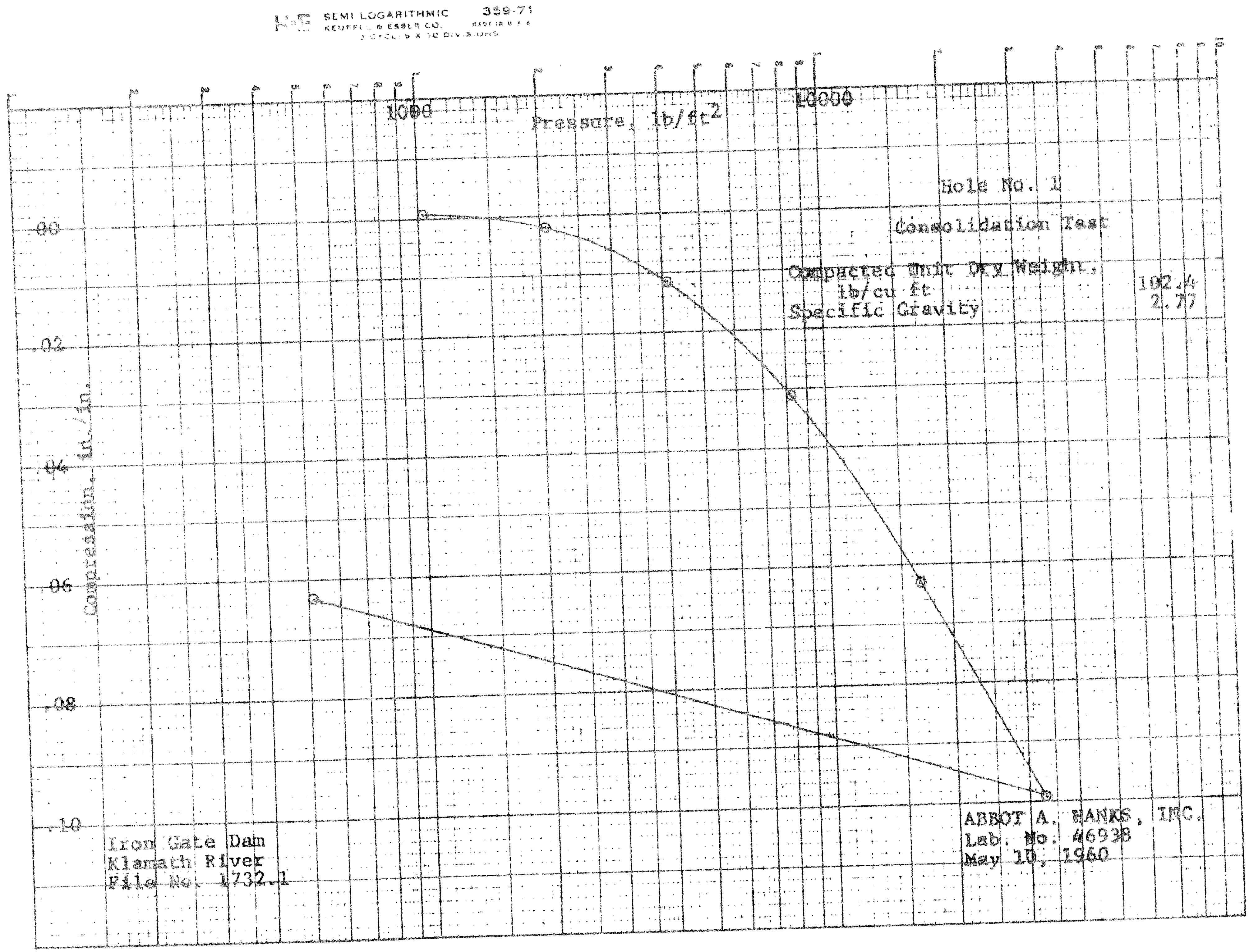
Hole No. 1
Mohr Diagram
c = 9 psi
ϕ = 10°
Shear Stress, psi
0
10
20
30
40
0
10
20
30
40
50
60
70
80
90
100
110
Effective Normal Stresses, psi
Iron Gate Dam
Klamath River
File No. 1732.1
ABBOT A. HANKS, INC.
Lab. No. 46938
May 10, 1960

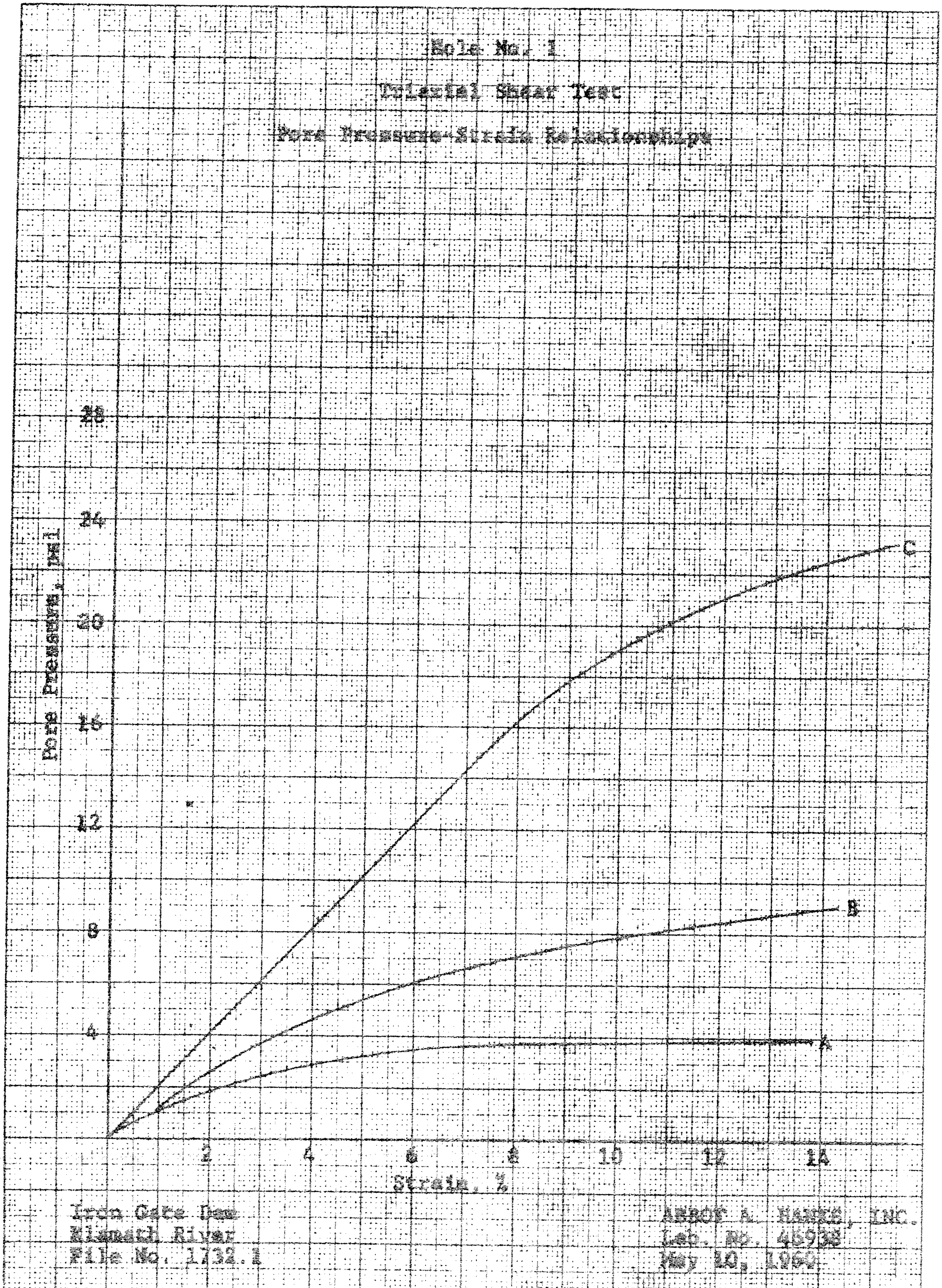


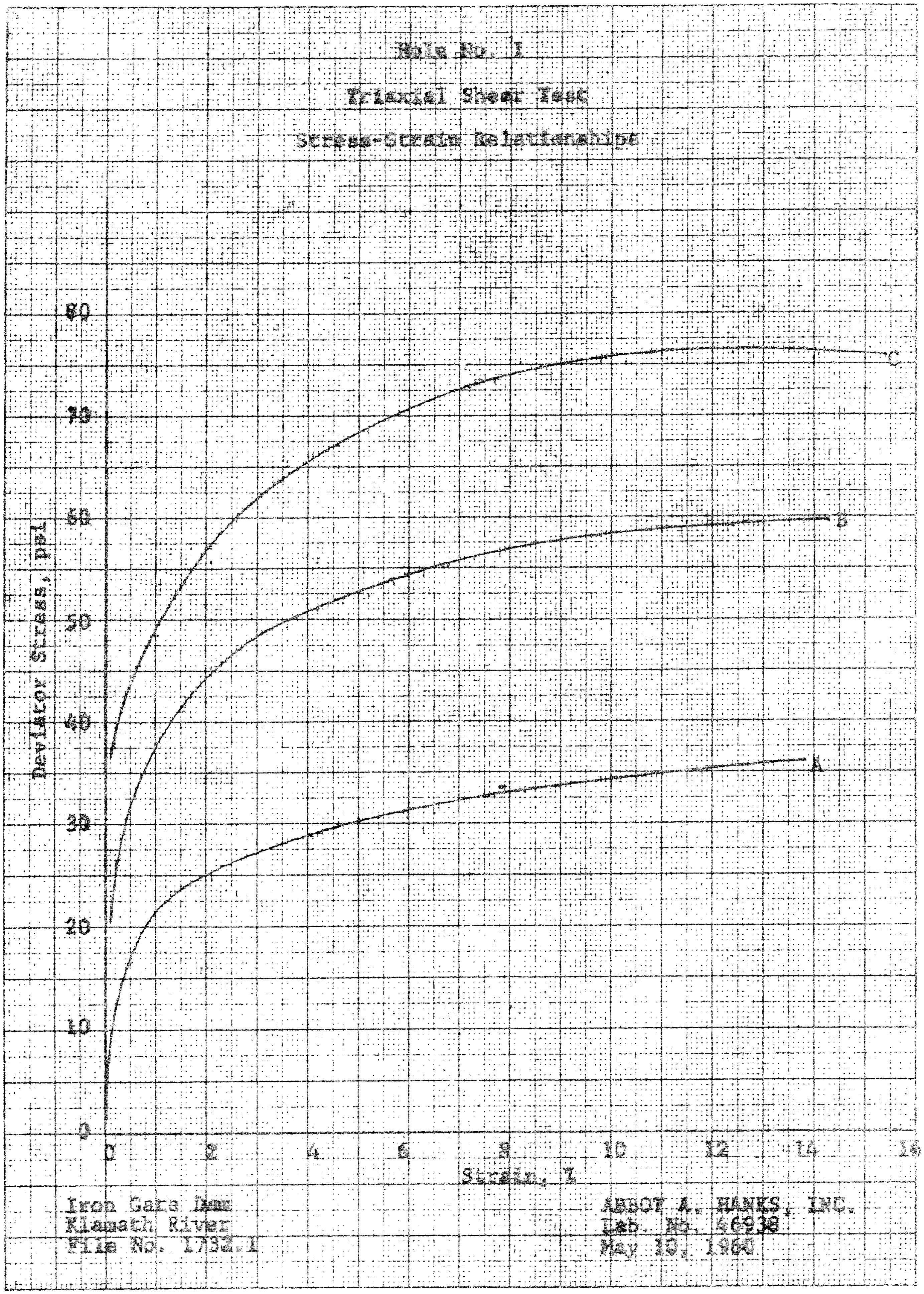
SEMI-LOGARITHMIC 359-91G
Time, min
Dial Reading, in.
.00
.01
.02
.03
.04
.05
.06
.07
1
10
100
1000
P = 2060 lb/ft2
P = 4120 lb/ft2
apparatus correction
P = 8250 lb/sq ft2
P = 16500 lb/ft2
Hole No. 1
Consolidation Test
Time Curves
ABBOT A. HANKS, INC.
Lab. No. 46938
May 10, 1960
Iron Gate Dam
File No. 1732.1



SEMI-LOGARITHMIC 359-91G
70 DIVISIONS
Time, min
1
10
100
1000
Dial Reading, in.
.06
.07
.08
.09
.10
.11
.12
Hole No. 1
Consolidation Test
Time Curves
(contd)
P - 33000 lb/ft$^2$
ABBOT A. HANKS, INC.
Lab. No. 46938
May 10, 1960
Iron Gate Dam
File No. 1732.1


SEMI LOGARITHMIC 359-71
KEUFFEL & ESSER CO.
3 CYCLES X 70 DIVISIONS
1000
10000
Pressure, lb/ft²
Compression, in./in.
.00
.02
.04
.06
.08
.10
Hole No. 1
Consolidation Test
Compacted Unit Dry Weight, lb/cu ft 102.4
Specific Gravity 2.77
Iron Gate Dam
Klamath River
File No. 1732.1
ABBOT A. HANKS, INC.
Lab. No. 46938
May 10, 1960


Hole No. 1
Triaxial Shear Test
Pore Pressure-Strain Relationships
Pore Pressure, psi
28
24
20
16
12
8
4
2
4
6
8
10
12
14
Strain, %
C
B
A
Iron Gate Dam
Klamath River
File No. 1732.1
Abbot A. Hanks, Inc.
Lab. No. 45938
May 10, 1960


Hole No. 1
Triaxial Shear Test
Stress-Strain Relationships
Deviator Stress, psi
0
10
20
30
40
50
60
70
80
A
B
C
0
2
4
6
8
10
12
14
16
Strain, %
Iron Gate Dam
Klamath River
File No. 1782.1
ABBOT A. HANKS, INC.
Lab. No. 46938
May 10, 1960

BRANCH LABORATORY 1086 MARTIN AVENUE • SANTA CLARA • CHERRY 8-3262
BRANCH OFFICE 10 DE LUCA PLACE • SAN RAFAEL • GLENWOOD 4-8650
CABLE HANX

ABBOT A. HANKS, INC.
ESTABLISHED 1866
1300 SANSOME STREET • SAN FRANCISCO 11, CALIFORNIA • EXBROOK 7-2464

*Engineers*
*Assayers*
*Chemists*
*Metallurgists*
*Spectrographers*
*Soils and Foundations*
*Consulting · Testing · Inspecting*

File No. 1732.1
Lab. No. 46938

June 29, 1960

Mr. W. L. Warren
Assistant Chief Engineer
The California Oregon Power Company
216 West Main Street
Medford, Oregon

Re: Iron Gate Dam
Soil Samples

Dear Mr. Warren:

Enclosed are results of triaxial tests that were performed on Sample No. 2 before it was noted that this sample required an exceptionally small compactive effort relative to the other samples submitted.

We are also enclosing miscellaneous test results not shown on previously submitted reports.

If you require additional tests of Sample No. 2, we should have a complete new sample of about 100 lb.

Very truly yours,

ABBOT A. HANKS, INC.

L. O. Long

L. O. Long

LOL:hms
Encls.
Reports to:
15-The California Oregon Power Company

Iron Gate Dam
Klamath River
File No. 1732.1

Abbot A. Hanks, Inc.
Lab. No. 46938
July 1, 1960

# TEST RESULTS

Hole No. 2.
Specific Gravity: 2.77.

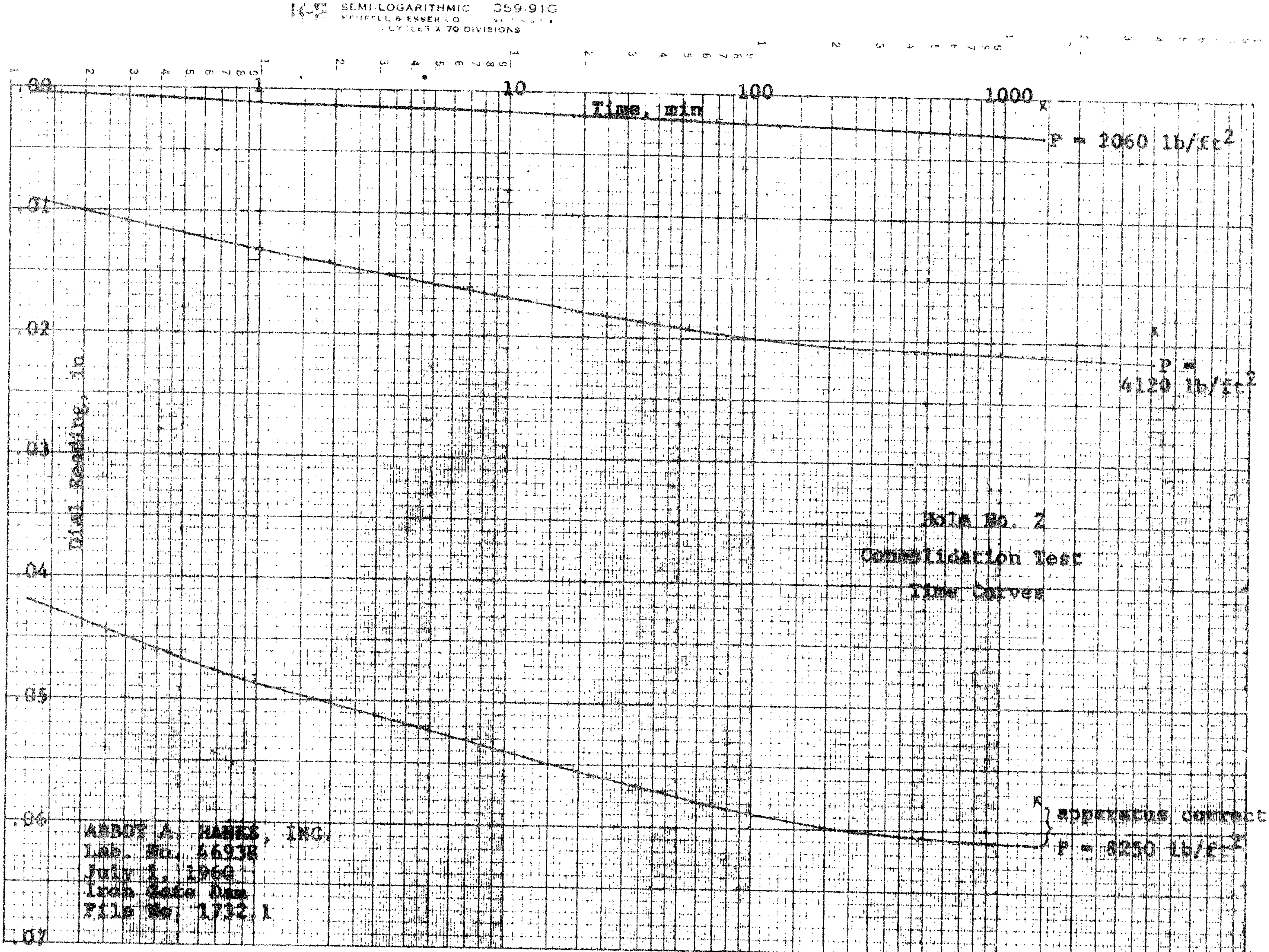
## Triaxial Shear Test

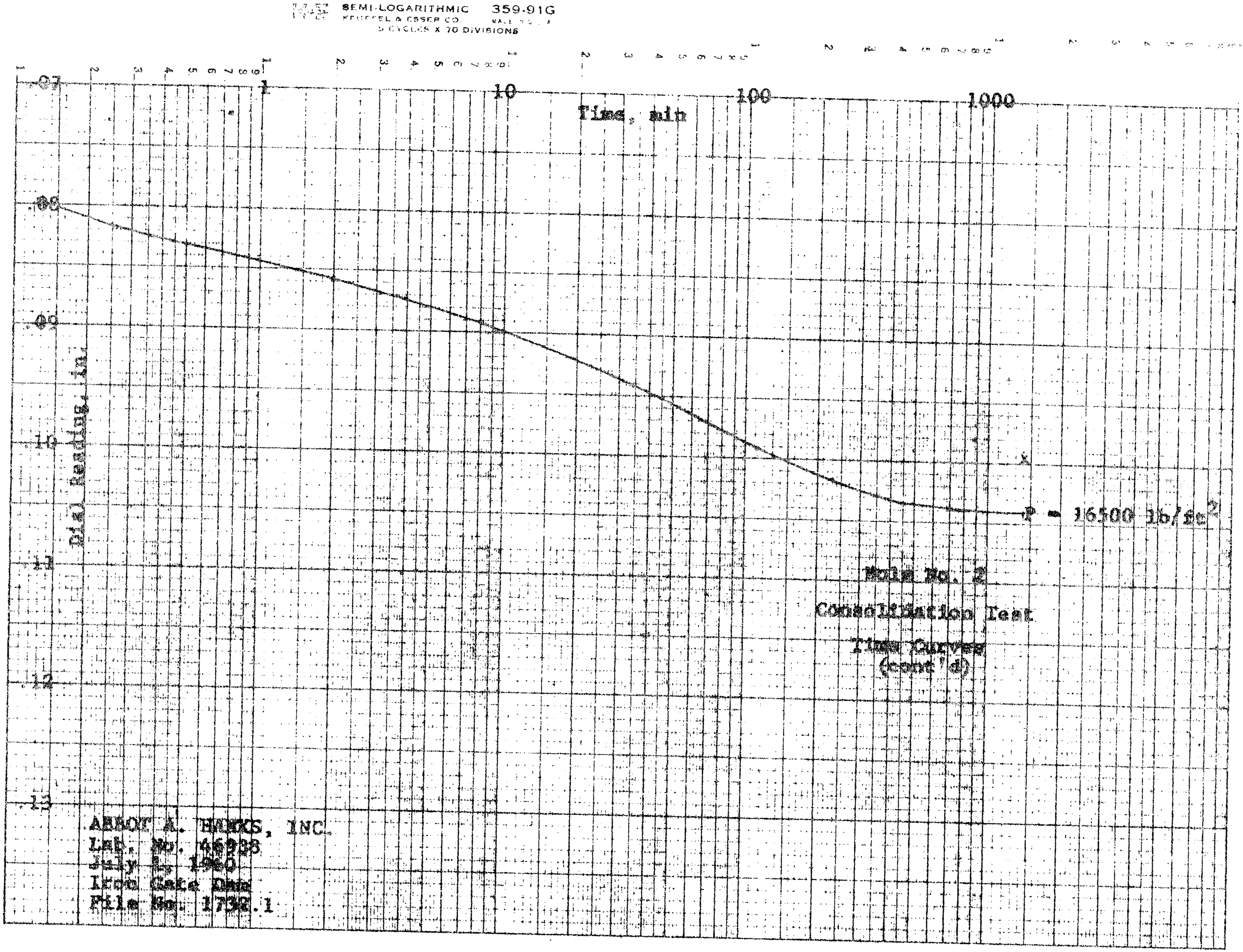
| | Sample A | Sample B | Sample C | Sample D |
|---|---|---|---|---|
| Chamber Pressure, psi | 15 | 50 | 50 | 80 |
| Unit Dry Weight at Compaction, $lb/ft^3$ | 98.0 | 95.1 | 98.8 | 99.3 |
| Moisture Content at Compaction, % | 21 | 21 | 21 | 21 |
| Unit Dry Weight at Test, $lb/ft^3$ | 99.4 | 109.0 | 106.3 | 100.2 |
| Moisture Content at Test, $lb/ft^3$ | 24.4 | 22.3 | 21.6 | 20.3 |
| Degree of Saturation at Test, % | 93 | 100+ | 97 | 93 |
| Maximum Deviator Stress, psi | 19 | 40 | 45 | 69 |
| Pore Pressure at Maximum Deviator Stress, psi | 8 | 26 | 24 | 15 |

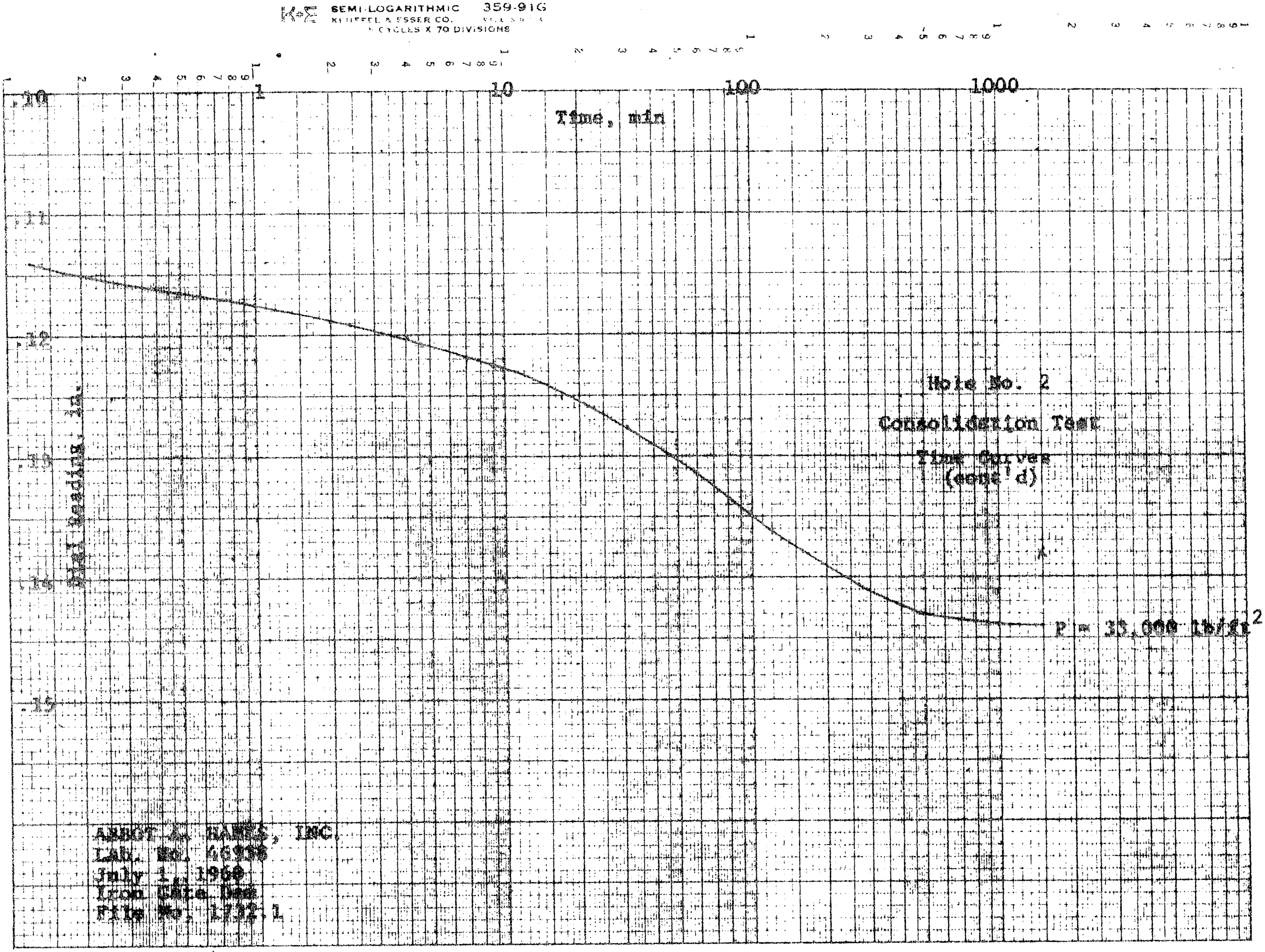
~~Perfect table~~

~~Optimum moisture 21 21~~

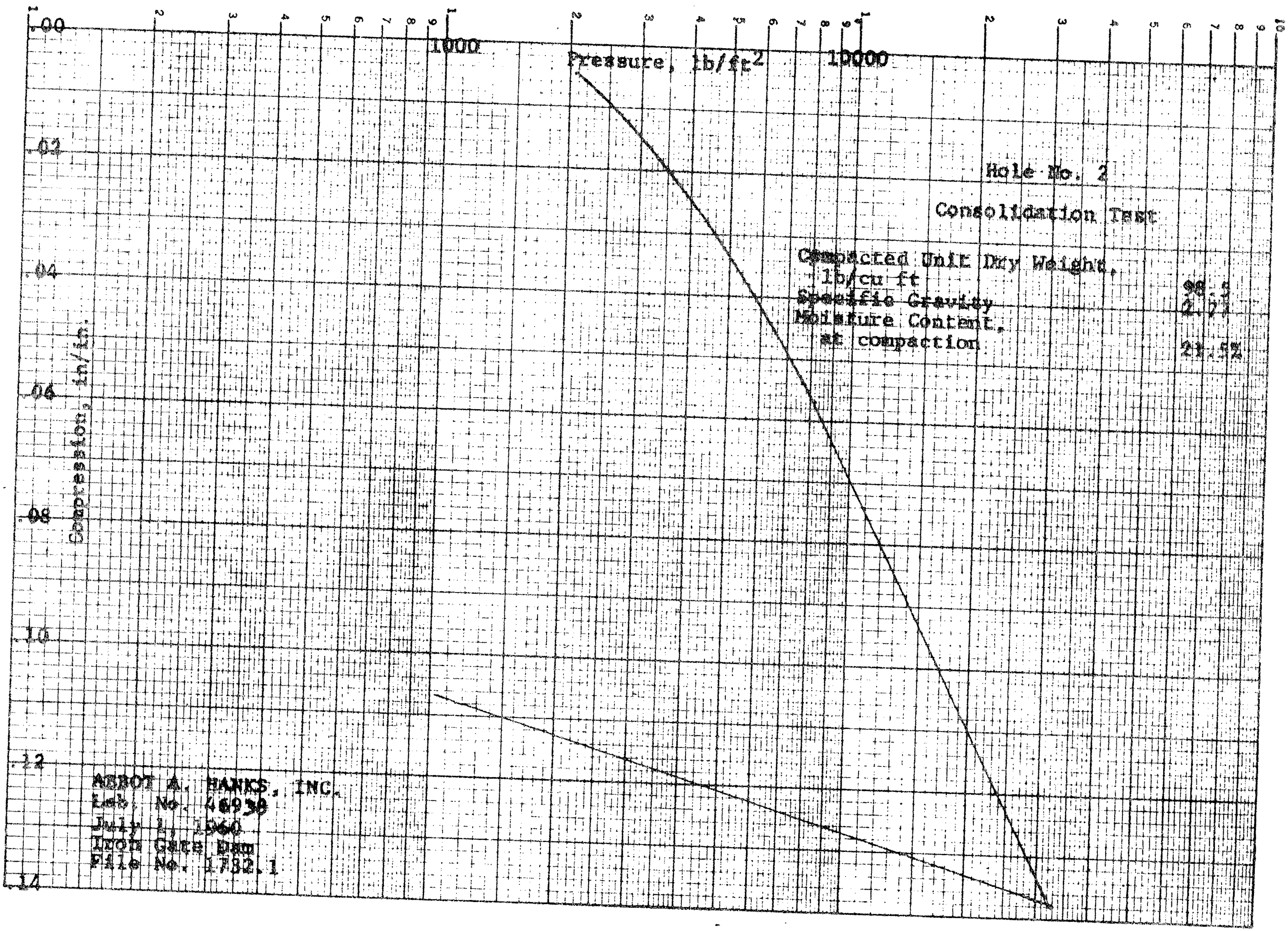
~~max dry density 102.8 103~~


SEMI-LOGARITHMIC 359-91G
KEUFFEL & ESSER CO.
3 CYCLES X 70 DIVISIONS
Time, min
1
10
100
1000
Dial Reading, in.
.00
.01
.02
.03
.04
.05
.06
.07
P = 2060 lb/ft²
P = 4120 lb/ft²
P = 8250 lb/ft²
apparatus correcti
Hole No. 2
Consolidation Test
Time Curves
ABBOT A. HANKS, INC.
Lab. No. 46938
July 1, 1960
Iron Gate Dam
File No. 1732.1


SEMI-LOGARITHMIC 359-91G
KEUFFEL & ESSER CO.
5 CYCLES X 70 DIVISIONS
Time, min
1
10
100
1000
Dial Reading, in.
.07
.08
.09
.10
.11
.12
.13
P = 16500 lb/ft2
Hole No. 2
Consolidation Test
Time Curves
(cont'd)
ABBOT A. HANKS, INC.
Lab. No. 46988
July 8, 1960
Iron Gate Dam
File No. 1732.1



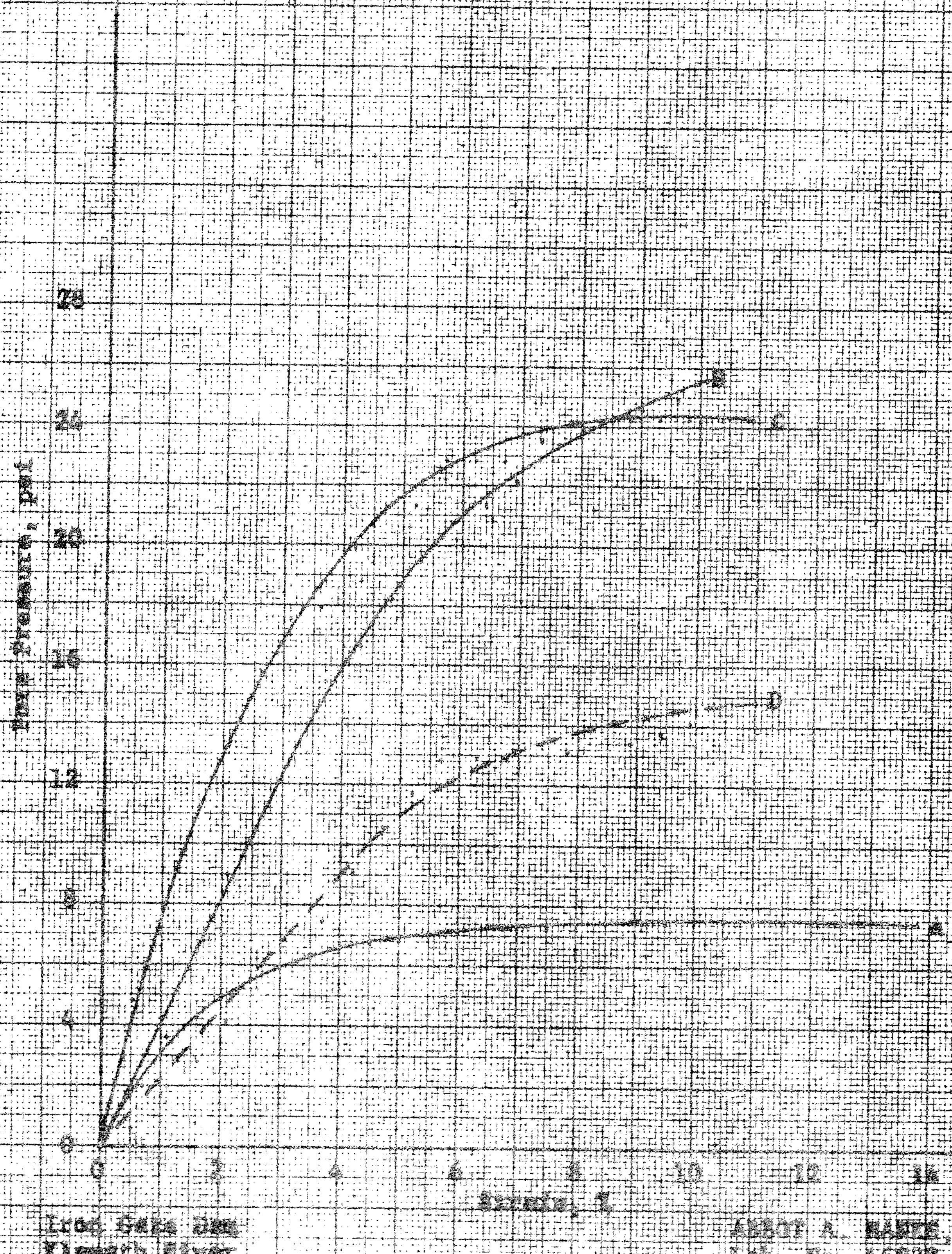
SEMI-LOGARITHMIC 359-91G
KEUFFEL & ESSER CO.
5 CYCLES X 70 DIVISIONS
Time, min
Dial Reading, in.
Hole No. 2
Consolidation Test
Time Curves
(cont'd)
P = 35,000 lb/ft²
ABBOT A. HANKS, INC.
July 1, 1960
Iron Gate Dam
File No. 1732.1


Pressure, lb/ft²
1000
10000
Compression, in/in.
.00
.02
.04
.06
.08
.10
.12
.14
Hole No. 2
Consolidation Test
Compacted Unit Dry Weight, lb/cu ft 98.3
Specific Gravity
Moisture Content, at compaction 21.5%
ABBOT A. HANKS, INC.
Lab. No.
July 1, 1960
Iron Gate Dam
File No. 1732.1

Hole No. 2

Triaxial Shear Test

Pore Pressure-Strain Relationships



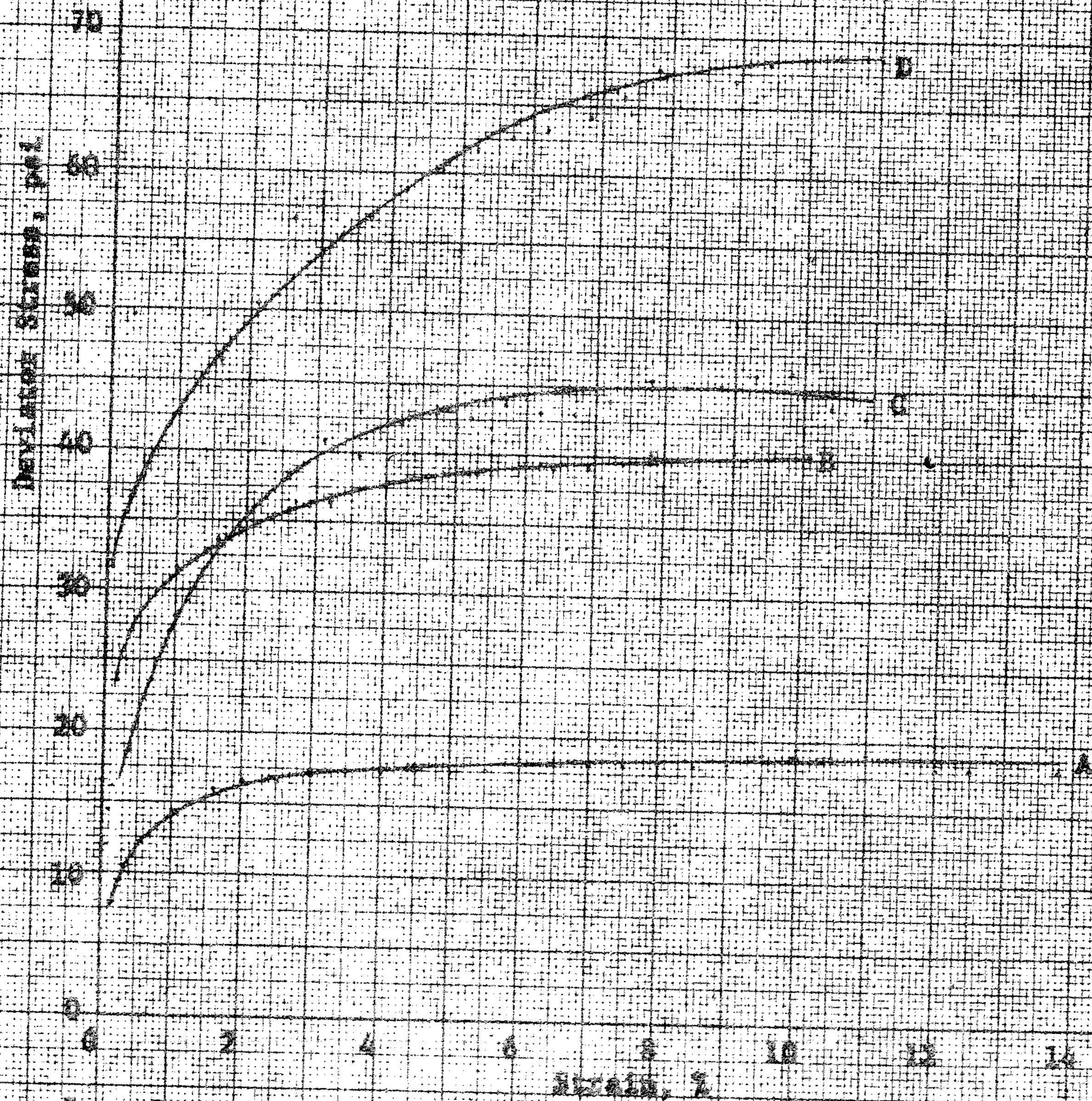

Iron Gate Dam
Klamath River
File No. 1732.1

ABBOT A. HANKS, INC.
Lab. No. [illegible]
July 1, 19[illegible]

Hole No. 2

Triaxial Shear Test

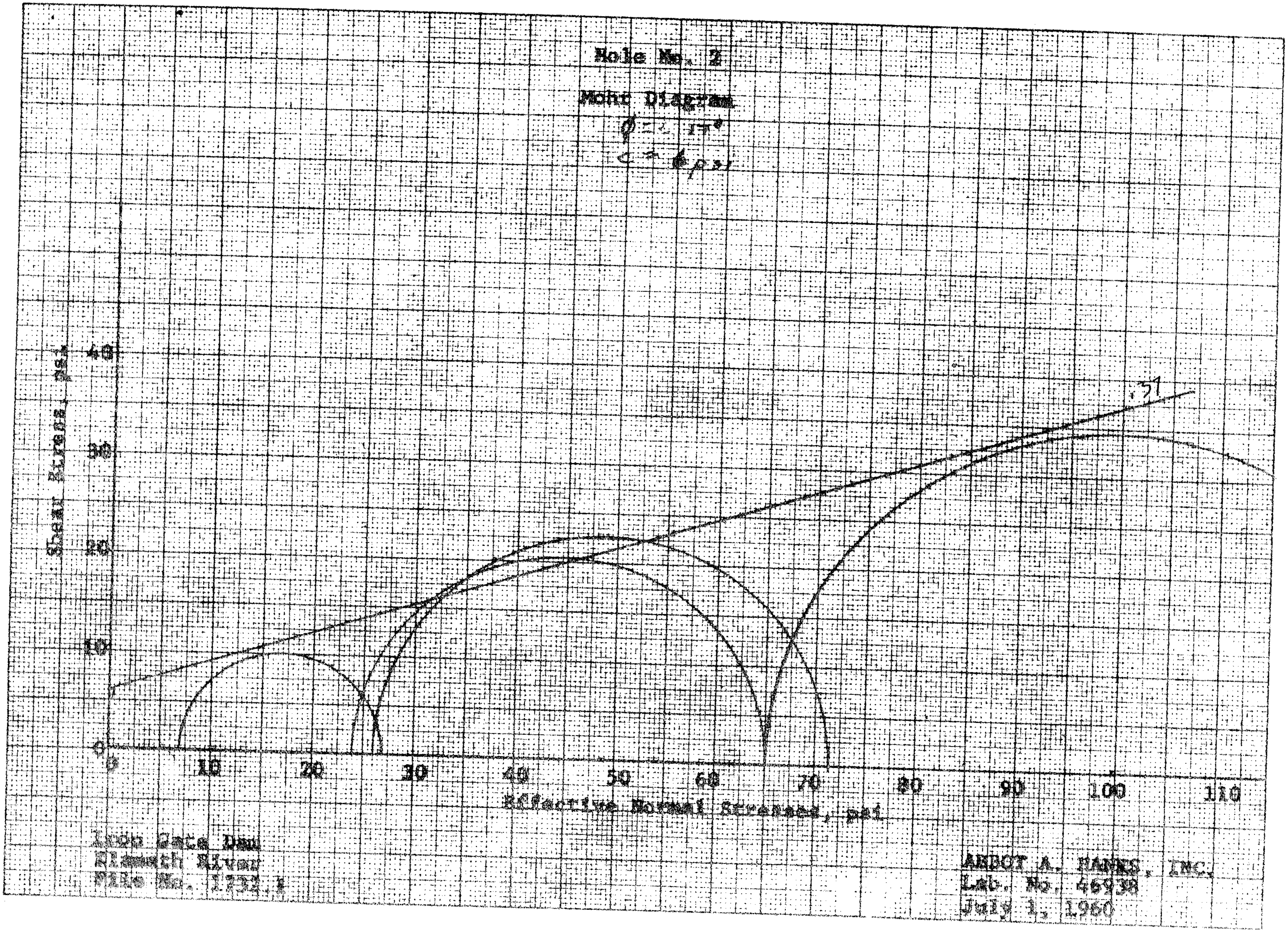
Stress-Strain Relationships




Iron Gate Dam
Klamath River
File No. 1732.1

ABBOT A. HANKS, INC.
Lab. No. 46938
July 1, 1960

K+E 10 X 10 TO THE CM. KEUFFEL & ESSER CO. 359-14G MADE IN U.S.A.



BRANCH LABORATORY 1086 MARTIN AVENUE • SANTA CLARA • CHERRY 8-5262
BRANCH OFFICE 10 DE LUCA PLACE • SAN RAFAEL • GLENWOOD 4-8650
CABLE, HANK

ABBOT A. HANKS, INC.
ESTABLISHED 1866
1300 SANSOME STREET • SAN FRANCISCO 11, CALIFORNIA • EXBROOK 7-2464

*Engineers*
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*Chemists*
*Metallurgists*
*Spectrographers*
*Soils and Foundations*
*Consulting · Testing · Inspecting*

File No. 1732.1
Lab. No. 46938

June 3, 1960

Mr. W. L. Warren
Assistant Chief Engineer
The California Oregon Power Company
216 West Main Street
Medford, Oregon

Re: Iron Gate Dam
Soil Samples

Dear Mr. Warren:

Enclosed are the findings from tests performed on soil samples marked Hole No. 3.

Very truly yours,

ABBOT A. HANKS, INC.

Donald W Radbruch

Donald W. Radbruch

hms
Encls.
Reports to:
3-The California Oregon Power Company

Iron Gate Dam
Klamath River
File No. 1732.1

Abbot A. Hanks, Inc.
Lab. No. 46938
June 3, 1960

## TEST RESULTS

Hole No. 3
Specific Gravity: 2.76

### Triaxial Shear Test

| | Samples A | Samples B | Samples C |
|---|---|---|---|
| Chamber Pressure, psi | 15 | 50 | 80 |
| Unit Dry Weight at Compaction, $lb/ft^3$ | 104.4 | 104.5 | 103.5 |
| Moisture Content at Compaction, % | 21.9 | 22.0 | 22.1 |
| Unit Dry Weight at Test, $lb/ft^3$ | 105.3 | 107.5 | 109.2 |
| Moisture Content at Test, $lb/ft^3$ | 24.0 | 22.4 | 23.5 |
| Degree of Saturation at Test, % | 100+ | 100+ | 100+ |
| Maximum Deviator Stress, psi | 34 | 59 | 79 |
| Pore Pressure at Max. Deviator Stress, psi | 2 | 5 | 2 |

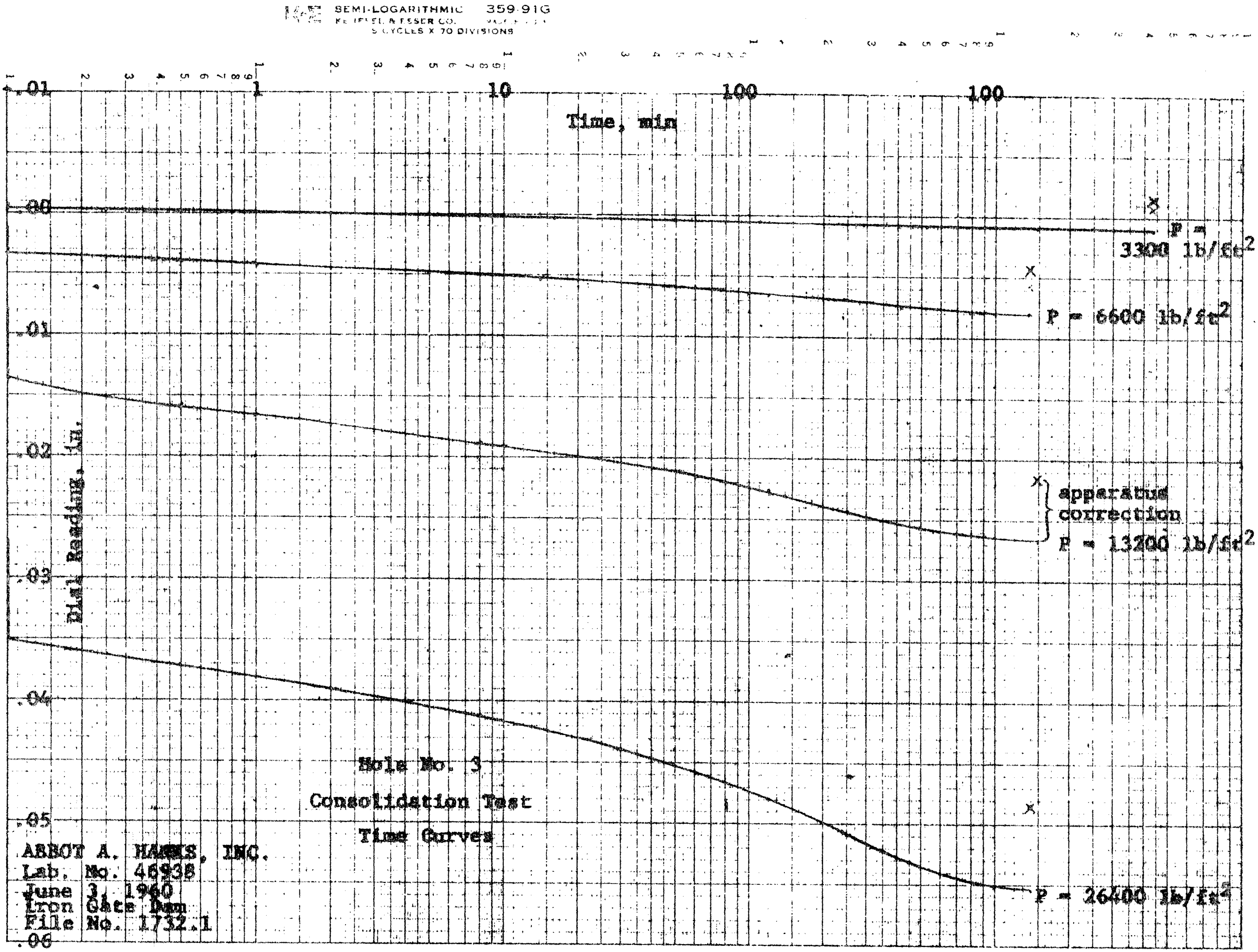
### Permeability Test
(Constant Head Test)

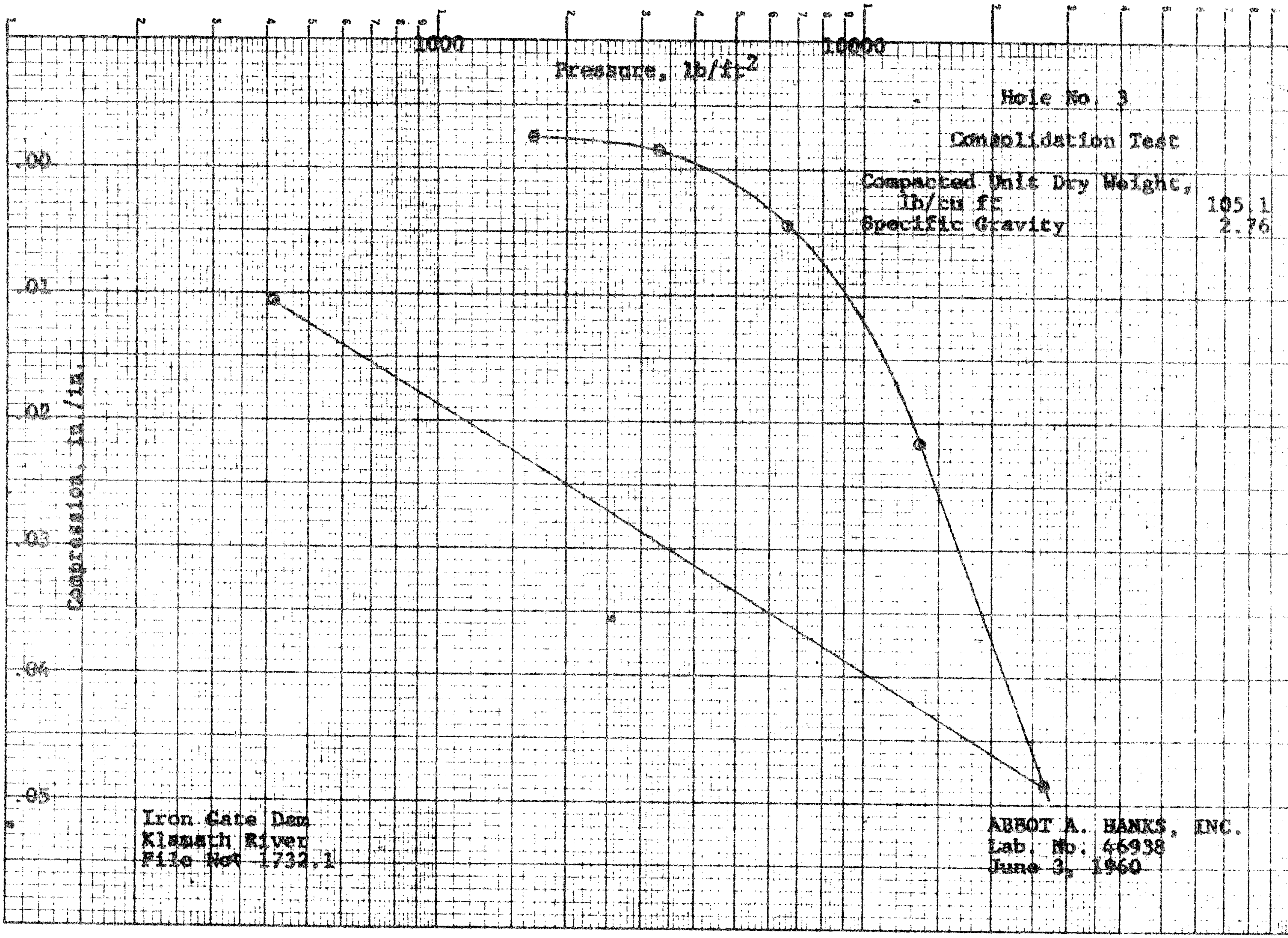
| | |
|---|---|
| Unit Dry Weight at Compaction, $lb/ft^3$ | 106.5 |
| Moisture Content at Compaction, % | 22.0 |
| Moisture Content at Test, % | 23.1 |
| Degree of Saturation at Test, % | 100+ |
| Permeability Coefficient, ft per yr | Less than .01 |
| " " , cm/sec | Less than $10^{-8}$ |

~~Report — Filter~~

~~Optimum moisture — 15.3 — 15.5~~

~~Max Dry density — 111.6 — 111.5~~

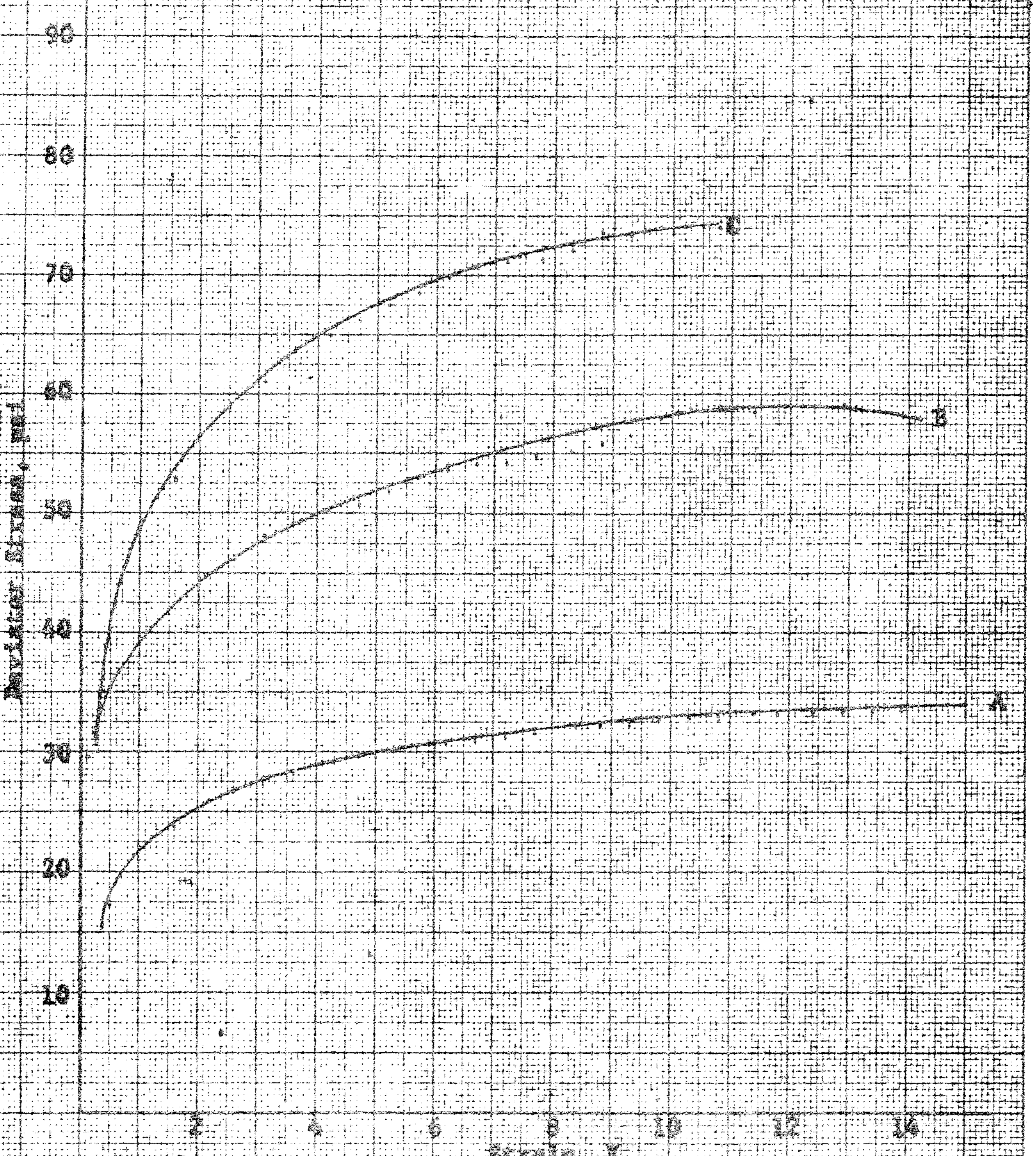

SEMI-LOGARITHMIC 359-91G
KEUFFEL & ESSER CO.
5 CYCLES X 70 DIVISIONS
.01
1
10
100
100
Time, min
.00
.01
.02
.03
.04
.05
.06
Dial Reading, in.
P = 3300 lb/ft2
P = 6600 lb/ft2
apparatus correction
P = 13200 lb/ft2
P = 26400 lb/ft2
Hole No. 3
Consolidation Test
Time Curves
ABBOT A. HANKS, INC.
Lab. No. 46938
June 3, 1960
Iron Gate Dam
File No. 1732.1


1000
10000
Pressure, lb/ft$^2$
Hole No. 3
Consolidation Test
Compacted Unit Dry Weight, lb/cu ft 105.1
Specific Gravity 2.76
.00
.01
.02
.03
.04
.05
Compression, in./in.
Iron Gate Dam
Klamath River
File No. 1732.1
ABBOT A. HANKS, INC.
Lab. No. 46938
June 3, 1960

## Hole No. 3

## Triaxial Shear Test

## Stress-Strain Relationships



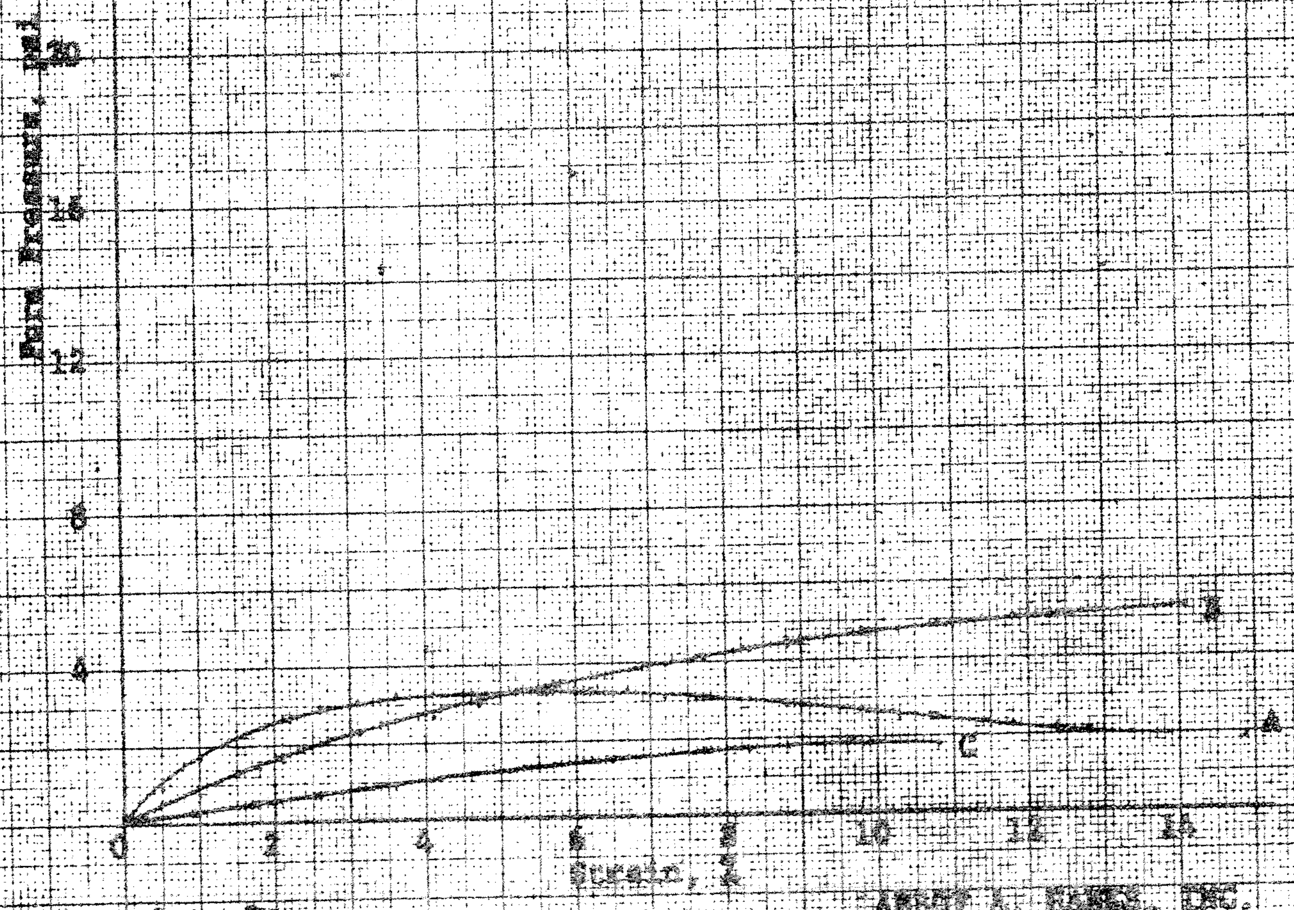

Iron Gate Dam
Klamath River
File No. 1732.1

ABBOT A. HANKS, INC.
Lab. No. 46938
June 3, 1960

Hole No. 3

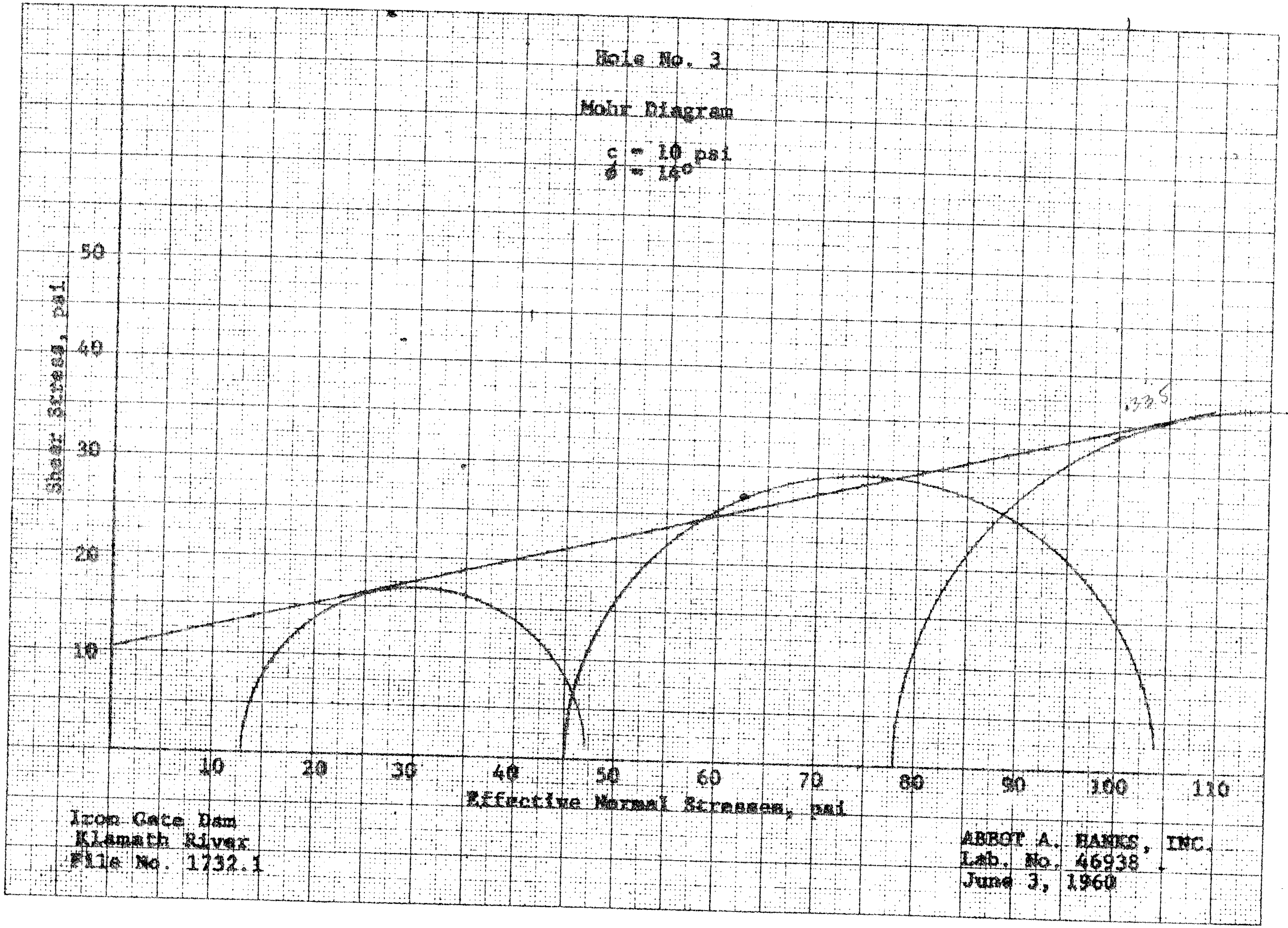
Triaxial Shear Test

Pore Pressure-Strain Relationships




Iron Gate Dam
Klamath River
File No. 1732.1

[illegible], INC.
Lab. No. [illegible]
June 2, [illegible]


Hole No. 3
Mohr Diagram
c = 10 psi
ø = 16°
Shear Stress, psi
10
20
30
40
50
.335
10
20
30
40
50
60
70
80
90
100
110
Effective Normal Stresses, psi
Iron Gate Dam
Klamath River
File No. 1732.1
ABBOT A. HANKS, INC.
Lab. No. 46938
June 3, 1960

BRANCH LABORATORY 1056 MARTIN AVENUE • SANTA CLARA • CHERRY 8-5262
BRANCH OFFICE 10 DE LUCA PLACE • SAN RAFAEL • GLENWOOD 4-8650

CABLE HANX

ABBOT A. HANKS, INC.

1300 SANSOME STREET • SAN FRANCISCO 11 CALIFORNIA • EXBROOK 7-2464

Engineers
Assayers
Chemists
Metallurgists
Spectrographers
Soils and Foundations
Consulting Testing Inspecting

File No. 1732.1
Lab. No. 46938

June 9, 1960

Mr. W. L. Warren
Assistant Chief Engineer
The California Oregon Power Company
216 West Main Street
Medford, Oregon

Re: Iron Gate Dam
Soil Samples

Dear Mr. Warren:

Enclosed are the findings from tests performed on soil samples marked Hole No. 4.

You will note that the permeability coefficient of the first sample is 3000 times the permeability coefficient of the second sample. We attribute this large difference to the differences in both density and moisture content at compaction. The second sample, compacted at 16% moisture content, appeared to be somewhat over optimum moisture.

Very truly yours,

ABBOT A. HANKS, INC.

Donald W Radbruch

Donald W. Radbruch

LOL:hms
Encls.
Reports to:
3-The California Oregon Power Company

Iron Gate Dam
Klamath River
File No. 1732.1

Abbot A. Hanks, Inc.
Lab. No. 46938
June 8, 1960

## TEST RESULTS

Hole No. 4
Specific Gravity: 2.77

### Triaxial Shear Test

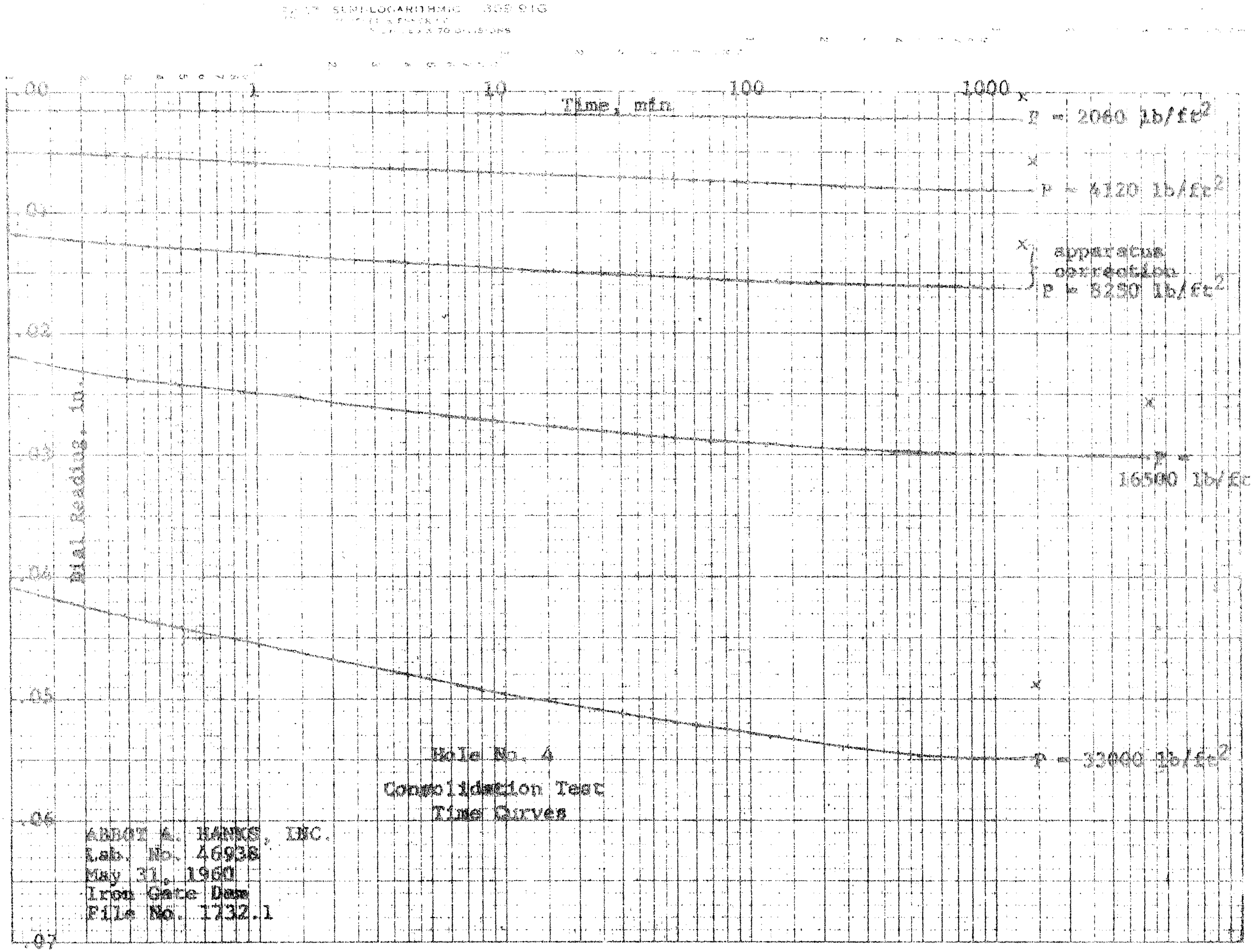
| | Sample A | Sample B | Sample C |
|---|---|---|---|
| Chamber Pressure, psi | 15 | 50 | 80 |
| Unit Dry Weight at Compaction, $lb/ft^3$ | 112.8 | 112.3 | 116.5 |
| Moisture Content at Compaction, % | 13.8 | 13.6 | 15.4 |
| Unit Dry Weight at Test, $lb/ft^3$ | 112.8 | 114.2 | 119.4 |
| Moisture Content at Test, $lb/ft^3$ | 16.5 | 17.6 | 16.0 |
| Degree of Saturation at Test, % | 87 | 96 | 100 |
| Maximum Deviator Stress, psi | 34 | 85 | 152 |
| Pore Pressure at Max. Deviator Stress, psi | 3 | 18 | 9 |

### Permeability Tests
(Constant Head Tests)

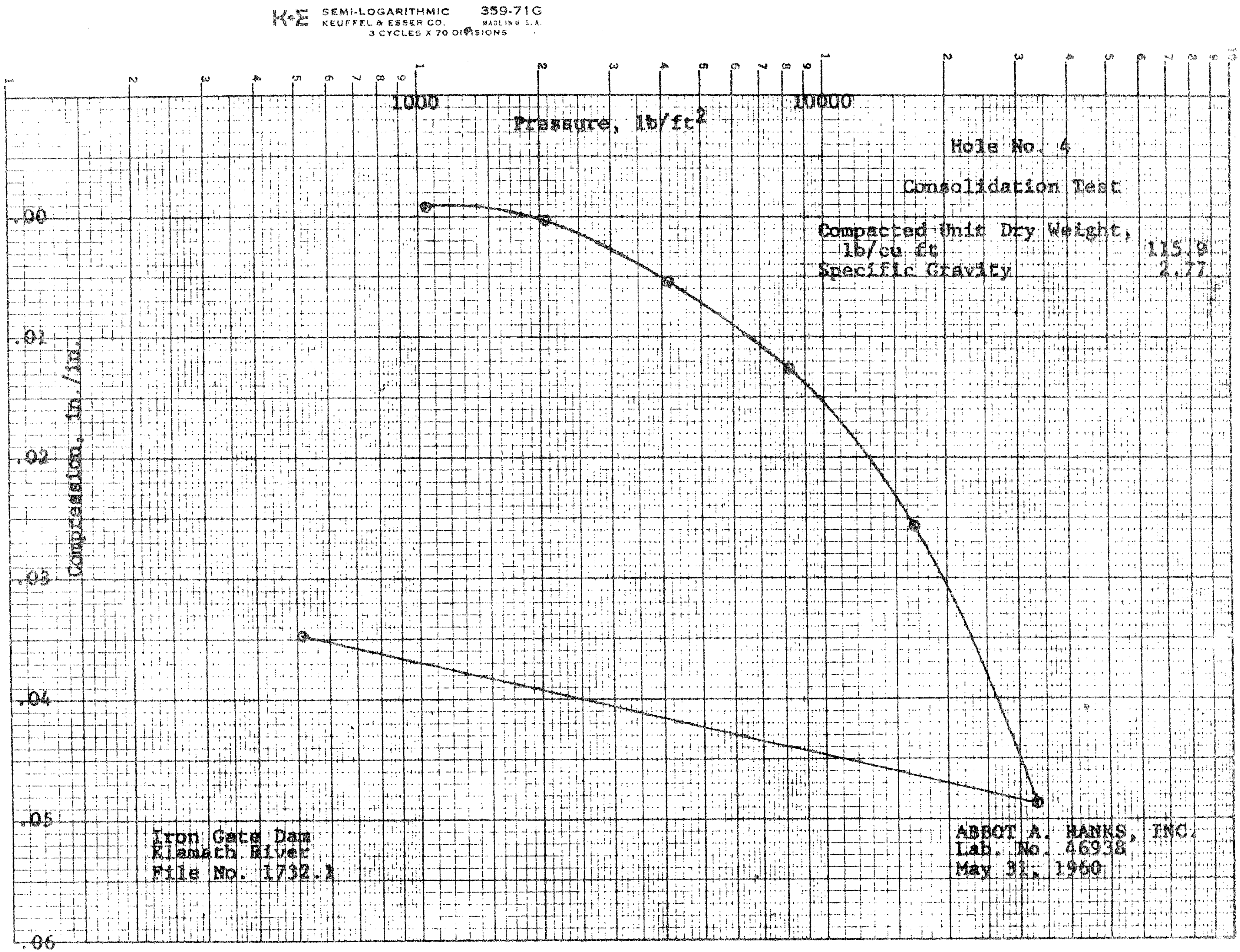
| | |
|---|---|
| Unit Dry Weight at Compaction, $lb/ft^3$ | 113.3 |
| Moisture Content at Compaction, % | 14.3 |
| Moisture Content at Test, % | 20.4 |
| Degree of Saturation at Test, % | 100+ |
| Permeability Coefficient, ft per yr | 30-40 |
| " " , cm/sec | $3\text{-}4 \times 10^{-5}$ |

| | |
|---|---|
| Unit Dry Weight at Compaction, $lb/ft^3$ | 116.2 |
| Moisture Content at Compaction, % | 16.0 |
| Moisture Content at Test, % | 17.0 |
| Degree of Saturation at Test, % | 97 |
| Permeability Coefficient, ft per yr | .01-.04 |
| " " , cm/sec | $1\text{-}4 \times 10^{-8}$ |

Report Letter
~~Optimum moisture 11.5 14-15~~
~~max dry density 115.9 115~~



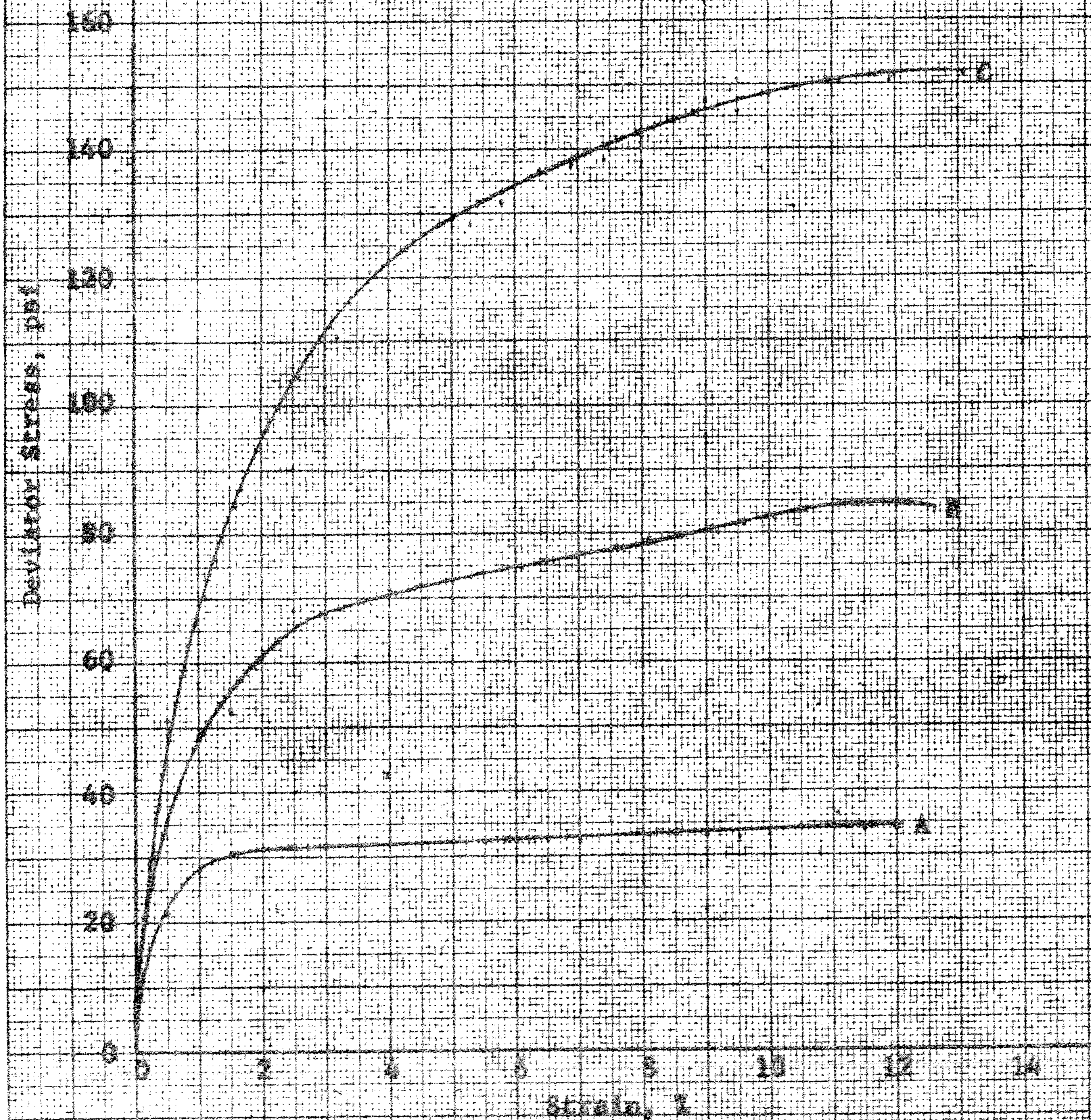
SEMI-LOGARITHMIC 358-91G
Time, min.
1
10
100
1000
Dial Reading, in.
.00
.01
.02
.03
.04
.05
.06
.07
p = 2060 lb/ft²
p = 4120 lb/ft²
apparatus correction
p = 8250 lb/ft²
p = 16500 lb/ft²
p = 33000 lb/ft²
Hole No. 4
Consolidation Test
Time Curves
ABBOT A. HANKS, INC.
Lab. No. 46938
May 31, 1960
Iron Gate Dam
File No. 1732.1


K·E SEMI-LOGARITHMIC 359-71G
KEUFFEL & ESSER CO. MADE IN U.S.A.
3 CYCLES X 70 DIVISIONS
1000
10000
Pressure, lb/ft2
Compression, in./in.
.00
.01
.02
.03
.04
.05
.06
Hole No. 4
Consolidation Test
Compacted Unit Dry Weight, lb/cu ft 115.9
Specific Gravity 2.77
Iron Gate Dam
Klamath River
File No. 1732.1
ABBOT A. HANKS, INC.
Lab. No. 46938
May 31, 1960

Hole No. 4

Triaxial Shear Test

Stress-Strain Relationships



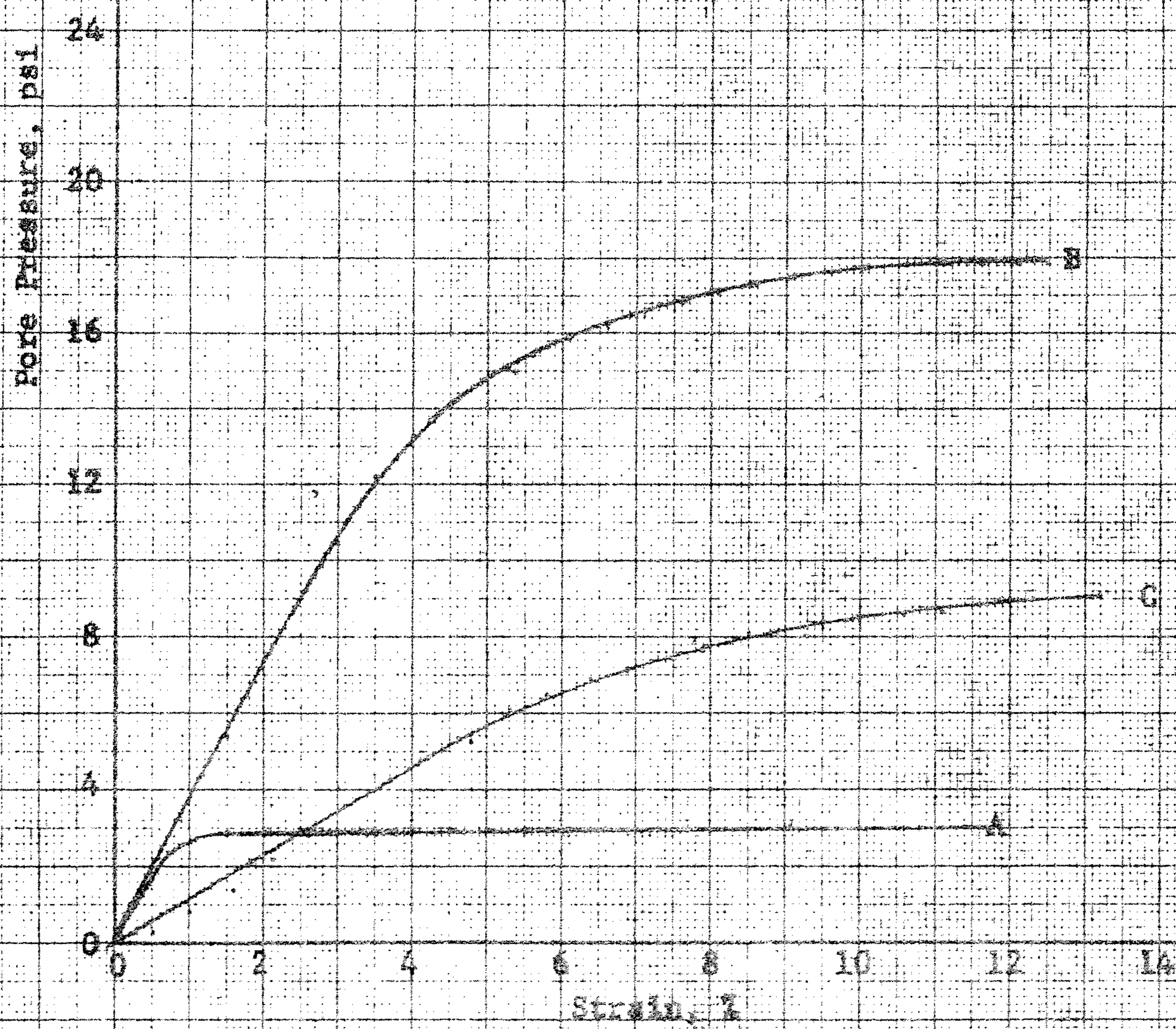

Iron Gate Dam
Klamath River
File No. 1732.1

ABBOT A. HANKS, INC.
Lab. No. 46938
May 31, 1960

Hole No. 4

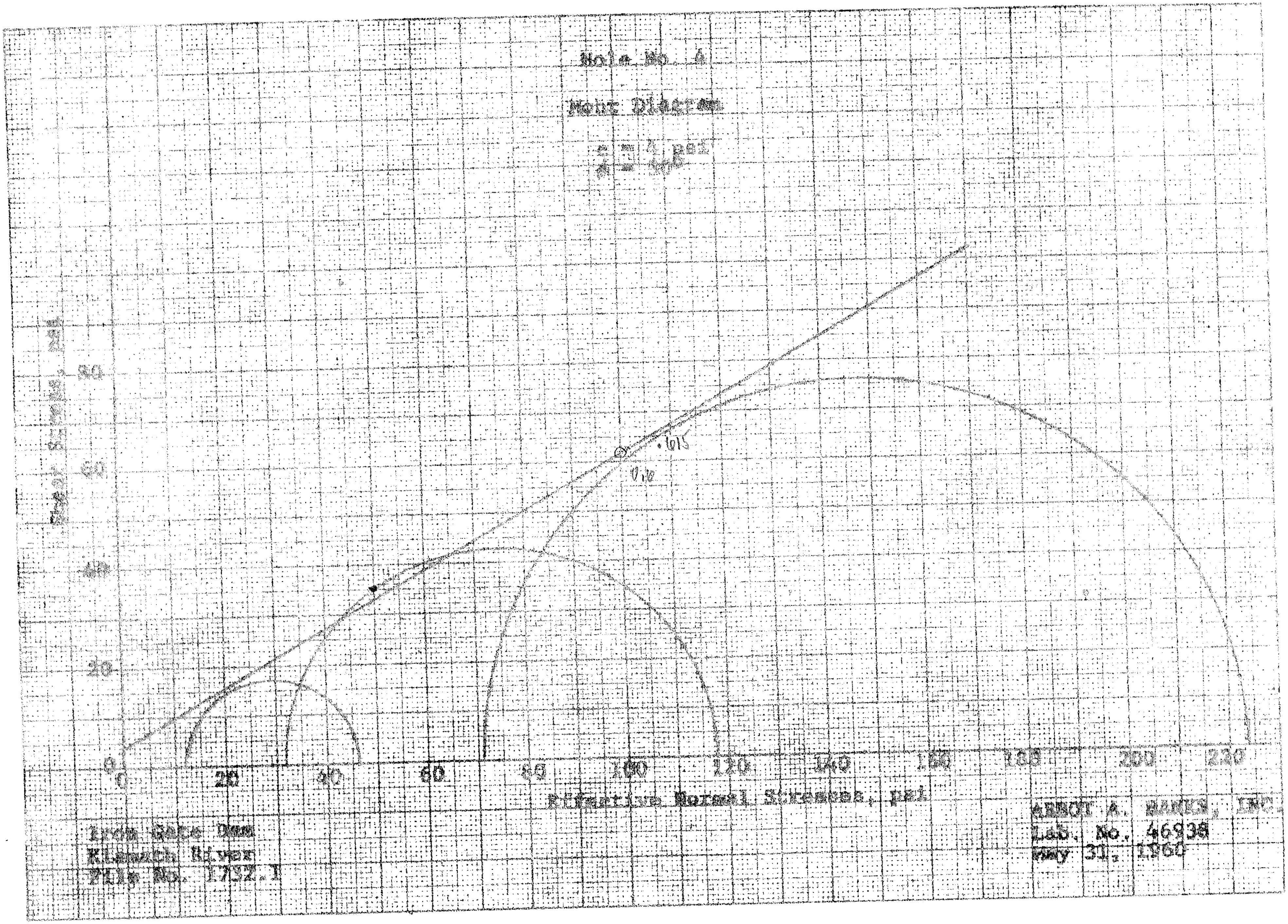
Triaxial Shear Test

Pore Pressure-Strain Relationships




Iron Gate Dam
Klamath River
File No. 1732.1

ABBOT A. HANKS, INC.
Lab. No. 46938
May 31, 1960


Hole No. A
Mohr Diagram
Shear Stress, psi
0
20
40
60
80
0
20
40
60
80
100
120
140
160
180
200
220
Effective Normal Stresses, psi
.615
Iron Gate Dam
Klamath River
File No. 1732.1
ABBOT A. HANKS, INC.
Lab. No. 46938
May 31, 1960

BRANCH LABORATORY 1085 MARTIN AVENUE · SANTA CLARA · CHERRY · · · · CABLE HANK
BRANCH OFFICE 10 DE LUCA PLACE · SAN RAFAEL · GLENWOOD 4 · · ·

ABBOT A. HANKS, INC.
ESTABLISHED 1866
1300 SANSOME STREET · SAN FRANCISCO 11 CALIFORNIA · EXBROOK 2 2464

Engineers
Assayers
Chemists
Metallurgists
Spectrographers
Soils and Foundations
Consulting · Testing · Inspecting

File No. 1732.1
Lab. No. 46938

June 9, 1960

Mr. W. L. Warren
Assistant Chief Engineer
The California Oregon Power Company
216 West Main Street
Medford, Oregon

Re: Iron Gate Dam
Soil Samples

Dear Mr. Warren:

Enclosed are the findings from tests performed on soil samples marked Hole No. 7.

Very truly yours,

ABBOT A. HANKS, INC.

Donald W Radbruch

Donald W. Radbruch

hms
Encls.
Reports to:
3-The California Oregon Power Company

Iron Gate Dam
Klamath River
File No. 1732.1

Abbot A. Hanks, Inc.
Lab. No. 46938
June 9, 1960

## TEST RESULTS

Hole No. 7
Specific Gravity: 2.74

### Triaxial Shear Test

| | Samples A | B | C | D |
|---|---|---|---|---|
| Chamber Pressure, psi | 15 | 50 | 80 | 80 |
| Unit Dry Weight at Compaction, $lb/ft^3$ | 109.1 | 110.0 | 110.0 | 109.3 |
| Moisture Content at Compaction, % | 17.6 | 17.3 | 19.0 | 19.3 |
| Unit Dry Weight at Test, $lb/ft^3$ | 106.7 | 111.5 | 114.7 | 114.8 |
| Moisture Content at Test, $lb/ft^3$ | 22.6 | 19.3 | 18.7 | 19.8 |
| Degree of Saturation at Test, % | 100+ | 100 | 100 | 100+ |
| Maximum Deviator Stress, psi | 22 | 67 | 77 | 79 |
| Pore Pressure at Max. Deviator Stress, psi | 6 | 12 | 23 | 17 |

### Permeability Test
(Constant Head Test)

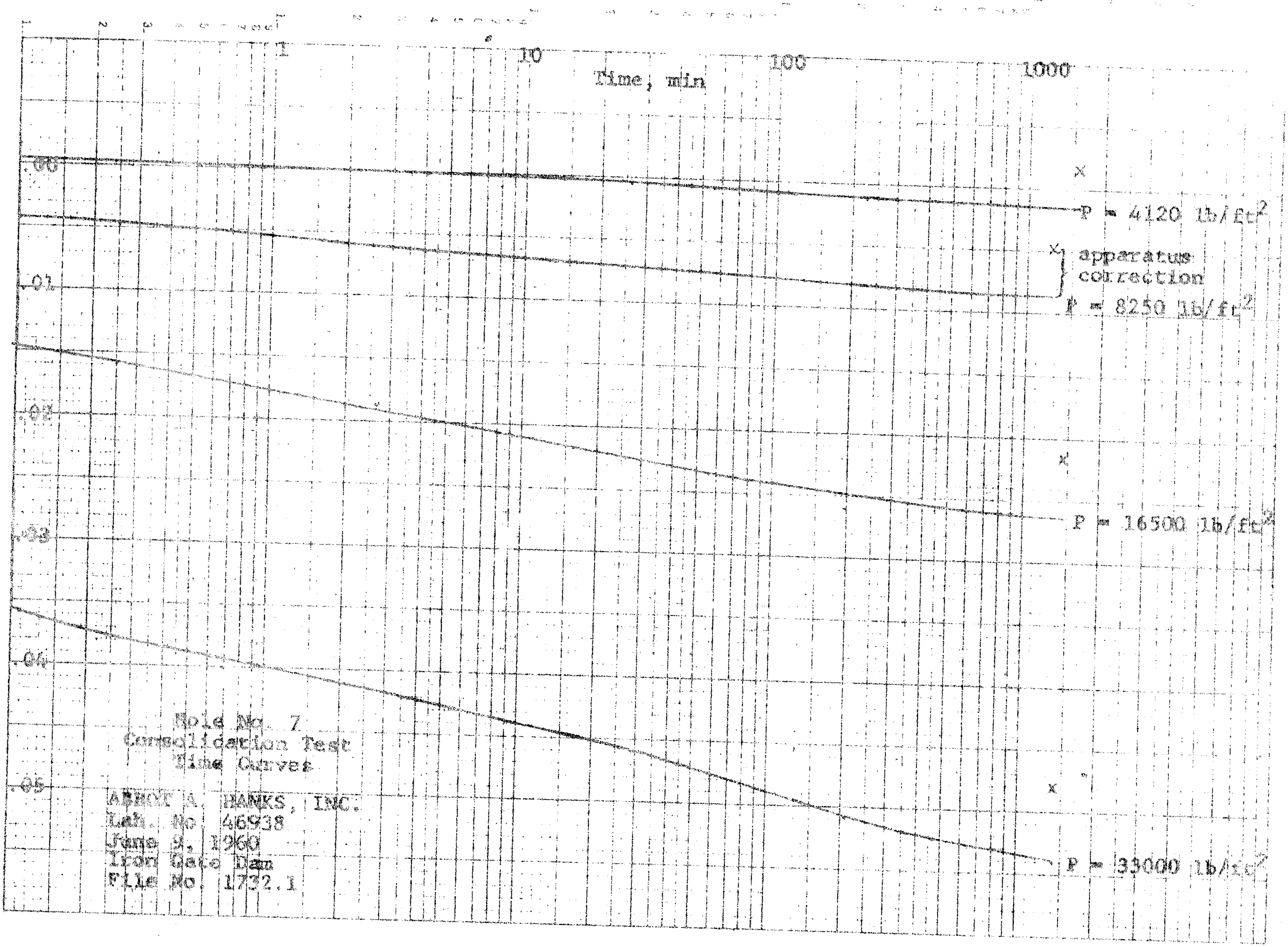
| | |
|---|---|
| Unit Dry Weight at Compaction, $lb/ft^3$ | 109.3 |
| Moisture Content at Compaction, % | 17.8 |
| Moisture Content at Test, % | 19.7 |
| Degree of Saturation at Test, % | 96 |
| Permeability Coefficient, ft per yr | Less than .01 |
| " " , cm/sec | Less than $10^{-8}$ |

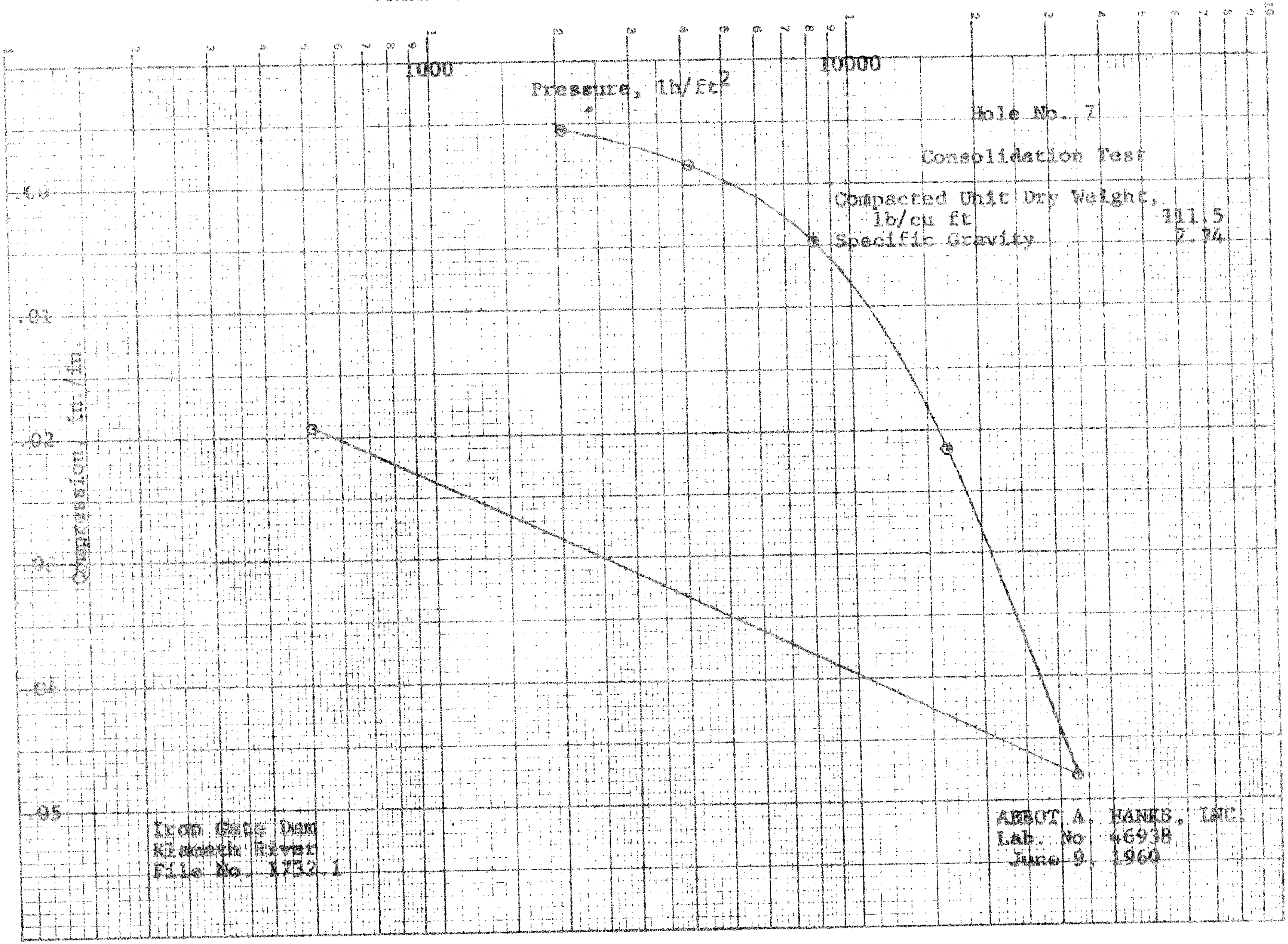
~~Letter~~ Report ~~a~~ Letter

~~Optimum moisture~~ 15.2 15

Max. ~~Dry density~~ 117.6 116.0

SEMI-LOGARITHMIC 359-91C

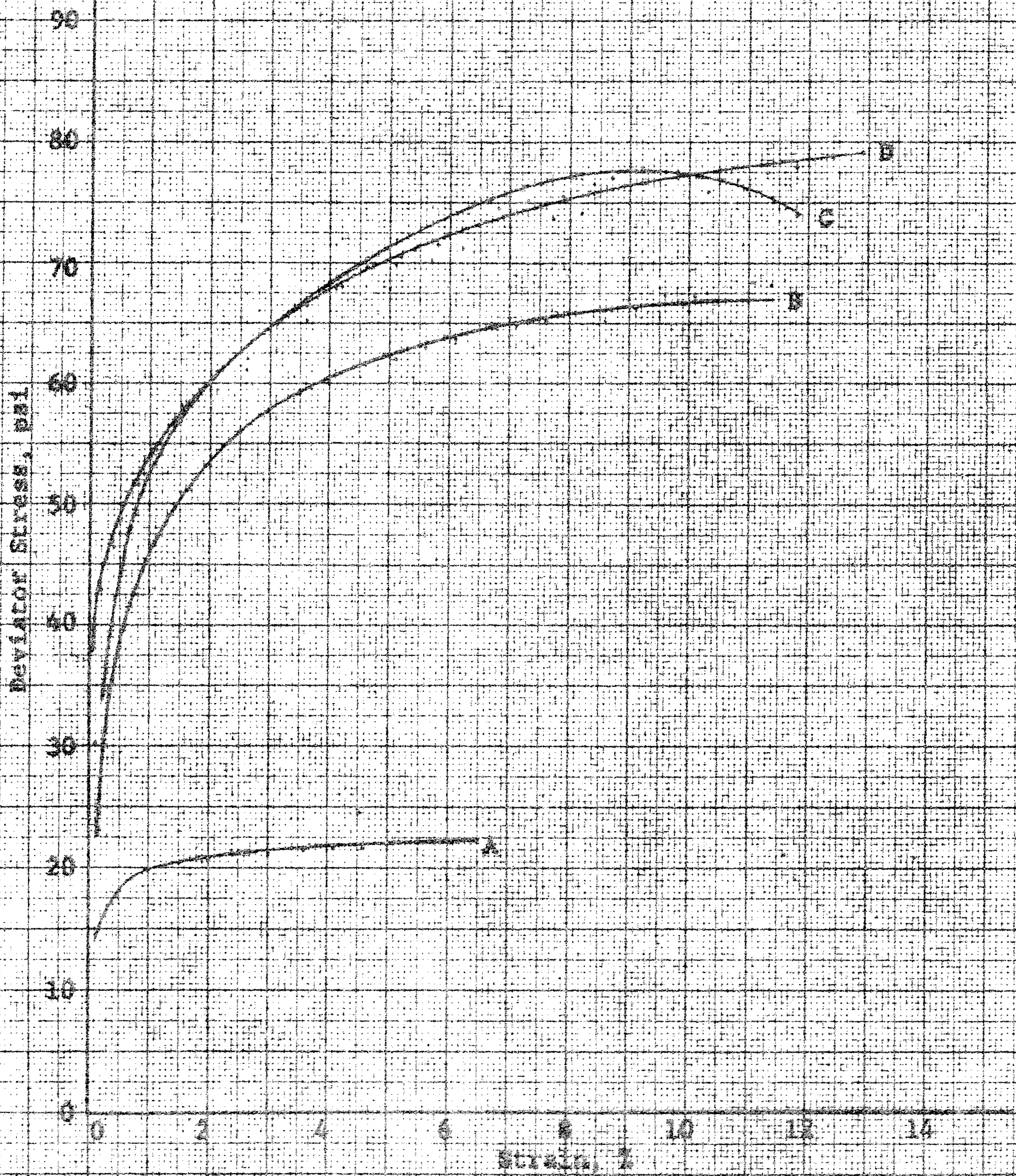



1000
10000
Pressure, lb/ft2
Compression, in./in.
.00
.01
.02
.03
.04
.05
Hole No. 7
Consolidation Test
Compacted Unit Dry Weight, lb/cu ft 111.5
Specific Gravity 2.74
Iron Gate Dam
Klamath River
File No. 1732.1
ABBOT A. HANKS, INC.
Lab. No 46938
June 9, 1960

Hole No. 7

Triaxial Shear Test

Stress-Strain Relationships



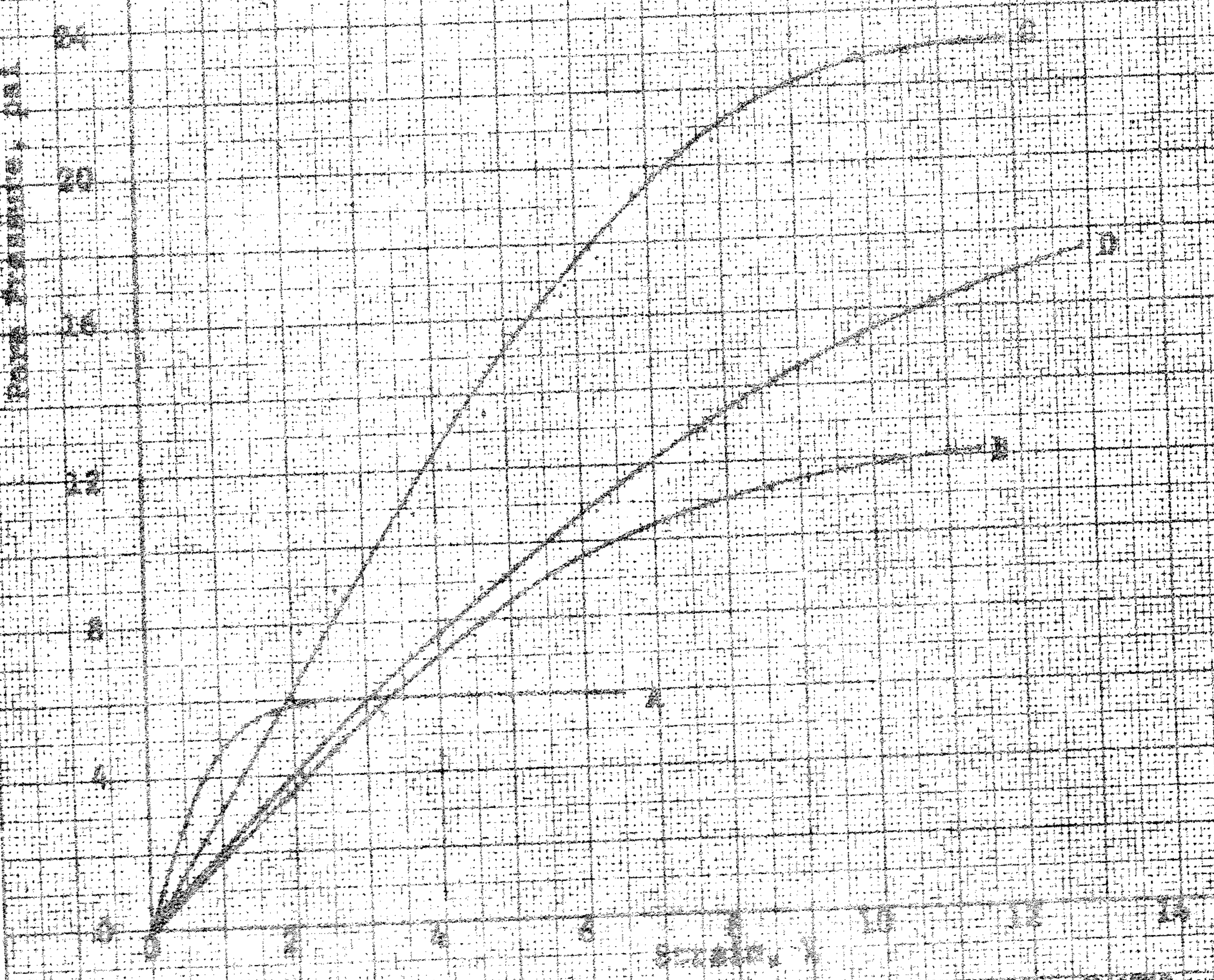

Iron Gate Dam
Klamath River
File No. 1732.7

Abbot A. Hanks, Inc.
Lab. No. 46836
June 9, 1960

Hole No. 7

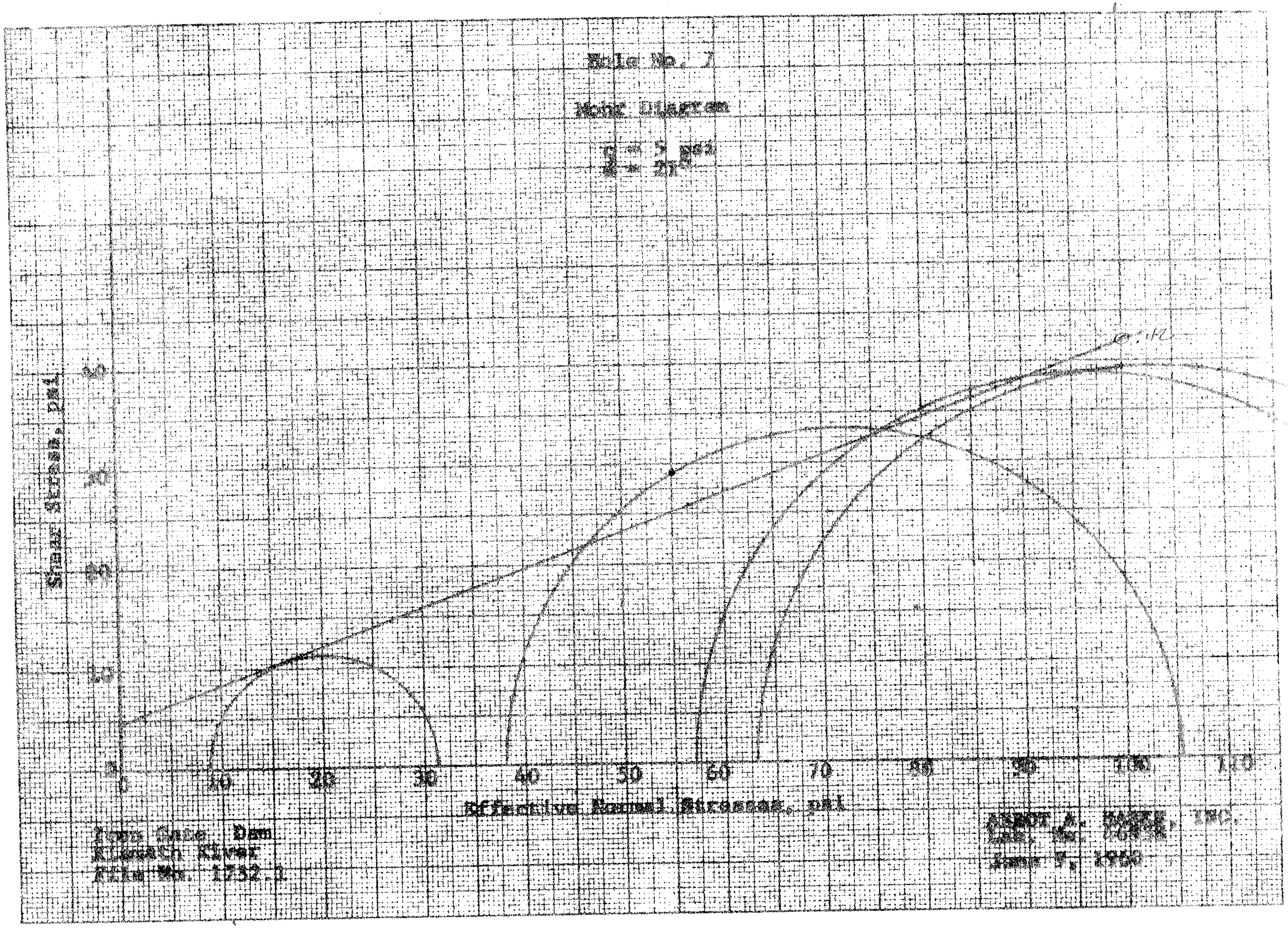
Triaxial Shear Test

Pore Pressure-Strain Relationships




Iron Gate Dam
Klamath River
File No. 1732.1

ABBOT A. HANKS, INC.
Lab. No. 64935
June 9, 1960


Hole No. 7
Mohr Diagram
Shear Stress, psi
10
20
30
40
0
10
20
30
40
50
60
70
80
90
100
110
Effective Normal Stress, psi
Iron Gate Dam
Klamath River
File No. 1732.1
INC.
1960

BRANCH LABORATORY 1080 MARTIN AVENUE • SANTA CLARA • CHERRY [illegible]
BRANCH OFFICE 10 DE LOLA PLACE • SAN RAFAEL • GLENWOOD 4 [illegible]

CABLE HANKS

**ABBOT A. HANKS, INC.**

1300 SANSOME STREET • SAN FRANCISCO 11 CALIFORNIA • EXBROOK [illegible]

Engineers
Assayers
Chemists
Metallurgists
Spectrographers
Soils and Foundations
Consulting Testing Inspecting

File No. 1732.1
Lab. No. 46938

May 24, 1960

Mr. W. L. Warren
Assistant Chief Engineer
The California Oregon Power Company
216 West Main Street
Medford, Oregon

Re: Iron Gate Dam
Soil Samples

Dear Mr. Warren:

Enclosed are the findings from tests performed on soil samples marked Hole No. 8.

Very truly yours,

ABBOT A. HANKS, INC.

Donald W Radbruch

Donald W. Radbruch

hms
Encls.
Reports to:
3-The California Oregon Power Company

Iron Gate Dam
Klamath River
File No. 1732.1

Abbot A. Hanks, Inc.
Lab. No. 46938
May 18, 1960

## TEST RESULTS

Hole No. 8
Specific Gravity: 2.75

### Triaxial Shear Test

| | Sample A | Sample B | Sample C |
|---|---|---|---|
| Chamber Pressure, psi | 15 | 50 | 80 |
| Unit Dry Weight at Compaction, $lb/ft^3$ | 98.6 | 99.7 | 98.9 |
| Moisture Content at Compaction, % | 19.9 | 19.9 | 20.1 |
| Unit Dry Weight at Test, $lb/ft^3$ | 95.4 | 100.6 | 102.9 |
| Moisture Content at Test, $lb/ft^3$ | 28.4 | 26.1 | 25.0 |
| Degree of Saturation at Test, % | 98 | 100+ | 100+ |
| Maximum Deviator Stress, psi | 21 | 48 | 66 |
| Pore Pressure at Max. Deviator Stress, psi | 5 | 13 | 30 |

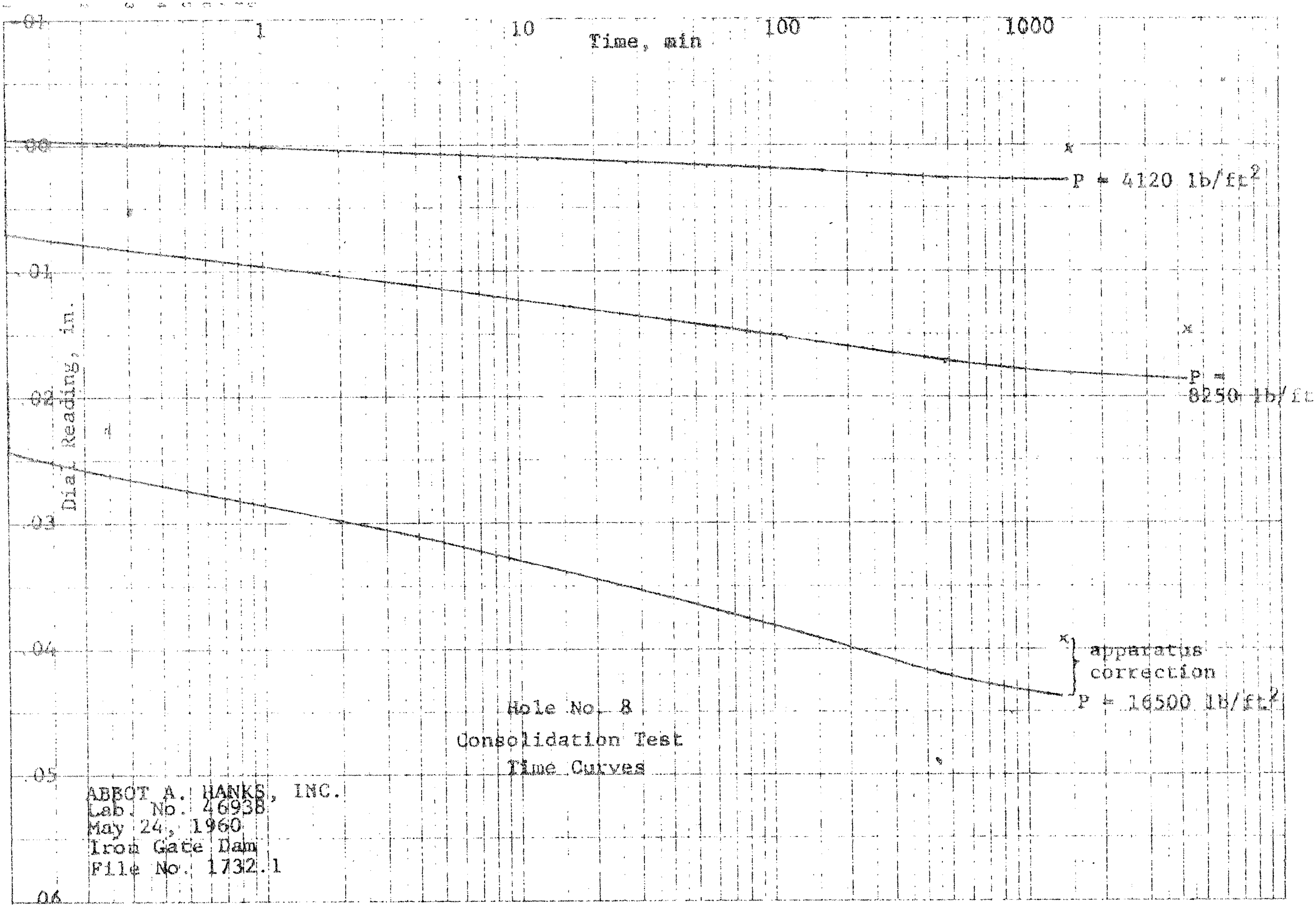
### Permeability Test
(Constant Head Test)

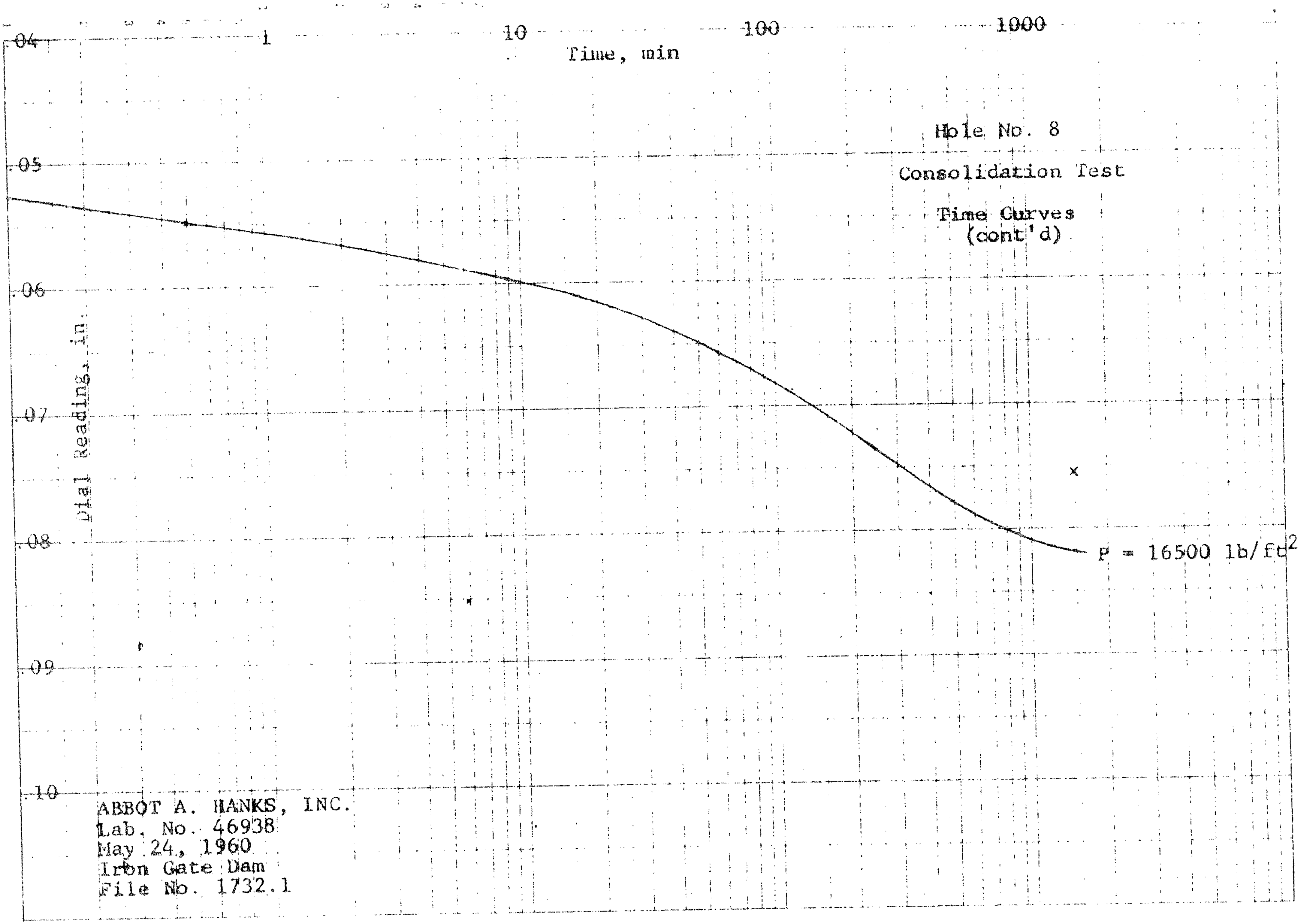
| | |
|---|---|
| Unit Dry Weight at Compaction, $lb/ft^3$ | 100.8 |
| Moisture Content at Compaction, % | 21.1 |
| Moisture Content at Test, % | 25.4 |
| Degree of Saturation at Test, % | 100 |
| Permeability Coefficient, ft per yr | Less than .01 |
| " " , cm/sec | Less than 10-8 |

~~Report~~ letter

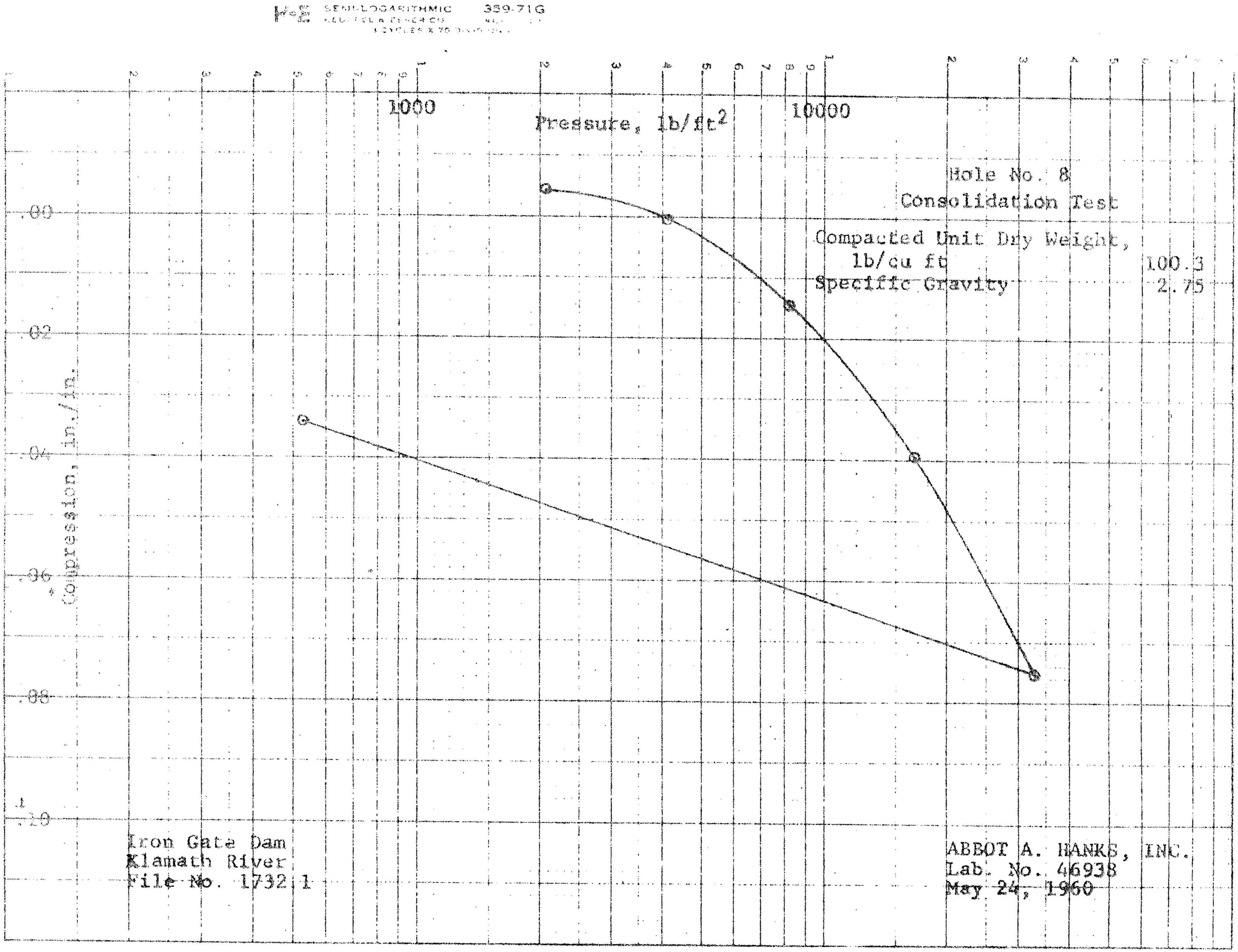
~~optimum moisture~~ 17.2 17.5

max. dry density ~~107.8 100.0~~


Time, min
1
10
100
1000
Dial Reading, in.
.00
.01
.02
.03
.04
.05
.06
P = 4120 lb/ft²
P = 8250 lb/ft
apparatus correction
P = 16500 lb/ft²
Hole No. 8
Consolidation Test
Time Curves
ABBOT A. HANKS, INC.
Lab. No. 46938
May 24, 1960
Iron Gate Dam
File No. 1732.1



Time, min
1
10
100
1000
Dial Reading, in.
.04
.05
.06
.07
.08
.09
.10
p = 16500 lb/ft$^2$
Hole No. 8
Consolidation Test
Time Curves
(cont'd)
ABBOT A. HANKS, INC.
Lab. No. 46938
May 24, 1960
Iron Gate Dam
File No. 1732.1

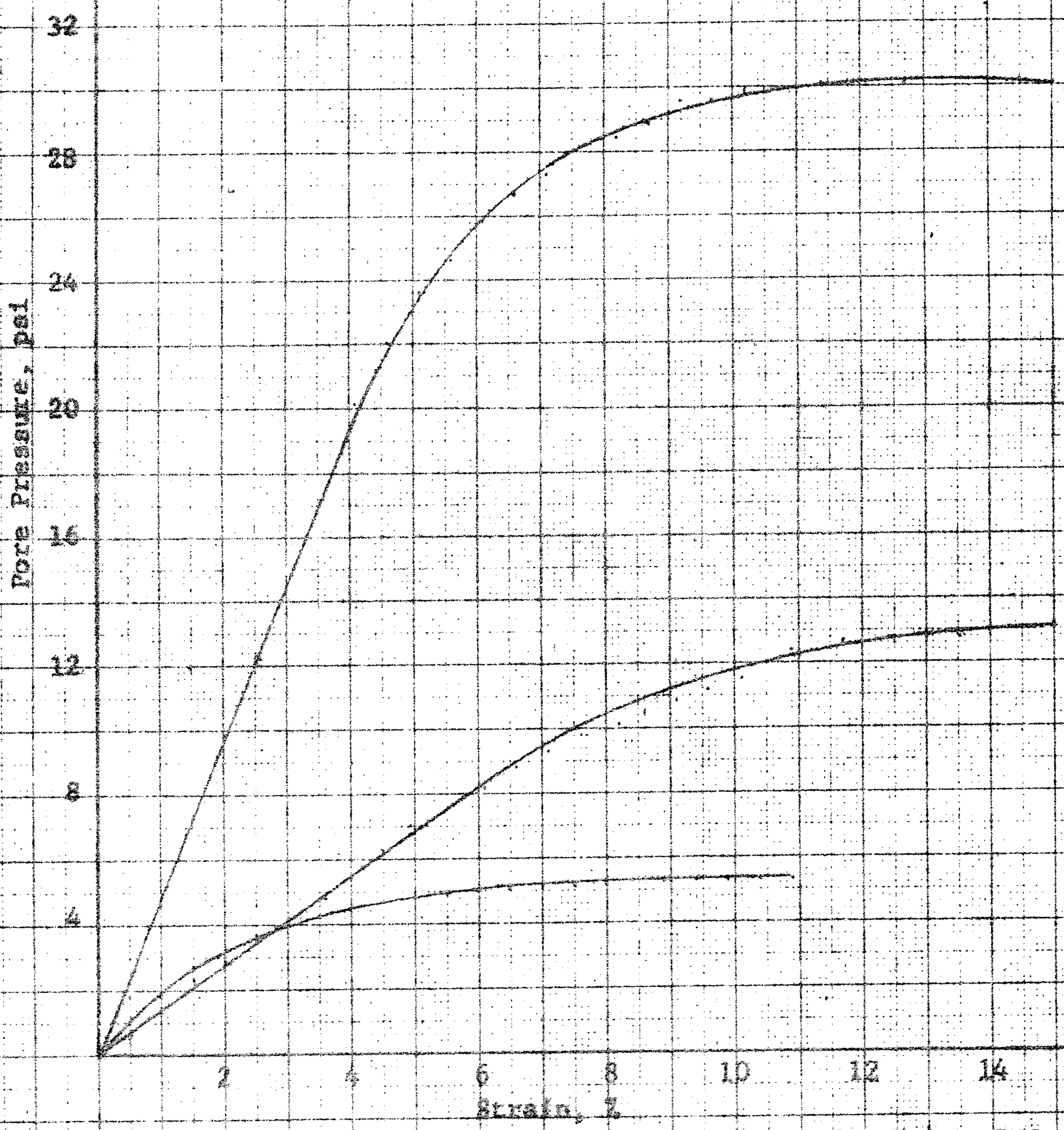


K&E SEMI-LOGARITHMIC 359-71G
1000
10000
Pressure, lb/ft²
Hole No. 8
Consolidation Test
Compacted Unit Dry Weight, lb/cu ft 100.3
Specific Gravity 2.75
Compression, in./in.
.00
.02
.04
.06
.08
.10
Iron Gate Dam
Klamath River
File No. 1732.1
ABBOT A. HANKS, INC.
Lab. No. 46938
May 24, 1960

Hole No. 8

Triaxial Shear Test

Pore Pressure-Strain Relationships



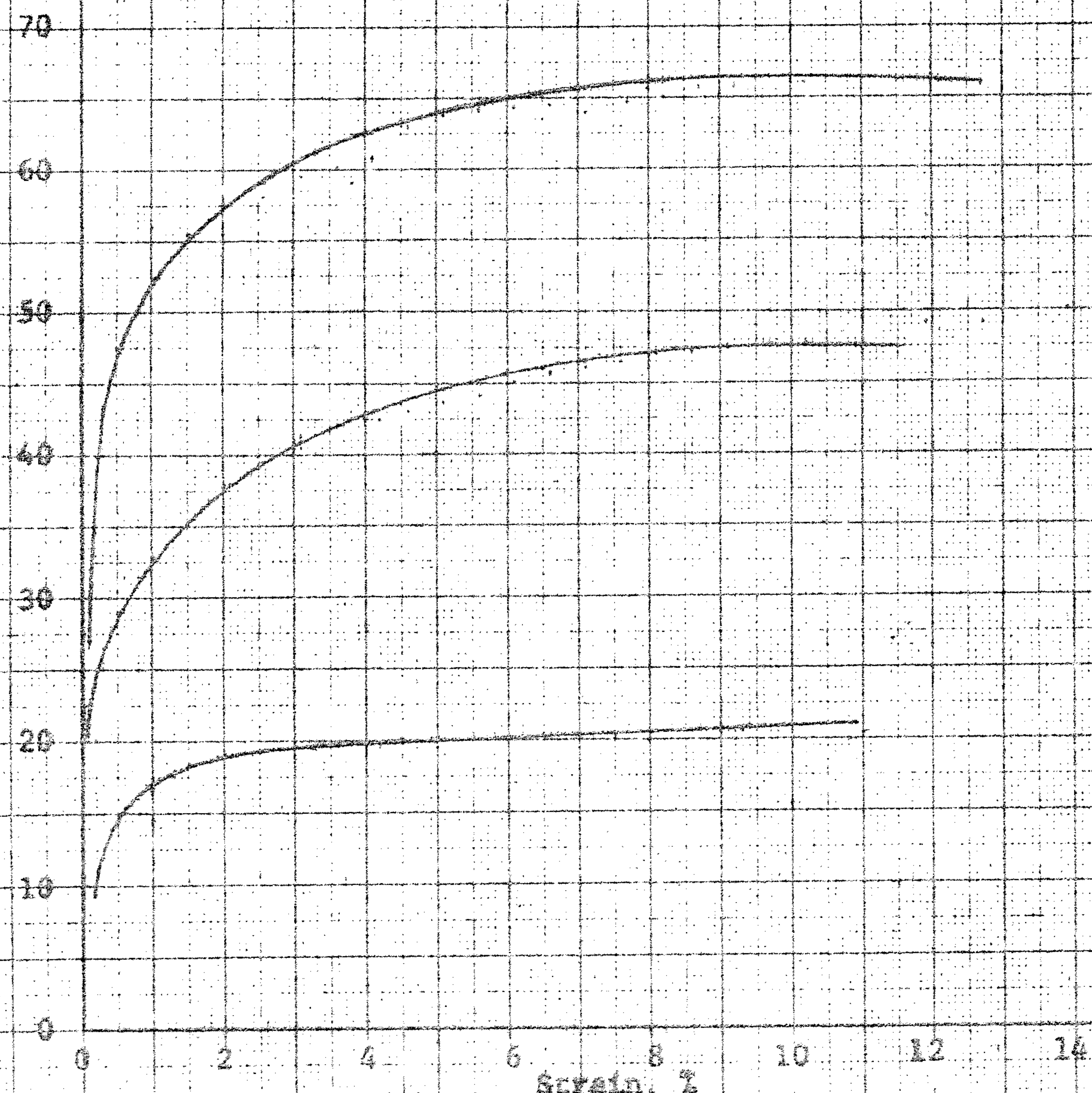

Iron Gate Dam
Klamath River
File No. 1732.1

ABBOT A. HANKS, INC.
Lab. No. 46938
May 18, 1960

Hole No. 8

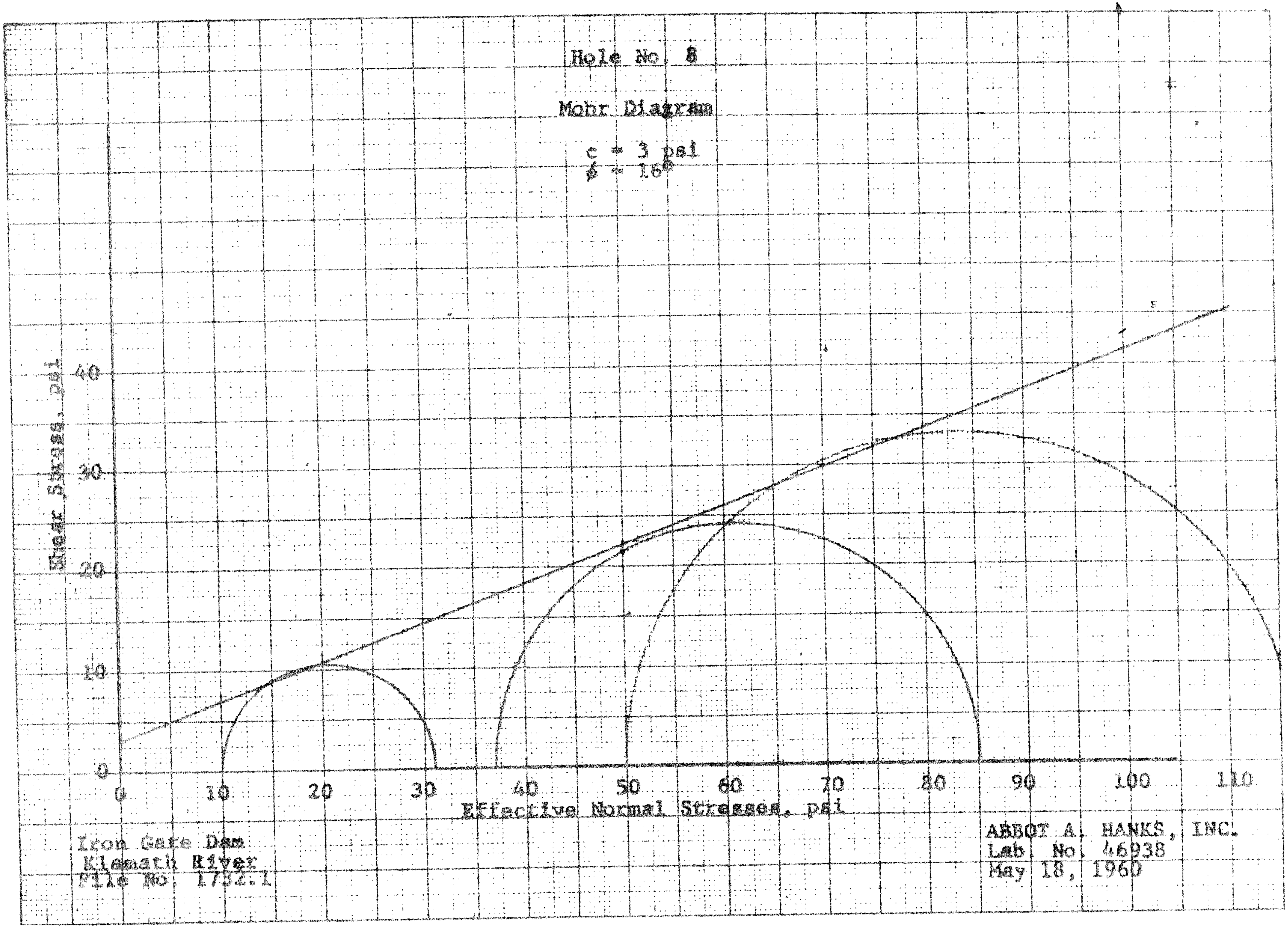
Triaxial Shear Test

Stress-Strain Relationships




Iron Gate Dam
Klamath River
File No. 1732.1

ABBOT A. HANKS, INC.
Lab. No. 45938
May 18, 1960



Hole No. 8
Mohr Diagram
c = 3 psi
ϕ = 16°
Shear Stress, psi
0
10
20
30
40
0
10
20
30
40
50
60
70
80
90
100
110
Effective Normal Stresses, psi
Iron Gate Dam
Klamath River
File No. 1732.1
ABBOT A. HANKS, INC.
Lab. No. 46938
May 18, 1960

BRANCH LABORATORY 1086 MARTIN AVENUE • SANTA CLARA • CHERRY 8 5262
BRANCH OFFICE 10 DE LUCA PLACE • SAN RAFAEL • GLENWOOD 4 8550

CABLE HANX

ABBOT A. HANKS, INC.
ESTABLISHED 1866
1300 SANSOME STREET • SAN FRANCISCO 11, CALIFORNIA • EXBROOK 7 2464

Engineers
Assayers
Chemists
Metallurgists
Spectrographers
Soils and Foundations
Consulting · Testing · Inspecting

File No. 1732.1
Lab. No. 46938

May 19, 1960

Mr. W. L. Warren
Assistant Chief Engineer
The California Oregon Power Company
216 West Main Street
Medford, Oregon

Re: Iron Gate Dam
Soil Samples

Dear Sir:

Enclosed are the findings from tests performed on soil samples marked Hole No. 11.

Very truly yours,

ABBOT A. HANKS, INC.

Donald W Radbruch

Donald W. Radbruch

hms
Encls.
Reports to:
3-The California Oregon Power Company

Iron Gate Dam
Klamath River
Rile No. 1732.1

Abbot A. Hanks, Inc.
Lab. No. 46938
May 19, 1960

# TEST RESULTS

Hole No. 11
Specific Gravity: 2.75

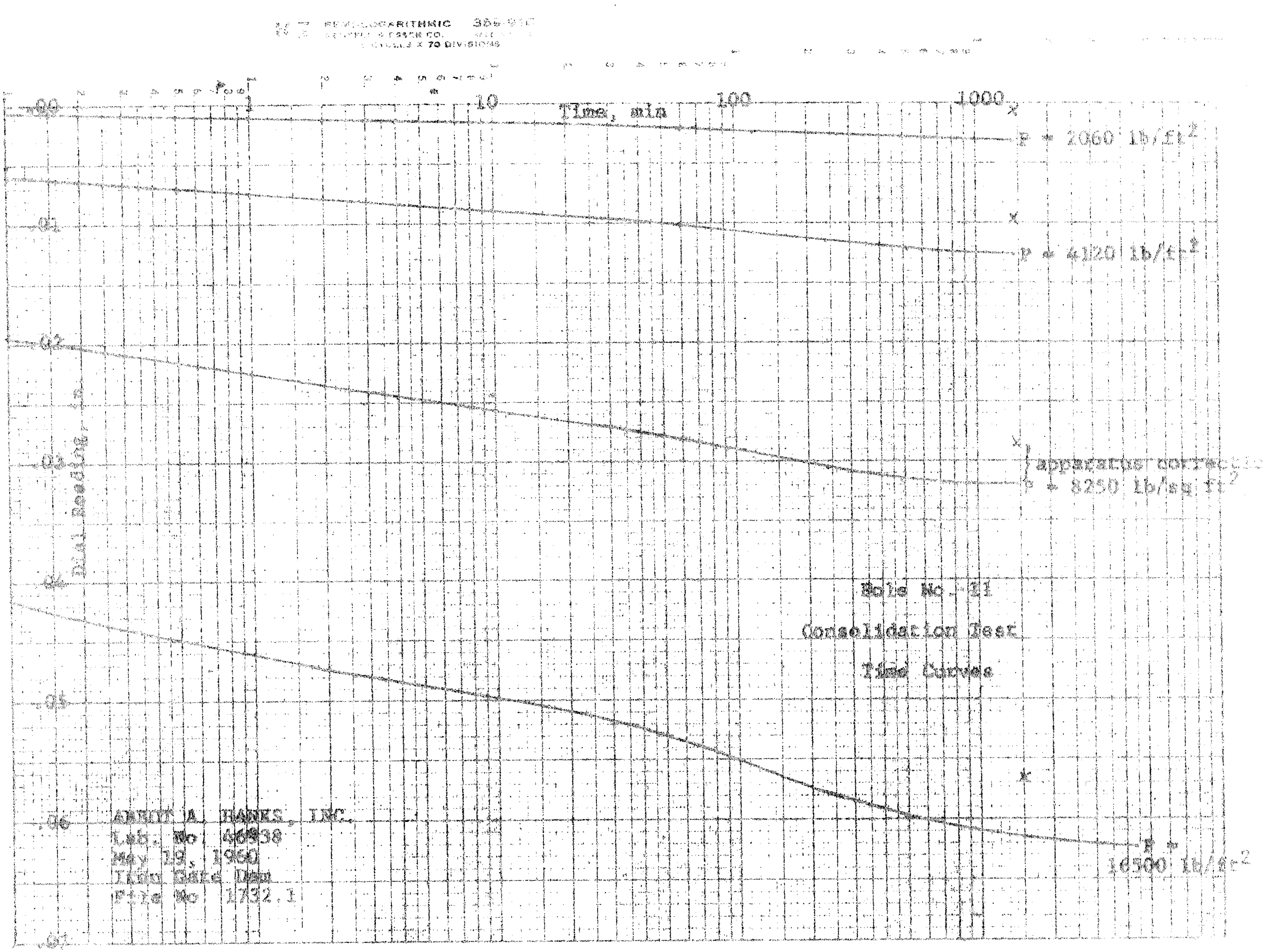
## Triaxial Shear Test

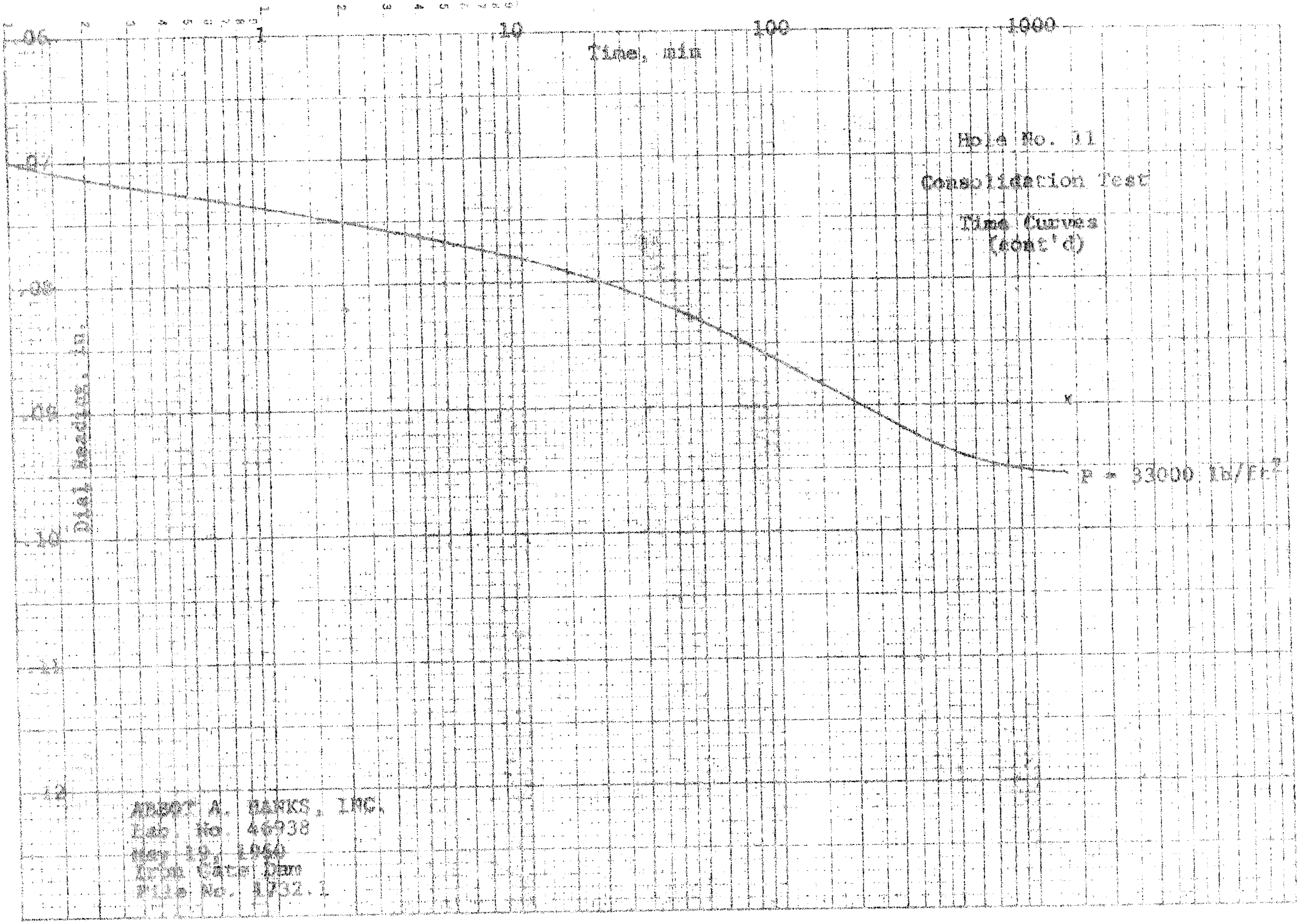
| | Sample A | Sample B | Sample C |
|---|---|---|---|
| Chamber Pressure, psi | 15 | 50 | 80 |
| Unit Dry Weight at Compaction, $lb/ft^3$ | 101.5 | 101.7 | 102.1 |
| Moisture Content at Compaction, % | 22.2 | 21.7 | 22.0 |
| Unit Dry Weight at Test, $lb/ft^3$ | 102.3 | 105.1 | 107.6 |
| Moisture Content at Test, $lb/ft^3$ | 25.0 | 22.9 | 21.7 |
| Degree of Saturation at Test, % | 100 | 100 | 100 |
| Maximum Deviator Stress, psi | 21 | 55 | 73 |
| Pore Pressure at Max. Deviator Stress, psi | 5 | 7 | 22 |

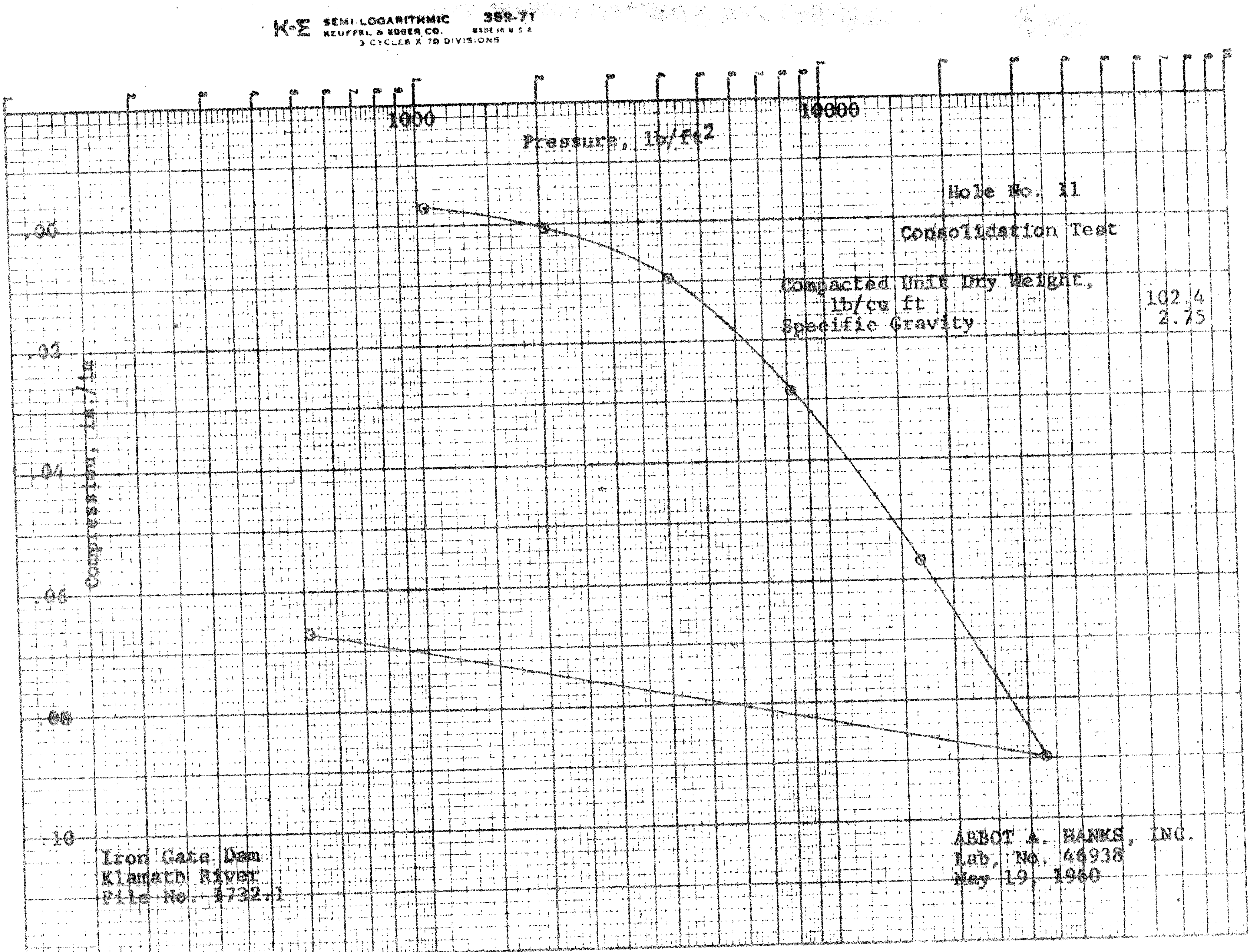
## Permeability Test
(Constant Head Test)

| | |
|---|---|
| Dry Density at Compaction, $lb/ft^3$ | 101.0 |
| Moisture Content at Compaction, % | 22.4 |
| Permeability Coefficient, ft per yr | Less than .01 |
| " " , cm/sec | Less than $10^{-8}$ |

~~[illegible]~~ ~~[illegible]~~
~~[illegible]~~ ~~[illegible]~~ ~~[illegible]~~
~~[illegible]~~ ~~[illegible]~~ ~~[illegible]~~


SEMI-LOGARITHMIC
Time, min
Dial Reading, in
1
10
100
1000
.00
.01
.02
.03
.04
.05
.06
.07
P = 2060 lb/ft²
P = 4120 lb/ft²
P = 8250 lb/sq ft²
P = 16500 lb/ft²
apparatus
Hole No. 21
Consolidation Test
Time Curves
HANKS, INC.
May 19, 1960
File No 1732.1

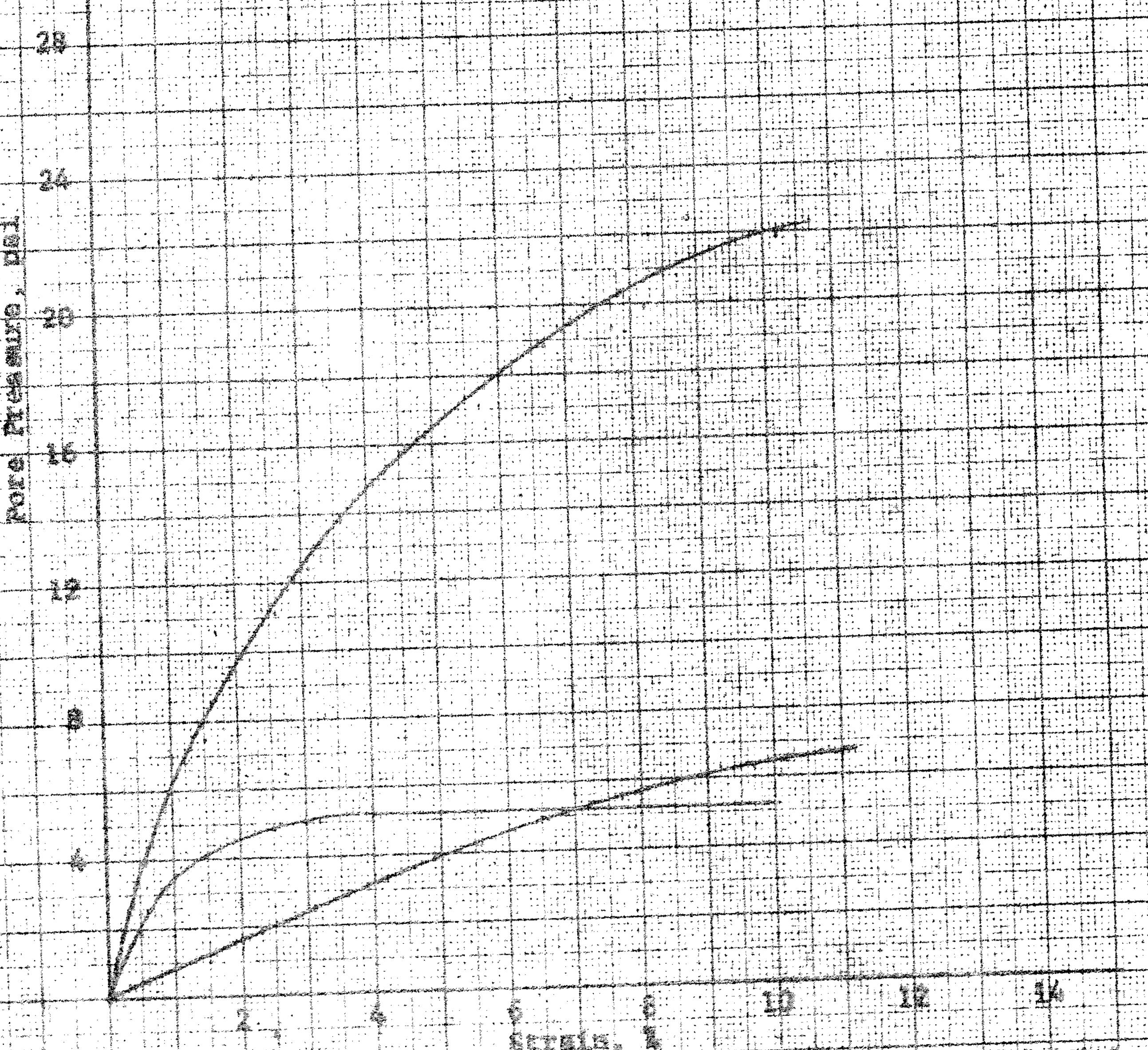

Time, min
.06
.07
.08
.09
.10
.11
.12
1
10
100
1000
Dial Reading, in.
Hole No. 11
Consolidation Test
Time Curves
(cont'd)
P = 33000 lb/Ft²
A. HANKS, INC.
Lab. No. 46938
1960
No. 1732.1


K&E SEMI-LOGARITHMIC 359-71
KEUFFEL & ESSER CO. MADE IN U.S.A.
3 CYCLES X 70 DIVISIONS
1000
10000
Pressure, lb/ft2
Compression, in./in.
.00
.02
.04
.06
.08
.10
Hole No. 11
Consolidation Test
Compacted Unit Dry Weight, lb/cu ft 102.4
Specific Gravity 2.75
Iron Gate Dam
Klamath River
File No. 1732.1
ABBOT A. HANKS, INC.
Lab. No. 46938
May 19, 1960

Hole No. 11

Triaxial Shear Test

Pore Pressure-Strain Relationships



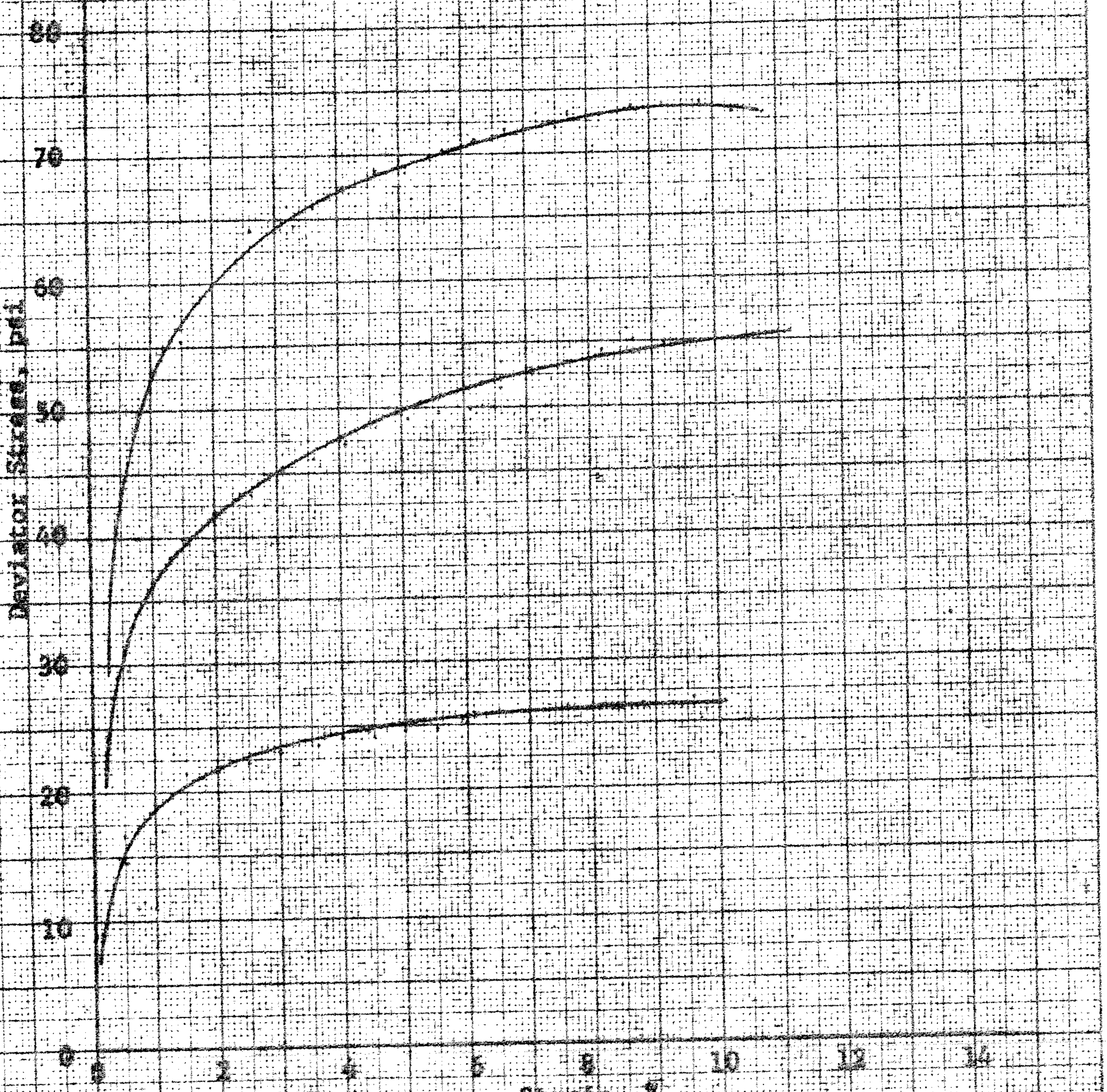

Iron Gate Dam
Klamath River
File No. 1732.1

ABBOT A. HANKS, INC.
Lab. No. 46936
May 19, 1960

Hole No. 11

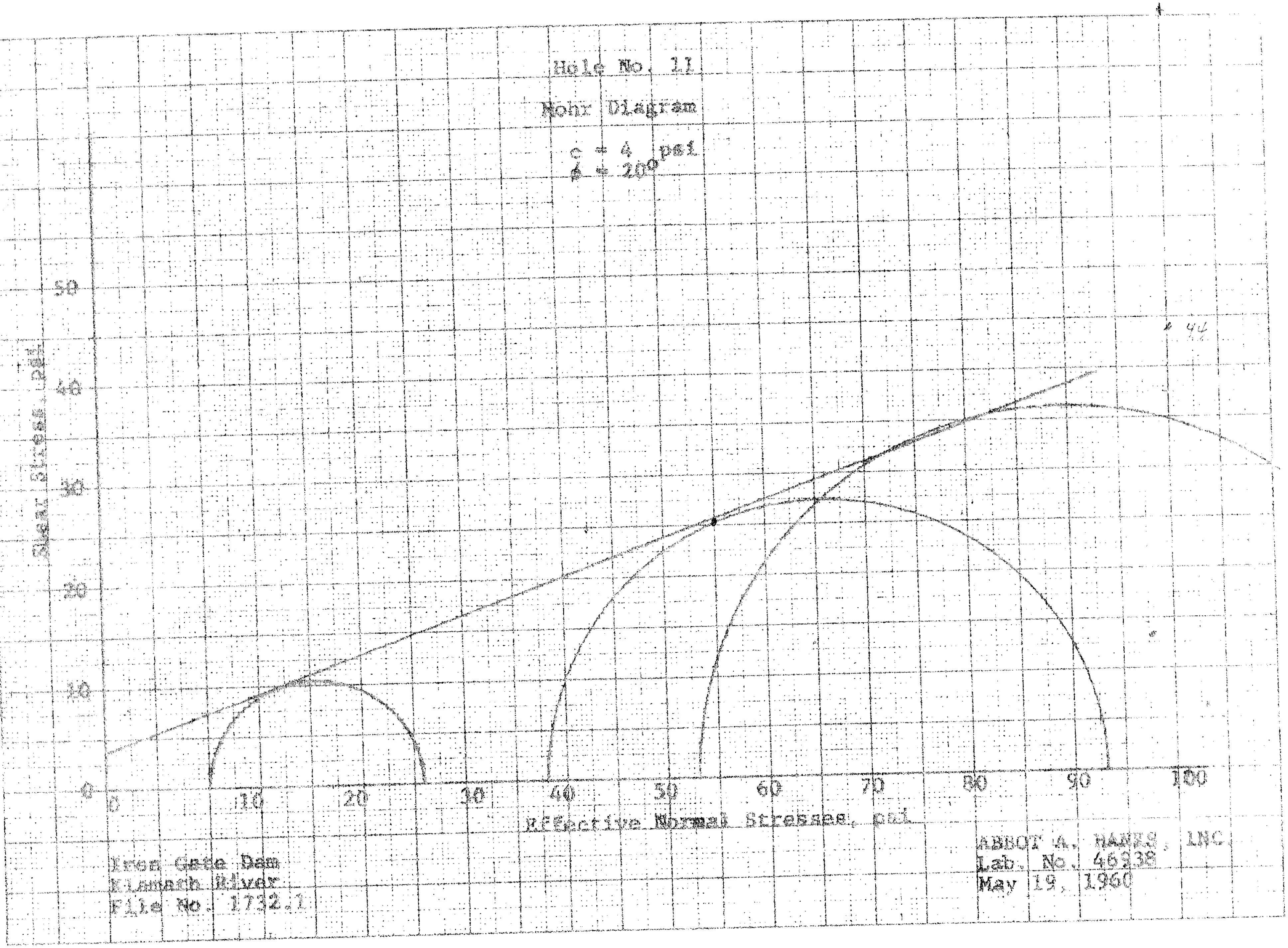
Triaxial Shear Test

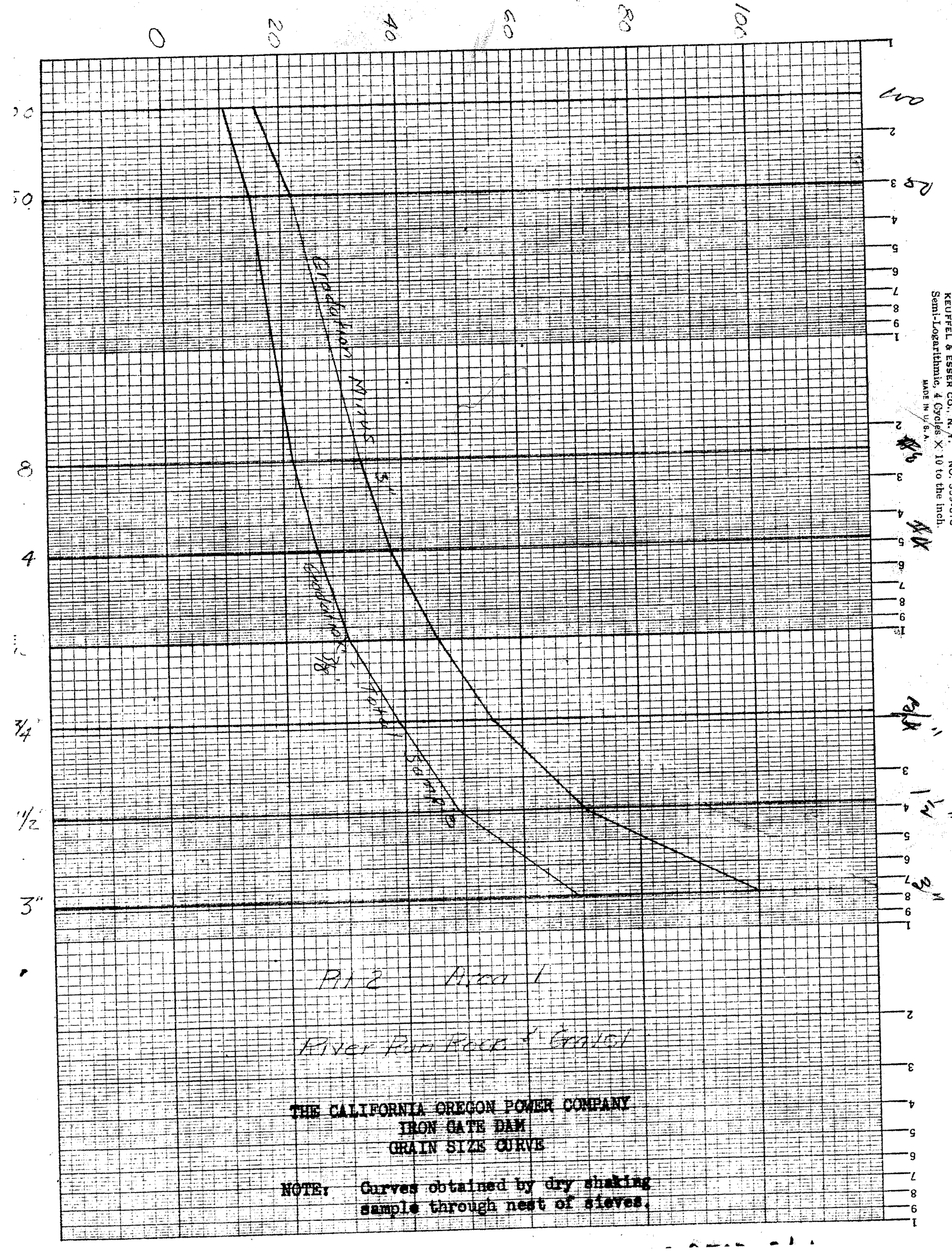
Stress-Strain Relationships




Iron Gate Dam
Klamath River
File No. 1732.1

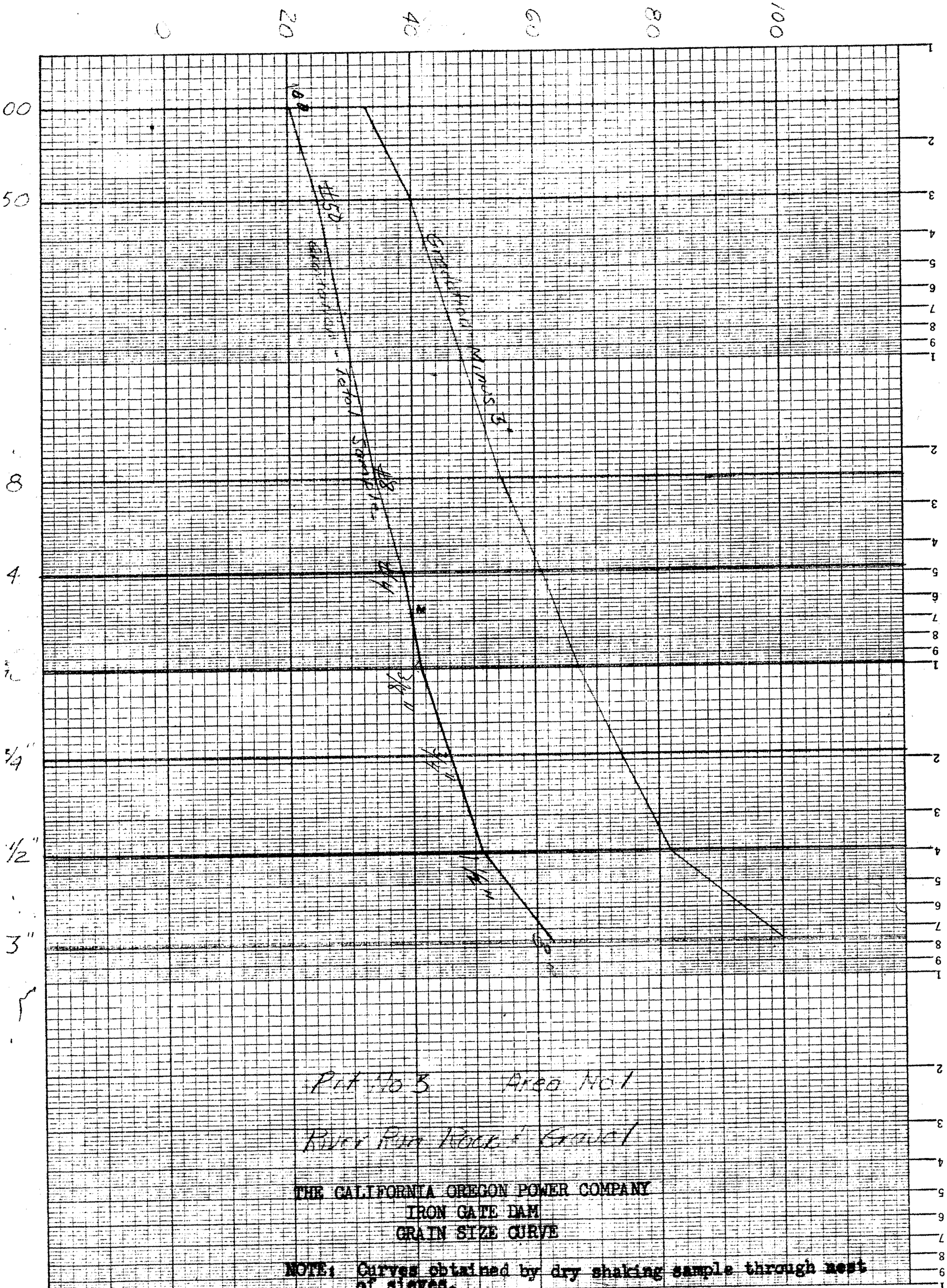
ABBOT A. HANKS, INC.
Lab. No. 46938
May 18, 1960


Hole No. 11
Mohr Diagram
c = 4 psi
ϕ = 20°
Shear Stress, psi
0
10
20
30
40
50
0
10
20
30
40
50
60
70
80
90
100
Effective Normal Stresses, psi
44
Iron Gate Dam
Klamath River
File No. 1732.1
ABBOT A. HANKS, INC.
Lab. No. 46938
May 19, 1960



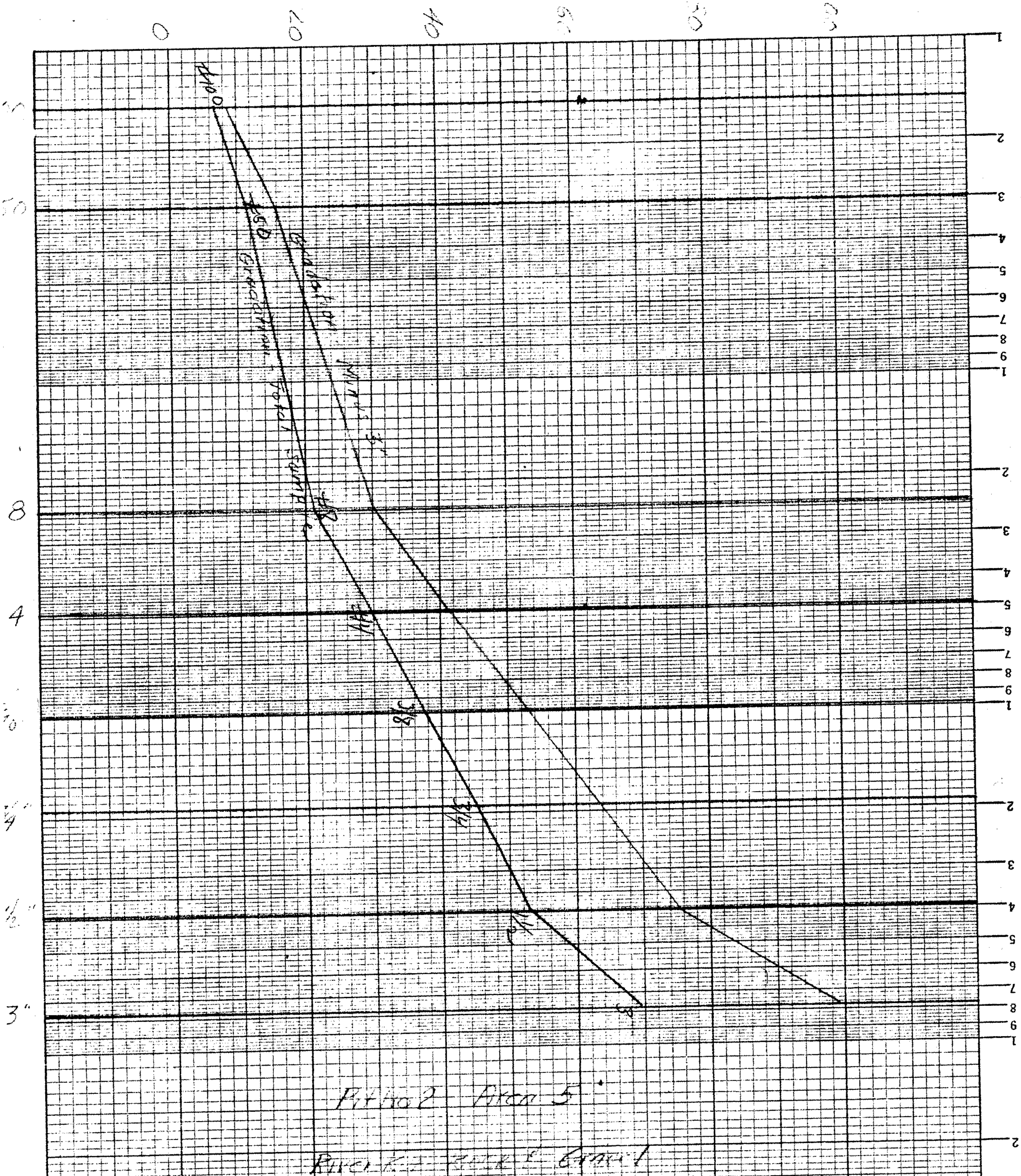

THE CALIFORNIA OREGON POWER COMPANY
IRON GATE DAM
GRAIN SIZE CURVE

NOTE: Curves obtained by dry shaking sample through nest of sieves.



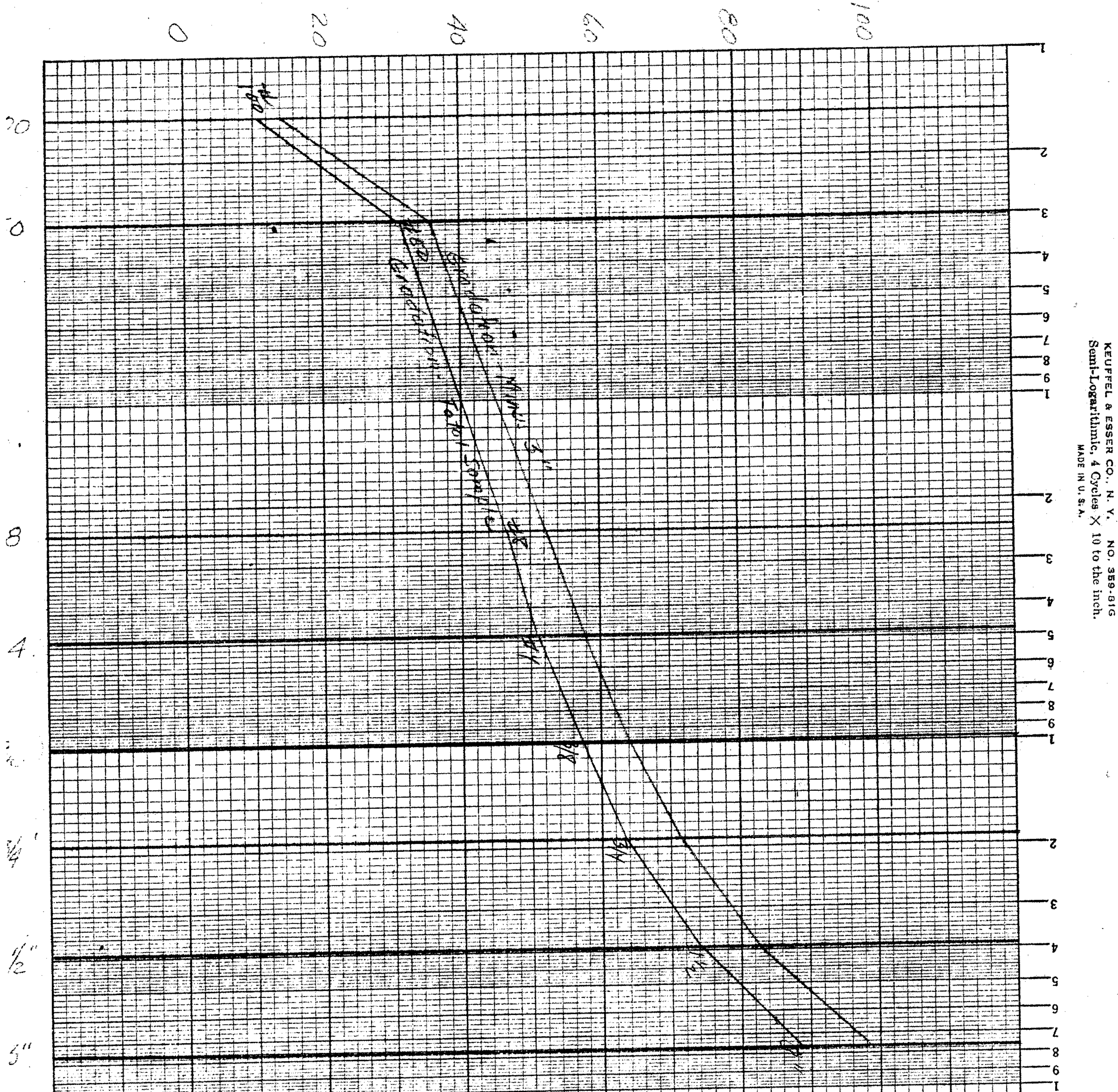

THE CALIFORNIA OREGON POWER COMPANY
IRON GATE DAM
GRAIN SIZE CURVE

NOTE: Curves obtained by dry shaking sample through nest of sieves.



THE CALIFORNIA OREGON POWER COMPANY
IRON GATE DAM
GRAIN SIZE CURVE

NOTE; Curves obtained by dry shaking sample through nest of sieves.

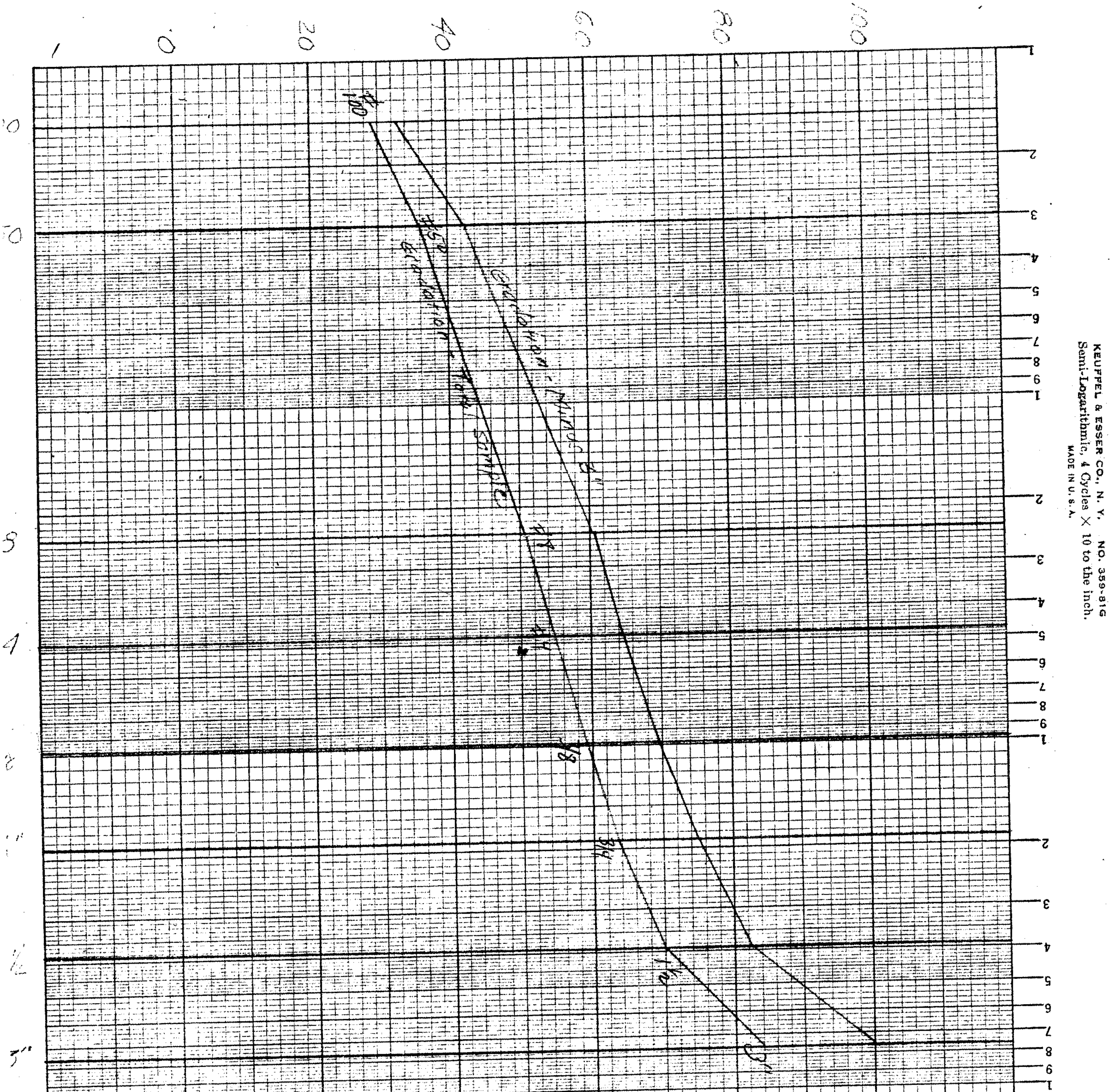



Pit No 3 Area 5

River Run Bank's Gravel

THE CALIFORNIA OREGON POWER COMPANY
IRON GATE DAM
GRAIN SIZE CURVE

**NOTE: Curves obtained by dry shaking sample through nest of sieves.**



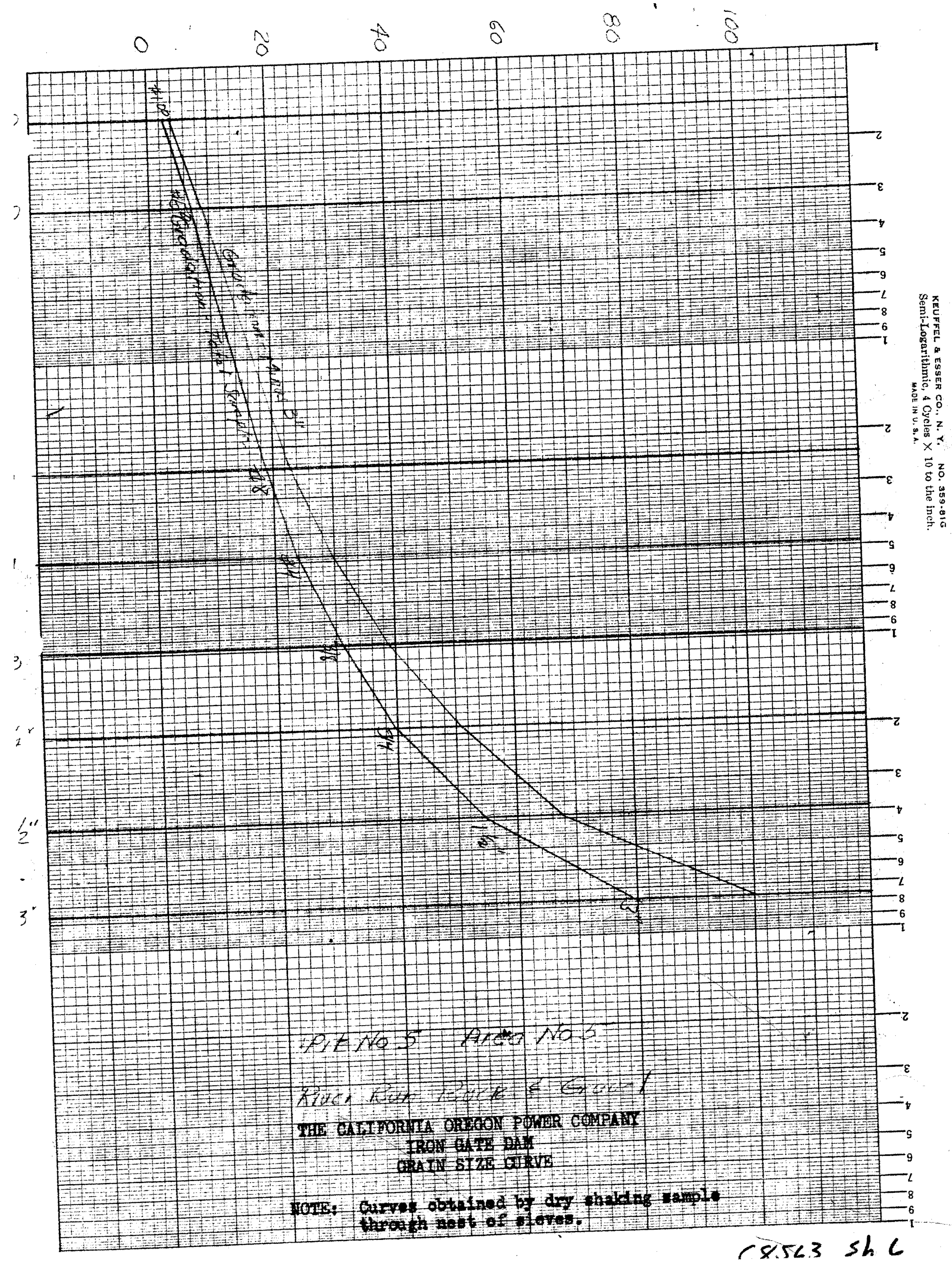

Pit No 4 Area 5

River Run Rock & Gravel

THE CALIFORNIA OREGON POWER COMPANY
IRON GATE DAM
GRAIN SIZE CURVE

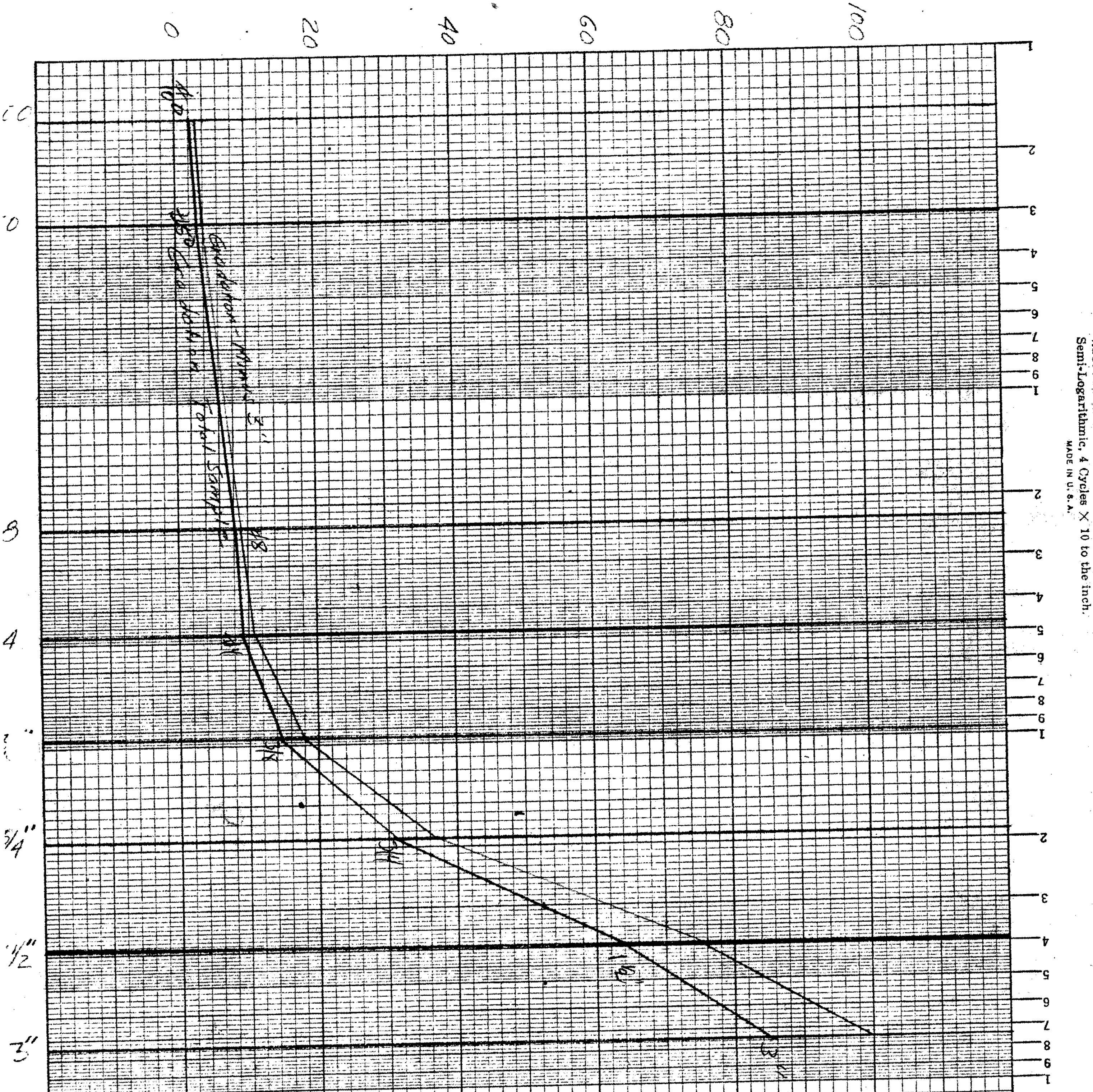
NOTE: Curves obtained by dry shaking sample through nest of sieves.

c 9523 545




THE CALIFORNIA OREGON POWER COMPANY
IRON GATE DAM
GRAIN SIZE CURVE

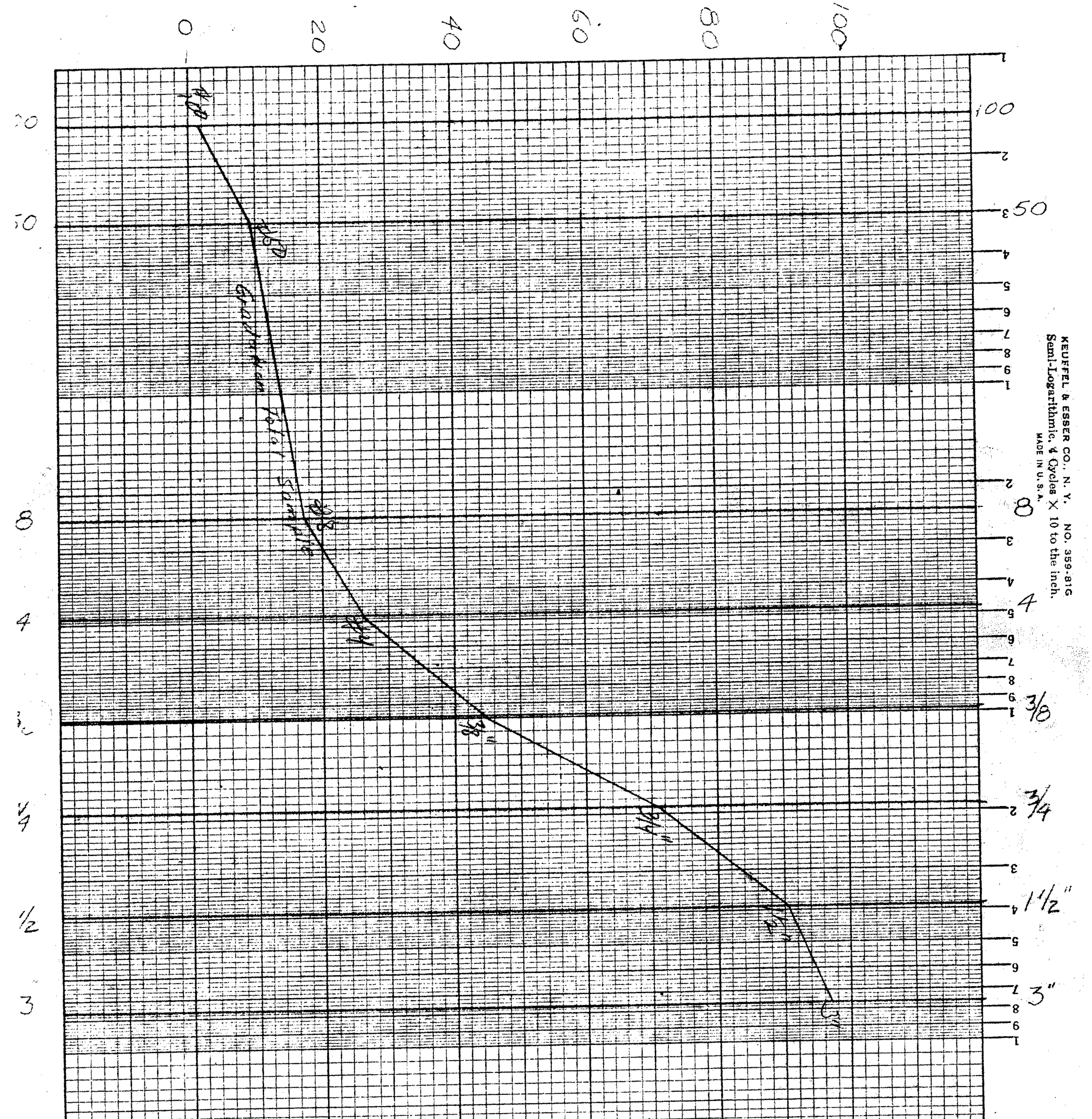
NOTE: Curves obtained by dry shaking sample through nest of sieves.




Pit 1 Dodson Area
Basaltic Talus

THE CALIFORNIA OREGON POWER COMPANY
IRON GATE DAM
GRAIN SIZE CURVE

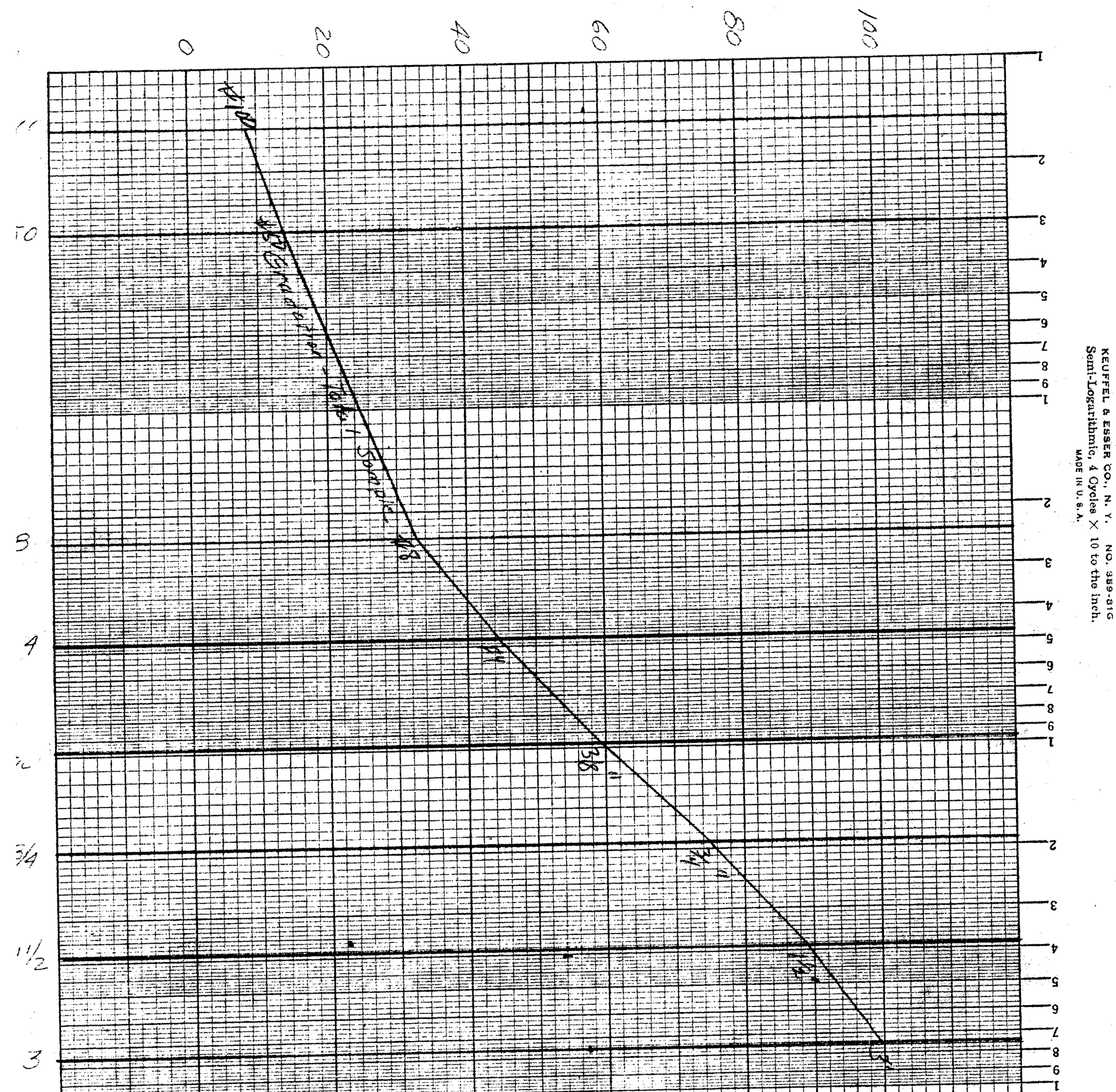
NOTE: Curves obtained by dry shaking sample through nest of sieves.




Hole No 9 Area No 3
Basaltic Talus

THE CALIFORNIA OREGON POWER COMPANY
IRON GATE DAM
GRAIN SIZE CURVE

NOTE: Curve obtained by dry shaking sample through nest of sieves.

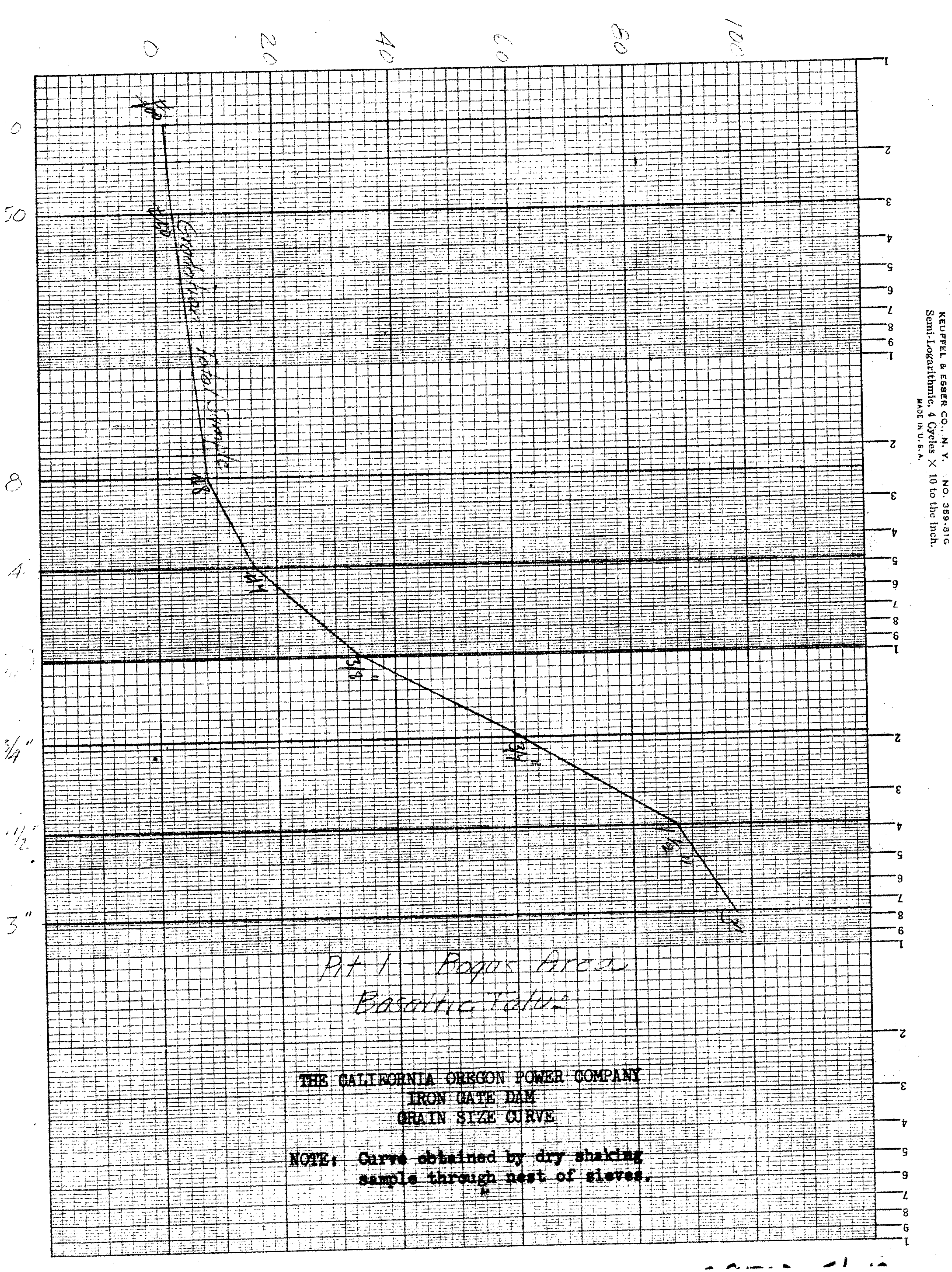



Hole 11 Area 3

Basaltic Talus

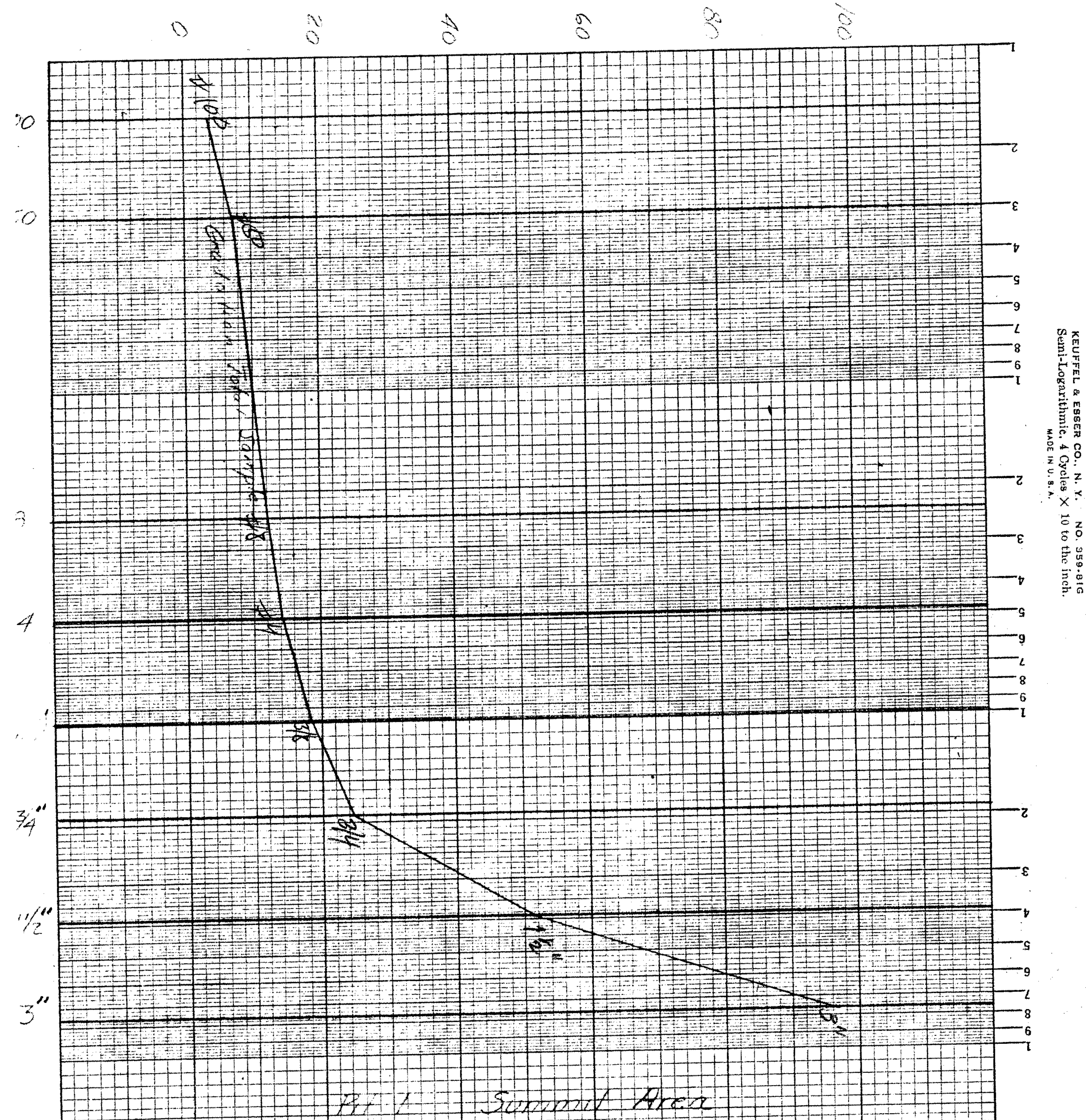
THE CALIFORNIA OREGON POWER COMPANY
IRON GATE DAM
GRAIN SIZE CURVE

NOTE: Curve obtained by dry shaking sample through nest of sieves.



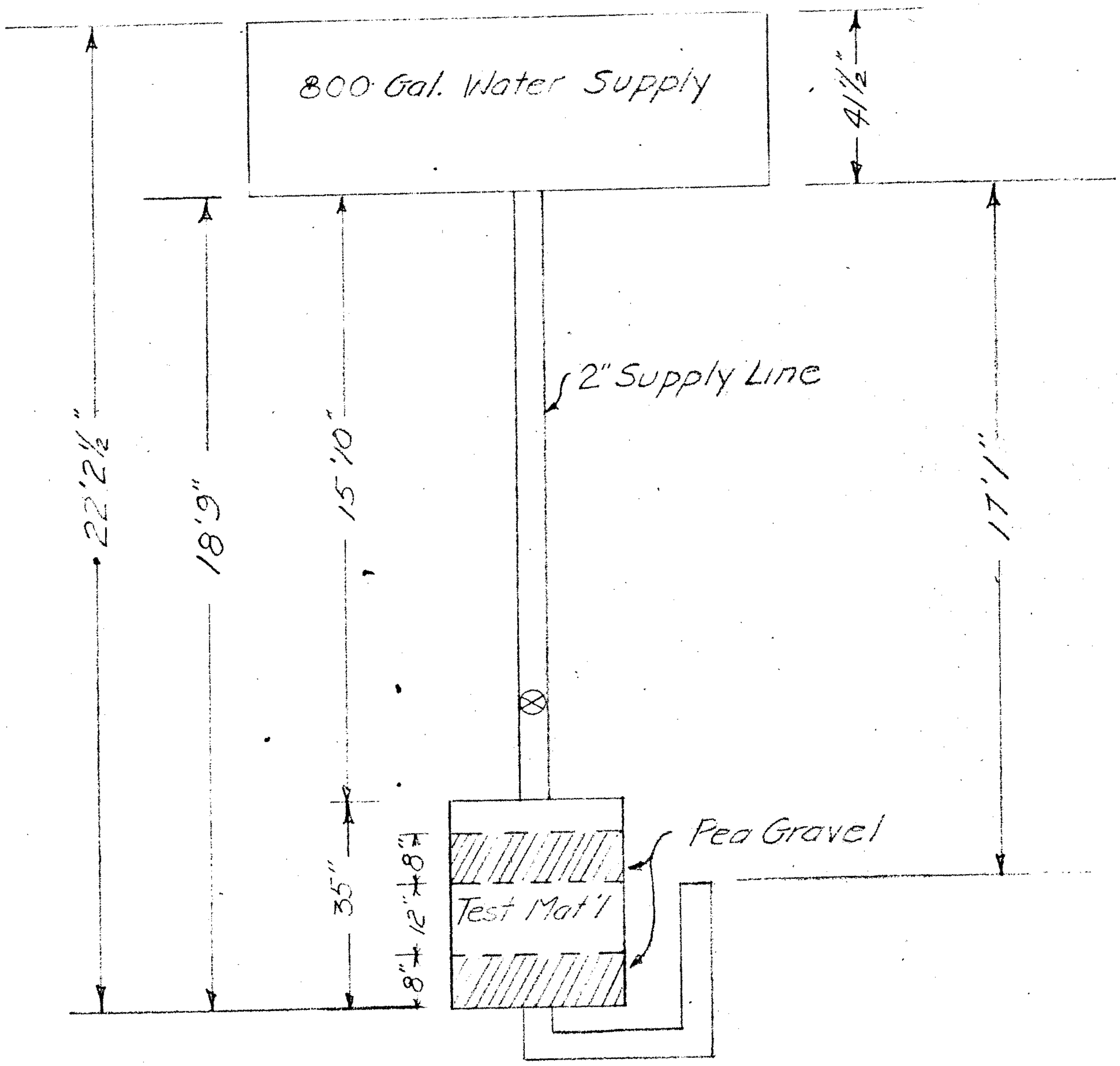

THE CALIFORNIA OREGON POWER COMPANY
IRON GATE DAM
GRAIN SIZE CURVE

NOTE: Curve obtained by dry shaking sample through nest of sieves.




THE CALIFORNIA OREGON POWER COMPANY
IRON GATE DAM
GRAIN SIZE CURVE

NOTE: Curves obtained by dry shaking sample through nest of sieves.




Permeability Test Method
No Scale
Iron Gate Project

| | | |
|---|---|---|
| DRAWN BY | | J. O. |
| TRACED BY | | J. O. REQ. |
| CHECKED BY | | MAP NO. |
| APPROVED BY | SEC. / TWP. / RANGE | AREA |
| SCALE | SCHOOL DIST. / ROAD DIST. | RURAL ☐ URBAN ☐ |
| DATE 7-20-60 | THE CALIFORNIA OREGON POWER COMPANY | C 8560 |

BRANCH LABORATORY 1086 MARTIN AVENUE • SANTA CLARA • CHERRY 8-5262 CABLE HANX
BRANCH OFFICE 61 JORDAN STREET • SAN RAFAEL • GLENWOOD 4-8650

ABBOT A. HANKS, INC.
ESTABLISHED 1866
1300 SANSOME STREET • SAN FRANCISCO 11, CALIFORNIA • EXBROOK 7-2464

*Engineers*
*Assayers*
*Chemists*
*Metallurgists*
*Spectrographers*
*Soils and Foundations*
*Consulting · Testing · Inspecting*

File No. 1732.2
Lab. No. 52348

August 8, 1961

The California Oregon Power Company
Iron Gate Project
Post Office Box 201
Hornbrook, California

Re: Iron Gate Dam - P. O. #39636
Soil Tests, Sample 16+00 300' L

Gentlemen:

Based on tests of four specimens compacted in the range of 81 to 82 lb per cu ft, it appears that the intergranular strength factors of the above sample in a consolidated shear test with pore pressures measured are as follows:

| | |
|---|---|
| Friction angle | 11½ - 15½ degrees |
| Cohesion | 450 - 800 lb/sq ft. |

This soil is a highly plastic, impervious clay. Consolidation was extremely slow, requiring 10 days to complete the consolidation and saturation of each 2 in. diameter by 4 in. length specimen. An extremely long seasoning period was also necessary to attain uniformity of moisture content prior to compaction of specimens at the specified moisture content.

We are proceeding with tests of Sample 12+00 400' L, and will submit details of all tests upon completion.

Very truly yours,

ABBOT A. HANKS, INC.

L. O. Long

L. O. Long

LOL:hms
Reports to:
3-Iron Gate Project, Hornbrook, Calif.
1-The California Oregon Power Company, Medford, Ore.

BRANCH LABORATORY: 1086 MARTIN AVENUE • SANTA CLARA • CHERRY 8-5262
BRANCH OFFICE: 61 JORDAN STREET • SAN RAFAEL • GLENWOOD 4-8650

CABLE: HANX

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*Engineers*
*Assayers*
*Chemists*
*Metallurgists*
*Spectrographers*
*Soils and Foundations*
*Consulting · Testing · Inspecting*

File No. 1732.2
Lab. No. 52348, 52871

October 20, 1961

Mr. M. L. Warren
Assistant Chief Engineer
The California Oregon Power Co.
216 Main Street
Medford, Oregon

Re: Iron Gate Project Samples

Dear Mr. Warren:

Attached are the findings from triaxial shear tests performed on soil samples marked "12+00, 400'L", and "16+00, 300'L".. The triaxial tests were performed in the same manner as described in our letter of June 29, 1960.

Complete saturation was not attained in the tests because, when confined under the higher lateral pressures, the specimens were virtually impermeable, and complete saturation could not be attained even by application of a high vacuum on the top of the specimens and a small positive pressure on the base.

You will note that we did not submit data for a specimen of sample 16+00, 300'L at 80 psi chamber pressure. The data for this specimen was not consistent with the remainder of the test data, and it appears likely that there was leakage of the membrane during the test. If you feel that a repetition

MW

of the test at 80 psi would serve a useful purpose, we should be pleased to repeat the test.

We should be pleased to discuss any questions in connection with these tests.

Very truly yours,

ABBOT A. HANKS, INC.

L. O. Long

L. O. Long

LOL:hms
Encls.
Reports to:
3-The California Oregon Power Co.

Iron Gate Project
The California Oregon Power Company
File No. 1732.2

Abbot A.Hanks, Inc.
Lab. No. 52348
October 17, 1961

TABLE NO. I

Sample: 16 + 00 300'L.
Soil Type: Dark yellow-brown clay.

| Sample | A | B | C | D |
|---|---|---|---|---|
| Chamber Pressure, psi | 15.5 | 15 | 50 | 50 |
| Unit Dry Weight at Compaction, $lb/ft^3$ | 81.3 | 81.2 | 82.7 | 82.5 |
| Moisture Content at Compaction, % | 25.0 | 24.6 | 24.2 | 23.7 |
| Unit Dry Weight at Test, $lb/ft^3$ | 76.8 | 74.7 | 84.7 | 84.7 |
| Moisture Content at Test, % | 42.3 | 36.8 | -- | 35.3 |
| Degree of Saturation at Test, % | 94 | 80 | -- | 97 |
| Maximum Deviator Stress, psi | 15 | 18 | 43 | 35 |
| Pore Pressure at Maximum Deviator Stress, psi | 6 | 4 | 1 | 2 |

Iron Gate Project
The California Oregon Power Company
File No. 1732.2

Abbot A. Hanks, Inc.
Lab. No. 52871
October 17, 1961

TABLE NO. II

Sample: 12 + 00, 400'L.
Soil Type: Very dusky red clay.

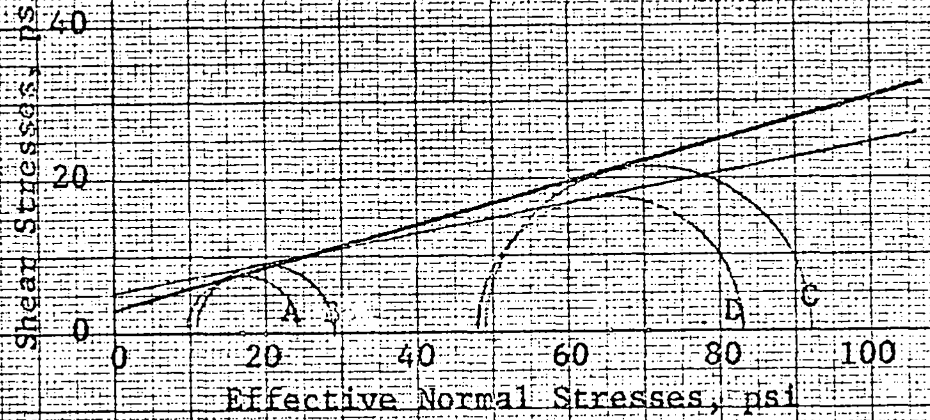
| Sample | A | B | C |
|---|---|---|---|
| Chamber Pressure, psi | 15 | 50 | 80 |
| Unit Dry Weight at Compaction, $lb/ft^3$ | 88.6 | 86.7 | 86.9 |
| Moisture Content at Compaction, % | 24.5 | 23.5 | 24.5 |
| Unit Dry Weight at Test, $lb/ft^3$ | 81.6 | 89.2 | 91.0 |
| Moisture Content at Test, % | 36.3 | 30.7 | 27.2 |
| Degree of Saturation at Test, % | 89 | 94 | 86 |
| Maximum Deviator Stress, psi | 16 | 48 | 81 |
| Pore Pressure at Maximum Deviator Stress, psi | 1 | 4 | 1 |

hms

Sample 16+00, 300'L

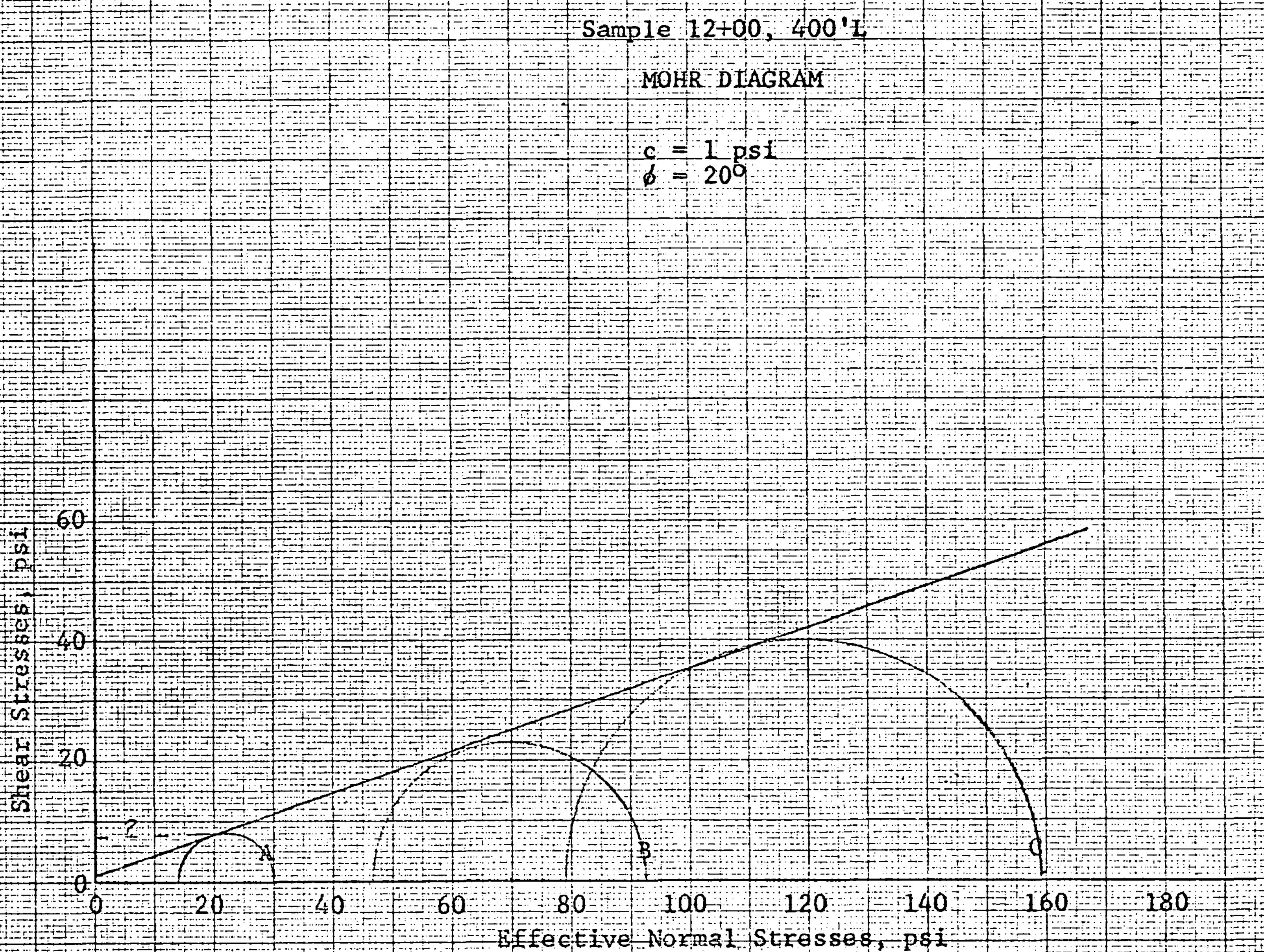
MOHR DIAGRAM

c = 3-5½ psi
ϕ = 11-15°




Iron Gate Dam
File No. 1732.2

ABBOT A. HANKS, INC.
Lab. No. 52348



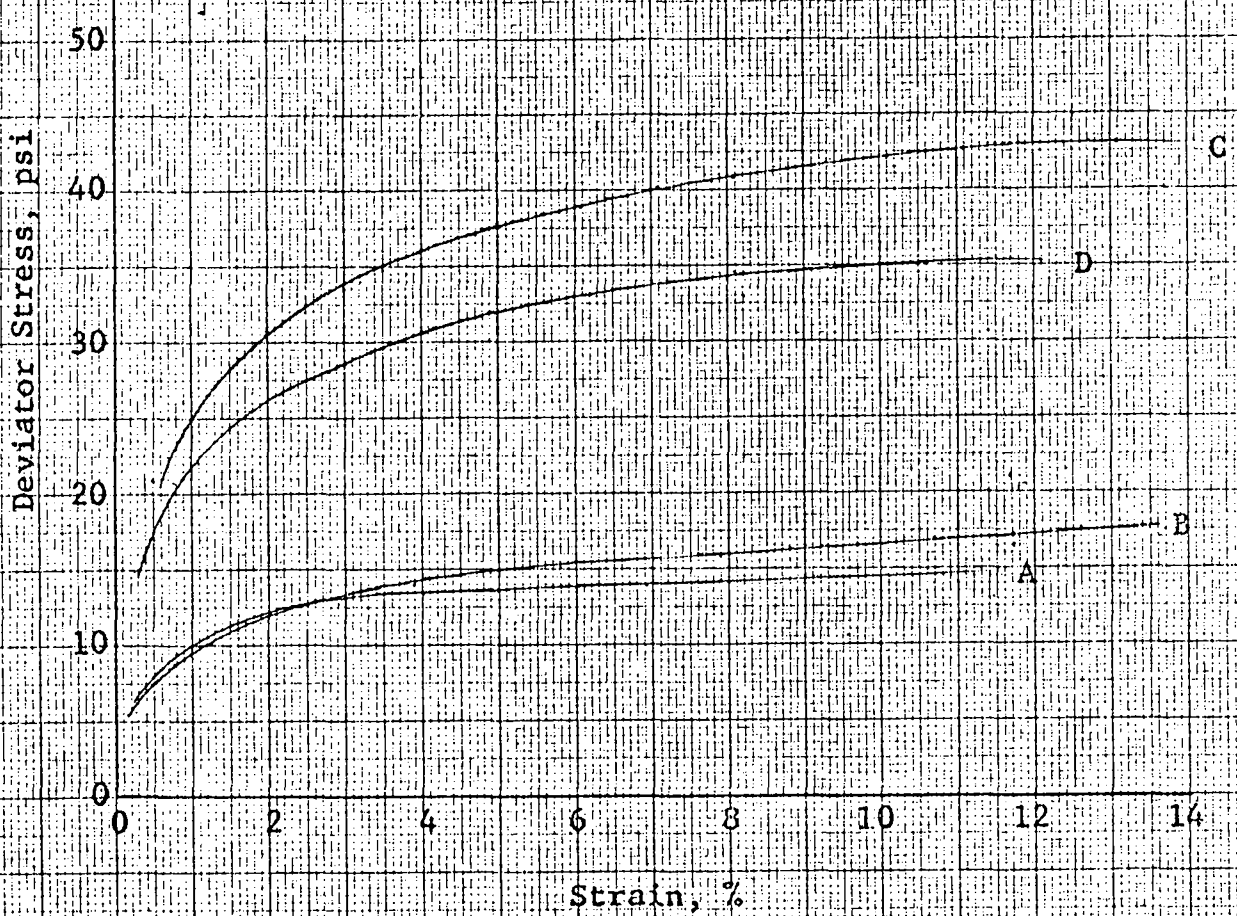

Iron Gate Dam
File No. 1732.2

ABBOT A. HANKS, INC.
Lab. No. 52871

Sample 16+00, 300'L

TRIAXIAL SHEAR TEST

Stress-Strain Relationships



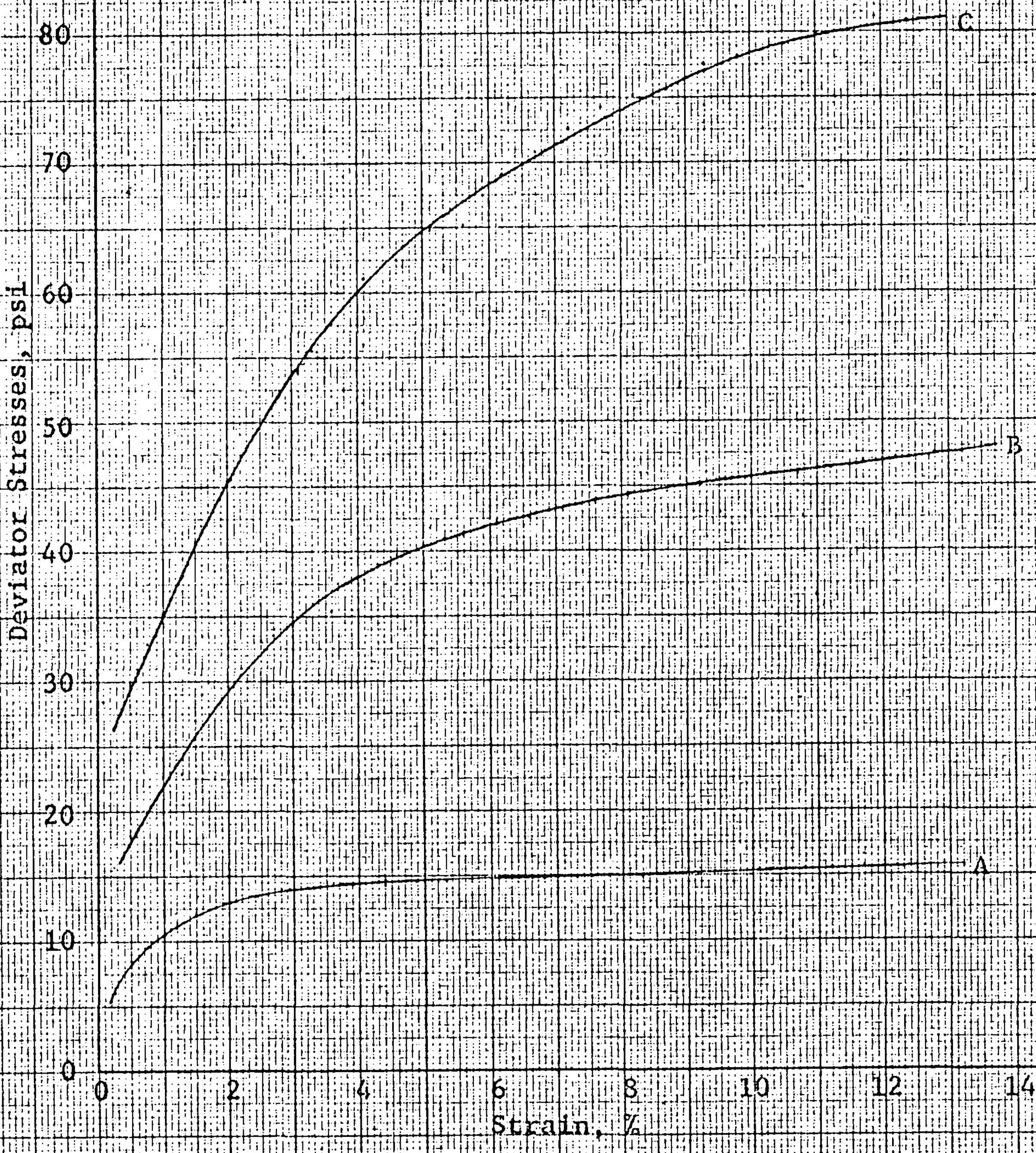

Iron Gate Dam
File No. 1732.2

ABBOT A. HANKS, INC.
Lab. No. 52348

Sample 12+00, 400'L

TRIAXIAL SHEAR TEST

Stress-Strain Relationships




Iron Gate Dam
File No. 1732.2

ABBOT A. HANKS, INC.
Lab. No. 52371

Undrained, consolidated triaxial shear tests with pore pressure measurements, consolidation tests, and constant head permeability tests were performed on representative samples of material for each hole by Abbot A. Hanks Laboratory in San Francisco. Before each test the material was compacted to near optimum moisture and maximum dry density. The results of these tests are shown in Abbot A. Hanks report as Plate IV. For convenient reference, the permeability coefficient, the angle of internal friction and cohesion for the material from each hole are tabulated below:

| HOLE NO. | COHESION p.s.i. (psf) | ANGLE OF INTERNAL FRICTION | PERMEABILITY FT/YEAR Less than | COEFFICIENT CM/SEC Less than |
|---|---|---|---|---|
| 1. | 9 (1300) | 10° | .01 | 10-8 |
| 2. | 6 (860) | 17° | - | - |
| 3. | 10 (1440) | 14° | .01 | 10-8 |
| 4. | 4 (580) | 30° | .01 - .04 | 1-4 x 10-8 |
| 7. | 5 (720) | 21° | .01 | 10-8 |
| 8. | 3 (430) | 16° | .01 | 10-8 |
| 11. | 4 (580) | 20° | .01 | 10-8 |

844 psf 7)128 (18° av.

The quantities of the impervious materials available in Areas "A" and "5", are estimated to be 264,000 cubic yards. The quantities in Area "1" are estimated to be 57,000 dubic yards. However, most of Area "1" will be inundated by backwater from the construction of the cofferdam so, in order to utilize this material, it will be necessary that it be stockpiled, which does not seem practical.

2. Pervious Shell Materials

Two types of pervious materials were investigated:

A. Gravels in the flood plain of the river in Areas "1" and "5"

B. Talus deposits of basaltic rock in Area "3", Bogus Creek Area, Summit Area and Dodson Area.

| Sample<br>Area "1" | % Passing<br>#100 Sieve | %<br>Moisture | Dry<br>Density<br>Lbs/cu ft | Wet<br>Density<br>Lbs/cu ft | Permeability<br>Coefficient<br>Ft/Day |
|---|---|---|---|---|---|
| Pit 2, 1-14' Depth | 15 | 8 | 119.5 | 129.2 | 11.1 |
| Pit 3, 3-12' " | 21 | 7 | 128.5 | 138.2 | 17.6 |
| Area "5" | | | | | |
| Pit 2, 2-16' Depth | 9 | 9 | 129.5 | 141.5 | 12.6 |
| Pit 3, 2-12' " | 14 | 9 | 137.5 | 151.0 | .59 |
| Pit 4, 4-20' " | 33 | 11 | 105.0 | 118.0 | 8.94 |
| Pit 5, 4-16' " | 3 | 9 | 125.0 | 137.0 | 3.95 |

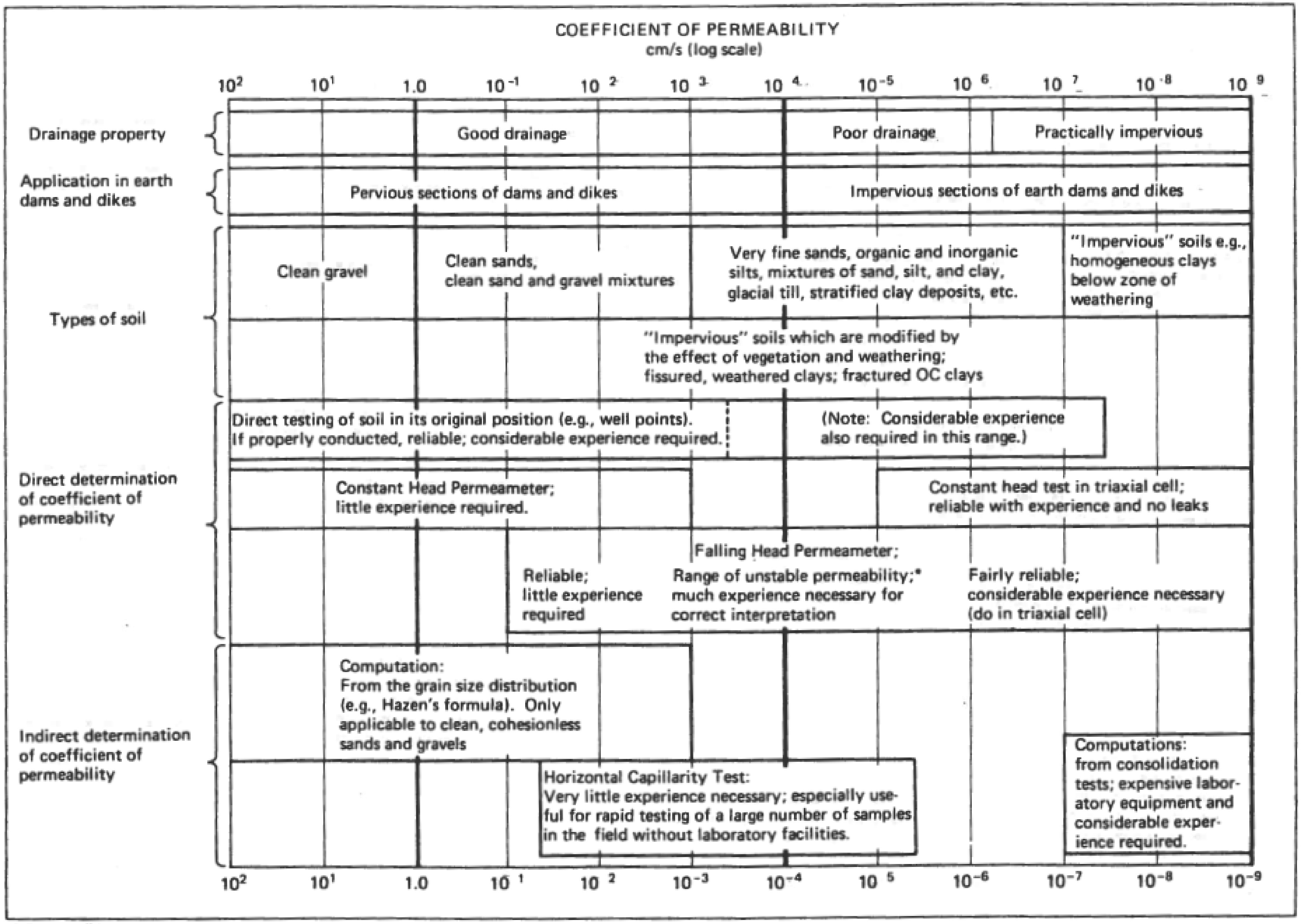
The estimated quantity of gravel materials in Area "1" is 90,000 cubic yards, which can be obtained without stockpiling the impervious material overlining the gravels, and in Area "5", is 381,000 cubic yards, making a total of 471,000 cubic yards.

Talus deposits.

The talus material was tested in a manner similar to that described in the section headed "Gravels". No settlement was noted after the permeability test on any of the samples of talus material. The results of the grain size distribution tests are shown on Drawing C-8563, Sheets 7 through 11, and attached hereto as Plate V. The results of the permeability tests are tabulated below:

| Sample<br>Area "3" | % Passing<br>#100 Sieve | %<br>Moisture | Dry<br>Density<br>Lbs/cu ft | Wet<br>Density<br>Lbs/cu ft | Permeability<br>Coefficient<br>Ft/Day |
|---|---|---|---|---|---|
| Hole 9, 0-12' Depth | 7 | 8 | 125.2 | 135.5 | 21.2 |
| Hole 11, 0-6' " | 9 | 13 | 116.5 | 134.0 | 5.45 |
| Dodson Area | | | | | |
| Pit 1, 0-10' Depth | 2 | 7 | 118.5 | 127.2 | 19.2 |
| Bogus Area | | | | | |
| Pit 1, 10' Depth | 8 | 8 | 113.3 | 124.0 | 10.5 |
| Pit 1, 0-9' " | 2 | 9 | 112.2 | 122.5 | 25.9 |
| Summit Area | | | | | |
| Pit 1, 0-7' Depth | 4 | 9 | 117.5 | 128.5 | 9.65 |

## Appendix C – Typical Ranges of Permeability for Different Materials




*Due to migration of fines, channels, and air in voids.

Direct shear tests were performed on each sample by Pittsburgh Laboratories. Results were unobtainable on Type 3 and Type 4 because of shear ring binding and mechanical interlocking of coarse sand particles. It is felt however that the shearing resistance of Types 3 and 4 is very similar to Types 2 and 3 and therefore may be used in design. The shear resistance of Types 1 and 2 are as follows:

| Type No. | 1 | 2 | Avg. |
|---|---|---|---|
| Cohesion (Tons/sq/ft/) | .37 | 1.64 | 1.00 |
| Angle of Internal Friction (Ø) | 34.4° | 19.4° | 26.9° |

A stability analysis was made using approximate methods, the above average test values and the section shown on Plate V. This analysis indicates that a factor of safety of approximately 2.25 will be obtained.

The volume of the material available as determined from the drill holes is as follows:

Types 1, 2 and 3 - 96,000 cubic yards
" 4 - - - - - - - 55,000 " "

Field observation indicates that additional material is available on the borders of the areas drilled which is similar to the material tested.

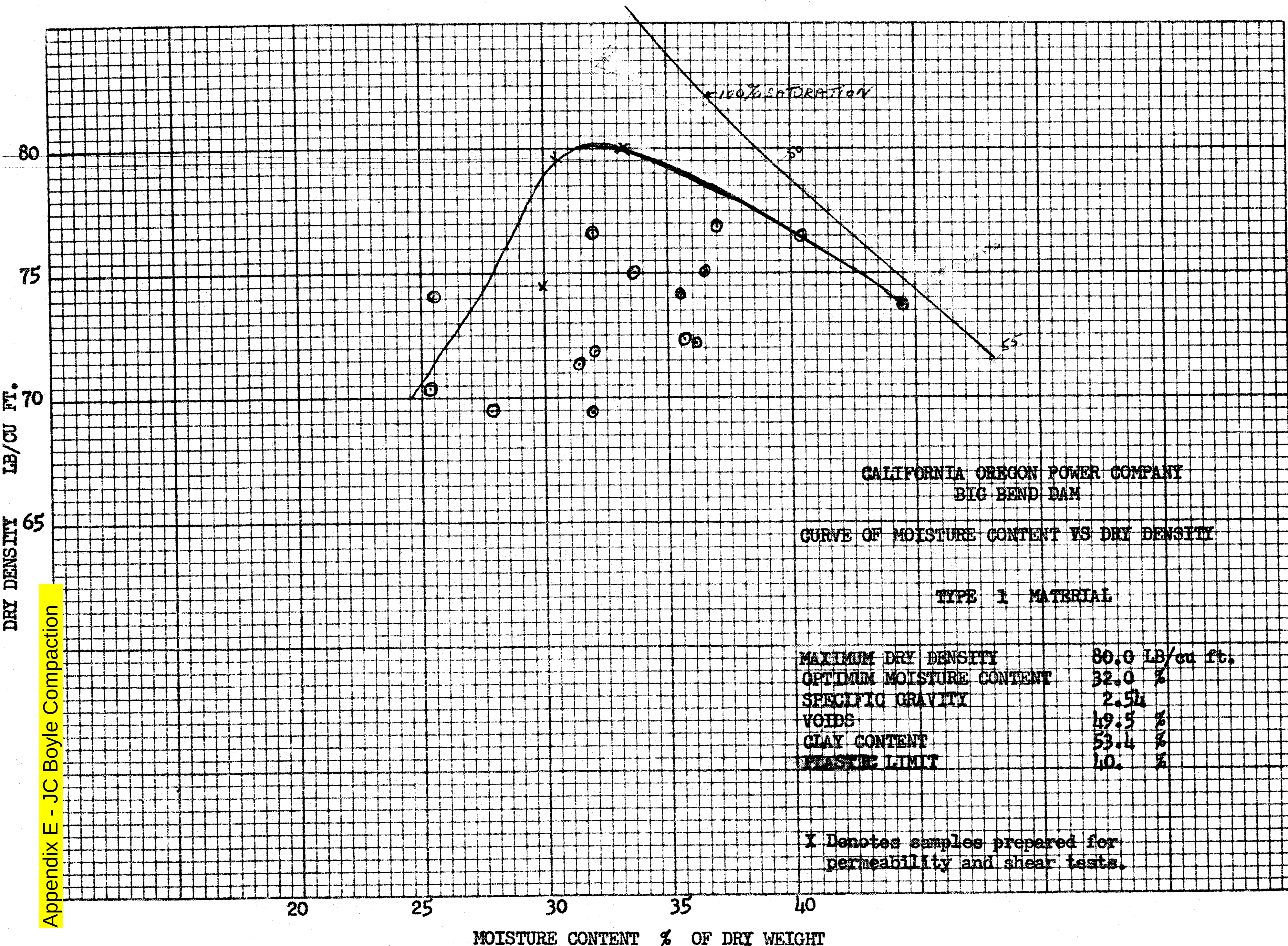
CONCLUSIONS:

It is concluded that the earthen embankment of Big Bend Dam may be constructed of the materials which have been analyzed in this report to the approximate typical section as shown on Plate V, and to specifications attached hereto entitled "Earthwork Specifications for Big Bend Dam" and labelled "Appendix 1".

The impervious core of the embankment, Zone 1, should be constructed of the materials classified in this report as Types 1, 2 and 3. The moisture content of these materials is about 25% and the maximum dry density between 85 and 95 lbs per cubic foot. The "yardstick" for construction should be set for this section at 25% moisture and 90 lbs per cubic foot. As construction progress is made, the "yardstick" may be varied to more closely conform to field results.

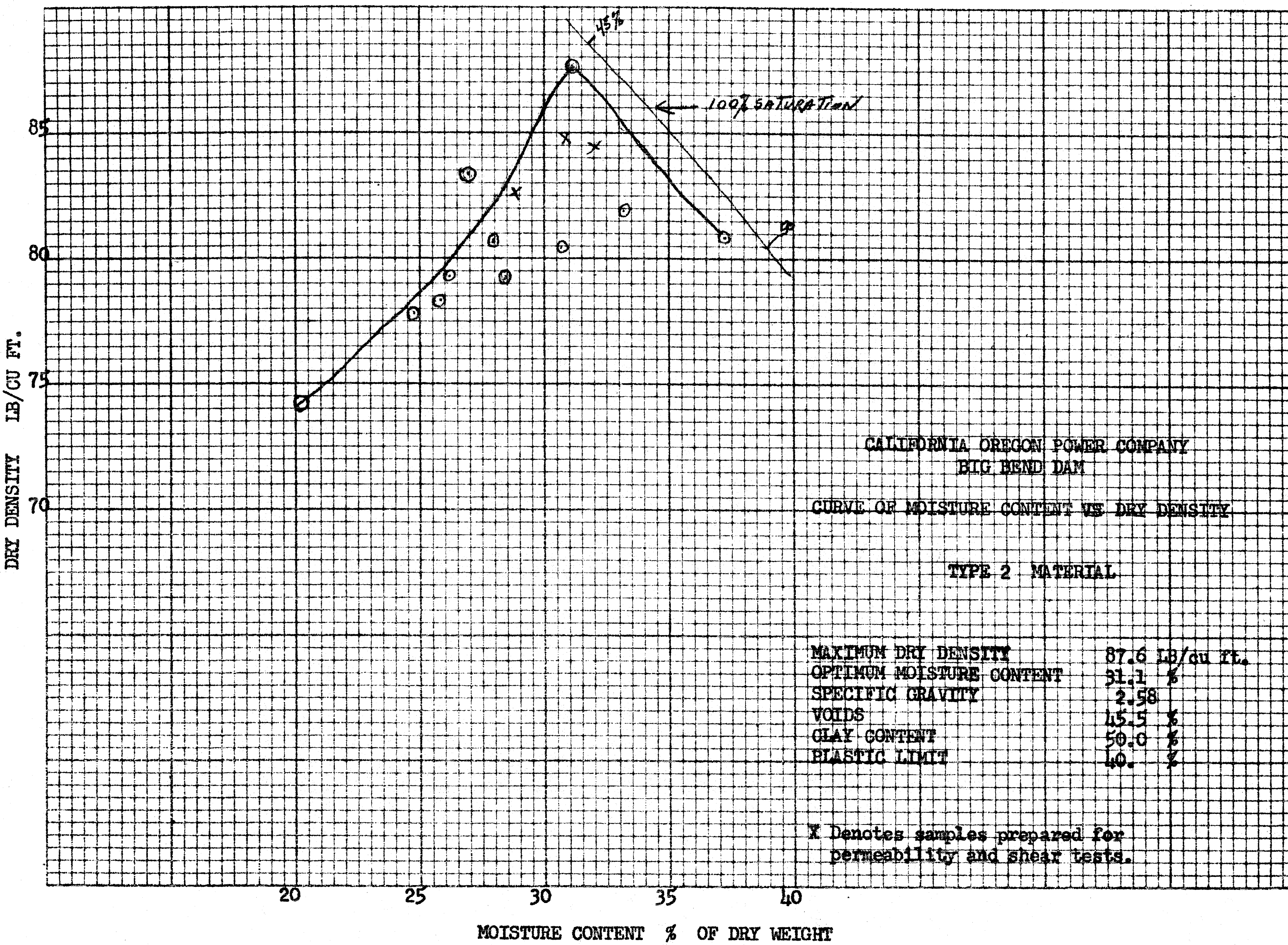
Zone 2 of the embankment, the semi-pervious section, should be constructed of the material classified as Type 4. The optimum moisture content of this material is about 18% with a dry density, including the gravel, of 128 lbs per cubic foot. Again, as field results are obtained, this "yardstick" may be varied.

Appendix E - JC Boyle Compaction




No.911-10 10 x 10 to 1" The A. Lietz Co., San Francisco Made in U.S.A.

PLATE III - Sheet No. 1



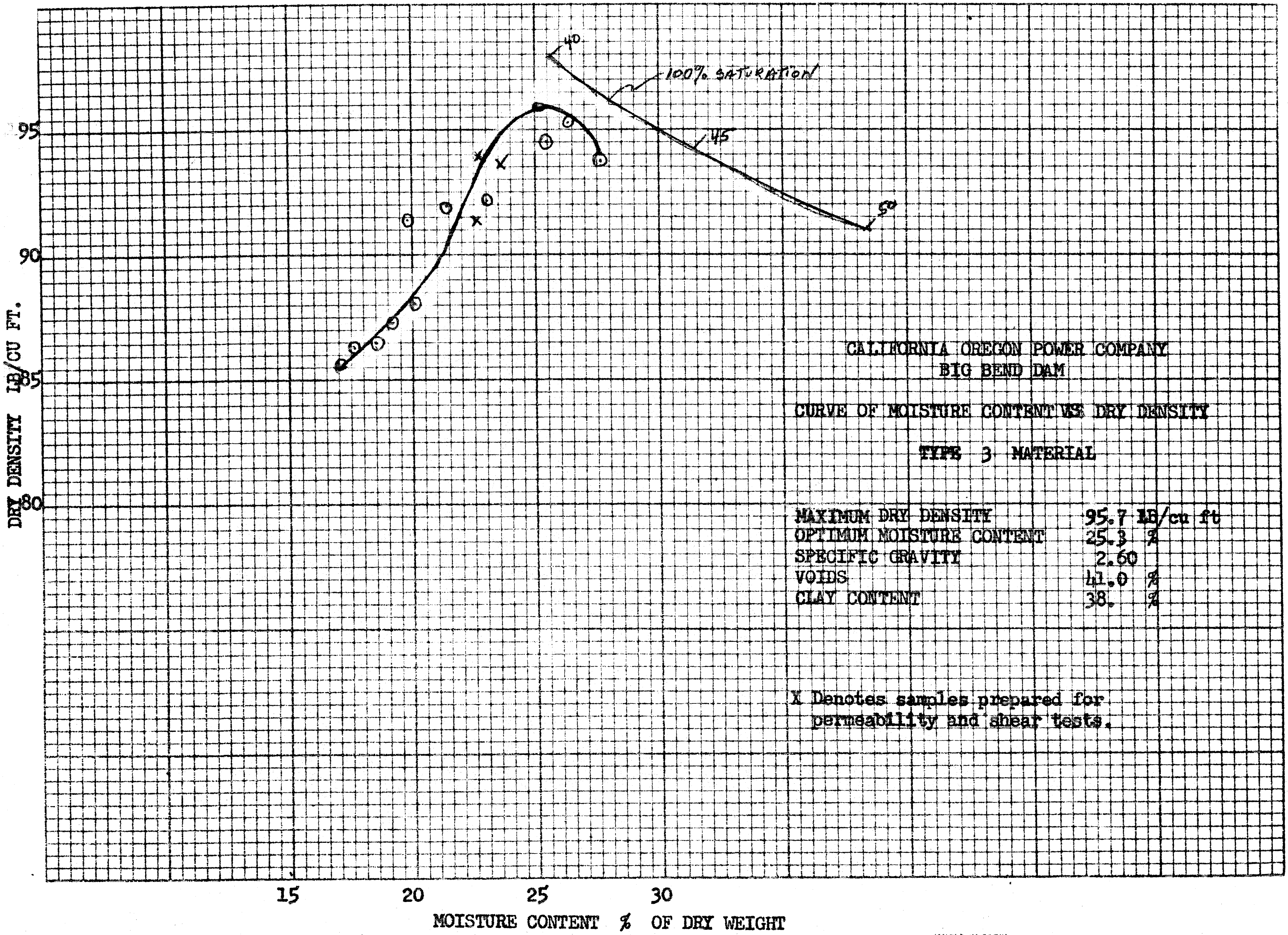

CALIFORNIA OREGON POWER COMPANY
BIG BEND DAM

CURVE OF MOISTURE CONTENT VS DRY DENSITY

TYPE 2 MATERIAL

| | |
|---|---|
| MAXIMUM DRY DENSITY | 87.6 LB/cu ft. |
| OPTIMUM MOISTURE CONTENT | 31.1 % |
| SPECIFIC GRAVITY | 2.58 |
| VOIDS | 45.5 % |
| CLAY CONTENT | 50.0 % |
| PLASTIC LIMIT | 40. % |

X Denotes samples prepared for permeability and shear tests.




CALIFORNIA OREGON POWER COMPANY
BIG BEND DAM

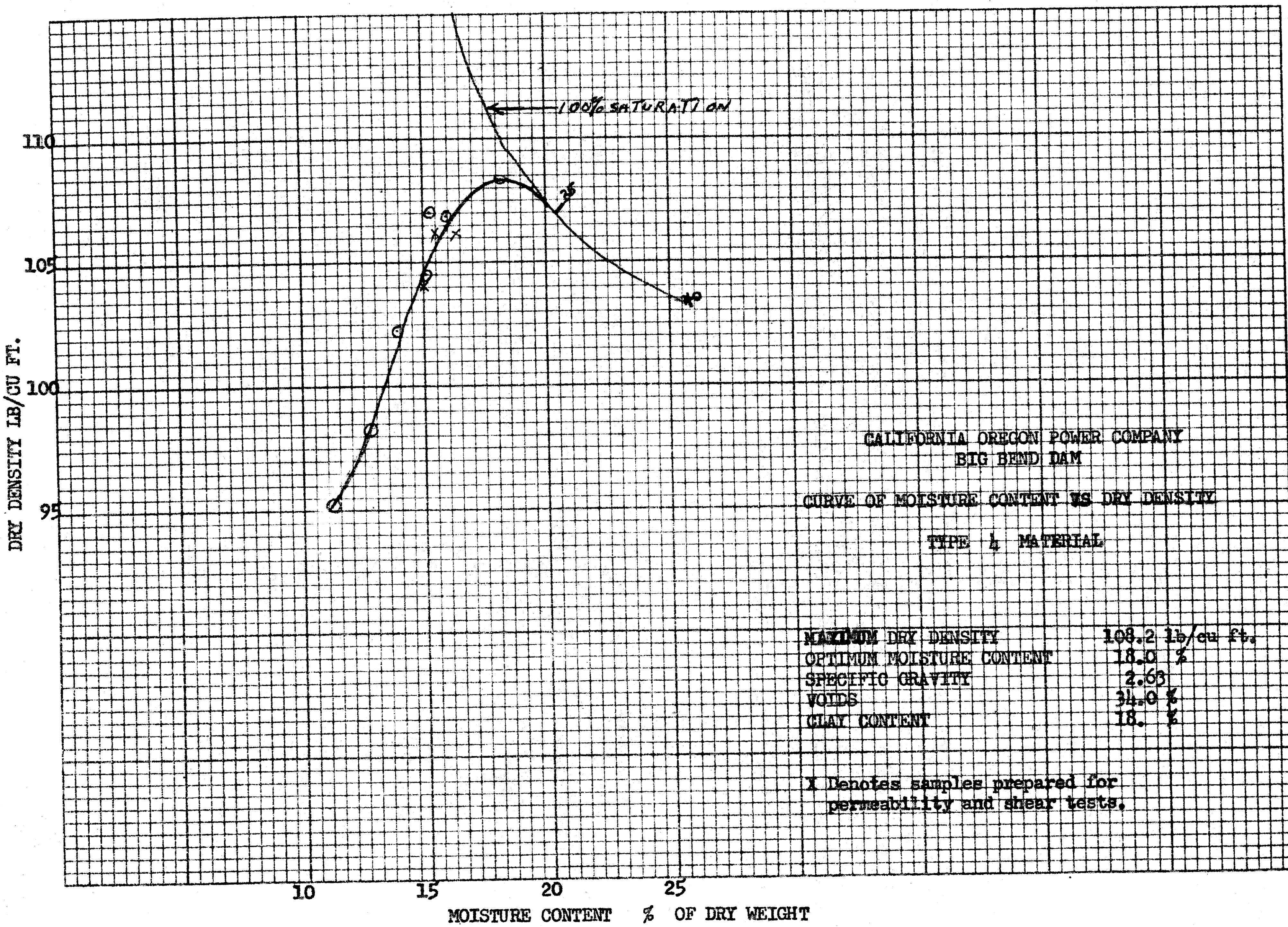
CURVE OF MOISTURE CONTENT VS DRY DENSITY

TYPE 3 MATERIAL

| | |
|---|---|
| MAXIMUM DRY DENSITY | 95.7 LB/cu ft |
| OPTIMUM MOISTURE CONTENT | 25.3 % |
| SPECIFIC GRAVITY | 2.60 |
| VOIDS | 41.0 % |
| CLAY CONTENT | 38. % |

X Denotes samples prepared for permeability and shear tests.

PLATE III - Sheet No. 4




CALIFORNIA OREGON POWER COMPANY
BIG BEND DAM

CURVE OF MOISTURE CONTENT VS DRY DENSITY

TYPE 4 MATERIAL

| | |
|---|---|
| MAXIMUM DRY DENSITY | 108.2 lb/cu ft. |
| OPTIMUM MOISTURE CONTENT | 18.0 % |
| SPECIFIC GRAVITY | 2.63 |
| VOIDS | 34.0 % |
| CLAY CONTENT | 18. % |

X Denotes samples prepared for permeability and shear tests.

Appendix F - JC Boyle Permeability

| | In Place Moisture | Clay Content (Percent) | Specific Gravity of Particles | % Finer than #4 Sieve |
|---|---|---|---|---|
| Avg. | 19.7 | 35 | 2.64 | 51 |
| Max. | 26.9 | 48 | 2.72 | 63 |
| Min. | 14.5 | 24 | 2.58 | 39 |

Number of Samples - 14.

Note: Material passing the No. 4 sieve was not plastic. Could not roll 1/8" diameter thread due to sand grains. Specific gravity of the rock (larger than #4 sieve) = 2.64.

The curves showing the moisture content dry density relation of the material finer than the No. 4 sieve are shown on Plate III, Sheet #4. At an optimum moisture content of 18%, the dry density was 108.2 lb/cu ft. with 3½% voids. When the material passing the No. 4 sieve and the larger material are combined, the theoretical density can be computed as follows:

$$Drs = \frac{Ds\ Dr}{PD_s + (1-P)\ D_r}$$

Where Drs = Theoretical density of combination
Ds = Density of soil
Dr = Density of rock
P = Percentage of rock (expressed as decimal)

$$Drs = \frac{(108.2)\ (62.4)\ (2.64)}{(\ .49)\ \ (108.2) + (\ .51)\ (165)} = 130 \text{ lb/cu ft.}$$

The above value is a theoretical quantity - which normally cannot be obtained in practice due to the interferance to compaction by the rock. A more practical equation is as follows:

$$Drs = (1-P)\ D_s + 0.9\ P\ Dr$$

$$Drs = (1-.49)\ 108.2 + 0.9\ (\ .49)\ (165) = 128 \text{ lb/cu ft.}$$

II. Qualitative capillarity tests were performed on each of the four types of material. The test consisted of placing a 4" diameter by 4" high compacted sample of the material in a pan of water. In each case the sample of material became saturated in approximately 4 hours. After 48 hours, no sloughing or breakdown of the sample had taken place.

Permeability tests by the falling head method were performed on each type of material by Pittsburgh Testing Laboratories. The permeability was determined to be as follows:

| | | | |
|---|---|---|---|
| Type 1 | - | 0.0000187 | centimeters per second |
| " 2 | - | 0.0000155 | " " " |
| " 3 | - | 0.000226 | " " " |
| " 4 | - | 0.00000383 | " " " |

These co-efficients of permeability fall within the impervious sections of earth dams or dikes as classified by Casagrande and Fadum, Harvard University. The permeability test on Type No. 4 material was performed on the material passing the No. 4 sieve. While this material seems to have the smallest permeability, the gravel content is so high (50%) as to make the overall material questionable as to watertightness.

# Appendix E Terrestrial Resources Measures

AECOM

# Klamath River Renewal Project

## California Environmental Quality Act (CEQA) and California and Oregon 401 Water Quality Certifications Technical Support Document

### Appendix E - Terrestrial Resource Measures

**Submitted to:** California State Water Resource Control Board and Oregon Department of Environmental Quality

**Submitted by:** Klamath River Renewal Corporation

**Date**: September 2017

**Prepared for:**

Klamath River Renewal Corporation
California State Water Resources Control Board
Oregon Department of Environmental Quality

**Prepared by:**

KRRC Technical Representative:

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

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

River Design Group
311 SW Jefferson Avenue
Corvallis, Oregon 97333

# Table of Contents

## Tables

## Attachments

# 1. Northern Spotted Owl Measures

## 1.1 Objectives

The primary objective of the Northern Spotted Owl (NSO) (*Strix occidentalis*) measures is to identify any NSO activity centers (including any nesting sites) that are located near proposed construction and disposal areas associated with Klamath River dam removal in order to avoid or minimize the potential for disturbance during NSO nesting, roosting, or foraging activities. The first step is to conduct surveys in suitable habitats as described below. If NSO are found within the area of potential effect, then the design plans and/or construction methods or sequencing would be modified to avoid and minimize potential effects on NSO.

The Klamath Facilities Removal Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR) (USBR and CDFW 2012) Mitigation Measure TER-2 described measures to reduce Project impacts on nesting birds including NSO. The EIS/EIR recommended surveys to identify the locations of active nests and then to incorporate that information into the project design and construction planning to avoid impacts. This measure has been incorporated into the project and will be implemented as described in the following sections. The objective of this NSO survey plan is to identify, document, and confirm spotted owl presence, and use of areas that may be directly or indirectly disturbed by Project construction activities including noise. That information will be used to develop a plan in coordination with the US Fish and Wildlife Service (USFWS) and California Department of Fish and Wildlife (CDFW) to provide avoidance and minimization measures that will reduce Project impacts on NSO habitat and use.

## 1.2 Desktop Evaluation

A desktop review of existing databases (including California Natural Diversity Database [CNDDB] and the Oregon Biodiversity Information Center [ORBIC]) was conducted to identify known NSO detections and activity centers in the Project area. During PacifiCorp surveys in 2002-2003, NSO presence was documented near J.C. Boyle Reservoir and along the J.C. Boyle peaking reach (the reach of the Klamath River that begins at the J.C. Boyle powerhouse and extends downstream to the mouth of Shovel Creek) (PacifiCorp 2004).

In addition to the 2002-2003 PacifiCorp protocol surveys, information was obtained from U.S. Fish and Wildlife Service (USFWS), U.S. Department of the Interior, Bureau of Land Management (BLM), and U.S. Forest Service (USFS) biologists, and the National Council for Air and Stream Improvement, Inc. (NCASI), a nonprofit research institute focusing on issues of concern to timber and other forest products companies. There were no NSO detections during NCASI surveys in 2002 and 2003, and NCASI no longer surveys for NSO in the Project area (Verschuyl, pers. comm., 2017).

USFS (Freeling 2017) confirmed a known NSO activity center located 1.3 miles southeast of the eastern end of the Copco Lake and over 5 miles southeast of the Copco No. 1 Dam and powerhouse. This activity center is also documented in the CNDDB. BLM (Hayner 2017) confirmed there are no NSO territories within the 1-mile noise disturbance buffer from potential blasting at the J.C. Boyle Dam (described below) or within 0.5 miles of the Project limits of work. Therefore, based on the desktop evaluation, no NSO activity centers have been documented within the disturbance distances established in the Biological Assessment (BA, U.S. Bureau of Reclamation [USBR] 2011) for the anticipated construction activities. This will be confirmed through field surveys, as described below.

The J.C. Boyle powerhouse is located within designated critical habitat for NSO. Effects on designated critical habitat at the J.C. Boyle facilities are not anticipated because removal of the facilities will not involve the removal of forest cover and would provide opportunities for habitat restoration. Removal of mature trees would occur at the proposed disposal site at J.C. Boyle, which consists of marginal habitat for NSO. The proposed disposal site is not located within designated critical habitat for NSO.

## 1.3 Methods

The proposed methodology for NSO surveys is based on the 2012 USFWS NSO Survey Protocol (USFWS 2012b). Surveys will be conducted within suitable habitat for NSO as identified through the desktop evaluation.

### 1.3.1 Selection of Proposed Calling Stations

USFWS provided KRRC with a Relative Habitat Suitability (RHS) model, which uses 2012 vegetation information (Galloway 2017). The RHS model indicates "highly suitable habitat" for NSO occurs adjacent to the J.C. Boyle powerhouse and approximately 1 mile away from the J.C. Boyle Reservoir. BLM also provided 2014 NSO habitat suitability data for the J.C. Boyle Project area. Based on a review of historical aerial photography, timber harvest has been conducted in several locations within the Project area. It is uncertain if this habitat alteration was considered in the USFWS or BLM habitat suitability data. However, this alteration may have reduced the habitat suitability for NSO within the noise disturbance areas.

Based on the habitat suitability information, suitable NSO habitat is not present within 1 mile of the Copco or Iron Gate Dams and facilities. Suitable habitat includes mature or old-growth forests containing large diameter trees with multiple canopy layers in areas with high canopy closure and complex structure. Based on the USFWS RHS, the nearest suitable habitat is approximately 3 miles southeast of the Copco No. 1 Dam and over 5 miles from Iron Gate Dam.

To develop proposed calling stations, aerial imagery with topographic contours was evaluated against the habitat suitability information and the construction limits of work, with haul and access roads and the boundaries of staging and disposal areas defined to the extent possible. Information on construction equipment and details regarding activities such as the potential for blasting (i.e., where it would occur, frequency, duration, and season) was used to outline potential calling stations based on the noise disturbance distances established in the BA. Activities such as grading or other use of heavy machinery that may occur during restoration of the reservoir areas were also considered.

Project activities that may remove individual or small numbers of trees or other vegetation, such as widening existing roads, are not anticipated to rise to the level of NSO habitat modification. Proposed disposal sites will be closely evaluated to determine that they are not placed within suitable habitat. The proposed sites at Iron Gate and Copco are not within potential NSO habitat. The boundaries of the proposed disposal site at J.C. Boyle Dam are still being refined although the general location has been identified. Although the habitat in the proposed J.C. Boyle disposal site does not appear to be high quality NSO habitat, the surveys will confirm whether there is NSO use in the area. If there are any Project activities that could result in NSO habitat modification, the KRRC will conduct 2 years of protocol surveys in those locations.

It should be noted that a distance of 1.3 miles in California and 1.2 miles in Oregon is used for analyzing effects to nesting spotted owls from habitat modification such as timber harvest. Since the Project will not result in NSO habitat modification, noise disturbance is the focus of the surveys.

The following NSO disturbance distances were developed for the BA:

- Blasting: 1,760 yards (1 mile)
- Hauling on open roads: 440 yards (0.25 mile)
- Heavy equipment: 440 yards (0.25 mile)
- Rock crushing: 440 yards (0.25 mile)
- Helicopter: 880 yards (0.5 mile)
- Fixed Wing Aircraft: 440 yards (0.25 mile)

Based on the desktop evaluation, it was determined that NSO protocol surveys will focus on suitable habitat around J.C. Boyle and Copco Dams and associated facilities, disposal sites, and haul and access roads around each. Facilities associated with Iron Gate Dam and Reservoir are not included based on the lack of suitable habitat for NSO.

The survey area encompasses the disposal site at J.C. Boyle due to its proximity to suitable habitat. A noise attenuation evaluation may be used to focus survey efforts, in accordance with the USFWS 2006 guidance (USFWS 2006) and agency input (Reilly 2017). Noise attenuation from topography and other features has not yet been evaluated to refine these survey areas.

### 1.3.2 Protocol Surveys

The BA and Measure NSO in the USFWS Biological Opinion (2012a) calls for protocol-level surveys to be conducted within suitable nesting and roosting habitats that occur within the NSO noise disturbance buffer around proposed construction activities. As described above, the Project is not anticipated to result in modification of NSO habitat. Therefore, protocol surveys will be conducted for noise-only disturbance following the 2012 USFWS NSO Survey Protocol.

For noise-only disturbance, 1 year of protocol surveys will be conducted including six visits in 2018 in suitable habitat within the noise disturbance areas shown in Figures 1 to 5 in Attachment A and as refined based on the field reconnaissance, noise attenuation evaluation, or other information. Figures 1 to 5 in Attachment A show the proposed survey locations on a habitat suitability model generated by USFS, a habitat suitability model generated by BLM, and on an aerial photo showing the existing vegetation. The BLM habitat suitability model is only applied to BLM lands and does not extend into California; therefore, there are no corresponding BLM figures for the Copco area.

NSO protocol surveys will be conducted by a team of at least two biologists, with at least one spotted owl surveyor meeting the qualifications outlined in the 2012 USFWS NSO Survey Protocol. Visits will be spaced out over the breeding season from March through August. At least three of the visits will be conducted before the end of June.

Survey methods will include spot calling and daytime stand searches and/or continuous walking surveys. The results of the reconnaissance visit in July 2017 will be used to identify the most appropriate study design for each area of suitable habitat. Both nighttime and daytime surveys will be conducted. If a spotted owl is detected during the night survey, the biologist will return to the area during the daytime as soon as possible (preferably within 48 hours) and conduct a follow-up visit to verify status as needed. Details of field efforts, including the methods used, weather conditions, and identified occupancy/nesting status, will be noted on field forms consistent with the 2012 USFWS NSO Survey Protocol.

Preliminary calling stations are shown in Figures 1-4 in Attachment A. Calling routes and stations will be confirmed in the field to achieve complete coverage of all habitat within the survey area such that surveyors are able to hear responding owls within the entire survey area. Spacing of calling stations will be determined by the topography and acoustical characteristics of the area (e.g., background noise such as creeks); preliminary stations are spaced between 0.25 and 0.5 mile apart.

To summarize, NSO surveys will be conducted as follows:

- Disturbance-only protocol surveys will be conducted.
- In the J.C. Boyle Project area, surveys will be conducted in suitable habitat within the 1-mile noise-disturbance area surrounding the J.C. Boyle Dam as shown in Figure 2 in Attachment A. This includes the disposal site due to its proximity to suitable habitat. Surveys will also be conducted in suitable habitat surrounding the J.C. Boyle powerhouse, as shown in Figure 3 in Attachment A. At the Copco Project area, surveys will be conducted southeast of the Copco Lake, as shown in Figure 4 in Attachment A.
- Six survey visits will take place between March 15 and August 31, with at least three visits before the end of June. The entire Project area will be covered in a span of 7 days for a complete visit; the visit will be completed on consecutive days if possible. Complete visits will be spaced at least 7 calendar days apart.
- Calling stations will be at least 0.25 to 0.50 miles apart. Preliminary calling stations are shown in Figures 1 to 4 in Attachment A and may be revised based on field conditions. A total of 21 calling stations are identified: 12 within the 1-mile noise disturbance area around the J.C. Boyle Dam, 6 within 0.5 miles of the limits of work downstream of the J.C. Boyle Dam, and 3 within suitable habitat southeast of the Copco Lake.
- Three survey techniques may be used to conduct a complete visit: spot calling (preferred), continuous walking, or leapfrog surveys. A minimum of 10 minutes will be spent at each calling station. Both nighttime and daytime surveys will be conducted.

- Surveys will not be conducted under inclement weather, including rain, heavy fog, high wind speed (> 12 mph), or at high noise levels (e.g., stream noise, tree drip after rain event, machine/road noise).

Survey reports will be provided to USFWS following completion. Based on the findings, additional protocol surveys may be conducted in 2019 (the next consecutive year following the 2018 surveys) in coordination with USFWS.

## 1.4 Avoidance and Minimization Measures

Measure NSO 1: The results of the field surveys will be used to modify the design and/or construction plans and timing as appropriate, with an overall goal of preventing or minimizing impacts. Locations of the individual components of the Proposed Action, noise disturbances, and habitat geographic information system (GIS) layers will be evaluated to determine whether or not additional measures are needed.

Measure NSO 2: Protocol-level surveys will be conducted within suitable nesting and roosting habitat (assessed by using best available GIS information, aerial photos, and coordination with the USFWS) as described above. If no nesting is observed, no seasonal restriction would be required. If nesting is observed, a California seasonal restriction (February 1–September 15) or Oregon seasonal restriction (March 1–September 30) will be followed or activity will be delayed as late as possible into the late breeding season for California (July 10–September 15) or Oregon (August 11–September 30) to minimize the disturbance to young prior to fledging.

Measure NSO 3: To prevent direct injury of young resulting from aircraft, no helicopter flights will occur within or at an elevation lower than 0.8 km (0.5 mi) of suitable nesting and roosting habitat during the entire breeding season unless the protocol level surveys identify no activity centers.

Measure NSO 4: No component of suitable nesting, roosting, foraging, or dispersal habitat will be modified or removed during the removal of transmission lines or installation or removal of fencing.

## 1.5 References

Freeling, Debra. 2017. Wildlife Biologist, U.S. Forest Service, Goosenest Ranger District. Personal communication with Jennifer Jones, KRRC, June 16, 2017.

Galloway, Shaughn. 2017. Wildlife Biologist, U.S. Fish and Wildlife Service, Yreka. Personal communication with Kate Stenberg, KRRC, May 24, 2017.

Hayner, Steve. 2017. Wildlife Biologist, Bureau of Land Management, Lakeview District, Klamath Falls Resource Area. Personal communication with Jennifer Jones, KRRC, August 24, 2017.

PacifiCorp. 2004. Terrestrial Resources Final Technical Report. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. February.

Reilly, Michelle. 2017. Wildlife Biologist, U.S. Fish and Wildlife Service, Yreka. Personal communication with Jennifer Jones, KRRC, June 21, 2017.

U.S. Bureau of Reclamation (USBR). 2011. Final Biological Assessment and Final Essential Fish Habitat Determination for the Preferred Alternative of the Klamath Facilities Removal EIS/EIR. U.S. Bureau of Reclamation, October.

USBR and CDFW. 2012. Klamath Facilities Removal. Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR). U.S. Bureau of Reclamation and California Department of Fish and Wildlife, December.

U.S. Fish and Wildlife Service (USFWS). 2006. Estimating the Effects of Auditory and Visual Disturbance to Northern Spotted Owls and Marbled Murrelets in Northwestern California. USFWS, Arcata Office. July 31.

USFWS. 2012a. Joint Preliminary Biological Opinion on the Proposed Removal of Four Dams on the Klamath River. Conducted By: National Marine Fisheries Service Southwest Region and Fish and Wildlife Service Region 8. November.

USFWS. 2012b. Protocol for Surveying Proposed Management Activities That May Impact Northern Spotted Owls. Endorsed by the U.S. Fish and Wildlife Service. February 2, 2011, Revised January 9, 2012.

Verschuyl, Jake. 2017. Wildlife Biologist, National Council for Air and Stream Improvement (NCASI). Personal communication with Jennifer Jones, KRRC, June 15, 2017.

# 2. Bald Eagle and Golden Eagle Measures

## 2.1 Objectives

Bald eagles (*Haliaeetus leucocephalus*) and golden eagles (*Aquila chrysaetos*) are protected under the Bald and Golden Eagle Protection Act (16 CFR 668), the Migratory Bird Treaty Act (16 U.S.C. §§ 701-12), and are fully protected under California law. Bald eagles are listed as Endangered under the California Endangered Species Act (CESA). (Bald eagles are not listed in the State of Oregon.)

The Klamath Facilities Removal Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR) (USBR and CDFW 2012, Section 3.5) Mitigation Measure TER-3 described measures to reduce Project impacts on bald and golden eagles. The EIS/EIR recommended surveys to identify the locations of active nests and then to incorporate that information into the project design and construction planning to avoid impacts. This measure has been incorporated into the project and will be implemented as described in the following sections. The objective of this eagle survey plan is to identify, document, and confirm eagle presence, and eagle use of areas that may be directly or indirectly disturbed by Project construction. That information will be used to develop a plan in coordination with the US Fish and Wildlife Service (USFWS) and California Department of Fish and Wildlife (CDFW) to provide avoidance and minimization measures that will reduce Project impacts on eagle nesting, roosting, and foraging activities.

## 2.2 Existing Information

The Upper Klamath Basin provides suitable habitat for and is known to support bald eagle and golden eagle populations.

### 2.2.1 Bald Eagle

The upper Klamath Basin supports a high number of nesting bald eagles and supports the largest wintering population of bald eagles in the coterminous United States (Shuford et al. 2004). In some years, up to 117 bald eagle pairs nest and 1,100 individuals winter in the Klamath Basin (PacifiCorp 2004). Bald eagle nesting trees are known to exist in the vicinity of the Project area and bald eagles often use the same nests in multiple years. In addition, eagles may have more than one nest within an active territory and they may alternate their use of the nests between years.

Bald eagle nest surveys were conducted by the Oregon Cooperative Fish and Wildlife Research Unit in the Klamath River area on March 27, 2002, and May 29, 2002 (PacifiCorp 2004). Six known nests were recorded in the vicinity of the Project area, with distances to the nearest facility ranging from approximately 0.7 miles to 7.1 miles (two near J.C. Boyle Reservoir, three near J.C. Boyle peaking reach, and one near Copco Lake). Aerial surveys conducted in 2003 found a new nest located approximately 540 feet southeast of Copco No. 1 Dam.

PacifiCorp has documented additional bald eagle observations at the Iron Gate, Copco, and J.C. Boyle Reservoirs, and at other locations along the middle and lower Klamath River. At least 32 individual sightings of bald eagles in flight, perched, or foraging were recorded during targeted avian surveys in 2002 (see Attachment B), and numerous incidental sightings occurred during general wildlife and facility surveys and other field studies (PacifiCorp 2004). These observation data are useful in establishing that nesting and foraging habitat are present within the vicinity of the Project area. By agency request, exact nesting locations were not published in the PacifiCorp 2004 report. To continue to protect eagle nests, exact locations will not be provided in this report.

This year, the US Fish and Wildlife Service and the BLM provided an updated dataset of bald and golden eagle nests and territories that have been monitored in the region (Willy 2017 and Hayner 2017). Based on these data, there are four bald eagle nests within 0.5 miles of J.C Boyle Reservoir and one bald eagle nest within 0.5 miles of the Copco Lake. A summary of all nests in the database within 2-miles of the Project limits of work is provided in Table 2-1. Other existing data sets, if available, will be incorporated into future reports.

### 2.2.2 Golden Eagle

Golden eagles are known to have historically nested on cliffs in the vicinity of the Project area (USBR and CDFW 2012). Golden eagles also nest within pine, juniper and oak trees and suitable habitat is present in the Project area. Golden eagles have historically nested on cliffs from J.C. Boyle bypass reach to Iron Gate Reservoir. During PacifiCorp surveys, golden eagles were observed in several locations, including Copco Lake and Iron Gate Reservoir and J.C. Boyle powerhouse, but no nests were found (PacifiCorp 2004). Natural densities for this species in southern Oregon and northern California are low.

## 2.3 Methods

Study methods include desktop analysis, a GIS viewshed analysis, and field surveys. Initially biologists compiled existing data on bald and golden eagles and conducted a desktop analysis to locate known nests and territories. A field reconnaissance survey was conducted in July 2017. The viewshed analysis will be used to refine the survey area and additional field surveys are planned as described below.

### 2.3.1 Desktop Analysis

The desktop analysis includes a review of existing data. These data are compiled from:

1. Federal and state agency databases (CNDDB and ORBIC) and datasets from the USFWS, ODFW, and CDFW (collectively, the wildlife agencies) and the BLM;
2. Previous biological survey data such as the PacifiCorp 2004 report; and
3. Reports of surveys completed at or near the Project area.

In addition to the above sources, regional experts, including Frank Isaacs of the Oregon Eagle Foundation, have been contacted. Mr. Isaacs conducted aerial helicopter surveys in 2002 and 2003 to document eagle nests, perching sites, and foraging sites, and to determine occupancy and productivity of territories in the Klamath Basin. If additional information is made available through contacts with regional experts it will be included in future reports.

Another component of the desktop analysis is an evaluation of aerial imagery and topography correlated with the results of the field reconnaissance. To refine the survey area, a viewshed analysis was conducted in ArcGIS (ESRI, Version 10.4.1) to generate visibility extents using a NED (National Elevation Dataset) topographic surface and observer points derived from the Project limits of work. This analysis calculates all locations that are simultaneously visible from any observer point distributed along the Project limits of work. It considers topography but not vegetation.

Because the Project construction limit's geometry is complex, there are potentially tens of thousands of observer points that could be used in the generation process. To limit the number of observer points, the analysis estimated observer points approximately every 20 feet along the Project limits of work, while retaining the limit's geometry. From each of these observer points, a hypothetical observer could look in any direction – any topographical feature that's within the view of this observer will be included in the viewshed.

To refine the survey area to areas where eagles are more likely to be affected by Project activities, and also to comply with recommended avoidance buffers for bald eagles (Jackman and Jenkins 2004), KRRC biologists propose limiting the surveys to those viewshed areas within 0.5 mile of the Project limits of work. This 0.5 buffer will be extended to the area within the viewshed for up to 2 miles where construction or demolitions will occur (Pagel et al. 2010). The variance will account for differences in the level of impact among locations within the Project limits of work. Proposed construction activities associated with the decommissioning of the dams and facilities, creation of disposal sites, and use of haul and access roads will be mostly limited to the areas where facilities are or will be located. Much of the Project area includes the associated reservoirs, where little construction work is currently anticipated. The proposed survey area and appropriate buffer distances will continue to be modified as Project construction activities and methods are further developed and the impact areas are refined. The survey area will be defined based on the nature and timing of proposed construction activities, the location of known eagle nests and use areas, and further evaluation of the viewshed, prior to initiating 2018 surveys.

### 2.3.2 Field Surveys

Bald and golden eagle surveys will be conducted concurrently by qualified avian biologists. To meet the Project schedule, all eagle surveys will be complete by the end of 2018. The surveys will focus on areas with suitable nesting, roosting, or foraging habitat for bald and golden eagles. The main goal of the surveys is to determine where nest sites are distributed within the survey area and to determine baseline eagle use and behavior at nests and other key habitat features so that any disturbances that may occur during construction can be recognized and corrective actions can be taken. Field surveys will employ a variety of techniques and multiple survey windows to capture seasonal activity. Prior to field surveys, the Klamath River Renewal Corporation's (KRRC) Technical Representative will coordinate site access with PacifiCorp.

#### 2.3.2.1 2017 Surveys

A field reconnaissance survey was conducted July 24-26, 2017. Surveyors assessed habitats in the vicinity of the Project area by vehicle and on foot, noted bird activity, and attempted to locate all known nests (based on data received to-date) within a 0.5-mile radius of the Project area. Biologists spent one day at each dam and associated facilities and reservoir.

#### 2.3.2.2 2018 Surveys

The 2018 bald and golden eagle survey protocol is informed by the desktop analysis, information obtained during the 2017 reconnaissance survey, and established protocols including:

- Bald Eagle Nest Survey and Reporting Guide: Reporting Observations at Nest Sites in Oregon (Isaacs 2009),
- Protocol for Evaluating Bald Eagle Habitat and Populations in California (Jackman and Jenkins 2004), and
- Interim Golden Eagle Inventory and Monitoring Protocols (Pagel et al. 2010).

In the field, surveyors will gather information on eagle nesting behavior and habitat use within the survey area that could potentially be directly or indirectly affected by Project construction activities. This information will provide a pre-construction baseline for monitoring eagles during construction to assess whether Project activities were adversely affecting eagle behavior or habitat use.

A synthesized field survey to encompass bald and golden eagle nesting habitat use will include:

1. Two breeding season surveys (late January through July).
    a. An initial nest search will be conducted early in the breeding season, when eagles are most likely to be found at nest sites, to determine occupancy. The first inventory and monitoring survey will be conducted early in the season, during courtship when the adults are mobile and conspicuous.
    b. A second survey will be conducted later in the season to observe any changes in eagle behavior or mid-late season nesting activity.
    c. During these breeding season surveys, biologists will conduct at least 2 ground observation periods lasting at least 4 hours or more as necessary to designate a survey area unoccupied. Ground observers will survey from observation points for a minimum of 4 hours, unless observations yield eagle presence, or eagle behavior indicates eggs or young, or observation suggests the observer is disturbing the birds.
2. Additional surveys will be conducted during the mid-nesting season to determine continued activity and to observe eagle activity patterns to establish a baseline of normal behavior, prior to construction.

Based on accessibility, surveys will be conducted on foot, with terrestrial vehicles and potentially by boat. Motorized vehicles will be used to transport KRRC biologists to the vicinity of nest site, but close access will be by foot to avoid disturbing nesting eagles should they be present. Several locations have been identified where unmanned aerial vehicle (UAV) surveys will be used to check the status of existing nests, and the intent is to use UAVs to assist in locating new or previously undocumented nests as well. The team has access to and experience with UAVs so this method is preferred to helicopter surveys. Biologists will always have binoculars on-hand and use spotting scopes when surveying for nest occupancy. Detailed data will be recorded based on the guidelines and datasheets provided in the protocols.

## 2.4 Preliminary Results

### 2.4.1 Desktop Analysis

GIS specialists mapped known bald and golden eagle nests (based on data received as of July 2017) within 2-miles of the Project limits of work and generated an initial viewshed analysis (Figure 1 in Attachment B). The areas in green are within the viewshed; any area in green is potentially visible to an observer standing at a point on the perimeter of the Project limits of work. This analysis is based on topography and does not account for environmental conditions, distance, trees, or other potential obstructions, which will result in additional visual blinding beyond what is suggested by the viewshed analysis. A 2-mile buffer around the Project limits of work encompasses an area of approximately 112 square miles. The viewshed analysis reduced this to approximately 57 square miles, approximately half of the original size. When more precise data delineating active work areas are available, the analysis will be re-run and used to refine the survey area prior to 2018 surveys.

### 2.4.2 Field Surveys

During the July 2017 reconnaissance survey, AECOM biologists located three of the four known nests within a 0.5-mile radius of the Project area. Of the three located, one juvenile bald eagle was observed near nest BE1-36 (Table 2-1). This nest was presumed active for this year. Biologist observed substantial whitewash and prey remains (fish bones) under the nest. The other two nests surveyed did not have conspicuous indications that they were active; no whitewash, prey remains, or juveniles were observed.  An additional nest location (BE3-1) within 0.5-miles of J. C. Boyle was provided after the reconnaissance survey was completed (Hayner 2017). This nest will be surveyed in 2018. A summary table of known bald and golden eagle nests within 2-miles of the Project limits of work is provided in Table 2-1.

## 2.5 Avoidance and Minimization Measures

The results of the surveys described above will be used to develop an eagle avoidance and minimization plan in coordination with USFWS that identifies procedures and protocols for avoiding and minimizing potential impacts to eagles.  If the survey results identify the potential for the Project to result in a take of bald or golden eagles and before approval of any construction activities, a permit from the USFWS will be obtained under the Bald and Golden Eagle Protection Act.  At this time, with implementation of the avoidance and minimization measures described below, it is not anticipated that there would be a take of bald or golden eagles.

The following measures will be implemented to avoid or reduce impacts on bald and golden eagles:

- The survey of eagle use patterns will be completed prior to construction activities as described above. Surveys will be conducted by a qualified avian biologist and will include any facilities to be removed or modified to determine bird use patterns. Surveys will be conducted during the time of year most likely to detect eagle usage.
- Prior to construction, at least one focused survey for bald and golden eagle nests within areas up to 2 miles of construction areas will be conducted, including along access roads and haul routes, during the early eagle breeding season (January 15 through February 28). An additional survey will be conducted during the breeding season (before July). One later survey will be timed to coincide with the middle of nesting season. Before commencing construction activities during the early breeding season, at least one survey will be conducted within 2 weeks prior to beginning operations. Additional survey visits would be conducted as needed to determine if eagles are nesting within 0.5 miles of the construction area. These pre-construction surveys would include unoccupied nests observed during the 2018 surveys to include alternate nests within active territories that may be used in the year that construction activities commence.
- Wherever possible, clearing, cutting, and grubbing activities shall be conducted outside the eagle breeding period (January 15 through August 15);
- If active nests are present within 2 miles of construction areas, a 0.5-mile restriction buffer would be established in consultation with the resource agencies to ensure nests are not disturbed. If active eagle nests are present within 0.5 miles of construction areas, construction activities would be halted until approval is obtained from the resource agencies to resume. If a nest is not within line of sight of the project, meaning that trees or topographic features physically block the eagle's view of construction activities, the buffer could be reduced to 0.25 miles. Further reduction of buffers or limited activity inside of buffers could occur in coordination with biological monitors and the USFWS, consistent with the eagle avoidance and minimization plan, if it is determined that the activities would not jeopardize nesting success.

## 2.6 References

Hayner, S. 2017. Unpublished Bald and Golden Eagle Nesting Data. Sent from Stephen Hayner, BLM to Jennifer Jones, CDM Smith by email on August 24, 2017.

Isaacs, F. 2009. Bald Eagle Nest Survey and Reporting Guide: Reporting Observations at Nest Sites in Oregon. Version: 3/16/09.

Jackman, R.E. and J. M. Jenkins. 2004. Protocol for evaluating bald eagle habitat and populations in California. Prepared for U.S. Fish and Wildlife Service Endangered Species Division. Sacramento. June 2004

PacifiCorp. 2004. Terrestrial Resources Final Technical Report Klamath Hydroelectric Project FERC No. 2082. February 2004.

Pagel, J. E., D. M. Whittington, and G. T. Allen. 2010. Interim Golden Eagle Inventory and Monitoring Protocols; and Other Recommendations. U. S. Fish and Wildlife Service. February 2010.

Shuford, W.D., Thomson, D.L, Mauser, D.M., and Beckstrand, J. 2004. Abundance, distribution, and phenology of nongame waterbirds in the Klamath Basin of Oregon and California in 2003. Point Reyes Bird Observatory Conservation Science.

USBR and CDFW. 2012. Klamath Facilities Removal. Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR). U.S. Bureau of Reclamation and California Department of Fish and Wildlife, December.

Willy, E. 2017. Unpublished Bald and Golden Eagle Nesting Data. Sent from Elizabeth Willy, USFWS to Jennifer Jones, CDM Smith by email on June 29, 2017.

## Table 2-1 Summary of Bald and Golden Eagle Nests within 2 Miles of the Project Construction Limits

| Reservoir | Name | Species | Distance | History | July 2017 Reconnaissance[3] |
|---|---|---|---|---|---|
| J.C. Boyle | BE1-31 | Bald Eagle | Within 0.5-mile | Active between 2004-2007. 1 nestling observed in 2013. Active but failed in 2014.[1] | Nest located, no activity or sign of recent activity observed. |
| J.C. Boyle | BE1-32 | Bald Eagle | Within 0.5-mile | Active between 2006-2010; one fledged in 2010; unoccupied in 2011; active 2012; nest down in 2013. [1] | Nest appears to have been rebuilt since the last survey, nest located, no activity or sign of recent activity observed. |
| J.C. Boyle | BE1-36 | Bald Eagle | Within 0.5-mile | Active between 1998-2010, 2 fledged chicks in 2013, occupied in 2014. [1] | Nest located, bald eagle juvenile observed nearby, abundant whitewash and prey remains at base of nest; presumed active this year. |
| J.C. Boyle | BE3-1 | Bald Eagle | Within 0.5-mile | Nest observed in 1995, no additional data.[2] | Nest location data received after reconnaissance, nest was not surveyed. |
| J.C. Boyle | BE1-30 | Bald Eagle | Within 2-miles | Potentially occupied in 1982, nest down in 1990.[1] | Not surveyed. |
| J.C. Boyle | BE1-33 | Bald Eagle | Within 2-miles | Active 1983-1986, nest down 2005. [1] | Not surveyed. |
| J.C. Boyle | BE1-34 | Bald Eagle | Within 2-miles | Active intermittently between 1987-2002, unoccupied 2011-2014. [1] | Not surveyed. |
| J.C. Boyle | BE1-35 | Bald Eagle | Within 2-miles | 1997-1999, nest down in 2005.[1] | Not surveyed. |
| J.C. Boyle | GE1-6 | Golden Eagle | Within 2-miles | No data, unverified nest.[1] | Not surveyed. |
| J.C. Boyle | GE3-1 | Golden Eagle | Within 2-miles | Active 2011 and 2012, no verified nesting.[2] | Not surveyed. |
| Iron Gate | BE2-1 | Bald Eagle | Within 2-miles | Active between 1986-1997.[1] | Not surveyed. |
| Copco | BE2-3 | Bald Eagle | Within 0.5-mile | 2002 - new nest.[1] | Searched for nest, but access was limited. Nest was not found. |
| Copco | BE2-0 | Bald Eagle | Within 2-miles | Active between 1993-1997.[1] | Not surveyed. |

[1] Nest location and history sourced from Willy 2017.
[2] Nest location and history sourced from Heyner 2017.
[3] Data collected during reconnaissance surveys in July 24-26, 2017.

# 3. Special Status Wildlife Species Measures

## 3.1 Objectives

Surveys will be conducted to identify the special status wildlife species and their habitats that are present in the Project area. By understanding how special status wildlife species use the Project area, the Project design and construction planning will be modified to avoid impacts where possible and where avoidance is not completely possible, measures will be implemented to minimize potential impacts on these species and their habitats. In coordination with the U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife (CDFW), and Oregon Department of Fish and Wildlife (ODFW), the minimization measures will be incorporated into any regulatory approvals that may be required for the Project.

For the purposes of this section, special status wildlife species include federal and state threatened, endangered, proposed, and candidate species, California Species of Special Concern, Oregon Natural Heritage Program (ONHP) List 1 and 2 species, and Oregon Sensitive species. Bureau of Land Management (BLM) and U.S. Forest Service Sensitive Species (USFS), Assessment Species, Tracking Species, and Survey and Manage species are also considered, where BLM and USFS lands occur in the Project area; however, not all of these species carry a regulatory concern. Specific focused field surveys will not be conducted for all of these species, except where required. Northern spotted owls, bald eagles, golden eagles, bats, and special status plants are covered under separate sections in this appendix and are not included here.

## 3.2 Existing Information

Several special status wildlife species (SSWS) have been identified as occurring in the Project area. PacifiCorp conducted comprehensive surveys of the Project area in 2002 and 2003 and the findings were compiled in the EIS/EIR for the Klamath Facilities Removal (USBR and CDFW 2012, Section 3.5). PacifiCorp documented several SSWS within 0.25 mile of the PacifiCorp facilities, reservoirs, and river reaches (PacifiCorp 2004, Attachment A). Information on SSWS occurrences has also been obtained from U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife, Oregon Department of Fish and Wildlife (ODFW), BLM, and USFS (Godwin 2017, Harris 2017, Henderson 2017, and Wray 2017). Most of the SSWS are birds, some of which are year-round residents while others are migratory, utilizing the Project area for nesting or for overwintering. In addition, a small number of invertebrate, amphibian, reptile, and mammal SSWS have potential to occur in the Project area, based on PacifiCorp surveys and information from the Oregon Biodiversity Information Center (ORBIC), the California Natural Diversity Database (CNDDB), and the UFWS Information for Planning and Conservation (IPaC) database.

Table 3-1 lists the SSWS that have been identified as having potential to occur in the Klamath River watershed. Those SSWS with documented occurrences within or in proximity to Project construction areas are shown in shaded rows. The list includes species with a range of regulatory protections and associated permitting considerations, and generally does not include species that are not federally or state listed and that are identified as lower priority on state sensitive species lists (e.g., Oregon Natural Heritage Program list 3 or 4) or other federal or state watch lists.

Table 3-1 presents summary information on each species' habitat and occurrence in the Project area. In addition, the proposed survey effort is identified. Proposed survey efforts are based on regulatory requirements, occurrence information, and a preliminary determination of the potential for impacts from Project implementation, using best professional judgement and input from the resource agencies.

## 3.3 Methods

### 3.3.1 Field Reconnaissance

A field reconnaissance was conducted in July 2017. During the field reconnaissance, biologists visited proposed construction areas, focusing on areas with documented occurrences of SSWS based on previous biological survey data, reports completed at or near the Project area (e.g., surveys conducted by PacifiCorp in 2001-2003), and additional existing information as outlined above.

Biologists gathered qualitative information on habitats present, determined access for surveys and other information to aid in planning for 2018 surveys. Biologists also noted evidence of changes to existing conditions since the PacifiCorp surveys were conducted, including wildfires, development, agriculture and grazing, and logging activities that may have altered the habitats present.

### 3.3.2 General Wildlife Surveys

General wildlife surveys will be conducted concurrent with vegetation and habitat mapping efforts. Biologists will record observations of birds and other wildlife heard or seen, including sign and other evidence of wildlife presence and use (e.g., courtship activities, breeding, nesting, dens and burrows, feeding, family groups).

Biologists will note special status bird species that are using the reservoirs and construction areas, including dams and associated facilities, disposal sites, and haul and access roads around each. Using a boat, if appropriate, biologists will survey reservoir shorelines and open water, noting all species seen or heard, their approximate number and behavior (e.g., roosting, loafing, foraging, courtship, mating, incubating eggs, feeding young).

Transects will be established to cover terrestrial areas within 0.25 miles of dams and structures to be removed, disposal sites, and haul and access roads. Biologists will walk the length of each transect, noting species seen or heard and their behavior, as described above. Night surveys may be conducted for northern spotted owls, based on input from USFWS, CDFW, and ODFW, and would entail walking transects and using a digital caller to elicit responses. These surveys will be conducted during both the spring and summer breeding season and the late fall/winter season in 2018 (spotted owl surveys are discussed in Section 1 of this appendix).

Focused surveys for amphibian and reptile species are not proposed; however, western pond turtle surveys may be conducted if needed (see "Western Pond Turtle Surveys" below). Rather, field surveys will identify suitable habitat for these species to determine if and to what extent suitable habitat would be modified or destroyed by Project activities. Amphibians and reptiles observed during SSWS surveys for birds and turtles will be noted.

Mammal trapping or other focused survey methods are not proposed. Any mammals or mammal sign observed during SSWS surveys will be noted. (The survey plan for bats is provided in a separate section of this appendix.)

### 3.3.3 Nest Surveys

Nearly all birds are protected by the Migratory Bird Treaty Act (MBTA). The MBTA prohibits disturbance of birds and their nests. Some species of birds may return to the same nesting site every year (e.g., Osprey nesting platform), while others may utilize a specific location (e.g., sandhill crane returning to the same wetland to nest and rear young).

Nest site surveys will focus on specific bird SSWS that may return to the same nest locations (e.g., osprey, peregrine falcon, sandhill crane). (The survey plan for eagles is provided in a Section 2 of this appendix.) The objective of bird nest site surveys is to identify and map any nest trees, heron colonies, cliff nests, nests on structures, or other types of nests that may be removed or disturbed by construction.

For osprey nests, biologists will survey all nest platforms, transmission line towers, and reservoir and river shorelines for nests within 0.75 miles of construction areas, defined as the potential area within which construction activities may affect active nests (USBR and CDFW 2012, Section 3.5). Nest surveys will be conducted in 2018 and nest sites will be checked for occupancy in the year that construction activities are planned to commence. In coordination with the resource agencies, osprey nests within 0.75 miles of construction areas may be removed or blocked from use following the breeding season in the year prior to drawdown.

For heron colonies, biologists will survey reservoir and river shorelines within 0.25 miles of construction areas. If an active heron colony is found, a spatial buffer may be established in coordination with the resource agencies.

For peregrine falcon nests, biologists will survey cliffs within 1 mile of construction areas. If an active peregrine falcon nest is found, a spatial buffer may be established in coordination with the resource agencies.

Documented nesting habitat for sandhill crane will be surveyed at J.C. Boyle Reservoir. A boat will be used as needed to access these areas. If sandhill crane nesting is found, a spatial buffer may be established in coordination with the resource agencies.

During surveys, biologists will note all species seen or heard, their approximate number and behavior (e.g., roosting, loafing, foraging, courtship, mating, incubating eggs, feeding young). GPS coordinates will be recorded for all active nests and spatial buffers established as needed in coordination with the resource agencies.

Nest site surveys will be conducted in 2018, the first in April and the second in June. Nest surveys will consider the viewshed analysis included under the Bald and Golden Eagle Measures (Section 2 of this appendix) in identifying priority areas for surveys.

### 3.3.4 Western Pond Turtle Surveys

Western pond turtles are known to occur at Project reservoirs. U.S. Geological Survey (USGS) conducted visual surveys of basking turtles at J.C. Boyle Reservoir in the mid- to late-1990s and recorded turtle use (Wray 2017). A petition for federal listing is currently being considered by USFWS. The 2001-2003 PacifiCorp surveys also noted the presence of western pond turtles at Project reservoirs (PacifiCorp 2004).

Impacts on western pond turtles from Project implementation are uncertain and depend on factors that are hard to predict, including the amount of sediment moved during drawdown. The next steps include a desktop analysis of western pond turtle habitat and overwintering requirements and the potential for impacts on pond turtles during drawdown. Following review and input from the resource agencies and other experts on the results of the analysis, additional pond turtle surveys may be conducted. Appropriate survey requirements will be developed in conjunction with ODFW, USFWS, and CDFW.

During general wildlife surveys, observations of turtles will be noted.

### 3.3.5 Willow Flycatcher Habitat Surveys

Willow flycatchers have been documented in the Project area (PacifiCorp 2004, Attachment A). Willow flycatcher is a California endangered species. Protocol surveys for willow flycatcher are not proposed; however, surveys will be conducted in willow-dominated riparian/meadow communities to identify potential habitat for willow flycatcher. If it is determined that there would be impacts on potential willow flycatcher habitat from Project implementation in areas where presence is uncertain or cannot be assumed, protocol surveys for willow flycatcher will be conducted in coordination with the resource agencies.

### 3.3.6 Pre-construction Nesting Bird Surveys

Prior to construction activities that involve clearing of vegetation or other habitat, targeted, pre-construction bird surveys will be conducted for all birds protected by the MBTA to avoid or minimize nesting disturbance. Nesting surveys will be conducted within 2 weeks before the start of construction activities that occur during nesting bird season (February through July). Biologists will search for nests in potential bird nesting habitat within 300 feet of construction areas. Active nests will be mapped and an activity restriction buffer may be established in coordination with the resource agencies to minimize disturbance from construction activities. Construction planning will include efforts to limit activities that would disturb vegetation to the non-breeding season.

### 3.3.7 Construction Monitoring

Biological monitoring will be conducted during construction. A detailed construction monitoring plan will be developed in coordination with the resource agencies.

## 3.4 Avoidance and Minimization Measures

The Project incorporates the following specific elements that would avoid or reduce potential impacts on migratory birds and their nests during construction:

- Removal or trimming of any trees or other vegetation for construction would be conducted outside of the nesting season (March 20 through August 20). This would include removal or trimming of trees along access roads and haul routes and within disposal sites.
- Where clearing, trimming, and grubbing work cannot occur outside the migratory bird nesting season, a qualified avian biologist will survey construction areas to determine if any migratory birds are present and nesting in those areas as described in Section 3.3.6.
- For all raptors (other than eagles), inactive nests will be removed before nesting season begins, to the greatest extent practicable. Deterrent actions may be implemented such as placing traffic cones or other exclusionary devices in nests or on nest platforms to prevent nesting in the year of construction. All deterrents will be removed as soon as possible after construction activities have progressed to a point beyond the disturbance buffer for that species. Buffer distances would be confirmed with the resource agencies for each species and location.
- If an active nest of a migratory bird species is located, a restriction buffer may be established and the resource agencies would be consulted to obtain concurrence prior to conducting construction activities. This may include consideration of noise effects and line of sight considerations.
- Osprey nests within 0.75 miles of construction areas may be removed or blocked from use following the breeding season in the year prior to drawdown. Osprey nests that are removed may be replaced following construction or relocated to suitable areas outside of the zone of construction disturbance.
- Biological monitoring will be conducted during construction. A detailed construction monitoring plan will be developed in coordination with the resource agencies and will include the following measures:
    - Biological Resources Awareness Training. Before any ground-disturbing work (including vegetation clearing and grading) occurs in the construction area, a qualified biologist will conduct a mandatory biological resources awareness training for all construction personnel and the construction foreman. This training will inform the crews about special-status species that could occur on site. The training will consist of a brief discussion of the biology and life history of the special-status species; how to identify each species, including all life stages; the habitat requirements of these species; their status; measures being taken for the protection of these species and their habitats; and actions to be taken if a species is found within the project area during construction activities. Species identification cards will be issued to shift supervisors; these cards would have photos, descriptions, and actions to be

taken upon sighting of special-status species during construction. Upon completion of the training, all employees will sign an acknowledgment form stating that they attended the training and understand all protection measures. An updated training will be given to new personnel and in the event that a change in special-status species occurs.

- Exclusion Measures for Special-Status Wildlife. Construction areas, including staging areas and access routes, will be fenced with orange plastic snow fencing to demarcate work areas. The approved biologist will confirm the location of the fenced area prior to habitat clearing, and the fencing would be maintained throughout the construction period. Additional exclusion fencing or other appropriate measures would be implemented in consultation with the resource agencies to prevent use of construction areas by special-status species during construction.
- To prevent entrapment of wildlife that do enter construction areas during construction, all excavated, steep-walled holes or trenches in excess of two feet deep will be inspected by a biologist or construction personnel approved by the resource agencies at the start and end of each working day. If no animals are present during the evening inspection, plywood or similar materials will be used to immediately cover the trench, or it will be provided with one or more escape ramps set at no greater than 1,000 foot intervals and constructed of earth fill or wooden planks. Trenches and pipes would be inspected for entrapped wildlife each morning prior to onset of activity. Before such holes or trenches are filled, they would be thoroughly inspected for entrapped animals. Any animals so discovered would be allowed to escape voluntarily, without harassment, before activities resume, or removed from the trench or hole by a qualified biologist approved by the resource agencies and the animals would be allowed to escape unimpeded. A biologist approved by the resource agencies would be responsible for overseeing compliance with protective measures during clearing and construction activities within designated areas throughout the construction activities.
- If the design includes coffer dams, they will be monitored immediately following closure and prior to the start of construction activities for the presence of special status species such as western pond turtles. If individuals are detected within enclosed spaces, they will be captured and removed by qualified biologists.

- General Requirements for Construction Personnel include the following:
  - The contractor would clearly delineate the construction limits and prohibit any construction-related traffic outside these boundaries.
  - Construction crews would be required to maintain a 20-miles per hour (mph) speed limit on all unpaved roads to reduce the chance of wildlife being harmed if struck by construction equipment.

- All food-related trash items such as wrappers, cans, bottles, and food scraps generated during construction or permitted operations and maintenance activities of existing facilities would be disposed of in closed containers only and removed at least once a week from the site. The identified sites for trash collection would be fenced to minimize access by wildlife.
- No deliberate feeding of wildlife would be allowed.
- No pets would be allowed on the project site.
- No firearms would be allowed on the project site.
- If vehicle or equipment maintenance is necessary, it would be performed in designated staging areas.
- Any worker who inadvertently injures or kills a federally or State listed species, bald eagle, or golden eagle, or finds one dead, injured, or entrapped would immediately report the incident to the construction foreman or biological monitor.
- The construction foreman or monitor would notify the resource agencies within 24 hours of the incident.

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## 3.5 References

Godwin, Steve. 2017. Wildlife Biologist, BLM, Medford office. Personal communication with Jennifer Jones, KRRC, June 21, 2017.

Harris, Michael. 2017. CDFW. Personal communication with Jennifer Jones, KRRC, June 13, 2017.

Henderson, Brad. 2017. Wildlife Biologist, CDFW. Personal communication with Jennifer Jones, KRRC, June 22, 2017.

PacifiCorp. 2004. Final Technical Report. Klamath Hydroelectric Project (FERC Project No. 2082), Terrestrial Resources. PacifiCorp, Portland, Oregon. February.

USBR and CDFW. 2012. Klamath Facilities Removal. Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR). U.S. Bureau of Reclamation and California Department of Fish and Wildlife, December.

Wray, Simon. 2017. Wildlife Biologist, ODFW. Personal communication with Jennifer Jones, KRRC, June 22, 2017.

## Table 3-1 Special Status Species with Potential to Occur in the Project Area (Terrestrial or Semi-Aquatic Species Only)

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| **Invertebrates** | | | | | |
| Conservancy fairy shrimp | *Branchinecta conservatio* | FE | Vernal pools | Not found during PacifiCorp surveys. Not listed on CNDDB search (2017); identified on IPaC (2017). | Vernal pools are not expected to be present. If noted during vegetation or wildlife surveys, focused surveys for vernal pool species will be conducted as appropriate based on the potential for impacts from project implementation. |
| Vernal pool fairy shrimp | *Branchinecta lynchi* | FT | Vernal pools | Not found during PacifiCorp surveys. Not listed on CNDDB search (2017); identified on IPaC (2017). | Vernal pools are not expected to be present. If noted during vegetation or wildlife surveys, focused surveys for vernal pool species will be conducted as appropriate based on the potential for impacts from project implementation. |
| Vernal pool tadpole shrimp | *Lepidurus packardi* | FE | Vernal pools | Not found during PacifiCorp surveys. Not listed on CNDDB search (2017); identified on IPaC (2017). | Vernal pools are not expected to be present. If noted during vegetation or wildlife surveys, focused surveys for vernal pool species will be conducted as appropriate based on the potential for impacts from project implementation. |
| Klamath pebblesnail | *Fluminicola sp. 5* | ONHP List 1 | Medium rivers in cold and relatively pristine hard-subhabitats with little disturbance | ORBIC occurrence at confluence of Spencer Creek and J.C. Boyle Reservoir/Klamath River and just east of powerhouse (ORBIC 2017). | Focused surveys are not proposed. |
| Klamath Rim pebblesnail | *Fluminicola sp.6* | ONHP List 1 | Small, cold, spring runs with shallow water and gravel-cobble substrate | ORBIC occurrence at Klamath River 0.3 miles east of J.C. Boyle powerhouse (ORBIC 2017). | Focused surveys are not proposed. |
| Blue Mountains juga (snail) | *Juga sp. 2* | ONHP List 1 | Freshwater | ORBIC occurrence near Rock Creek (ORBIC 2017). | Focused surveys are not proposed. |
| Scale lanx (snail) | *Lanx klamathensis* | ONHP List 1 | Freshwater | ORBIC occurrence near Rock Creek (ORBIC 2017). | Focused surveys are not proposed. |
| Siskiyou (= Chase) sideband | *Monadenia chaceana* | BLM, ONHP List 1, tracked on CNDDB | Lower reaches of major drainages, in talus and rock slides, under rocks and woody debris in moist conifer forests, in | Not documented during PacifiCorp surveys. Historic occurrence 0.25 miles below Copco Dam in lava rockslide (CNDDB 2017). May occur | Focused surveys are not proposed. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| | | | caves, and in shrubby areas in riparian corridors. Rocks and large woody debris serve as refugia during the summer and late winter seasons. | in large piles of rocks (termed “derrick pile” by KNF) (Henderson 2017). | |
| Terrestrial snail | *Monadenia fidelis leonine* | Tracked on CNDDB | Associated with dead alder leaves and trunks near streams, in relatively undisturbed forest; among leaves (deep maple and alder leaf litter); and under debris on ground forested and open talus or rocky areas. | Documented on CNDDB in the Beaver Creek drainage. Possibly extirpated (Henderson 2017). | Focused surveys are not proposed. |
| **Amphibians** | | | | | |
| Tailed frog | *Ascaphus truei* | FSC, CSSC | Perennial, cold, fast-flowing mountain streams with dense vegetation cover, or streams in steep-walled valleys in non-forested areas. | Widespread in tributary streams in the lower Klamath River (Green Diamond Resource Company 2006). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Western toad | *Anaxyrus boreas* | BLM, OSS | Breeds from February to early May in ponds, the edges of shallow lakes, and in slow-moving streams. Adults are common near marshes and small lakes but may also be found in dry forests, shrubby areas, and meadows. | Documented during PacifiCorp surveys along J.C. Boyle peaking reach, along the north shore of Iron Gate Reservoir, and along Klamath River near river mile 185 (between the confluence of Bogus and Cottonwood Creeks). One occurrence near Frain Ranch, Klamath River Canyon (ORBIC 2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Northern red-legged frog | *Rana aurora* | FSC, USFS, OSS, CSSC | Breeds in quiet low-velocity habitats, such as wetlands, ponds, and disconnected side channel habitats in coastal areas of the Lower Klamath River. Usually breeds January through March (Lannoo 2005). | Documented by CDFW as breeding in coastal areas of the Lower Klamath River. | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Foothill yellow-legged frog | *Rana boylii* | FSC, BLM, OSS, CSSC, Request for CA candidate | Streams and rivers with cobble-size or larger substrate. Breeds generally between late April and June (Lannoo 2005). | Known to CDFW to breed in the Lower Klamath River Mainstem and major tributaries. ORBIC occurrence downstream of J.C. Boyle Reservoir (ORBIC 2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| Cascades frog | *Rana cascadae* | FSC, OSS, CSSC | Montane aquatic habitats such as mountain lakes, small streams, and ponds in meadows; open coniferous forests. | Documented occurrence in Klamath National Forest (CNDDB 2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Oregon spotted frog | *Rana pretiosa* | FT, BLM, OSS, CSSC | Highly aquatic and generally avoids dry uplands. It is rarely found far from permanent quiet water. Usually occurs in vegetated shallows or among grasses or sedges along the margins of streams, lakes, ponds (including those behind beaver dams), oxbows, springs, and marshes. | Not found during PacifiCorp surveys. Not listed on CNDDB search (2017); identified on IPaC (2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Siskiyou Mountain salamander | *Plethodon stormi* | FSC, CT, OSS | Mixed conifer habitat of dense, pole-to-mature size, trees. Active above ground only during spring & fall rains. | Documented occurrences along Klamath River in Klamath National Forest (CNDDB 2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Southern torrent salamander | *Rhyacotriton variegatus* | FSC, OSS, CSSC | Uppermost portions of cold, well shaded permanent streams with a loose gravel substrate, springs, headwater seeps, waterfalls, and moss covered rock rubble with flowing water. | Widespread in tributary streams in the lower Klamath River (Green Diamond Resource Company 2006). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Cope's giant Salamander | *Dicamptodon copei* | OSS | Streams and rivers in moist coniferous forests. Sometimes found in clear, cold mountain lakes and ponds | Not known to occur in project area. | Focused surveys are not proposed due to unlikelihood of occurrence. |
| **Reptiles** | | | | | |
| Western pond turtle | *Actinemys marmorata* | FSC, BLM, OSS, ONHP List 2, CSSC | Prefers quiet water in small lakes, marshes, and sluggish streams and rivers; requires basking sites. | Documented during PacifiCorp surveys at Keno, J.C. Boyle, Copco, and Iron Gate Reservoirs, along J.C. Boyle bypass reach, along J.C. Boyle peaking reach in California, and along Klamath River from Iron Gate Dam to Shasta River. Also documented at Iron Gate Reservoir and along Klamath River (ORBIC, CNDDB 2017). | TBD based on additional input from the resource agencies, other experts, and analysis of potential for impacts based on life history and existing conditions. Reservoir surveys may be needed to determine the size of the population, where the turtles are overwintering, and to determine what actions would minimize impacts. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| Western painted turtle | *Chrysemys picta bellii* | OSS | Ponds, marshes, lakes, ditches, quiet streams with sandy or muddy bottoms and aquatic vegetation. | Not known to occur in project area. | Focused surveys are not proposed due to unlikelihood of occurrence. |
| Northern sagebrush lizard | *Sceloporus graciosus graciosus* | FSC, BLM, ONHP List 4 | Inhabits sagebrush, chaparral, juniper woodlands, and dry conifer forests. | Documented during PacifiCorp surveys in the rocky riparian shrub habitat of Keno reach, along J.C. Boyle peaking reach, near J.C. Boyle powerhouse intake canal, and near the edge of a forested wetland along Iron Gate Reservoir. | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Sharptail snake | *Contia tenuis* | BLM | Inhabits moist sites in chaparral, conifer forests, and deciduous forests, but primarily occurs in oaks and other deciduous tree woodlands, particularly in the forest edges. | Known to occur along upper J.C. Boyle peaking reach west of Frain Ranch in Douglas-fir habitat but not detected by PacifiCorp during its surveys. | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| California mountain kingsnake | *Lampropeltis zonata* | FSC, BLM, OSS, ONHP List 4 | Inhabits thick vegetation along watercourses, farmland, chaparral, deciduous, and mixed-coniferous forests; specifically associated with moist river valleys and dense riparian vegetation. | Documented during PacifiCorp surveys along Copco Road and in close proximity to J.C. Boyle powerhouse intake canal. Also known to occur along J.C. Boyle peaking reach. Documented in Klamath River Canyon and east of J.C. Boyle powerhouse (ORBIC 2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Common kingsnake | *Lampropeltis getula* | FSC, BLM, OSS, ONHP List 4 | Occurs in pine forests, oak woodlands, and chaparral in, under, or near rotting logs and usually near streams; associated with well-illuminated rocky riparian habitat with mixed deciduous and coniferous trees. | Documented during PacifiCorp surveys along J.C. Boyle peaking reach in oak/woodland and mixed conifer woodland and along Copco Road. | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| **Birds** | | | | | |
| Common loon | *Gavia immer* | FSC, CSSC | May over-winter on project reservoirs or occur in aquatic habitat associated with large bodies of water like the project reservoirs while migrating from sub-arctic freshwater breeding | Documented during PacifiCorp surveys at Iron Gate Reservoir. | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| | | | grounds to coastal and near-shore pelagic marine habitat along the Pacific coast. | | |
| American white pelican | *Pelecanus erythrorhynchos* | BLM, OSS, ONHP List 2, CSSC | Nests at lakes and marshes and uses almost any lake outside of the breeding season; have a restricted range in southern Oregon and along the California border, where they are found to be associated with only a few large bodies of inland water. | Documented during PacifiCorp surveys on all project reservoirs, with the highest number occurring on Keno Impoundment, and along Link River, Keno reach, J.C. Boyle bypass reach, and on Klamath River between Iron Gate Dam and Shasta River. | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Double-crested cormorant | *Phalacrocorax auritus* | Nesting colonies afforded special protection by CDFW | Colonial nester on coastal cliffs, rocks, offshore islands, and along lake margins. | Documented during PacifiCorp surveys at Keno and J.C. Boyle Dams. Documented nesting colonies near mouth of Klamath River (CNDDB 2017). | Wildlife surveys will note presence and nesting colonies to identify potential for impacts from project implementation. |
| Black-crowned night heron | *Nycticorax nycticorax* | FSC, Nesting colonies afforded special protection by CDFW | Found in riparian habitats and in wetland sites. | Documented during PacifiCorp surveys primarily along Keno reach, but also along Link River, at Keno Impoundment, and along Klamath River from Iron Gate Dam to Shasta River. Communal roost used by night herons and other heron species in a group of willow trees near the East Side powerhouse adjacent to Link River. | Wildlife surveys will note presence and nesting colonies to identify potential for impacts from project implementation. |
| Snowy egret | *Egretta thula* | BLM, OSS, ONHP List 2, Nesting colonies afforded special protection by CDFW | Inhabits emergent wetlands associated with freshwater marshes and along the periphery of large water bodies. The northern limit of the species range includes southern Oregon. | Documented during PacifiCorp surveys near Link River Dam, at Keno Dam, and along Keno reach. | Wildlife surveys will note presence and nesting colonies to identify potential for impacts from project implementation. |
| Great egret | *Casmerodius albius* | BLM, Nesting colonies afforded special | Nests in willows and other trees; forages in shallow water, wetlands, and fields. Range includes Klamath basin and eastern Siskiyou County. Known | Documented during PacifiCorps surveys at J.C. Boyle and Keno Impoundments, Keno Canyon reach, J.C. Boyle bypass and peaking reaches, and Link River. | Wildlife surveys will note presence and nesting colonies to identify potential for impacts from project implementation. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| | | protection by CDFW | to occur in the study area. | | |
| Great blue heron | *Ardea herodias* | Nesting colonies afforded special status protection by CDFW | Forages mostly in slow-moving or calm salt, fresh, or brackish water in a variety of habitats, including rocky shores, coastal lagoons, saltwater and freshwater marshes, mudflats, bays, estuaries, along the margins of rivers, lakes, and irrigation canals, and in flooded fields. Nesting colonies are typically found in groves of large trees, often in mixed colonies with other herons, egrets, and cormorants. | Documented during PacifiCorps surveys at all reservoirs and most study area reaches. Known colony documented along the south side of Copco Lake (Harris 2017). No known rookeries at J.C. Boyle (Wray 2017). Several rookeries documented along the Klamath River (CNDDB 2017). | Wildlife surveys will note presence and nesting colonies to identify potential for impacts from project implementation. |
| White-faced ibis | *Plegadis chihi* | FSC, BLM, ONHP List 4, CSSC | Breeds in freshwater marshes and lakes, and estuaries, and nests near the water on mats of vegetation and twigs; usually occurs in isolated con-specific flocks. Does not typically overwinter in Oregon but is a fairly common visitor in the Klamath Wildlife Area during the spring and summer. | Documented during PacifiCorp surveys along Link River and at Keno Impoundment and J.C. Boyle Reservoir. | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Bufflehead | *Bucephala albeola* | BLM, ONHP List 4 | Typically breeds around isolated mountain lakes; nesting habitat includes mixed conifer forest and ponderosa pine forests with sparse to moderate tree canopy closure close to lakes and ponds. Nests in cavities, including artificial nest boxes. May be found in open water and riverine habitat throughout southern Oregon after the breeding season. | Documented during PacifiCorp surveys primarily from January until April along the Link River, at Keno Impoundment and Copco and Iron Gate Reservoirs. | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Barrow's goldeneye | *Bucephala islandica* | ONHP List 4, CSSC | Tends to breed along high-elevation mountain lakes and | Documented during PacifiCorp surveys along Keno Impoundment, | Wildlife surveys will note presence and nesting activity to identify |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| | | | winter in coastal areas. Potential nesting habitat includes forests with sparse to moderate tree canopy closure next to rivers and reservoirs. | in an inundated drainage ditch off of Copco Lake, and on Iron Gate Reservoir. Common winter migrant on the Link River and Keno Impoundment (R. Larson, USFWS). | potential for impacts from project implementation. |
| Trumpeter swan | *Cygnus buccinator* | OSS | Relatively shallow (less than 6 feet deep), undisturbed bodies of freshwater with abundant aquatic plants. | Not documented in project area. | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Osprey | *Pandion haliaetus* | CSSC | Nests in all forested vegetation types with large trees near water, as well as on platforms erected in less optimal habitat. | A minimum of 16 active osprey nests, both artificial nesting platforms and natural sites, are found along the shores of the project reservoirs and river reaches. Documented during PacifiCorp surveys along the Keno reach, along the J.C. Boyle bypass reach, along the J.C. Boyle peaking reach, at J.C. Boyle, Copco, and Iron Gate Reservoirs, along Fall Creek, and along Klamath River from Iron Gate Dam to Shasta River. Several occurrences along lower Klamath River (CNDDB 2017). | Wildlife surveys will note presence and nest sites to identify potential for impacts from project implementation. |
| Northern harrier | *Circus cyaneus* | CSSC | Nests and forages in grasslands and emergent wetlands. Permanent residents in the project vicinity and common at the Klamath Wildlife Area. | Documented during PacifiCorp surveys in the low-lying marshland and agricultural fields east of Keno Impoundment and along Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Golden eagle | *Aquila chrysaetos* | CSSC, FP | Breeds in open mountain and hill habitats, nests on cliff ledges, and forages in grasslands and open conifer forests and woodlands with sparse to open tree canopy closure. Eagles use two to three nests during a lifetime. | Historical records exist of several golden eagle nests on cliffs from J.C. Boyle bypass reach to Iron Gate Reservoir. Documented during PacifiCorp surveys at J.C. Boyle powerhouse, along the lower section of J.C. Boyle peaking reach, along Copco and Iron Gate Reservoirs, and Copco bypass | Wildlife surveys will note presence and nest sites to identify potential for impacts from project implementation.<br>See eagle measures. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| | | | | reach. | |
| Bald eagle | *Haliaeetus leucocephalus* | CE, OSS, ONHP List 4 | Nests in large conifers within several miles of water; forages in rivers and lakes for fish and waterfowl; requires large snags for perching and conifers for night roosts. | Documented during PacifiCorp surveys at all project reservoirs and in all project reaches throughout the project vicinity. Also documented on Upper Klamath River, on the Klamath River near OR-CA border (ORBIC 2017), and along lower Klamath River (CNDDB 2017). | Wildlife surveys will note presence and nest sites to identify potential for impacts from project implementation.<br>See eagle measures. |
| Cooper's hawk | *Accipiter cooperii* | CSSC | Inhabits riparian deciduous forest, montane hardwood oak woodland, montane hardwood oak-juniper, montane hardwood oak-conifer, juniper woodland, mixed conifer forest, ponderosa pine forest, and lodgepole pine with any level of tree canopy closure. | Documented during PacifiCorp surveys along J.C. Boyle bypass and peaking reaches, and along Klamath River from the Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Northern goshawk | *Accipiter gentilis* | FSC, BLM, OSS, ONHP List 4, CSSC | Inhabits forested communities with at least 60 percent canopy cover and trees greater than 6 inches in diameter, except oak woodland, oak-conifer woodland, and oak-juniper woodland; forages over large home ranges. | Documented during PacifiCorp surveys flying over J.C. Boyle peaking reach. Documented near tributaries of lower Klamath River (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Sharp-shinned hawk | *Accipiter striatus* | CSSC | Inhabits riparian deciduous forest, montane hardwood oak woodland, montane hardwood oak juniper, montane hardwood oak-conifer, juniper woodland, mixed conifer forest, ponderosa pine forest, and lodgepole pine with any level of tree canopy closure and tree diameters ranging from 6 to 24 inches. | Documented during PacifiCorp surveys in oak habitat along J.C. Boyle bypass and peaking reaches, and along Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Swainson's hawk | *Buteo swainsoni* | CT, BLM, OSS, ONHP List 4 | Dwells in open country and typically inhabits sagebrush, annual grassland, juniper woodland, montane hardwood oak-juniper, and riparian | Documented during PacifiCorp surveys flying over agricultural fields southeast of Keno Impoundment. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
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| | | | deciduous forest with sparse to open tree canopy closure. The species' range generally lies east of the project vicinity and includes the plains of the Great Basin in southeast Oregon and eastern northern California. | | Focused surveys are not proposed. |
| Merlin | *Falco columbarius* | BLM, ONHP List 2, CSSC | Uses a variety of forested and open habitats. Ranges throughout North America and travels great distances during migration from breeding grounds in northern Canada and Alaska to wintering habitat through the contiguous United States south to Central America. | Documented during PacifiCorp surveys at J.C. Boyle Reservoir and along J.C. Boyle peaking reach. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Prairie falcon | *Falco mexicanus* | CSSC | Uses cliffs for nesting and plateau grasslands for foraging. | Documented during PacifiCorp surveys near Keno campground and boat ramp, above J.C. Boyle bypass reach, near Copco Lake, and flying over Klamath Wildlife Refuge. Several occurrences listed as sensitive (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| American peregrine falcon | *Falco peregrinus anatum* | BLM, OSS, ONHP List 2, FP | Breeds at suitable nest sites on cliffs and rocky outcroppings. Uses a variety of habitats, including open grassland areas, forest stands, and reservoirs throughout the project vicinity. | The project vicinity is in a management area designated for peregrine falcon recovery. Known to occur along Keno Impoundment and the J.C. Boyle bypass reach but not documented during PacifiCorp surveys. Several occurrences listed as sensitive (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Long-billed curlew | *Numenius americanus* | OSS | Sparse, short grasses, including shortgrass and mixed-grass prairies as well as agricultural fields. | Not documented in project area. | Wildlife surveys will note any nesting activity to identify potential for impacts from project implementation. |
| Yellow rail | *Coturnicops noveboracensis noveboracensis* | OSS | Shallow marshes, and wet meadows; in winter, drier fresh-water and brackish marshes, as well as dense, deep grass, and rice fields. | Not documented in project area. | Wildlife surveys will note any nesting activity to identify potential for impacts from project implementation. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
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| Mountain quail | *Oreortyx pictus* | FSC, BLM, ONHP List 4 | Inhabits open forests, chaparral, and juniper woodlands with dense undergrowth offering suitable refuge; breeds in higher elevation areas; migrates on foot up to 40 miles to lower elevation winter grounds. | Documented during PacifiCorp surveys at J.C. Boyle reservoir, along the J.C. Boyle bypass reach and peaking reaches, along Fall Creek, and along Klamath River from the Iron Gate Dam to Shasta River. | Wildlife surveys will note any nesting activity to identify potential for impacts from project implementation. |
| Greater sandhill crane | *Grus canadensis tabida* | FSC, BLM, OSS, ONHP List 4, CT, FP | Nests in marshes and wet meadows, and occasionally in pastures and irrigated hayfields. A primary requirement for suitable nesting habitat is the presence of surrounding water or undisturbed habitat. | Documented during PacifiCorp surveys east of Keno Impoundment and along J.C. Boyle reservoir. PacifiCorp located an active nest with two eggs in it in the emergent wetland bordering J.C. Boyle Reservoir. Several occurrences in the Lower Klamath Lake NWR (CNDDB 2017). | Wildlife surveys will note any nesting activity to identify potential for impacts from project implementation. |
| Caspian tern | *Sterna caspia* | OSS | Nests in tightly packed colonies on undisturbed islands, levees, and shores along inland water bodies during the summer breeding season. Forages over water. | Documented during PacifiCorp surveys on all project reservoirs as well as along Link River, Keno and J.C. Boyle bypass reaches, and along the Klamath River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note any nesting activity to identify potential for impacts from project implementation. |
| Forster's tern | *Sterna forsteri* | BLM, ONHP List 4 | Breeds at lakes and marshes and on mud or sand flats near water; forages over water. | Documented during PacifiCorp surveys along Link River, along Keno and J.C. Boyle bypass and peaking reaches, and at all project reservoirs. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note any nesting activity to identify potential for impacts from project implementation. |
| Black tern | *Chlidonias niger* | FSC, BLM, ONHP List 4, CSSC | Nests in emergent vegetation along the shoreline periphery of freshwater lakes, wetlands, and marshes along rivers and ponds; forages in wet meadows, pastures, agricultural fields, and water. | Documented during PacifiCorp surveys at Keno and J.C. Boyle Reservoirs. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note any nesting activity to identify potential for impacts from project implementation. |
| Marbled murrelet | *Brachyramphus marmoratus* | FT, OT, ONHP List 2, CE | Spends most of the time in the marine environment foraging in nearshore areas. Uses old- | Known to occur within National Forest lands and Green Diamond Resource Company managed lands | Focused surveys are not proposed due to unlikelihood of occurrence. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| | | | growth forests (coast Redwood forests in California) for nesting. | near the coast. Critical habitat has been designated near the mouth of the Klamath River. | |
| Flammulated owl | *Otus flammeolus* | BLM, OSS, ONHP List 4 | Nests in abandoned woodpecker nest cavities in open forests with a ponderosa pine component. | Documented during PacifiCorp surveys along J.C. Boyle bypass and peaking reaches. | Wildlife surveys would note any nesting activity to identify potential for impacts from project implementation. |
| Great gray owl | *Strix nebulosa* | BLM, OSS, ONHP List 4, CE | Inhabits mixed conifer, ponderosa pine, and riparian mixed forest stands with trees greater than 11 inches in diameter providing at least 60 percent canopy cover within at least 984 feet of a natural or manmade opening greater than 10 acres. Breeds in tree cavities, typically near suitable open grassland foraging habitat. | Documented during PacifiCorp surveys east of Fall Creek near Jenny Creek. Not listed on CNDDB for project area; nearest location is 24 miles west of Iron Gate Dam (CNDDB 2017). Rarely detected south of Highway 66 by BLM (Godwin 2017). | Wildlife surveys will note any nesting activity to identify potential for impacts from project implementation. Focused surveys are not proposed due to unlikelihood of occurrence. |
| Northern spotted owl | *Strix occidentalis caurina* | FT, OT, ONHP List 1 | Inhabits ponderosa pine forest, mixed conifer forest, and conifer forest with trees greater than 11 inches in diameter. Prefers old-growth forests with multi-layered tree canopies. Critical habitat occurs within the project area upstream of Copco Lake and south of the Klamath River and along portions of the lower Klamath River. | Documented during PacifiCorp surveys near J.C. Boyle Reservoir and along J.C. Boyle peaking reach. Several occurrences within the project area (CNDDB 2017, ORBIC 2017). Known to occur within National Forest lands and Green Diamond Resource Company managed lands near the coast. Critical habitat has been designated near the mouth of the Klamath River. | Protocol surveys are proposed (see separate northern spotted owl measures). |
| Yellow-billed cuckoo | *Coccyzus americanus* | FT, CE, OSS, BLM | Riparian forest nester, along the broad, lower flood-bottoms of larger river systems. | Not found during PacifiCorp surveys. Not listed on CNDDB search (2017); identified on IPaC (2017). | Focused surveys are not proposed due to unlikelihood of occurrence. |
| Vaux's swift | *Chaetura vauxi* | CSSC | Found in mixed conifer, ponderosa pine, lodgepole pine, riparian deciduous, montane hardwood oak woodland, montane hardwood oak-conifer, | Documented during PacifiCorp surveys at J.C. Boyle, Copco, and Iron Gate Reservoirs, along the J.C. Boyle bypass and peaking reaches, along Fall Creek, and along Klamath | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|
| | | | and montane hardwood oak-juniper forests with trees greater than 11 inches in diameter. | River from Iron Gate Dam to Shasta River. Not listed on CNDDB for project area (CNDDB 2017). | |
| Black swift | *Cypseloides niger* | OSS, ONHP List 2, CSSC | Suitable nesting habitat is limited to cliffs near water courses. Breeding sites are widely distributed in Oregon and California; none known in Klamath or northern Siskiyou Counties. | Not documented during PacifiCorp surveys. Documented along Klamath River near Orleans (CNDDB 2017). | Observations during general wildlife surveys will be noted. |
| Pileated woodpecker | *Drycopus pileatus* | BLM, OSS, ONHP List 4 | Occurs in all forest and woodland cover types with moderate to dense tree canopy closure. Requires large snags 25 inches or more in diameter for excavating suitable nest cavities. | Documented during PacifiCorp surveys along Keno reach, at J.C. Boyle Reservoir, along J.C. Boyle bypass and peaking reaches, and along Fall Creek. | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Acorn woodpecker | *Melanerpes formicivorus* | FSC, BLM, OSS, ONHP List 4 | Nests in cavities in snags of deciduous tree species, particularly oak snags at least 17 inches in diameter. | Several nesting colonies documented during PacifiCorp surveys in oak, oak-juniper, and oak/conifer habitats, primarily at Copco Lake. Also documented during PacifiCorp surveys at J.C. Boyle and Iron Gate Reservoirs, along J.C. Boyle peaking reach, along Copco bypass reach, along Fall Creek, and along Klamath River from Iron Gate Dam to Shasta River. | Wildlife surveys will note presence, nesting activity, and granary trees to identify potential for impacts from project implementation. |
| Lewis' woodpecker | *Melanerpes lewis* | FSC, BLM, OSS, ONHP List 2 | Associated with oak woodlands and mixed oak conifer habitat, but also can be found in a variety of open forest stands including ponderosa pine and cottonwood-dominated riparian areas. | Documented during PacifiCorp surveys in upland habitats along J.C. Boyle peaking reach, in riparian habitats at Iron Gate Reservoir, and along Klamath River from Iron Gate Dam to Shasta River. Documented in Klamath River Canyon (ORBIC 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| White-headed woodpecker | *Picoides albolarvatus* | FSC, BLM, OSS, ONHP List 2 | Nests in cavities typically in ponderosa pine at least 18 inches in diameter. Occurs in lodgepole pine, ponderosa pine, and Klamath mixed conifer | Documented during PacifiCorp surveys along J.C. Boyle bypass reach. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
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| | | | forests with trees greater than 11 inches in diameter. | | |
| Black-backed woodpecker | *Picoides arcticus* | BLM, OSS, Petitioned for listing under CESA | Recently burned coniferous forest in the Sierra Nevada and Cascades to the Siskiyou Mtns; areas with dense standing dead trees, and less commonly in unburned forests. | Not documented during PacifiCorp surveys or listed on CNDDB or ORBIC for the project area. May occur based on information from USFWS Yreka office (May 23, 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Olive-sided flycatcher | *Contopus cooperi* | FSC, BLM, OSS, ONHP List 4 | Typically found in coniferous forests with tall trees providing suitable perch sites. | Documented during PacifiCorp surveys along Link River, at Keno, J.C. Boyle and Iron Gate Reservoirs, and along Keno and J.C. Boyle peaking reaches. Not listed on CNDDB for project area (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Willow flycatcher | *Empidonax traillii* | FSC, CE BLM, OSS | Associated with dense riparian willow thickets. | Documented during PacifiCorp surveys in some of the denser willow patches along Link River, at J.C. Boyle, Copco, and Iron Gate Reservoirs, along the J.C. Boyle peaking reach, and along Klamath River from Iron Gate Dam to Shasta River. Also documented at Iron Gate Reservoir at Jenny Creek (CNDDB 2017). | In addition to noting presence and nesting activity, surveys will be conducted in suitable habitat to quantify and map potential habitat and identify potential for impacts from project implementation. |
| Purple martin | *Progne subis* | FSC, BLM, OSS, ONHP List 2, CSSC | Riparian and wetland forests, as well as Klamath mixed conifer forest, ponderosa pine forest, montane hardwood oak woodland, montane hardwood oak-conifer, and montane hardwood oak-juniper with sparse to moderate tree canopy closure (<60 percent). Range is patchy and may include portions of the study area. | Documented during PacifiCorp surveys above the upper falls at Fall Creek. | Wildlife surveys will note presence and nesting activity/colonies to identify potential for impacts from project implementation. |
| Red-necked grebe | *Podiceps grisegena* | OSS | Breeds on shallow freshwater lakes, bays of larger lakes, marshes, and other inland bodies of water. Winters on open ocean | Not documented in project area. | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
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| | | | or on large lakes. | | |
| Black-capped chickadee | *Parus atricapillus* | CSSC | Nests in a variety of woodland habitats wherever suitable, small nest cavities can be found. | Documented during PacifiCorp surveys along Link River and at Copco and Iron Gate Reservoirs. | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Pygmy nuthatch | *Sitta pygmea* | BLM, OSS | Typically found in ponderosa pine forests with less than 70 percent canopy closure. | Documented during PacifiCorp surveys at Keno Impoundment and J.C. Boyle Reservoir. | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Yellow warbler | *Dendroica petechia* | CSSC | Found in riparian deciduous forest, riparian shrub, scrub-shrub wetland, and forested wetland. Breeds in riparian habitat throughout North America and winters south from Mexico through South America. | Documented during PacifiCorp surveys throughout the project vicinity at all project reservoirs and in all project reaches. Incidental occurrence documented with Willow flycatcher at Copco/Iron Gate Reservoirs (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Yellow-breasted chat | *Icteria virens* | FSC, BLM, OSS, CSSC | Found in the brushy understory of deciduous and mixed woodlands; breeds in brushy vegetation, typically willow thickets, along rivers and streams. | Documented during PacifiCorp surveys primarily in wetland and riparian habitats along J.C. Boyle peaking reach, at Copco Lake, along Fall Creek, and along Klamath River from Iron Gate Dam to Shasta River. Incidental occurrence documented with Willow flycatcher at Copco/Iron Gate Resevoirs (CNDDB 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Northern waterthrush | *Parkesia noveboracensis* | ONHP List 2 | Nests in dense riparian willow thickets. | ORBIC occurrence at Grizzly Butte along Klamath River (ORBIC 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| Tricolored blackbird | *Agelaius tricolor* | BLM, CSSC, Candidate for listing under CESA as endangered | Highly colonial species; requires open water, protected nesting substrate, and foraging area with insect prey within a few km of the colony. | Not documented during PacifiCorp surveys or listed on CNDDB or ORBIC for the project area. Nearest occurrences just north of Keno (Wray 2017). | Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation. |
| **Mammals** | | | | | |
| Townsend's big-eared bat | *Corynorhinus townsendii* | FSC, BLM, OSS, ONHP | Generally found in open forests and a variety of habitats; the | Known from J.C. Boyle peaking reach but not documented during | See bat measures. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
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| | | List 2, CSSC | availability of suitable roost sites (rock crevices, cliff ledges, and human-made structures) limits distribution and occurrence. | PacifiCorp surveys. One occurrence in project area listed as sensitive by ORBIC (2017). Documented occurrences along Klamath River near Somes Bar (CNDDB 2017). | |
| Yuma myotis | *Myotis yumanensis* | FSC, BLM, ONHP List 4 | Generally found in open forests and a variety of habitats; the availability of suitable roost sites (rock crevices, cliff ledges, and human-made structures) limits distribution and occurrence. | Documented during PacifiCorp surveys roosting in J.C. Boyle forebay spillway house, in transformer bays at Copco No. 1 powerhouse, and in rafters at Iron Gate south gatehouse. Also known from J.C. Boyle peaking reach. One occurrence outside project area (CNDDB 2017). | See bat measures. |
| California myotis | *Myotis californicus* | OSS | Wide tolerance of habitat including forested regions of the Pacific Northwest, humid coastal forests and montane forests. | Not documented in project area. Range overlaps with project area. | See bat measures. |
| Fringed myotis | *Myotis thysanodes* | BLM, FSC, OSS | Oak and pinyon woodlands appear to be the most commonly used vegetative associations. Roost sites may be in caves, mines, and buildings. | Not documented in project area. Range overlaps with project area. | See bat measures. |
| Hoary bat | *Lasiurus cinereus* | OSS | May prefer trees at the edge of clearings, but have also been found in trees in heavy forests, open wooded glades, and shade trees along urban streets and in city parks. | Not documented in project area. Range overlaps with project area. | See bat measures. |
| Long-legged myotis | *Myotis volans* | OSS | Roosts in trees, rock crevices, fissures in stream banks, and buildings. Caves and mines are used at night. | Not documented in project area. Range overlaps with project area. | See bat measures. |
| Pallid bat | *Antrozous pallidus* | BLM, CSSC, FSC, OSS | Variety of structures for day and night roosting, including live trees and snags, a rock crevice, and buildings. | Not documented in project area. Range overlaps with project area. | See bat measures. |
| Silver-haired bat | *Lasionycteris* | OSS | Prefer temperate, northern | Not documented in project area. | See bat measures. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
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| | *noctivagans* | | hardwoods with ponds or streams nearby. The typical day roost for the bat is behind loose tree bark. | Range overlaps with project area. | |
| Western gray squirrel | *Sciurus griseus* | BLM, ONHP List 4 | Found in a variety of forested habitat types including mixed conifer forest, ponderosa pine forest, lodgepole pine, montane hardwood oak woodland, montane hardwood oak-conifer, and montane hardwood oak juniper with trees greater than 6 inches in diameter. | Documented during PacifiCorp surveys at J.C. Boyle Reservoir and Copco Lake, along J.C. Boyle peaking reach, and along Copco bypass reach. | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Ringtail | *Bassariscus astutus* | BLM, OSS, ONHP List 4, FP | Uses a mixture of forest and shrublands or other habitats that provide vertical structure near rocky or riparian areas. Range overlaps the study area. The species is known to occur in the study area. | Not documented during PacifiCorp surveys. Documented in Klamath River Canyon (ORBIC 2017). Not listed on CNDDB for project area (CNDDB 2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Fisher- West Coast DPS | *Martes pennanti (Pekania pennanti)* | FC, BLM, OSS, ONHP List 2, CSSC | Mature, closed canopy forests with some deciduous trees; intermediate to large tree stages of conifer forests and riparian deciduous forests both with high tree canopy closure. Habitats in the study area include lodgepole pine, Klamath mixed conifer forest, ponderosa pine forest, riparian deciduous forest, montane hardwood oak-conifer with trees >11 inches dbh. Range overlaps the study area. | Not documented during PacifiCorp surveys. ORBIC occurrences along Klamath River near Rock Creek (ORBIC 2017). Documented along lower Klamath River (CNDDB 2017). Has been documented in the Upper Klamath Basin within the last two years (T. Collom, ODFW, personal communication, April 29, 2011). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Wolverine | *Gulo gulo* | FPT, CT, OT, FP | Found in the north coast mountains and the Sierra Nevada. Found in a wide variety of high elevation habitats. | Documented occurrence outside of project area (CNDDB 2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| American badger | *Taxidea taxus* | CSSC | Most abundant in drier open stages of most shrub, forest, and herbaceous habitats, with friable | Documented occurrences outside of project area (CNDDB 2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
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| | | | soils. | | |
| Canada lynx | *Lynx canadensis* | FT, ONHP List 2 | Generally occurs in boreal and montane regions dominated by coniferous or mixed forest with thick undergrowth, but also sometimes enters open forest, rocky areas, and tundra to forage for abundant prey. | Not found during PacifiCorp surveys. Not listed on CNDDB search (2017); identified on IPaC (2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |
| Gray wolf | *Canis lupus* | FE, CE, ONHP List 2 | Habitat generalists, historically occupying diverse habitats including tundra, forests, grasslands, and deserts. Primary habitat requirements are the presence of adequate ungulate prey, water, and low human contact. | Not found during PacifiCorp surveys. Not listed on CNDDB search (2017); identified on IPaC (2017). | Focused surveys are not proposed. Observations during general wildlife surveys will be noted. |

Notes:
Shaded rows indicate the species has been documented to occur in the project area.
*Information on occurrence in the project area is based on PacifiCorp surveys (PacifiCorp 2004a) and information obtained from Oregon Biodiversity Information Center (ORBIC), California Natural Diversity Database (CNDDB), USFWS Information for Planning and Conservation (IPaC) databases (2017), and input for federal and state resource agencies. Please see Table 3.5-1 for a list of species observed during the July 2017 site reconnaissance.

Key:

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|---|---|
| BLM | Bureau of Land Management sensitive species -species that could easily become endangered or extinct; and/or Survey and Manage Species |
| CDFW | California Department of Fish and Wildlife |
| CE | California Endangered |
| CSSC | California Department of Fish and Wildlife Species of Special Concern -not listed under the Federal or California Endangered Species Act but are believed to: 1) be declining at a rate that could result in listing, or 2) historically occurring in low numbers and having current known threats to their persistence |
| CT | California Threatened |
| FC | Federal Candidate Species |
| FE | Federal Endangered |
| FP | Fully protected under the California Fish and Game Code |
| FSC | Federal Species of Concern |
| FT | Federal Threatened |
| OC | Candidate listing by Oregon Department of Agriculture (ODA) or Oregon Department of Fish and Wildlife (ODFW) |
| OE | Listed as endangered by ODA or ODFW |
| ONHP List 1 | Oregon Natural Heritage Program (ONHP) threatened with extinction or presumed to be extinct throughout their entire range |
| ONHP List 2 | threatened with extirpation or presumed to be extirpated from the State of Oregon |
| ONHP List 3 | more information is needed before status can be determined, but may be threatened or endangered in Oregon or throughout their range |
| OHNP List 4 | of conservation concern but not currently threatened or endangered |

| Common Name | Scientific Name | Status | Habitat | Occurrence in Project Area* | Proposed Survey Effort |
|---|---|---|---|---|---|

| | |
|---|---|
| OT | Listed as threatened by ODFW |
| OSS | Oregon Sensitive or Sensitive- Critical Species, East Cascades, West Cascades, and Klamath Mountains Ecoregions |
| USFS | U.S. Forest Service sensitive species |
| USFWS | United States Fish and Wildlife Service |

# 4. Bats Measures

## 4.1 Objectives

The objectives of the bat survey are to document and confirm roosting locations and determine bat roost patterns at dam structures and associated facilities. The information collected during surveys will be used to identify where roost structures can be retained and protected, if practicable, and will inform the development of bat exclusion and structure demolition plans prior to construction, as well as replacement habitat design.

The Klamath Facilities Removal Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR) (USBR and CDFW 2012, Section 3.5) Mitigation Measure TER-6 describes measures to reduce Project impacts on special status bats. The EIS/EIR recommended surveys to identify the locations of active bat roosts in facilities that may be affected by the Project. This measure has been incorporated into the project and will be implemented as described in the following sections. The recommended avoidance and minimization measures are incorporated into the Project design and construction planning. This Section describes the initial phase of this process.

## 4.2 Existing Information

Based on a review of California and Oregon occurrence records, presence of suitable habitat, species range overlap, and previous survey results, eight bat species have potential to occur in the Project vicinity. These species are listed in Table 4-1.

Townsend's big-eared bat and Yuma myotis have been previously documented at structures within the Project construction limits, including mixed-species groups of over 800 bats at J.C. Boyle and aggregations at Copco No. 1 and No. 2. Both species have also been previously documented in the Klamath Basin outside of the Project area, in maternity roosts at Hoover Ranch and Salt Caves (approximately 6 miles east of Copco Reservoir and 9 miles downstream from the J.C. Boyle powerhouse) (Cross et al. 1998; PacifiCorp 2004). Of 24 facility sites visually-surveyed in June 2003, 6 had roosting bats, and 10 had evidence of recent bat use (PacifiCorp 2004, Attachment A).

## 4.3 Methodology

### 4.3.1 Data Review

Recently-published data and literature, along with a current list of species with potential to occur obtained in coordination with ODFW, CDFW, BLM, USFS, and USFWS (Table 4-1), have been reviewed to complement and update the information cited in the 2012 Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR) (USBR and CDFW 2012, Section 3.5). Coordination with local bat experts, including Joe Szewczak (Humboldt State University), Greg Tatarian (Wildlife Research Associates), Dave Johnston (H. T. Harvey and Associates), and Leila Harris (ICF International), is ongoing as of August 2017. As of August 2017, additional data requests have been submitted to state and federal agencies and are pending.

### 4.3.2 Bat Roost Surveys

Bat roost surveys will be conducted for 2 years prior to construction activities (2017-2018). Roost surveys will be conducted cautiously to avoid disturbing bats at roost sites. An initial site reconnaissance and daytime visual inspection of buildings within the Project limits of work was conducted during the summer 2017 maternity season, and is further described in the Preliminary Results section. A follow-up survey was planned during the 2017 maternity season to conduct dusk emergence surveys and pre-dawn re-entry surveys but the survey was cancelled due to lack of right-of-entry to PacifiCorp property for the specific survey task. The need to assess significant roosting habitat outside of buildings will be considered as Project activities are further developed and refined. If determined to be potentially affected by noise or vibrations, significant roosting habitat in the vicinity of major Project disturbances (such as bridges associated with transportation improvements, trees planned for removal) will be evaluated during 2018 survey efforts, or as otherwise dictated by the Project schedule.

The data review, coordination with regional bat experts, and conditions observed during the initial 2017 reconnaissance survey and daytime visual inspections are being used to inform the design of and need for future survey efforts outside of the maternity season. Future surveys will be conducted to identify which species occupy the habitat throughout the year, understand how the habitat is utilized throughout the year, and quantify habitat usage. Recommendations for future surveys are included in Table 4-2. Future focused surveys will include dusk emergence surveys and pre-dawn re-entry surveys, using night vision as appropriate. Acoustic monitoring will be implemented as needed to determine bat roost patterns. The number and location of emergence/re-entry surveys and acoustic monitoring surveys will be tailored to the size of each structure and the species which have the potential to occupy it. The emergence surveys will be conducted when weather conditions are suitable for the evening emergence of bats (e.g., temperatures are warm enough and rain and wind are minimal).

The information obtained during the surveys will be used to 1) determine which facilities need to be removed or modified outside of the bat roosting and breeding period, 2) inform the design of bat exclusion methods where needed, and 3) determine the appropriate design and placement of artificial bat roosts. The Western Bat Working Group species-specific survey methodologies (http://wbwg.org/matrices/survey-matrix/) will be considered and implemented as appropriate.

Winter hibernacula surveys will be conducted between November and March, with the specific survey time frame to be determined by site conditions and weather patterns. Spring and fall migration surveys will be conducted in approximately April/May and September/October. The level of survey effort throughout 2017-2018 will continue to be informed and modified according to the ongoing planning and development of the Project design, findings of each consecutive focused survey, and in coordination with CDFW and ODFW.

## 4.4 Preliminary Results

A general site reconnaissance and daytime visual inspections of most Project structures were conducted during the 2017 maternity season, from July 24-26, 2017 at J.C. Boyle, Copco No.

1 and No. 2, and Iron Gate. Qualified bat biologists conducted daytime visual inspections of each facility to be removed or modified for indications of bat use (e.g., occupancy, guano, staining, smells or sounds). The exterior and interior of most structures were inspected. When bats were found, the species were identified visually to the extent possible. In order to minimize disturbance to roosting bats during the maternity season, interaction with live bats was limited to brief viewing to confirm presence only. Initial survey findings and future survey plans are summarized in Table 4-2. Recommendations for future surveys are informed by habitat suitability, the presence of bats or bat sign, and the presence of entry and exit points.

Five structures at Copco Village were not inspected due to time constraints. For houses that are currently inhabited, the inspection was limited to the exterior. Interior inspections of these structures are planned for future site visits. Because the tunnels near the Copco No. 1 and Iron Gate powerhouses were not accessible during the site reconnaissance, a qualified bat biologist will accompany future tunnel inspections to assess the habitat suitability inside of the tunnels, if possible, and/or bat use will be assessed using dusk emergence surveys and pre-dawn re-entry surveys.

## 4.5 Avoidance and Minimization Measures

If surveys indicate a facility is utilized as a bat roost, then one or more of the following measures will be employed to minimize disturbance and mortality to roosting bats:

- The facility shall be removed or modified outside the bat roosting and breeding period (i.e. November 1 to March 1). If the facility is used as winter hibernacula (November 1 to March 1), then the facility shall be removed or modified when it is determined to be unoccupied.
- 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.
- If demolition at a time when a structure is unoccupied and complete bat exclusion are both found to be infeasible at a given structure, a plan will be developed to carefully remove the occupied bat habitat at a time when it would have the least impact on the bats present and in a manner that avoids bat injury and mortality.
- To reduce impacts on bats from the permanent loss of roosting habitat, preference will be given to on-site and in-kind solutions. Facilities occupied by significant bat roosts may be retained, to the extent practicable. For those facilities that cannot be retained, free-standing bat roosts will be constructed in consultation with bat specialists and the resource agencies. The size and design of each artificial bat roost will be informed by the features of the facility being utilized by roosting bats, the type of roost, and the size of the roost. Critical design elements will include access, ventilation, and thermal conditions. The total number of artificial bat roosts will depend on the total number of facilities with significant bat roosts to be demolished. Experienced contractors will perform the installation of bat roosts. The structures will meet the specifications of Bats in American Bridges (Keeley and Tuttle 1999) and California Bat Mitigation Techniques, Solutions, and Effectiveness (H.T. Harvey and Associates 2004).
- Post-construction monitoring of the replacement bat roosts will occur seasonally (four times/year) for up to three years or until the mitigation can be considered successful.

Success will be defined as the mitigation roost or roosts being occupied by bats. If this standard is not met, KRRC will coordinate with the USFWS and CDFW or ODFW, as appropriate, to ascertain the potential need for further measures.

## 4.6 References

Cross, S.P., H. Lauchstedt, M. Blankenship. 1998. Numerical status of Townsend's Big-eared Bats at Salt Caves in the Klamath River Canyon and other selected sites in Southern Oregon, 1997. Southern Oregon University, Ashland, Oregon.

Johnson, D., G. Tatarian, E. Pierson. 2004. California Bat Mitigation Techniques, Solutions, and Effectiveness. Prepared for California Department of Transportation and California State University Sacramento Foundation. Project Number 2394-01. December 29, 2004.

PacifiCorp. 2004. Terrestrial Resources Final Technical Report Klamath Hydroelectric Project FERC No. 2082. February 2004.

USBR and CDFW. 2012. Klamath Facilities Removal. Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR). U.S. Bureau of Reclamation and California Department of Fish and Wildlife, December.

**Table 4-1 Bat species with potential to occur in the project area**

| Common Name | Scientific Name | Status[1] | Suitable Habitat[2] | Known Occurrences within Project Area | Range Overlap? |
|---|---|---|---|---|---|
| Pallid bat | *Antrozous pallidus* | BLM, CSSC, OSS, USFS, WBWG-H | 1) Buildings, bridges, and tree bark/hollows. 2) Caves, mines and cliffs/rock crevices. | None | Yes |
| Townsend's big-eared bat[3] | *Corynorhinus townsendii* | BLM, CSSC, OSS, USFS, WBWG-H | 1) Caves, mines. 2) Buildings, bridges. 3) Tree bark/hollows. | Known from J.C. Boyle peaking reach. Not documented during PacifiCorp surveys (PacifiCorp 2004). Multiple observations in Rock Creek-Klamath River watershed (exact location not given; ORBIC 2017). Occurrences along Klamath River near Somes Bar (CNDDB 2017). | Yes |
| Silver-haired bat | *Lasionycteris noctivagans* | OSS, WBWG-M | 1) Tree bark/hollows. 3) Bridges. | None | Yes |
| California myotis | *Myotis californicus* | OSS, WBWG-L | 1) Buildings, cliffs/rock crevices. | None | Yes |

| | | | | | |
|---|---|---|---|---|---|
| | | | 2) Bridges, caves, mines, tree bark/hollows. | | |
| Hoary bat | *Lasiurus cinereus* | OSS, WBWG-M | 1) Tree foliage. | None | Yes |
| Fringed myotis | *Myotis thysanodes* | BLM, OSS, USFS, WBWG-H | 1) Caves, mines, tree bark/hollows. 2) Buildings, bridges, cliffs/rock crevices. | None | Yes |
| Long-legged myotis | *Myotis volans* | OSS, WBWG-H | 1) Tree bark/hollows. 2) Buildings, bridges, caves, mines. | None | Yes |
| Yuma myotis | *Myotis yumanensis* | BLM, OSS, WBWG-L | 1) Buildings, bridges. 2) Caves, mines, tree bark/hollows. 3) Cliffs/rock crevices. | Documented during PacifiCorp surveys roosting in J.C. Boyle forebay spillway house, in transformer bays at Copco No. 1 powerhouse, and in rafters at Iron Gate south gatehouse (PacifiCorp 2004) | Yes |

[1] USFS US Forest Service sensitive species not listed or proposed for listing under the federal Endangered Species Act for which population viability is a concern, as evidenced by significant current or predicted downward trends in population numbers or density, or significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution.
BLM Bureau of Land Management sensitive species are species that could easily become endangered or extinct.
CSSC California Department of Fish and Wildlife Species of Special Concern are species not listed under the federal or California Endangered Species Act but are believed to: 1) be declining at a rate that could result in listing, or 2) historically occur in low numbers and have current known threats to their persistence.
OSS Oregon Sensitive or Sensitive-Critical Species, East Cascades, West Cascades, and Klamath Mountains Ecoregions.
WBWG Western Bat Working Group High (H), Medium (M), or Low (L) Priority for funding, planning and conservation actions in Ecoregion 5 (http://wbwg.org/matrices/species-matrix/).
[2] 1 = used frequently; 2 = used sometimes; 3 = used rarely (Johnson et al. 2004).
[3] PacifiCorp (2004) treated this as two subspecies; however, *Corynorhinus townsendii* is currently listed as one species.

## Table 4-2 Initial findings (July 2017) and recommendations for future surveys

| Building Name | Suitability for Roosting | Live Bats Present? | Evidence of Bats Found? | Survey Recommendation |
|---|---|---|---|---|
| **J.C. Boyle Dam and Facilities** | | | | |
| Red Barn | High | No | Yes - found dead bats outside of the building and inside the attic (badly dessicated - likely *Myotis* sp.). Abundant guano in attic. | Determine seasonal use. Next survey in winter 2017-2018. |
| Truck Shop | High | No | No | Emergence/re-entry survey. |

| Building Name | Suitability for Roosting | Live Bats Present? | Evidence of Bats Found? | Survey Recommendation |
|---|---|---|---|---|
| HazMat | Low | No | No | No additional survey needed. |
| Well House | Low | No | No | No additional survey needed. |
| Fire System Control | Moderate-High | No | Yes - small amounts of guano. | Emergence/re-entry survey. |
| Dam Communications | Moderate | No | No | No additional survey needed. |
| Fish Screen House | Moderate | No | No | No additional survey needed. |
| Headgate Control | Moderate | No | No | Emergence/re-entry survey. |
| Headgate structure/concrete canal | Low | No | No | No additional survey needed. |
| Concrete Spillway (along canal) | Moderate | No | Yes - small amounts of guano. | No additional survey needed. |
| Spillway Gatehouse | High | Yes | Yes - occupied by several hundred bats. | Determine seasonal use. Next survey in winter 2017-2018. |
| M+K building | High | No | Yes - small amounts of guano. | Determine seasonal use. Next survey in winter 2017-2018. |
| **Copco No. 1 and No. 2 Dams and Facilities** | | | | |
| Schoolhouse | Low | No | No | No additional survey needed. |
| House 19038 (next to schoolhouse) | High | No | Yes - abundant guano in crawlspace. | Determine seasonal use. Next survey in winter 2017-2018. |
| Vacant House 1 (tan) | High | Yes | Yes - small numbers of bats present under wood panels outside. | Determine seasonal use. Next survey in winter 2017-2018. |
| Vacant House 2 (blue) | High | Yes | Yes - small numbers of bats present under wood panels outside. | Determine seasonal use. Next survey in winter 2017-2018. |
| Vacant House 3 (yellow) | High | Yes | Yes - large colony in garage behind wood window framing, whole structure is being heavily used. | Determine seasonal use. Next survey in winter 2017-2018. |
| Vacant House 4 (peach) | High | Yes | Yes - colony between flashing & fascia board all around roof edge. Pups present. | Determine seasonal use. Next survey in winter 2017-2018. |
| Cookhouse | Moderate | Yes | Yes - bats present in awning over side door outside, no sign inside. | Determine seasonal use. Next survey in winter 2017-2018. |
| Bunkhouse | Moderate | No | Yes - guano on bed. | Emergence/re-entry |

| Building Name | Suitability for Roosting | Live Bats Present? | Evidence of Bats Found? | Survey Recommendation |
|---|---|---|---|---|
| | | | Night roosting suspected from staining around outside lighting. | survey. |
| Copco No. 1 Dam - C12 gatehouse | High | No | Yes - abundant guano/staining inside & out, dead bat (Myotis sp.) found outside on windowsill. | Emergence/re-entry survey. |
| Copco No. 1 powerhouse | High | Yes | Yes - several dozen bats clustered on wall above Transformer 3781; abundant staining/guano on basement level. | Determine seasonal use. Next survey in winter 2017-2018. |
| Tunnel outside of Copco No. 1 powerhouse | High | Unknown | Not inspected | Emergence/re-entry survey. Accompany future tunnel inspection. |
| Copco No. 2 Diversion Dam | Low | No | No | No additional survey needed. |
| Vacant House #21601 (light yellow house) | High | Yes | Yes - ~200 bats roosting in attic. | Determine seasonal use. Next survey in winter 2017-2018. |
| Shed (next to power station) | High | No | None found in main portion of shed. Back area of building was inaccessible. | Emergence/re-entry survey. |
| Vacant House (light blue) | Moderate | No | Yes - dead bat found in bathroom sink. No guano/staining inside. Attic vents are closed. No points of entry found. | No additional survey needed. |
| Tin Pumphouse (across fromlight. blue house) | Low | No | No | No additional survey needed. |
| Tin Pumphouse at entrance to Copco Village | Moderate | No | Yes - small amount of guano outside. Multiple points of entry. Inside inaccessible. | Emergence/re-entry survey. |
| Copco No. 2 powerhouse | High | No | Yes - many dead bats on ground level (on floor, in storage room, control room) and dead pups at bottom of stairs on lower level. More sign/activity found at ground level. | Determine seasonal use. Next survey in winter 2017-2018. |
| Control Room at Copco No. 2 powerhouse | - | Unknown | Not inspected | Daytime inspection during future survey. |
| Shop next to powerstation at Copco No. 2 | - | Unknown | Not inspected | Daytime inspection during future survey. |

| Building Name | Suitability for Roosting | Live Bats Present? | Evidence of Bats Found? | Survey Recommendation |
|---|---|---|---|---|
| Occupied House next to Vacant House 4 | - | Unknown | Not inspected | Daytime inspection during future survey. |
| Equipment shed (in front of bunkhouse/cookhouse) | - | Unknown | Not inspected | Daytime inspection during future survey. |
| Waste storage/wood shop by gas pumps (near houses/bunkhouse/cookhouse) | - | Unknown | Not inspected | Daytime inspection during future survey. |
| **Iron Gate Dam and Facilities** | | | | |
| Gatehouse for low-level outlet (upstream side of dam) | Moderate | No | Yes - night roosting evidence outside. No sign found inside. | No additional survey needed. |
| Tunnel near Iron Gate powerhouse | High | Unknown | Not inspected | Emergence/re-entry survey. Accompany future tunnel inspection. |
| Iron Gate Powerhouse intake | High | Yes | Yes - from ground level, bats can be heard through grating below. Entry via open grate on outside. Two dead bats, abundant guano on plastic sheeting on floor inside. | Determine seasonal use. Next survey in winter 2017-2018. |
| Iron Gate Emergency Spill Equipment shed | Low | No | No | No additional survey needed. |
| Iron Gate Hydro Resources office/powerhouse | High | No | Yes - heavily used night roost by light fixture under stairwell (abundant staining on concrete wall). Sign of significant roost inside concrete shaft (heavy staining/guano). Confined space entry to bottom level of powerhouse, did not inspect. | Emergence/re-entry survey. |
| Bathroom/storage building near powerhouse | Moderate | No | No - multiple potential entry/exit points. | Emergence/re-entry survey. |
| Spawning building | Moderate | No | Yes - small amount of guano. Potential night roosting outside. | No additional survey needed. |
| 2 storage trailers (parked next to each other) | Low | No | No | No additional survey needed. |
| Barn/garage at Iron Gate Village | High | Yes | Yes - bats present in rafters/ceiling, abundant guano. | Determine seasonal use. Next survey in winter 2017-2018. |
| Residence 1 (occupied) | High | No | No (inspected outside | Daytime interior (attic) |

| Building Name | Suitability for Roosting | Live Bats Present? | Evidence of Bats Found? | Survey Recommendation |
|---|---|---|---|---|
| blue/gray | | | only - inside/attic not accessed). | inspection during future survey. |
| Residence 2 (occupied) tan w/green roof | High | Yes | Yes - ~15 bats present behind clock on back porch. Attic access likely through loose screen over vent. Outside inspection only - inside/attic not accessed. | Daytime interior (attic) inspection during future survey. |

# 5. Special Status Plants Measures

## 5.1 Objectives

Special status plants include those species with federal status (federally listed as threatened, endangered, or proposed for listing), state threatened or endangered species, Oregon Natural Heritage Program Lists 1 and 2, and California Rare Plant Rank 1 and 2. Measures to avoid or minimize potential impacts will be developed for special status plants located within areas potentially subject to ground disturbance.

The Klamath Facilities Removal Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR) (USBR and CDFW 2012, Section 3.5) Mitigation Measure TER-4 described measures to reduce Project impacts on special status plants. The EIS/EIR recommended surveys to identify the locations of special status plants that may be affected by the Project. This measure has been incorporated into the project and will be implemented as described in the following sections. Where occurrences of special status plants cannot be avoided, minimization measures such as propagation and establishment in new locations will be incorporated into the restoration plans. Other minimization measures may be developed in coordination with the U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife (CDFW), and Oregon Department of Fish and Wildlife (ODFW). This section describes the initial phase of this process.

## 5.2 Existing Information

PacifiCorp conducted focused surveys for special status plants from May through July 2002 at representative cross sections of all the major habitats and topographic features in the study area, particularly in areas with a high potential for supporting special status plants. Several sites were revisited later in 2002 and in 2003 (PacifiCorp 2004, Attachment A).

In addition to the findings of the PacifiCorp surveys, special status plant occurrences in the Project area were identified through the following information sources: the Oregon Biodiversity Information Center (ORBIC), the California Natural Diversity Database (CNDDB), and the U.S. Fish and Wildlife Service (USFWS) Information for Planning and Conservation (IPaC) database.

Additional information on the occurrence of special status plants in the Project area was obtained from USFWS (Yreka), Bureau of Land Management (BLM, Klamath Falls), and U.S. Forest Service (USFS, Klamath National Forest).

Table 5-1 presents the list of special status plants that have potential to occur in or near Project construction areas. This is a preliminary list of species with potential to occur; additional information may be obtained through further coordination with resource agencies.

## 5.3 Methodology

A field reconnaissance was conducted in July 2017. During the field reconnaissance, biologists visited proposed construction areas to assess the potential for suitable habitat for special status plants. The biologists considered existing information from biological survey data and reports completed at or near the Project area (e.g., surveys conducted by PacifiCorp in 2001-2003), and data obtained from a desktop review of existing databases (CNDDB, ORBIC, and California Native Plant Society).

During the field reconnaissance, biologists gathered qualitative information on habitats present and determined access for surveys. The potential presence of wetlands and other sensitive natural communities within the construction limits were noted for future investigation. Biologists also looked for evidence of changes to existing conditions since the PacifiCorp surveys were conducted, including wildfires, development, agriculture and grazing, and logging activities.

Focused surveys for special status plants will be conducted in areas within the construction limits of work following the CDFW "Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities," as described further below. In areas outside of the construction limits but along reservoir shorelines, where changes in hydrology and geomorphology could occur due to the Project, surveys will be focused on the locations of known and potential occurrences of special status plants as shown in Table 5-1.

KRRC biologists will familiarize themselves with the morphological and habitat characteristics of the species with potential to occur within the Project area. To the extent feasible, reference populations will be visited prior to field surveys or field survey crews will include at least one member who has seen the target species growing in their natural habitat. Surveys will coincide with plant bloom times, as shown in Table 5-1.

In accordance with the 2009 CDFW protocol, detailed surveys within the construction limits of work will be floristic, identifying every plant taxon that occurs to the taxonomic level necessary to determine rarity and listing status. Detailed surveys will be conducted at proposed disposal sites (including a 100-meter buffer around each) and within 10 meters of access and haul roads. Within proposed disposal sites, biologists will walk parallel transects spaced 5 to 10 meters apart.

GPS coordinates will be recorded of all observed special status plants found and a protection plan will be developed in coordination with the regulatory agencies. If special status plants cannot be avoided during construction, the restoration plan will evaluate the potential for seed collection and propagation at local nurseries for replanting and/or as part of a seed mix to be used during restoration activities. Relocation of special status plants is not recommended by agency personnel.

Three surveys will be conducted in 2018, the first in early to mid-April, the second in mid-May, and the third in mid-July to encompass the range in bloom times for species with the potential to occur in the Project area.

## 5.4 Summary of Special Status Plant Survey Plan

Special status plant surveys will entail the following:

- Detailed floristic surveys for special status plants within the construction limits of work following the CDFW "Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities"
- Focused surveys for the special status plants listed in Table 5-1 that may occur in suitable habitat along reservoir shorelines, but outside of the construction limits (i.e., not within the proposed disposal sites or 100-meter buffer or within 10 meters of access and haul roads).

## 5.5 Avoidance and Minimization Measures

- If any special status plants are found to occur within the construction limits of work, the project design will be modified if possible to avoid special status plants. Where special status plants cannot be preserved in place, a combination of relocation, propagation, and establishment of new populations in designated conservation areas within the Project site would be implemented, as determined in coordination with the resource agencies.
- The restoration plans developed for both reservoir and non-reservoir areas would include provisions for the establishment of special status plants, if any are found within the Project area.
- To minimize the potential for invasive plants to recolonize and infest disturbed areas, construction vehicles and equipment would be cleaned with compressed water or air within a designated containment area to remove pathogens, invasive plant seeds, or plant parts and dispose of them in an appropriate disposal facility.

## 5.6 References

PacifiCorp. 2004. Final Technical Report. Klamath Hydroelectric Project (FERC Project No. 2082), Terrestrial Resources. PacifiCorp, Portland, Oregon. February.

USBR and CDFW. 2012. Klamath Facilities Removal. Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR). U.S. Bureau of Reclamation and California Department of Fish and Wildlife, December.

### Table 5-1 Preliminary List of Special Status Plants with Potential to Occur in or near Construction Limits of Work

| Species | Status | Habitat | Location of Documented Occurrence(s) | Bloom Time | Proposed Survey Effort |
|---|---|---|---|---|---|
| Greene's mariposa-lily *Calochortus* | FSC, BLM, OC, ONHP List 1, | Occurs primarily in annual grassland, wedgeleaf ceanothus | Several locations around Iron Gate Reservoir | May through July | Within construction limits in suitable habitat |

| Species | Status | Habitat | Location of Documented Occurrence(s) | Bloom Time | Proposed Survey Effort |
|---|---|---|---|---|---|
| *greenei* | CNPS List 1B | chaparral, and oak and oak-juniper woodlands. | | | |
| Bristly sedge *Carex comosa* | ONHP List 2 | Marshes, lake shores, and wet meadows. | East shore of J.C. Boyle Reservoir in 2 locations (east of Dam and south of Highway 66); also west of Dam | May-September | Along reservoir margins and within construction limits in suitable habitat |
| Mountain Lady's Slipper *Cypripedium montanum* | ONHP List 4, CNPS List 4 | Dry, open conifer forests, more often in moist riparian habitats | J.C. Boyle peaking reach (location details unknown) | March-August | Within construction limits in suitable habitat |
| Gentner's fritillary *Fritillaria gentneri* | FE, CNPS List 1B | Cismontane woodland, chaparral. Mixed hardwood-conifer vegetation dominated by Oregon oak. | Habitat present in the reach along Copco and Iron Gate Reservoirs. No known locations. | Late March to early April; April-May at higher elevations | Within construction limits in suitable habitat |
| Bolander's sunflower *Helianthus bolanderi* | BLM, ONHP List 3 | Occurs in yellow pine forest, foothill oak woodland, chaparral, and occasionally in serpentine substrates or wet habitats. | South of Iron Gate Reservoir near proposed disposal site, J.C. Boyle peaking reach (location details unknown) | June-October | Within construction limits in suitable habitat |
| Bellinger's meadow-foam *Limnanthes floccosa ssp. bellingerana* | FSC, BLM, OC, ONHP List 1, CNPS List 1B | High elevation vernal pools located in shallow soiled rocky meadows in spots that are at least partially shaded in the spring. | J.C. Boyle peaking reach (location details unknown) | April-June | Within construction limits in suitable habitat |
| Detling's silverpuffs *Microseris laciniata* ssp. *detlingii* | CNPS List 2 | Chaparral and grassy openings among Oregon white oak trees. | One location on west side of Iron Gate Reservoir | May-June | Within construction limits in suitable habitat |
| Egg Lake monkeyflower *Mimulus pygmaeus* | FSC, CNPS List 4 | Occurs in damp areas or vernally moist conditions in meadows and open woods. | East of J.C. Boyle Reservoir in 2 locations (north of Highway 66 and southeast of Dam); west of Dam in two locations in damp mudflats; also west of canal near access road in one location | May-August | Along reservoir margins and within construction limits in suitable habitat |
| Holzinger's orthotrichum moss *Orthotrichum holzingeri* | CNPS List 1B.3 | Found on vertical calcareous rock surfaces and at the bases of Salix bushes just above rock that is frequently inundated by seasonally high water in dry coniferous forests. | Just upstream of Iron Gate Reservoir on Jenny Creek. | | Where in-stream work could occur at Jenny Creek at bridge |
| Red-root yampah *Perideridia erythrorhiza* | FSC, BLM, OC, ONHP List 1 | Occurs in moist prairies, pastureland, seasonally wet meadows, and oak or pine woodlands, often in dark wetland | Along 3 drainages into west side of J.C. Boyle Reservoir and in 2 locations west of canal near access road | Mid July - August | Along reservoir margins and within construction limits in suitable habitat |

| Species | Status | Habitat | Location of Documented Occurrence(s) | Bloom Time | Proposed Survey Effort |
|---|---|---|---|---|---|
| | | soils and clay depressions. | | | |
| Howell's yampah (Howell's false caraway) *Perideridia howelii* | ONHP List 4 | Moist meadows, stream banks. | One location along drainage southeast of J.C. Boyle Reservoir; one location along north side of Copco Lake north of road | July-August | Along reservoir margins and within construction limits in suitable habitat |
| Yreka phlox *Phlox hirsuta* | FE, CE, CNPS List 1B | Open areas on dry serpentine soils and is found at elevations ranging from 2,500 to 4,400 feet. | Not known to occur near construction limits. No suitable ultramafic soils occur within 0.5 miles of construction limits (NRCS 2017). | March-April | None- suitable soils not present within construction limits |
| Strapleaf willow *Salix ligulifolia* | ONHP List 3 | Riverbanks, wetlands, floodplains | One location west of J.C. Boyle Dam in a boulder flood channel in dam release zone | March-June | Along reservoir margins and within construction limits in suitable habitat |
| Fleshy sage *Salvia dorrii* var. *incana* | CNPS List 3 | Occurs in silty to rocky soils in great basin scrub, pinyon, and juniper woodland. | 3 locations around Iron Gate Reservoir | May- July | Within construction limits in suitable habitat |
| Pendulous bulrush *Scirpus pendulus* | BLM, ONHP List 2, CNPS List 2 | Occurs along streambanks and in wet meadows. | One location along Fall Creek | June-August | Along reservoir margins and within construction limits in suitable habitat |
| Lemmon's silene *Silene lemmonii* | ONHP List 3 | Open pine woodlands | J.C. Boyle peaking reach to J.C. Boyle Reservoir (location details unknown) | Spring-Summer | Within construction limits in suitable habitat |
| Western yellow cedar *Callitropsis nootkatensis* | Petitioned for federal listing, CNPS List 4.3 | Wet to moist sites, from the coastal rainforests to rocky ridgetops near the timberline in the mountains. | Not documented during PacifiCorp surveys or listed on CNDDB or ORBIC for the project area. May occur based on information from USFWS Yreka office (May 23, 2017). | | Within construction limits in suitable habitat |

Key:

| | |
|---|---|
| BLM | Bureau of Land Management sensitive species -species that could easily become endangered or extinct. |
| CE | California Endangered |
| CNPS List 1A | California Native Plant Society (CNPS)-Presumed extinct in California. |
| CNPS List 1B | rare, threatened, or endangered in California and elsewhere. |
| CNPS List 2 | rare, threatened, or endangered in California, but more common elsewhere. |
| CNPS List 3 | on the review list -more information needed |
| CNPS List 4 | on the watch list -limited distribution |
| FE | Federal Endangered |
| FSC | Federal Species of Concern |
| OC | Candidate listing by Oregon Department of Agriculture (ODA) |
| ONHP List 1 | Oregon Natural Heritage Program (ONHP) threatened with extinction or presumed to be extinct throughout their entire range |
| ONHP List 2 | threatened with extirpation or presumed to be extirpated from the State of Oregon |

| Species | Status | Habitat | Location of Documented Occurrence(s) | Bloom Time | Proposed Survey Effort |
|---|---|---|---|---|---|

| | |
|---|---|
| ONHP List 3 | more information is needed before status can be determined, but may be threatened or endangered in Oregon or throughout their range |
| ONHP List 4 | of conservation concern but not currently threatened or endangered |

# 6. Vegetation Communities and Wetlands Measures

## 6.1 Objectives

This section describes the proposed approach for mapping vegetation communities and assessing wetlands prior to the start of construction activities. The purpose of vegetation community and wetlands mapping is to identify the location and extent of wetlands and other natural communities, including rare natural communities that may be affected by the Project. Vegetation community mapping will also be used to identify suitable habitat for special status species (plants and wildlife). Communities dominated by invasive plant species will also be identified.

Based on the information in the 2004 PacifiCorp report, the Klamath Facilities Removal Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR) (USBR and CDFW 2012, Section 3.5) identified potential impacts on 244.4 acres of wetland and riparian habitat and proposed Mitigation Measure TER-5 to provide compensatory mitigation.  However, the EIS/EIR also identified that PacifiCorp estimated that 272 acres of wetland and riparian habitat would become re-established in the event of dam decommissioning.  If the Project does not result in a net loss of wetland and riparian habitat, then a compensatory mitigation plan would not be required by regulatory agencies.  The Project will comply with regulatory requirements in delineating wetlands and evaluating potential impacts to acreage and functions. The Project design and construction planning will incorporate avoidance and minimization measures to the maximum extent practicable.  The restoration plans for the reservoir and non-reservoir areas will both include design for wetland and riparian habitat restoration as appropriate to result in no net loss of wetland or riparian habitat functions.

## 6.2 Existing Information

### 6.2.1 Vegetation Communities

PacifiCorp mapped existing vegetation cover types/wildlife habitat within a primary study area of 0.25 miles surrounding the reservoirs, facilities, and river reaches. Vegetation community maps are found in PacifiCorp (2004).

The vegetation classification system was based on the California Wildlife Habitat Relations System (CWHRS) and refined through coordination with the Terrestrial Resources Work Group, consisting of representatives from several state and federal agencies. The classification scheme, including the dominant species of each cover type, is described in PacifiCorp (2004) Additional data, including the species frequency and abundance for the sampled vegetation cover types, are provided in the PacifiCorp (2004).

Preliminary vegetation polygons were delineated by PacifiCorp in 2001 using aerial and infrared photography and other mapped information. The minimum mapping unit for upland types was approximately 1 acre (0.4 hectare [ha]). More unique types such as riparian areas and wetlands were delineated as small as possible (approximately 0.1 acre and 0.4 ha, respectively). Polygon delineations and vegetation cover maps were field verified in 2001 (PacifiCorp 2004).

Further characterization of each cover type was conducted in 2002 (PacifiCorp 2004). This characterization consisted of sampling randomly selected polygons (295 of the 2,900 polygons in the study area), with greater emphasis on wetlands and riparian habitats. Sampling consisted of estimates of areal foliar cover by cover class for each species in each of the vegetation layers (i.e., tree, shrub, and herb layer); the areal cover and height of each vegetation layer in the plot; the aspect; and the slope. The number of living trees was tallied and the tree diameters at breast height (dbh) were recorded. The amount of dead wood in the plot was assessed by collecting data on coarse woody debris, snags, and wood cover for pieces greater than 4 inches (10 centimeters [cm]) in diameter.

Since the 2012 EIS/EIR was published, there have not been any significant changes in habitats within the Project limits of work. Based on a review of historical aerial photography conducted by CDM Smith, timber harvest has been conducted in several locations within 0.5 miles of the construction limits of work in the J.C. Boyle portion of the Project area. These timber harvests have occurred since the PacifiCorp habitat and species surveys were conducted in 2001-2003. The analysis of historical imagery noted that logging and forest thinning occurred in late summer/fall of 2003 and between 2003 and 2005 in the vicinity of the J.C. Boyle Reservoir and east of the Klamath River canyon between the J.C. Boyle Dam and the powerhouse. Although these habitat alterations have the potential to reduce habitat suitability for some species, they are located outside of the Project limits of work and are not on PacifiCorp land. No major wildfires or other significant habitat alterations were identified in the Project area since the PacifiCorp surveys.

The following sections describe the vegetation communities observed within the proposed construction limits of work and areas surrounding the reservoirs during the July 2017 site reconnaissance.

#### 6.2.1.1 J.C. Boyle

The J.C. Boyle Reservoir is approximately 420 acres of open water situated within Klamath mixed conifer forest dominated by ponderosa pine (*Pinus ponderosa*), with Douglas-fir (*Pseudotsuga menziesii*) also common. North of Highway 66, the reservoir supports a broad, shallow emergent marsh along both edges supporting a large community of bulrush (*Schoenoplectus* spp.) and aquatic vegetation including pondweeds (*Potamogeton* spp.) and coontail (*Ceratophyllum demersum*) along the eastern shoreline. Sportsmen's Park is located just east of this marsh and provides limited access. South of Highway 66, the reservoir is relatively narrow with forested upland slopes and some flatter areas that support wetland patches of bulrush, cattail (*Typha* spp.), and rushes (*Juncus* spp.) along the shoreline.

Developed areas associated with the dam and power facilities consist of annual grasses dominated by cheatgrass (*Bromus tectorum*) and other non-native species. Vegetation around recreational areas consist primarily of scattered ponderosa pine and Douglas-fir.

The proposed J.C. Boyle disposal site is located adjacent to a high-power transmission line corridor. A portion of the site was likely used as a borrow site during dam construction. The majority of the area is heavily disturbed and consists of bare ground used for ATV recreation. Evidence of cattle grazing was also observed. Several depressions support dense stands of coyote willow (*Salix exigua*) in some areas, while others are sparsely vegetated with herbaceous vegetation including cudweed (*Gnaphalium palustre*), Bach's calicoflower (*Downingia bacigalupii*), and Bermuda grass (*Cynodon dactylon*).

A portion of the proposed disposal site is located within a deep ravine that supports a dispersed mixed chaparral/sagebrush scrub community consisting of antelope bitterbrush (*Purshia tridentata*), deerbrush (*Ceanothus integerrimus*), big sagebrush (*Artemisia tridentata*), gray rabbitbrush (*Chrysothamnus nauseosus*), greenleaf manzanita (*Arctostaphylos patula*), and serviceberry (*Amelanchier alnifolia*). Herbaceous species observed in this area include nettleleaf horsemint (*Agastache urticifolia*), parched willowherb (*Epilobium brachycarpum*), needle navarretia (*Navarretia intertexta*), lupine (*Lupinus argenteus*), yarrow (*Achillea millefolium*), bull thistle (*Cirsium vulgare*), cheatgrass, and other non-native grasses. A narrow drainage channel was noted at the bottom of the ravine. The channel was dry during the July 2017 site reconnaissance.

Downstream of the dam, the Klamath River runs through a narrow canyon with steep, forested slopes and exposed rock cliffs and talus slopes in many areas. Reed canarygrass (*Phalaris arundinacea*) dominates the Klamath River shoreline downstream of the dam. Water from the reservoir is conveyed through an approximately 2.2-mile long power canal located along a bench cut in the face of the river canyon. The canal is a concrete flume approximately 17-feet wide and 12-feet high and single-walled in places, supporting patches of arroyo willow (*Salix lasiolepis*) and other riparian vegetation on the uphill side of the channel in some areas along its route to the forebay.

Vegetation on the slopes surrounding the J.C. Boyle powerhouse, including the former access roads to the penstocks, consists of an open forest of Oregon oak and conifers with mixed chaparral/sagebrush vegetation.

#### 6.2.1.2 Copco

The Copco No. 1 Dam is situated in a narrow canyon adjacent to exposed rock faces. The dam impounds an approximately 1,000-acre reservoir. Much of the reservoir shoreline is steeply sloped and consists of open Oregon oak (*Quercus garryana*) and western juniper (*Juniperus occidentalis*) woodland, with large expanses of annual and perennial grassland on the slopes north of the reservoir dominated by invasive yellow star-thistle (*Centaurea solstitialis*) and medusahead (*Taeniatherum caput-medusae*). Denser mixed oak-conifer forests are found along the slopes south of the reservoir. There is evidence of cattle grazing around the reservoir, and feral horses were noted during the July 2017 reconnaissance.

Riparian habitat dominated by coyote willow and shining willow (*Salix lucida*) is primarily found where stream channels enter the reservoir. An area of seeps and springs supports a dense willow and hardwood forest along the slope on the northwest shore of the reservoir. Patches of emergent vegetation, including bulrush, cattail, and rushes, exist in areas where the shoreline topography supports areas of shallow water.

Copco No. 2 Dam is situated approximately 1/4-mile downstream of Copco No. 1 Dam, creating a narrow reservoir with steep sides. The north slope of this reach is developed with access roads to Copco No. 1 Dam, the powerhouse at the base of Copco No. 1 dam, and to Copco No. 2 Dam. The northern slope is vegetated with yellow star-thistle, non-native grasses, and scattered native forbs including giant blazing-star (*Mentzelia laevicaulis*). Exposed basalt outcrops form cliff faces on the northern slope. The southern slope is forested with willows, oaks, and conifers.

The proposed Copco disposal site is located on the slope north of Copco No. 2 Reservoir. The site is developed with a house and other structures. The topography of the site suggests it was used as a borrow site for dam construction. Vegetation at the site consists of yellow star-thistle, medusahead and other non-native grasses, weedy species such as mullein (V*erbascum thapsus*), and scattered sagebrush shrubs such as rabbitbrush. Two mature eastern arborvitae (*Thuja occidentalis*) trees and irrigated lawn surround the house.

Downstream of Copco No. 2 Dam, the river winds through a horseshoe-shaped canyon with steep exposed cliff faces along the northern slope. The large wooden Copco No. 2 penstock is located on a terrace above the south shore of the river. Vegetation along the southern bank is dominated by willows and white alder (*Alnus rhombifolia*). Himalayan blackberry (*Rubus armeniacus*), and poison oak (*Toxicodendron diversilobum*) were observed in the understory.

Water leaking from the Copco No. 2 penstock supports wetland vegetation in several locations, including broadleaf cattail (*Typha latifolia*), water smartweed (*Polygonum amphibium*), and beggarstick (*Bidens frondosa*). Culverts drain these ponded areas down to the river. Open disturbed sites dominated by invasive yellow star-thistle are located along the penstock, including a large flat area at the eastern end that was likely created during the penstock construction.

Copco No. 2 powerhouse is situated along the southern bank of the river upstream of the Daggett Road crossing. Several residences and other structures are also located in this area, known as Copco Village. Vegetation is disturbed with irrigated lawns surrounding the structures.

The confluence of Fall Creek and the Klamath River is located just downstream of Copco Village and supports a willow riparian and emergent wetland vegetation community. The City of Yreka water supply line is located in this vicinity. Wetland vegetation includes hardstem bulrush and reed canarygrass. Several weedy species including teasel (*Dipsacus fullonum*), curly dock (*Rumex crispus*), lambsquarters (*Chenopodium album*), and oxeye daisy (*Leucanthemum vulgare*) were noted on the southern bank of the Klamath River in the vicinity of the City of Yreka water supply line.

#### 6.2.1.3 Iron Gate

Iron Gate Reservoir consists of approximately 944 acres situated within open oak and juniper woodlands, similar to those found at Copco Lake. The reservoir shorelines are less steep than those of Copco Lake. Annual grasslands are dominated by invasive yellow star-thistle and medusahead, and there is evidence of cattle grazing in many areas. A single-lane bridge crosses the Klamath River downstream of the dam and provides access to the powerhouse and fish hatchery. Several structures, including two residences, are located on the north side of the river and are surrounded by irrigated lawns.

Several day-use sites and campgrounds are located around the reservoir. Vegetation within these areas consists primarily of Oregon oak, western juniper, willows, and chaparral/sagebrush scrub. A few mature black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) and weeping willow (*Salix babylonica*) were observed. Dense willow riparian communities consisting of coyote and shining willow are associated with the mouths of Jenny, Scotch, and Camp creeks. Emergent wetland vegetation in these areas consists of hardstem bulrush, cattails, rushes, and other species.

The proposed Iron Gate disposal site consists of annual grassland dominated by yellow star-thistle and medusahead, with scattered forbs including barestem buckwheat (*Eriogonum nudum*), sunflower (*Helianthus* sp.), turkey mullein (*Eremocarpus setigerus*), and wild onion (Allium sp.). The site also supports open Oregon oak and western juniper woodlands, and chaparral communities dominated by wedgeleaf ceanothus (*Ceanothus cuneatus*) with three-leaf sumac (*Rhus trilobata*) also observed. The site appears to be used for target shooting and there is evidence of cattle grazing. The site may have been used as a borrow area during construction of the dam. A shallow drainage swale that runs south toward Bogus Creek was dry during the July 2017 site reconnaissance.

### 6.2.2 Invasive Species

As noted above, large infestations of invasive yellow star-thistle and medusahead were observed adjacent to the Copco Lake and Iron Gate Reservoir and other disturbed areas. Himalayan blackberry was also observed in localized areas, including along the Klamath River near the Copco No. 2 penstock. Reed canarygrass was dominant along most reaches of the Klamath River within the Project area.

Additional information on invasive species in the J.C. Boyle Project area was obtained from the BLM National Invasive Species Information Management System (NISIMS) database. Spatial data show large infestations of medusahead around the J.C. Boyle Reservoir, yellow star-thistle in the vicinity of the J.C. Boyle powerhouse, Scotch thistle (*Onopordum acanthium*) around the J.C. Boyle Dam, and common St. Johnswort (*Hypericum perforatum*) along the Klamath River canyon between the J.C. Boyle Dam and powerhouse. Other invasive species mapped in the J.C. Boyle area include diffuse knapweed (*Centaurea diffusa*), bull thistle, Canada thistle (*Cirsium arvense*), Scotch broom (*Cytisus scoparius* var. *scoparius*), Dyer's woad (*Isatis tinctorial*), and smallflower tamarisk (*Tamarix parviflora*).

### 6.2.3 Wetlands and Other Waters

Wetlands and riparian communities were mapped and field verified in 2002 during the vegetation community mapping described above (PacifiCorp 2004). PacifiCorp further characterized wetlands and riparian communities in 2002 to collect information on the species composition, general structural characteristics, and relative condition of existing wetland and riparian plant communities. This assessment considered the distribution of channel geomorphic types and hydrologic data. Riparian/wetland transects were established and sampled in 2002 and 2003. Data included plant cover, height, and tree and shrub regeneration estimates within 1-m by 4-m plots. Qualitative information on recreation, livestock, and wildlife use and erosion/deposition was also collected. These methods are described in PacifiCorp (2004).

PacifiCorp evaluated pre-construction and post-dam construction wetland and riparian conditions. The study concluded that, in general, the distribution of wetland and riparian habitat consisted of long, thin bands running along the historic Klamath River channel. In comparison, somewhat wider, but more widely scattered patches of these vegetation types exist along the present-day Project reservoir shorelines. The analysis concluded that the area of wetland and riparian habitat is somewhat greater along the J.C. Boyle Reservoir under current conditions and that there is less area along the Copco Lake and Iron Gate Reservoir as compared to historical conditions (PacifiCorp 2004). It is anticipated that wetland and riparian areas similar to those that previously existed will become re-established along the restored Klamath River following restoration. In addition, the tributary riparian habitats would be expected to extend farther downstream as the currently drowned stream channels are restored. In addition to simple area considerations, the functions of wetlands and riparian areas along the river would be different from those on the fringes of a reservoir. As part of the permitting process, KRRC biologists will conduct a functional assessment of existing wetlands potentially affected by the project and those expected to be restored by the project.

Wetland surveys or focused delineations were not conducted during the July 2017 site reconnaissance. Emergent wetlands are found along the fringes of the reservoirs in many places, and willow riparian habitat was observed to be primarily associated with streams and drainages that flow into the reservoirs. Each reservoir has several tributary streams and ephemeral drainages that could potentially contain wetlands.

At the J.C. Boyle disposal site, several depressions were observed to support coyote willow, sedges, and rushes, indicating the potential presence of wetlands in some areas. A narrow drainage channel was noted at the bottom of the deep ravine in the J.C. Boyle disposal area. The channel was dry during the July 2017 site reconnaissance. The reservoir is relatively narrow and shallow and contains many areas where the reservoir edge slopes gently toward the former river channel. These shallow reservoir areas have developed emergent wetland vegetation.

There were no potential wetlands within the disposal site at the Copco dams. As described above, the Copco Lake is relatively steep-sided, but there are places where a narrow fringe of emergent wetland vegetation has become established. On the north side of the Copco Lake there are only a couple of streams that support riparian vegetation at the reservoir edge. There is more riparian vegetation along the south side of the Copco Lake, but it is also mixed with residential development and is not as strongly associated with tributary stream channels.

Downstream of the Copco No. 2 dam, a large wooden penstock is located on a terrace above the south shore of the river. Water leaking from the Copco No. 2 penstock supports wetland vegetation in several locations, including broadleaf cattail (*Typha latifolia*), water smartweed (*Polygonum amphibium)*, and beggarstick (*Bidens frondosa*). Culverts drain these ponded areas down to the river. Open disturbed sites dominated by invasive yellow star-thistle are located along the penstock, including a large flat area at the eastern end that was likely created during penstock construction.

Narrow patches of emergent wetland vegetation along the edges of Iron Gate Reservoir consists of hardstem bulrush, cattails, rushes, and other species. Dense willow riparian communities consisting of coyote and shining willow are associated with the mouths of Jenny, Scotch, and Camp creeks on Iron Gate Reservoir. Road crossings of some of these riparian areas along Iron Gate are within the construction limits of work.

A shallow drainage swale that runs south toward Bogus Creek through the Iron Gate disposal site was dry during the July 2017 site reconnaissance. The Iron Gate disposal site will be evaluated closely for wetland characteristics.

## 6.3 Methodology

Surveys of vegetation communities, including wetlands and riparian habitats, and special status plants will initially focus on verifying the existing information collected by PacifiCorp and described above. Outside the construction limits of work, surveys will entail spot-checking of PacifiCorp mapping. More detailed surveys of wetlands and special status plants will be conducted within the construction limits of work.

### 6.3.1 Field Reconnaissance

A field reconnaissance was conducted in July 2017. During the field reconnaissance, KRRC biologists visited proposed construction areas to gather qualitative information on habitats present, determine access for future surveys, and identify proposed survey transects and/or survey points on aerial photos. Biologists noted areas with the potential to support wetlands and other sensitive natural communities within the construction limits of work. Biologists also looked for evidence of changes to existing conditions since the PacifiCorp surveys were conducted, including wildfires, development, agriculture and grazing, and logging activities.

### 6.3.2 Vegetation Communities

Eight vegetation cover types were mapped by PacifiCorp (2004), and each cover type was further sub-classified. The results of the 2004 mapping are available in the PacifiCorp Terrestrial Resources report.

During the field reconnaissance survey, it was noted that current conditions did not match the 2004 PacifiCorp mapping data in some places. Vegetation community maps will be updated as needed to reflect existing conditions. Initial verification will be conducted through comparison with current aerial photography to produce updated maps.

Field verification will include visual observation of representative portions of each vegetation community within 0.25 miles of the limits of construction around the dams and facilities, access and haul roads, and disposal sites. Surveyors will traverse the areas on foot and/or by boat to verify that the vegetation classification described in the PacifiCorp 2004 report is still accurate. Biologists will use binoculars in areas with limited access such as along steep slopes adjacent to roads.

A crosswalk table that compares the classification system used in the 2004 report to other classifications (e.g., Manual of California Vegetation) will be produced to align the PacifiCorp data with current regulatory requirements. Communities dominated by invasive plant species will also be identified.

### 6.3.3 Wetlands

Wetlands within the limits of construction around the dams and facilities, access and haul roads, and disposal sites will be delineated in accordance with the 1987 U.S. Army Corps of Engineers (USACE) Wetland Delineation Manual and applicable Regional Supplements (i.e., Western Mountains, Valleys, and Coast Region and Arid West). Additionally, the Oregon Rapid Wetland Assessment Protocol (ORWAP) will be used to assess functional values of wetlands.

PacifiCorp mapping of wetlands and riparian habitats adjacent to reservoirs and/or associated with streams but outside the direct construction limits of work will be field verified by traversing the areas on foot and/or by boat, using binoculars as needed. Previously unidentified wetlands and riparian habitats observed adjacent to reservoirs but outside the construction limits of work will be mapped and described consistent with the PacifiCorp vegetation classification system described above. The boundaries of wetlands outside of the construction limits of work will be mapped based on observed changes in vegetation, topography, and hydrology, but these areas will not be formally delineated.

## 6.4 Survey Plan Summary

Mapping of vegetation communities and wetlands will entail the following:

- Desktop verification of the PacifiCorp vegetation community mapping based on comparison with current aerial photography. New maps will be produced for field verification.
- Field verification of PacifiCorp mapping of a representative portion of each vegetation community within 0.25 miles of the limits of construction around the dams and facilities, access and haul roads, and disposal sites.
- Areas dominated by invasive species will be mapped.
- Delineation of wetlands and riparian habitats within the construction limits in accordance with regulatory requirements.
- Field verification of PacifiCorp mapping of wetlands and riparian habitats adjacent to reservoirs and/or associated with streams but outside the direct construction limits of work.
- Map previously unidentified wetlands and riparian habitat noted adjacent to reservoirs but outside the construction limits of work.

## 6.5 Avoidance and Minimization Measures

The Project will comply with regulatory requirements in delineating wetlands and evaluating potential impacts to acreage and functions. The Project design and construction planning will incorporate avoidance and minimization measures to the maximum extent practicable.

- The results of the wetland delineation will be incorporated into the project design to avoid and minimize direct impacts on wetlands to the maximum extent practicable. Potential measures might include redesign of the construction footprint or location of access and staging areas, or redesign of fill slopes to avoid wetland areas.
- Wetland areas adjacent to the construction limits of work will be fenced with orange plastic snow fencing to demarcate work areas and prevent inadvertent impacts.
- The restoration plans developed for both reservoir and non-reservoir areas would include provisions for the establishment of wetland and riparian areas within the Project area to result in no net loss of wetland and riparian habitat functions.
- Wetlands established in restored areas will be monitored for up to five years or as required by permit requirements. Specific performance measures will be identified in the restoration plans and approved by the regulatory agencies.

To reduce potential impacts on water quality in wetlands during construction (for example, the wetlands around the confluence of Fall Creek and the Klamath River), the following construction best management practices will be implemented.

- Pollution and erosion control measures will be implemented to prevent pollution caused by construction operations and to reduce contaminated stormwater runoff.
- Oil-absorbing floating booms will be kept onsite and the contractor will respond immediately to aquatic spills during construction.
- Vehicles and equipment will be kept in good repair, without leaks of hydraulic or lubricating fluids. If such leaks or drips do occur, they will be cleaned up immediately. Equipment maintenance and/or repair will be confined to one location at each project construction site. Runoff in this area will be controlled to prevent contamination of soils and water.
- Dust control measures will be implemented, including wetting disturbed soils.
- A SWPPP will be implemented to prevent construction materials (fuels, oils, and lubricants) from spilling or otherwise entering waterways or water bodies.

## 6.6 References

California Department of Fish and Wildlife (CDFW). 2017. Notification of Lake or Streambed Alteration. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=3773&inline.

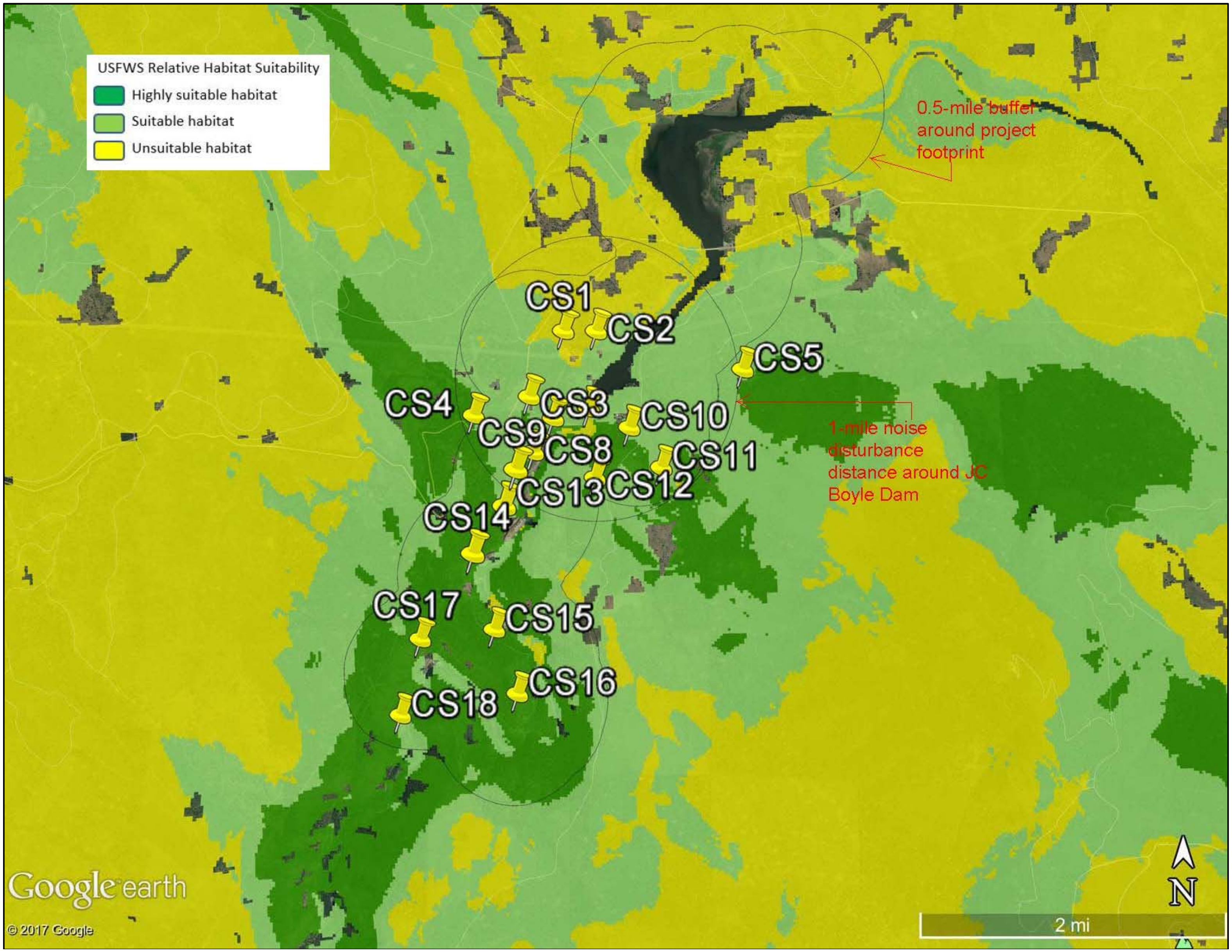
Oregon Department of State Lands (ODSL). 2017. Oregon Rapid Wetland Assessment Protocol (ORWAP). Available at: http://www.oregon.gov/dsl/WW/Pages/ORWAP.aspx.

PacifiCorp. 2004. Final Technical Report. Klamath Hydroelectric Project (FERC Project No. 2082), Terrestrial Resources. PacifiCorp, Portland, Oregon. February.

USACE Environmental Laboratory. 1987. U.S. Army Corps of Engineers Wetlands Delineation Manual. Technical Report YL-87-1. U.S. Army Corps of Engineers, Waterways Experiment Station. Vicksburg, MS.

USBR and CDFW. 2012. Klamath Facilities Removal. Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR). U.S. Bureau of Reclamation and California Department of Fish and Wildlife, December.

# Attachment A  Northern Spotted Owl Figures



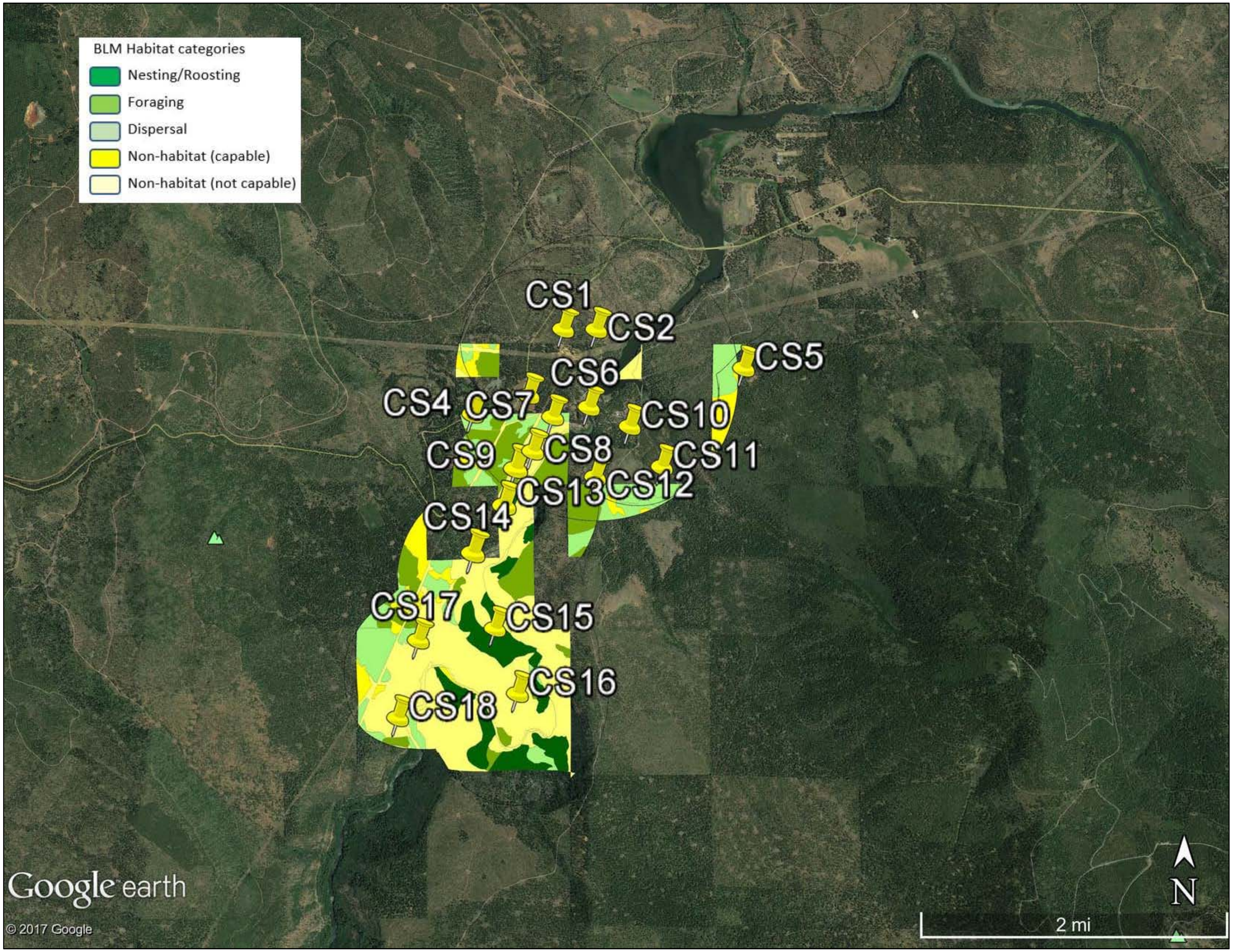

USFWS Habitat Layer



**FIGURE 1: PRELIMINARY NSO CALLING STATIONS (USFWS HABITAT LAYER)**

*JC Boyle Project Area*

*Sheet 1 of 3*

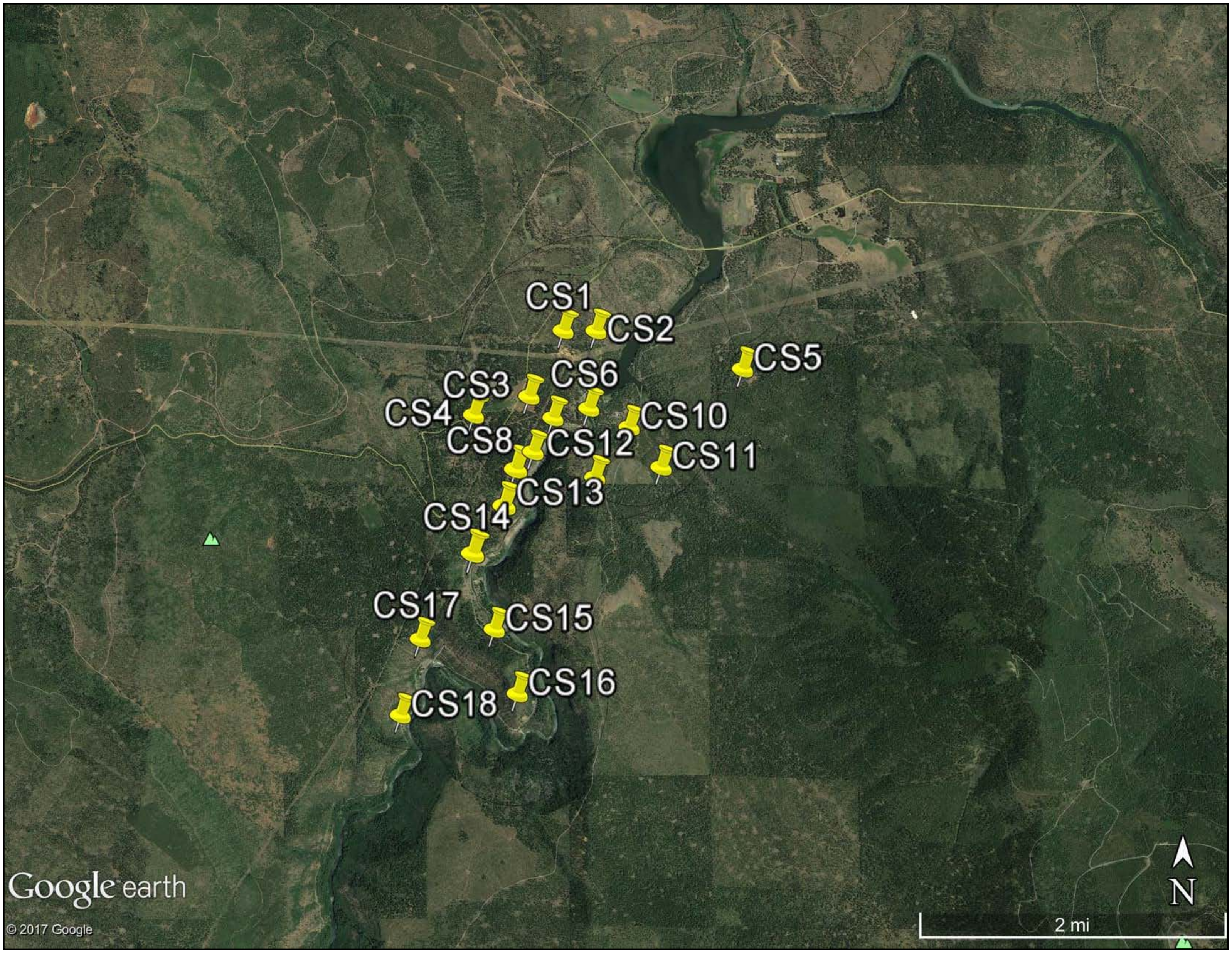



BLM Habitat Layer

**Klamath River Renewal Corporation**
*Klamath River Renewal Project*

# FIGURE 1: PRELIMINARY NSO CALLING STATIONS (BLM HABITAT LAYER)

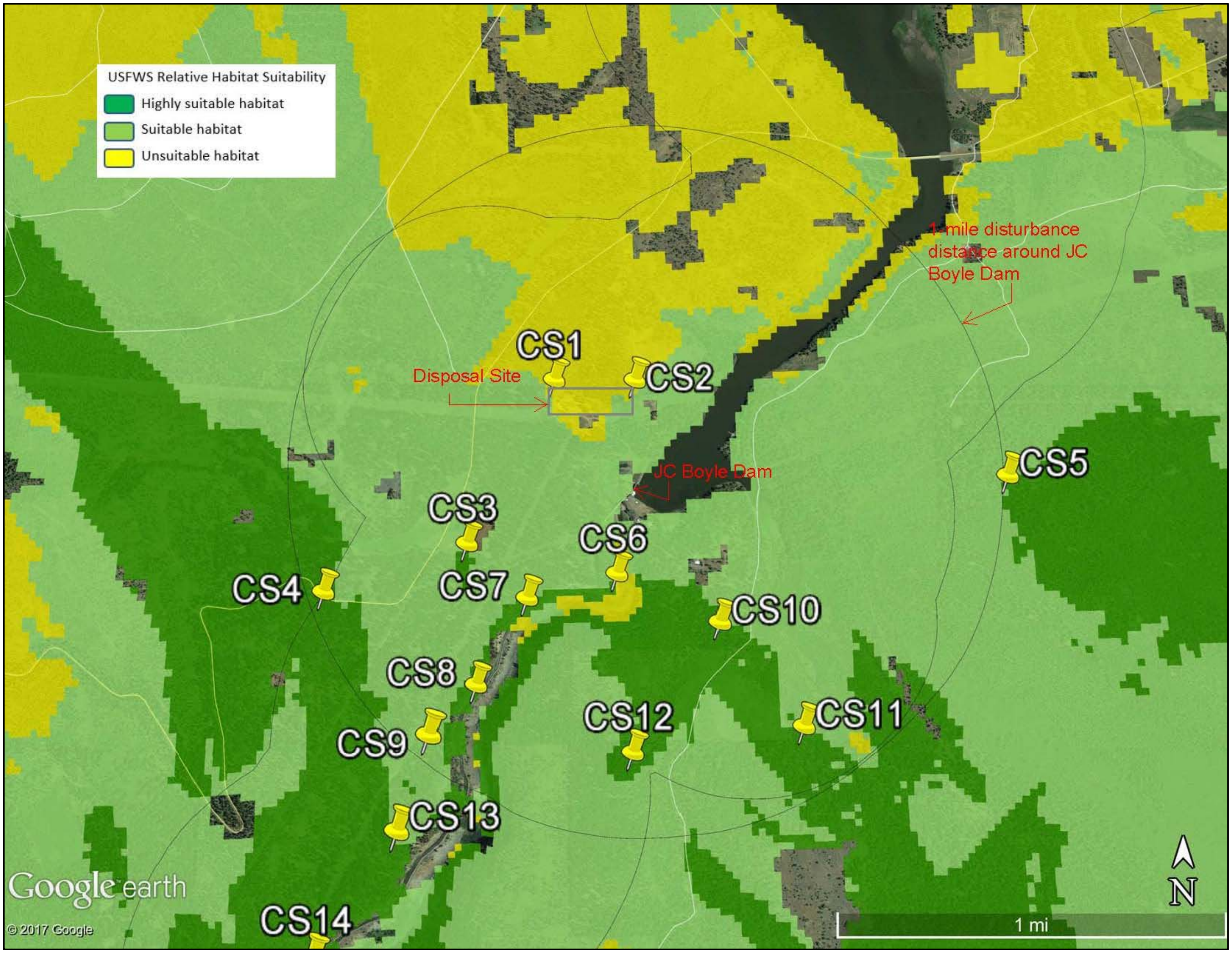
*JC Boyle Project Area*
*Sheet 2 of 3*




**Klamath River Renewal Corporation**
*Klamath River Renewal Project*

**FIGURE 1: PRELIMINARY NSO CALLING STATIONS**

*JC Boyle Project Area*
*Sheet 3 of 3*




USFWS Habitat Layer

**Klamath River Renewal Corporation**
*Klamath River Renewal Project*

## FIGURE 2: PRELIMINARY NSO CALLING STATIONS (USFWS HABITAT LAYER)

*JC Boyle Dam*
*Sheet 1 of 3*

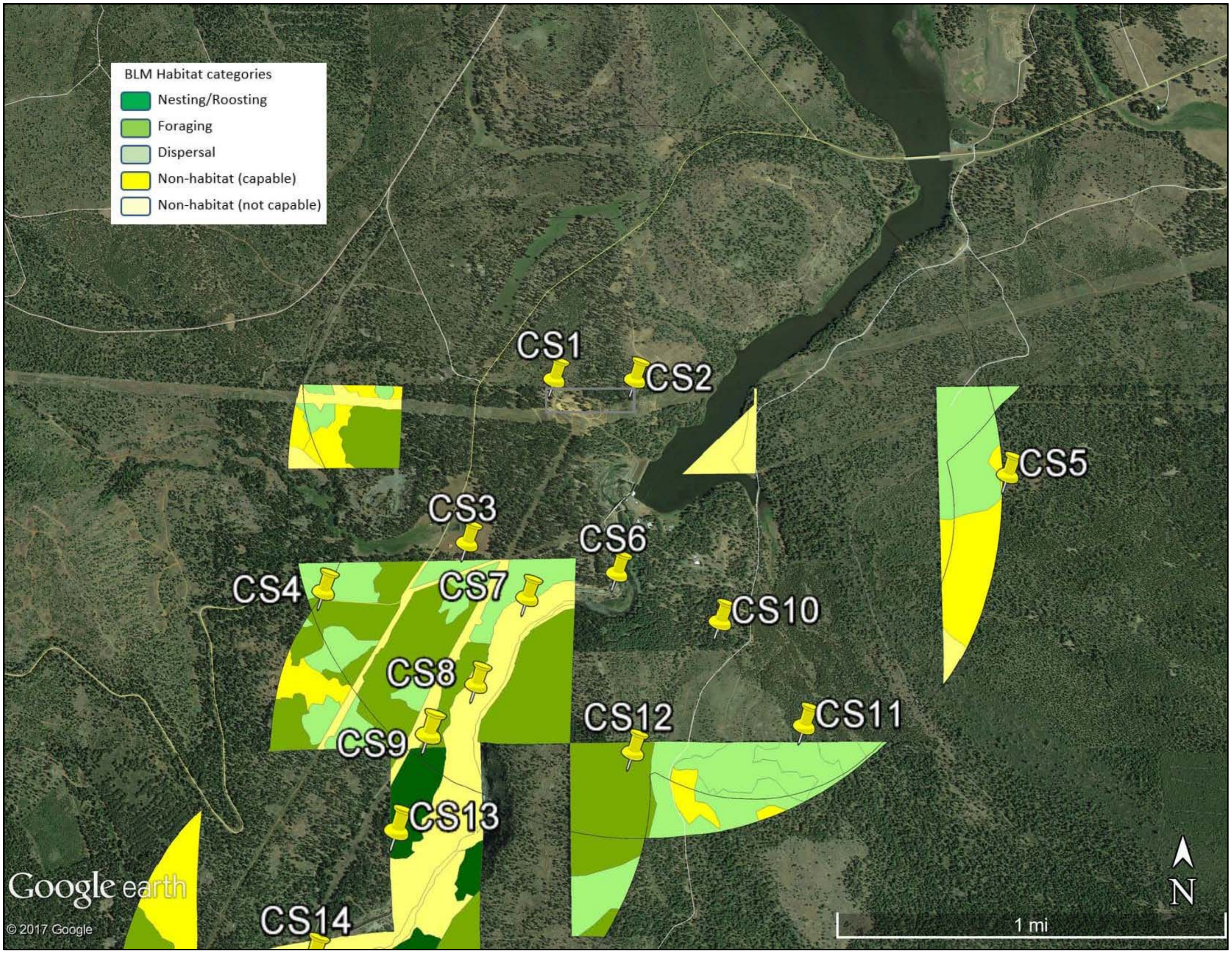







**FIGURE 2: PRELIMINARY NSO CALLING STATIONS (BLM HABITAT LAYER)**

*JC Boyle Dam*
*Sheet 2 of 3*

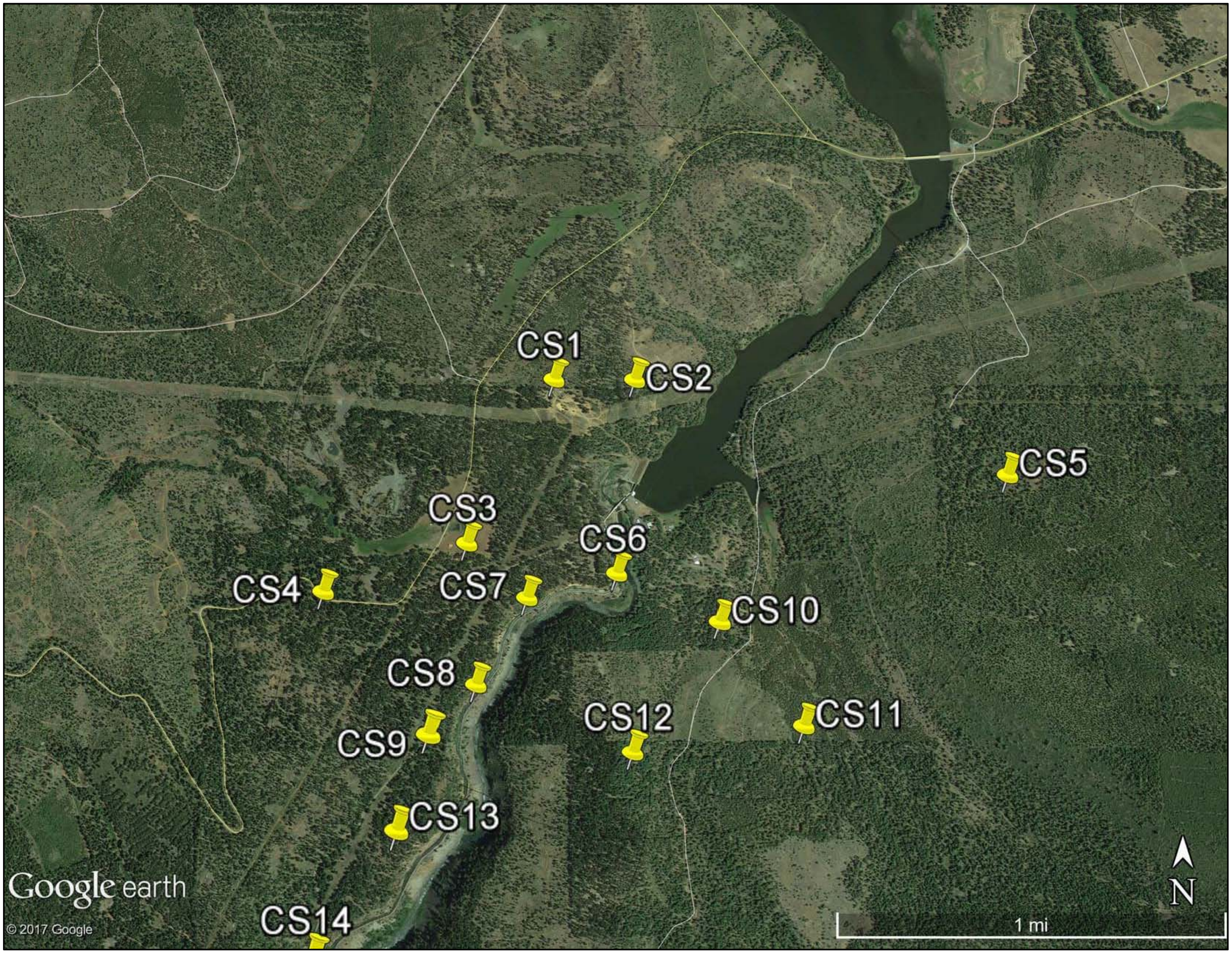
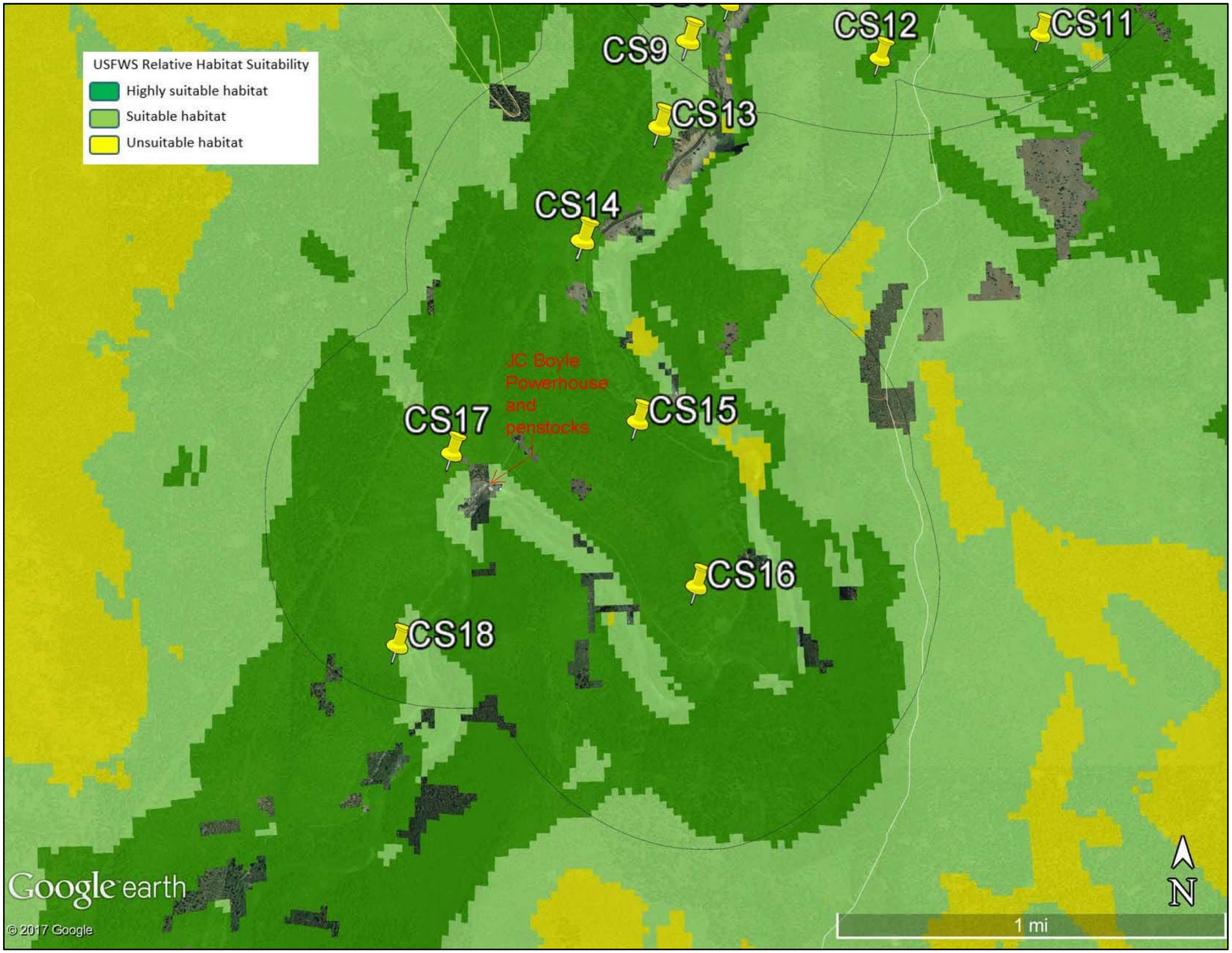





**FIGURE 2: PRELIMINARY NSO CALLING STATIONS**

*JC Boyle Dam*
*Sheet 3 of 3*

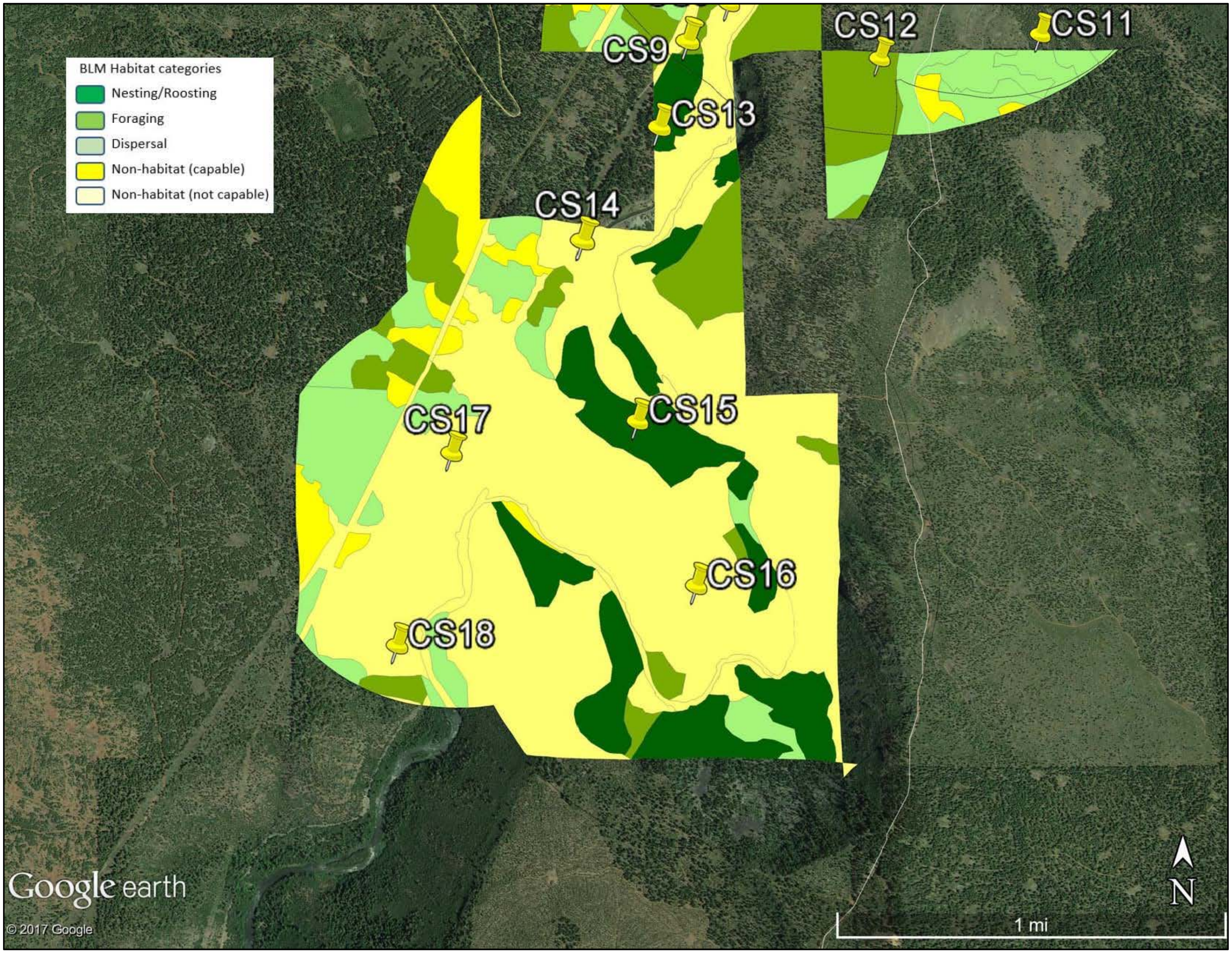



USFWS Habitat Layer

**Klamath River Renewal Corporation**
*Klamath River Renewal Project*

## FIGURE 3: PRELIMINARY NSO CALLING STATIONS (USFWS HABITAT LAYER)

*JC Boyle Powerhouse and Penstocks*
*Sheet 1 of 3*




BLM Habitat Layer

**Klamath River Renewal Corporation**
*Klamath River Renewal Project*

## FIGURE 3: PRELIMINARY NSO CALLING STATIONS (BLM HABITAT LAYER)

*JC Boyle Powerhouse and Penstocks*
*Sheet 2 of 3*

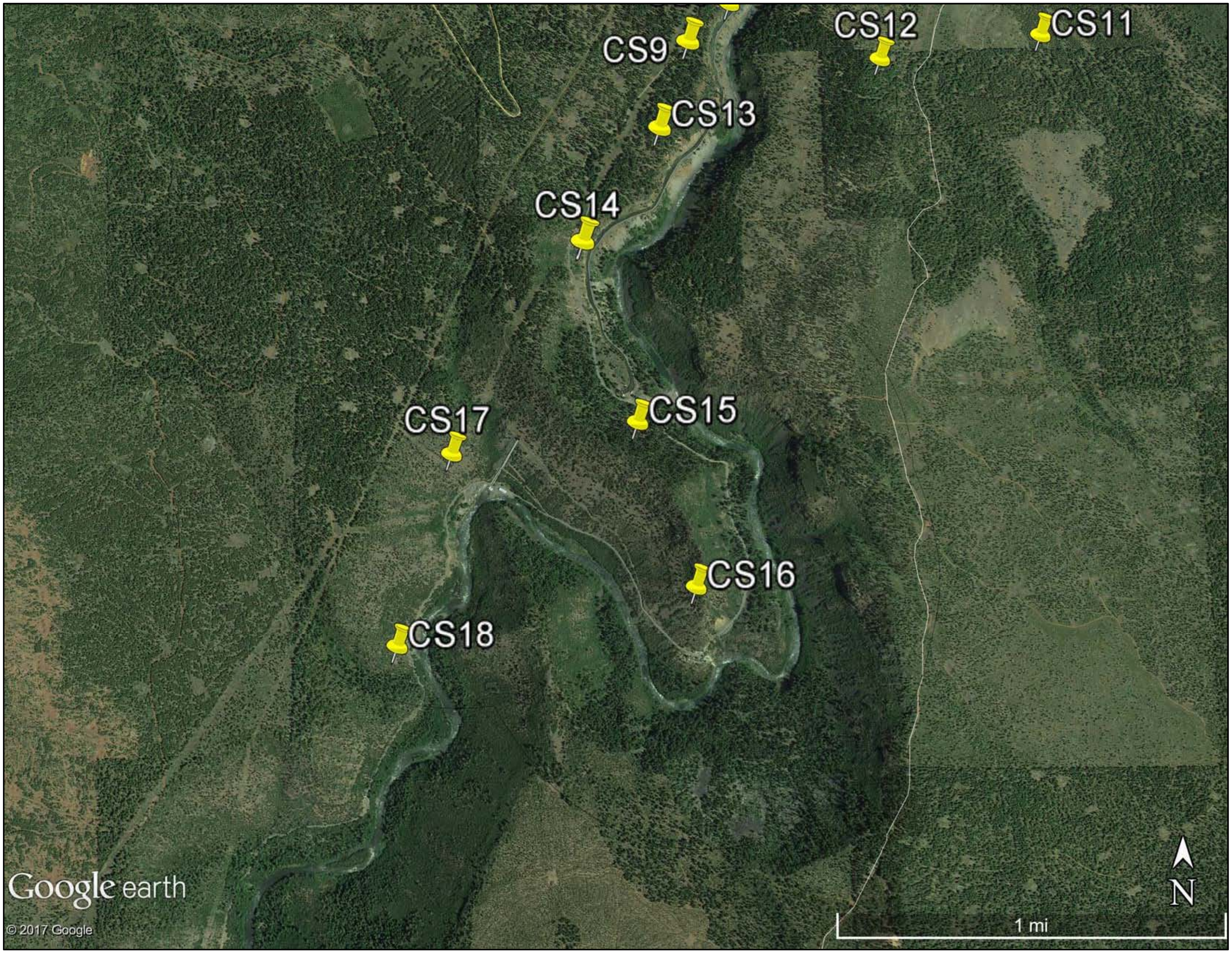
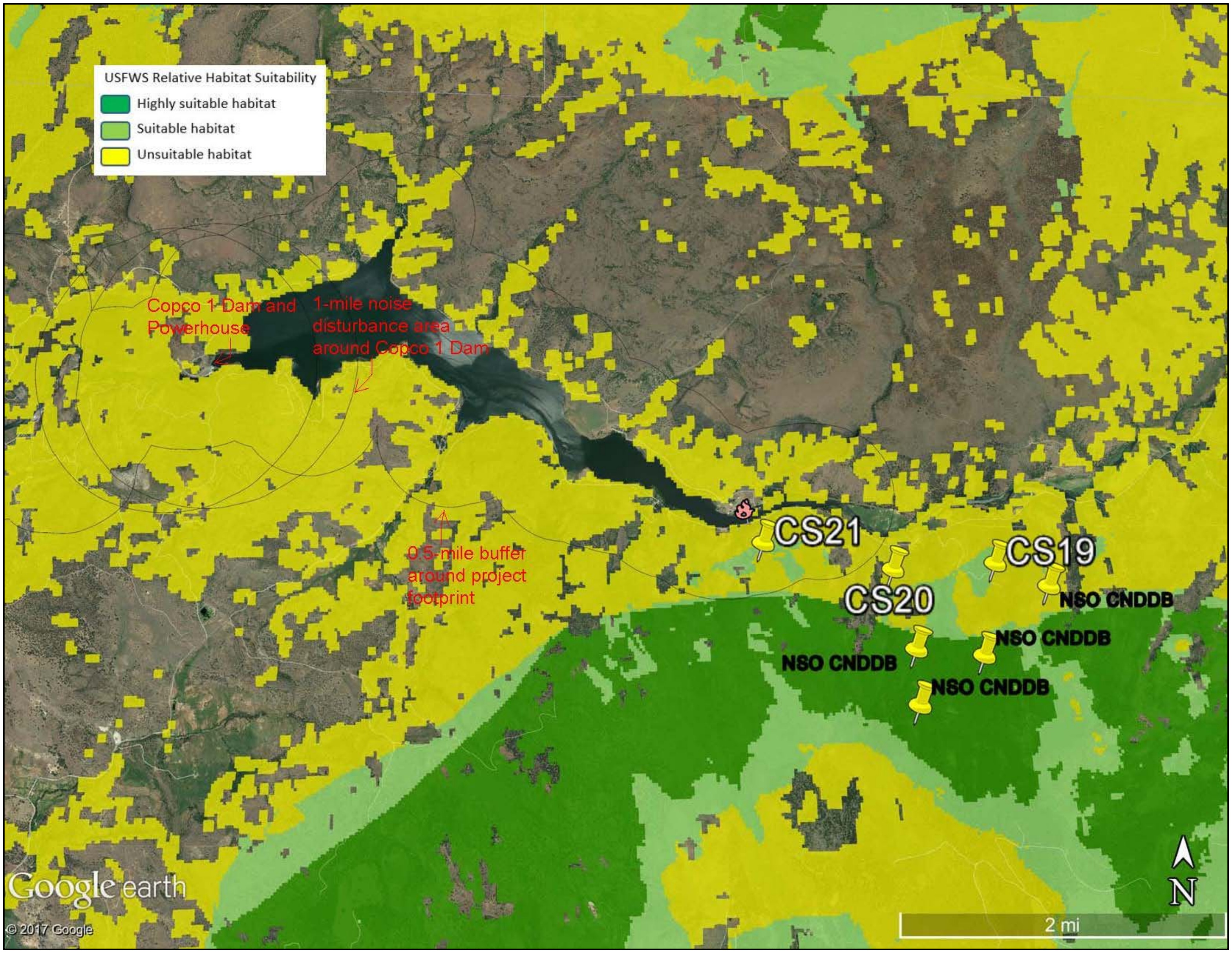





**FIGURE 3: PRELIMINARY NSO CALLING STATIONS**

*JC Boyle Powerhouse and Penstocks*

*Sheet 3 of 3*




USFWS Habitat Layer



**FIGURE 4: PRELIMINARY NSO CALLING STATIONS (USFWS HABITAT LAYER)**

*Copco Reservoir*
*Sheet 1 of 2*

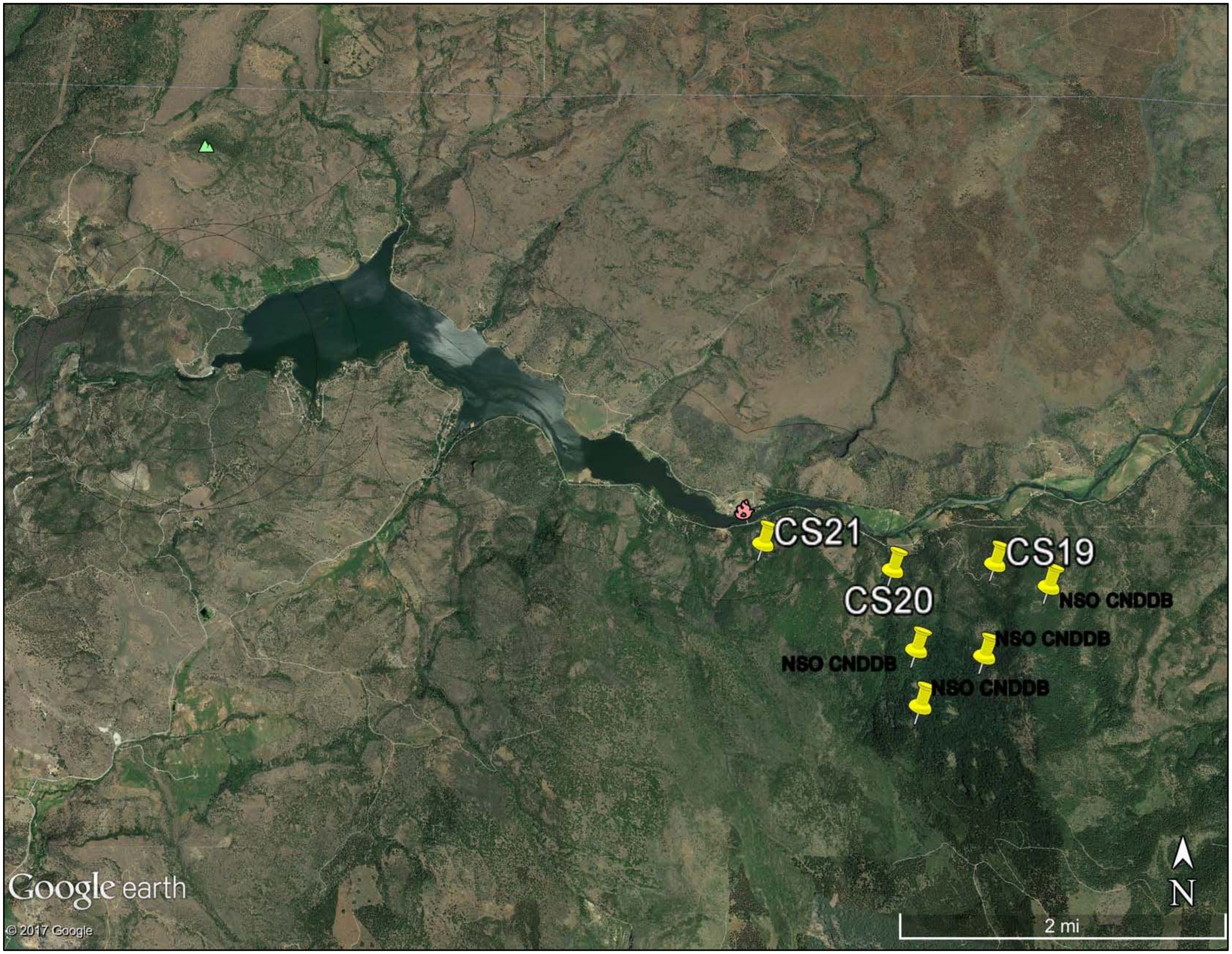
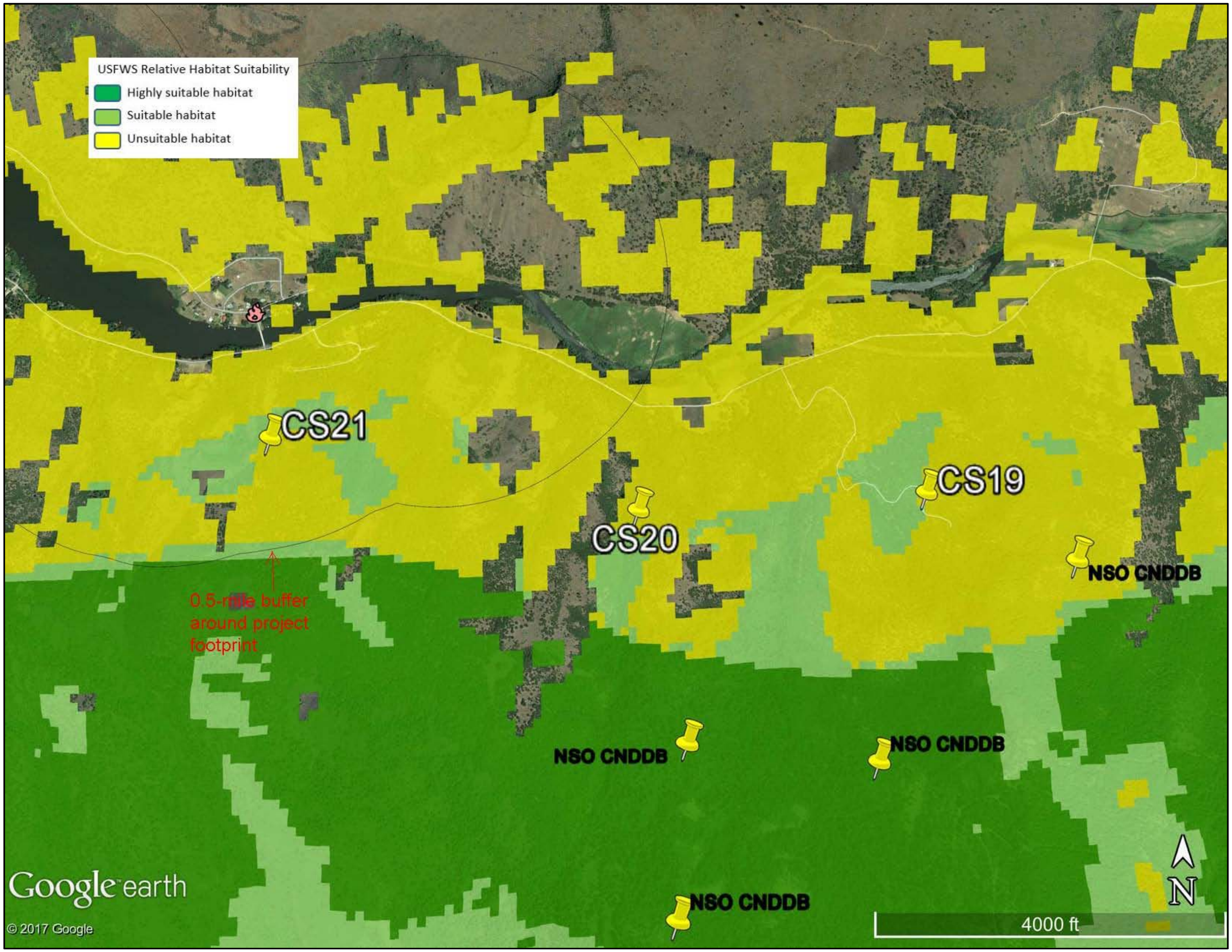





**FIGURE 4: PRELIMINARY NSO CALLING STATIONS**

*Copco Reservoir*
*Sheet 2 of 2*




USFWS Habitat Layer



**FIGURE 5: PRELIMINARY NSO CALLING STATIONS (USFWS HABITAT LAYER)**

*Copco Reservoir – Upstream End*

*Sheet 1 of 2*

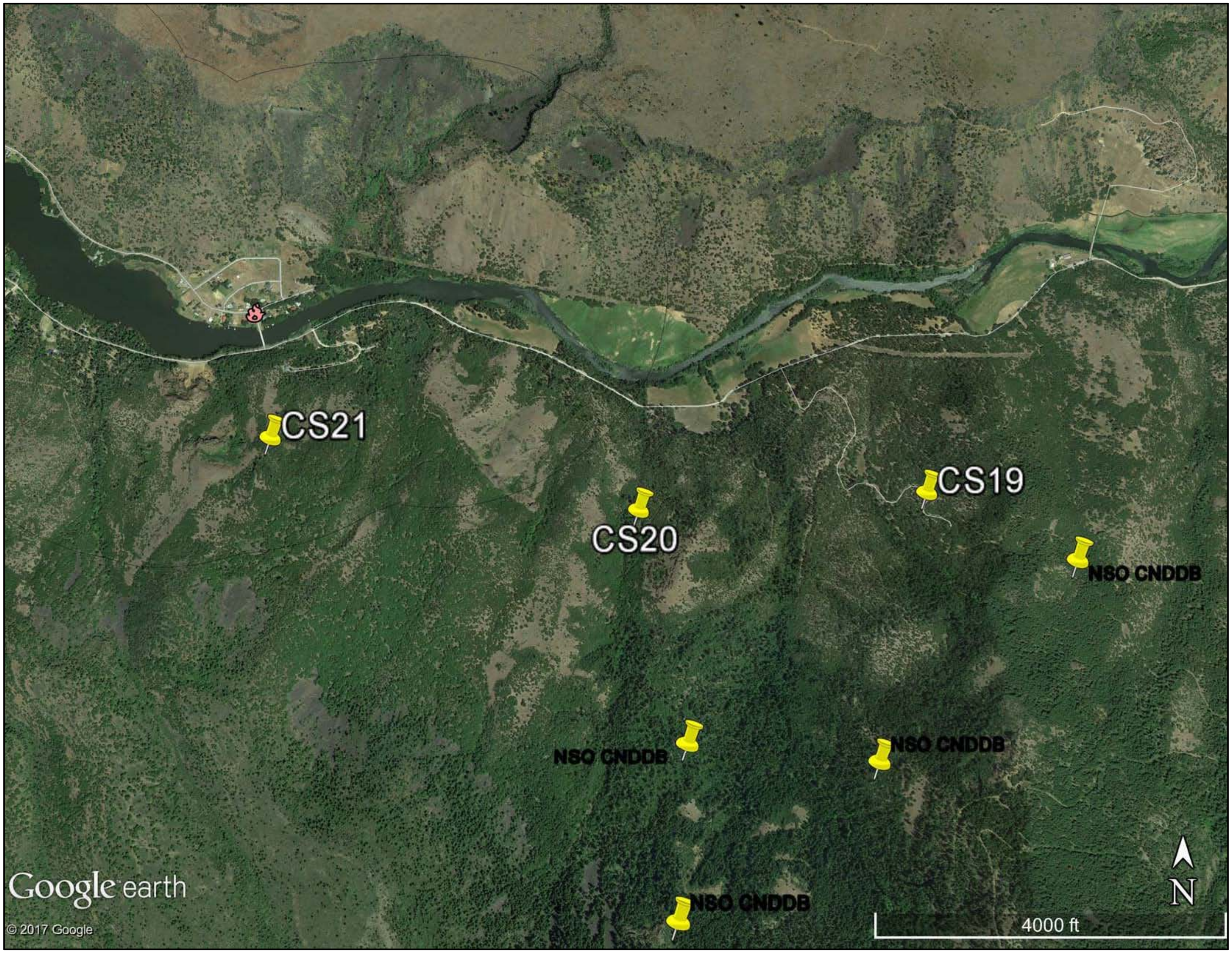


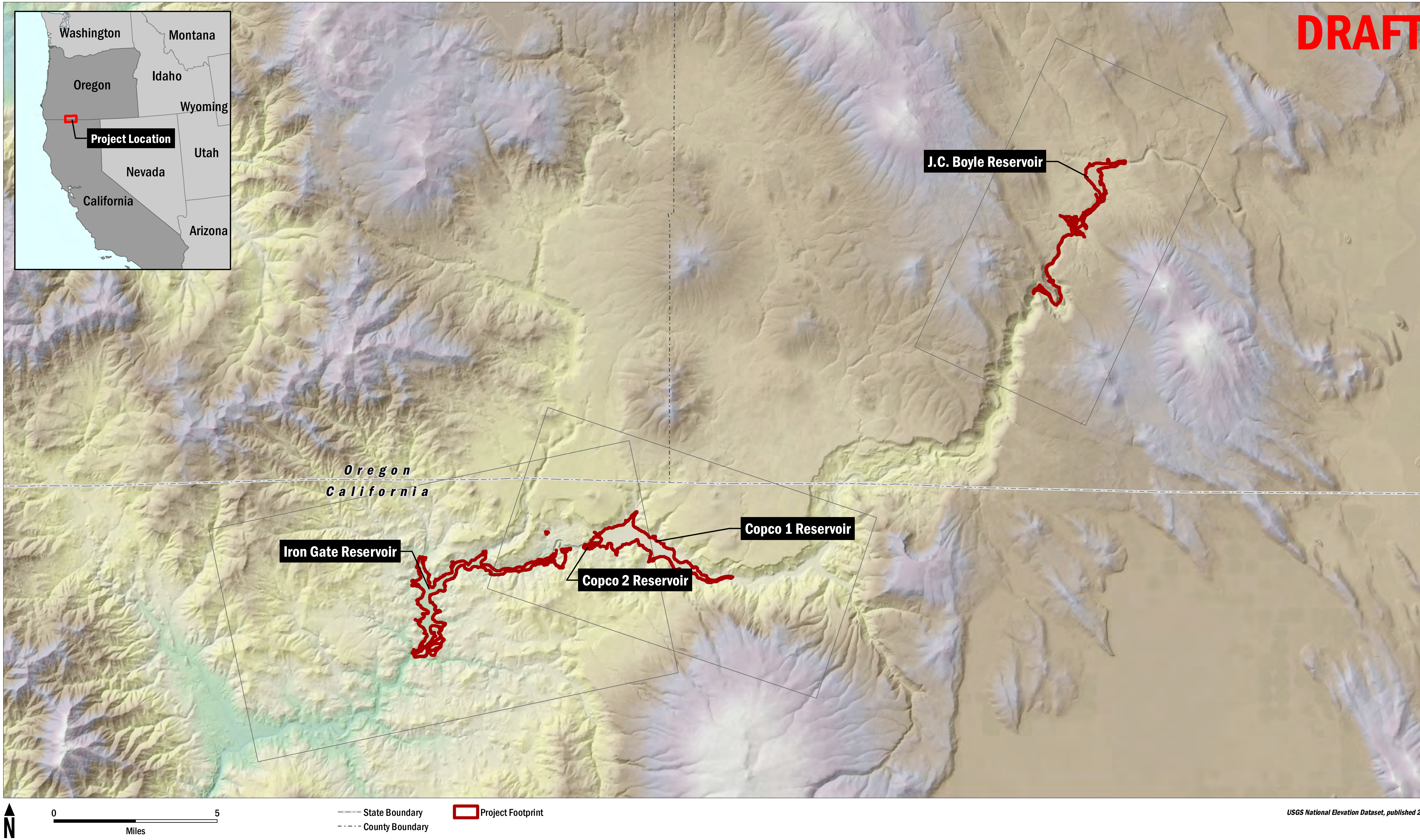



**FIGURE 5: PRELIMINARY NSO CALLING STATIONS**

*Copco Reservoir – Upstream End*

*Sheet 2 of 2*

# Attachment B  Viewshed Analysis Figures and Eagles Table




AECOM

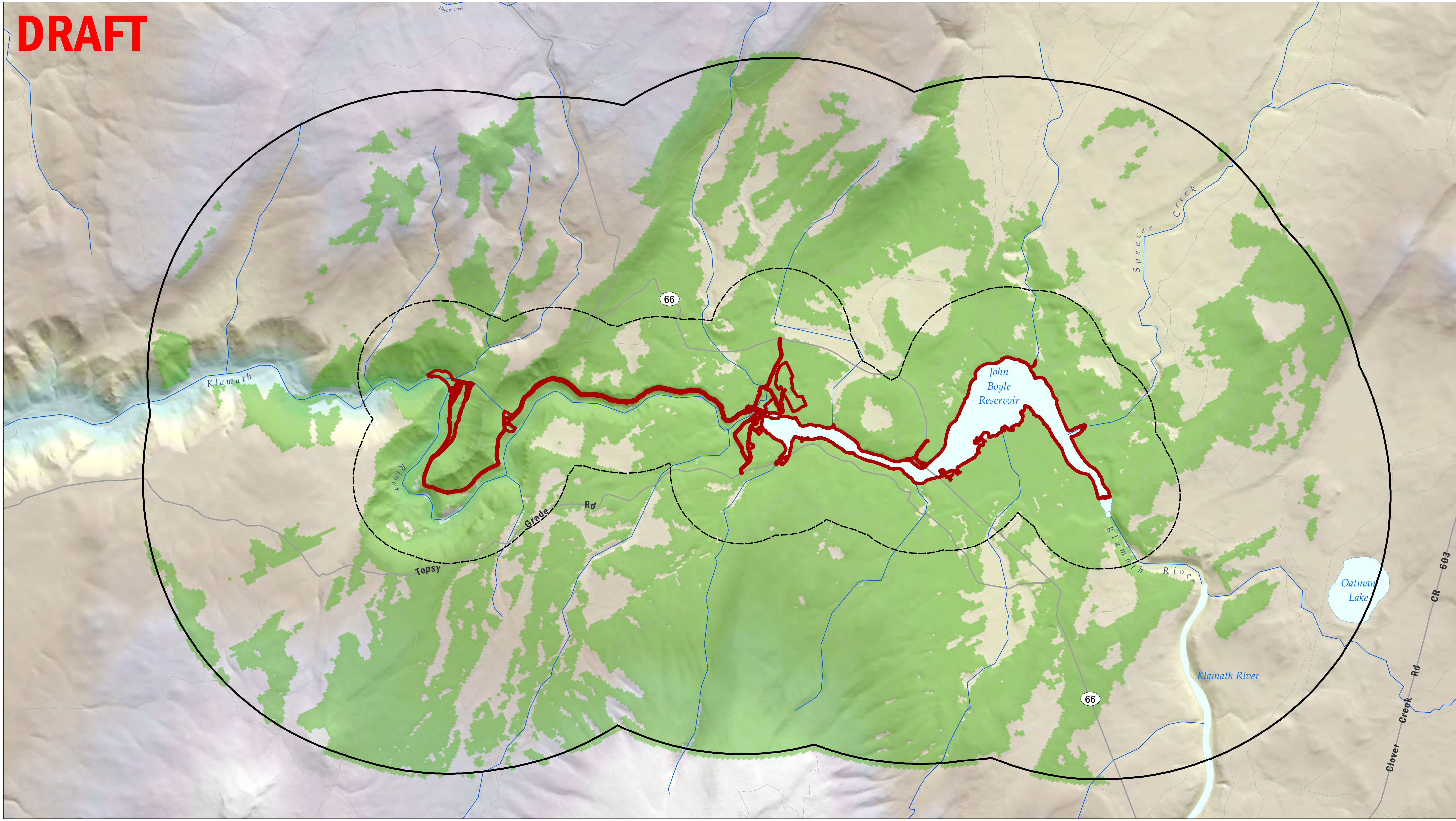
Klamath River Renewal Corporation

*Klamath River Renewal Project*

# FIGURE 1: PRELIMINARY PROJECT FOOTPRINT VIEWSHED

*Overview*

AECOM Oakland CA 8/30/2017 USER caitlin.jensen PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\01_Field Maps\Biology\Viewshed\Fig1_ProjectFootprint_Viewshed_Mapbook.mxd

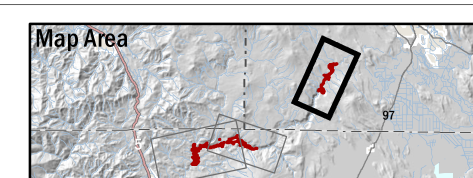



0 0.5
Miles

USGS National Elevation Dataset, published 2013

AECOM
Klamath River Renewal Corporation
*Klamath River Renewal Project*

- 0.5-Mile Buffer
- 2-Mile Buffer
- Project Footprint
- Viewshed from Project Footprint

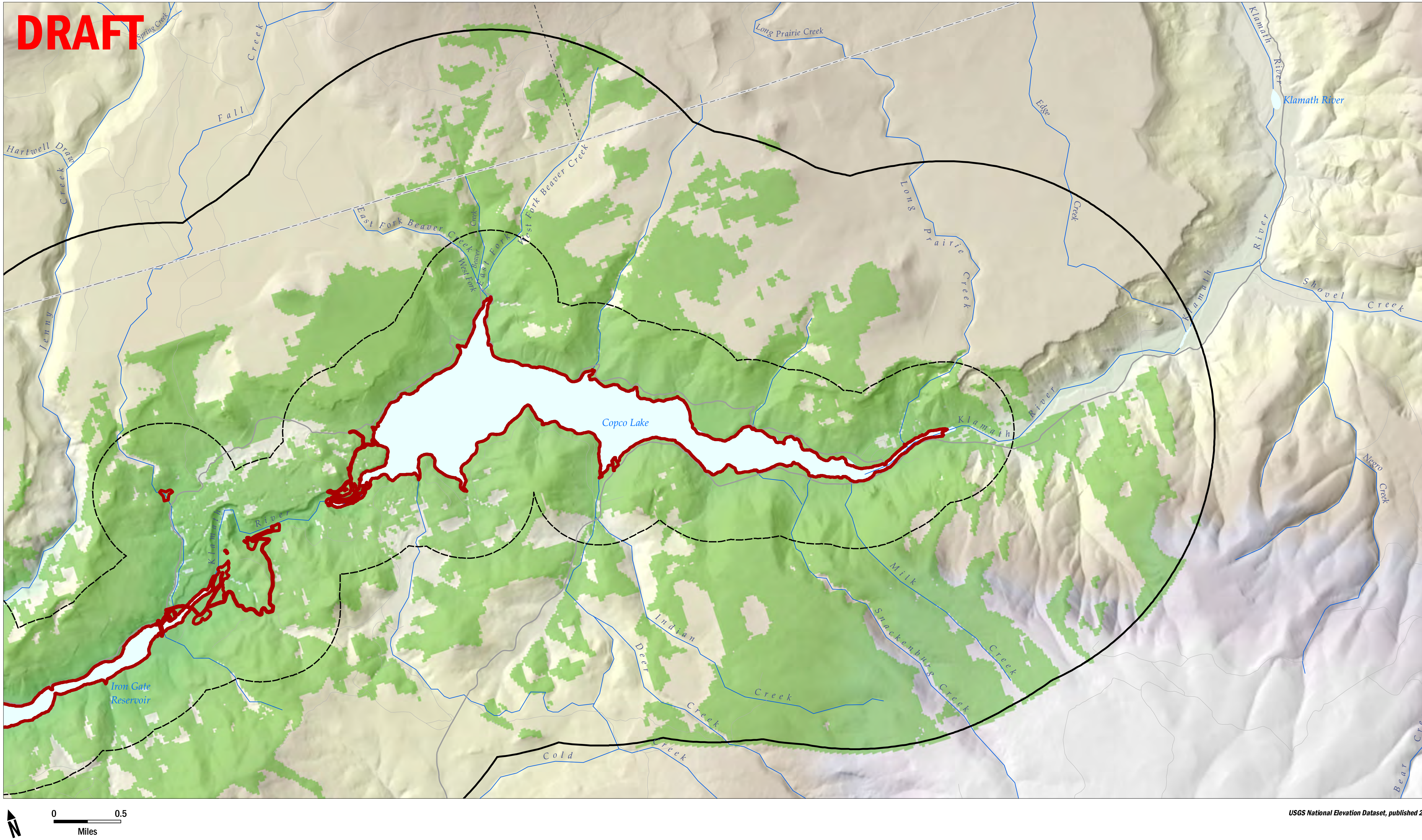



# FIGURE 1: PRELIMINARY PROJECT FOOTPRINT VIEWSHED

*J.C. Boyle Reservoir*

*Sheet 1 of 3*

AECOM Oakland CA 8/30/2017 USER caitlin.jensen PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\01_Field Maps\Biology\Viewshed\Fig1_ProjectFootprint_Viewshed_Mapbook.mxd




USGS National Elevation Dataset, published 2013

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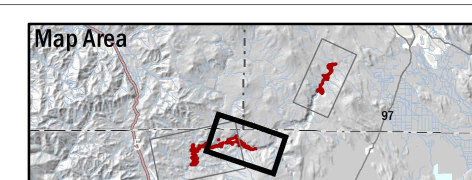
*Klamath River Renewal Project*

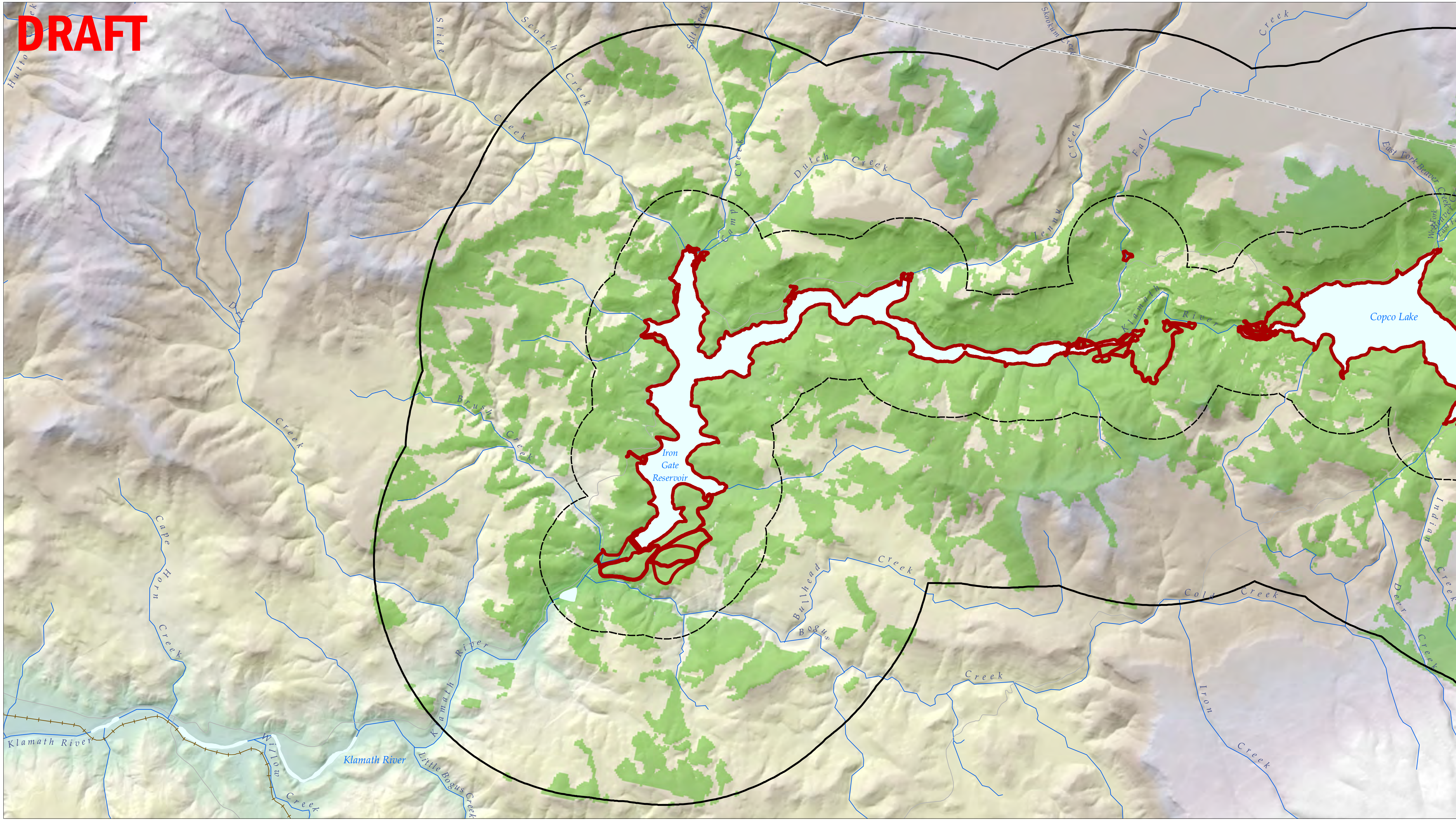
- 0.5-Mile Buffer
- 2-Mile Buffer
- Project Footprint
- Viewshed from Project Footprint




# FIGURE 1: PRELIMINARY PROJECT FOOTPRINT VIEWSHED

*Copco 1 and 2 Reservoirs*

*Sheet 2 of 3*



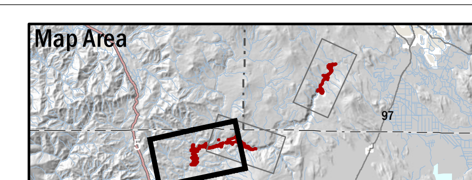

USGS National Elevation Dataset, published 2013

**AECOM**

Klamath River Renewal Corporation

*Klamath River Renewal Project*

- 0.5-Mile Buffer
- 2-Mile Buffer
- Project Footprint
- Viewshed from Project Footprint




# FIGURE 1: PRELIMINARY PROJECT FOOTPRINT VIEWSHED

*Iron Gate Reservoir*

*Sheet 3 of 3*

Table 5A-12. Number of bald eagles detected during field surveys.

| Habitat Type* | Iron Gate-Shasta | Iron Gate Reservoir | Fall Creek | Copco Bypass | Copco Reservoir | J.C. Boyle Peaking Reach | J.C. Boyle Bypass | J.C. Boyle Reservoir | Keno Canyon | Keno Reservoir | Link River | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Plot Surveys*** | *(n=18)* | *(n=38)* | *(n=16)* | *(n=4)* | *(n=37)* | *(n=72)* | *(n=22)* | *(n=20)* | *(n=18)* | *(n=23)* | *(n=18)* | *(n=286)* |
| Unidentified Habitat | | | | | | 1 | | | | | | **1** |
| Flyover | | | | | 5 | 3 | 1 | | | 1 | | **10** |
| Lacustrine Unconsolidated Bottom | | 1 | | | 1 | | | 1 | | | | **10** |
| Montane Hardwood Oak | | | | | 2 | | | | | | | **2** |
| Ponderosa Pine | | | | | | | | 1 | | | | **1** |
| Riparian/Wetland Forest | | 1 | | | | | | | | 1 | | **2** |
| Riparian/Wetland Scrub-shrub | | | | | | | | 1 | | | | **1** |
| Sagebrush | | | | | | | | 1 | | | | **1** |
| ***Facility Surveys*** | *(n=1)* | *(n=3)* | *(n=4)* | *(n=3)* | | *(n=1)* | *(n=2)* | | *(n=1)* | | *(n=3)* | *(n=18)* |
| All Habitats | | | | 1 | | | | | | | | **1** |
| ***Reservoir Surveys*** | | *(n=6)* | | | *(n=6)* | | | *(n=5)* | | *(n=6)* | *(n=1)* | *(n=24)* |
| All Habitats | | | | | 4 | | | 1 | | 3 | | **8** |
| ***Total*** | | **2** | | **1** | **12** | **4** | **1** | **5** | | **5** | | **37** |

*Detections were not recorded in habitat types not included in table.

# Appendix F  Reservoir Drawdown Analysis

AECOM

# Klamath River Renewal Project

**California Environmental Quality Act (CEQA) and California and Oregon 401 Water Quality Certifications Technical Support Document**

Appendix F – Reservoir Drawdown Modeling Output

**Submitted to:** California State Water Resource Control Board and Oregon Department of Environmental Quality

**Submitted by:** Klamath River Renewal Corporation

**Date**: September 2017

**Prepared for:**

Klamath River Renewal Corporation
California State Water Resources Control Board
Oregon Department of Environmental Quality

**Prepared by:**

KRRC Technical Representative:

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Sacramento, California 95833

River Design Group
311 SW Jefferson Avenue
Corvallis, Oregon 97333

# Table of Contents



# Figures

## Tables

# F1. Drawdown Analysis

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

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

## Topography/Bathymetry

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

Stage-storage relationships were determined using output from the HEC-RAS model for each of the three large reservoirs. The HEC-RAS storage curves were compared to the stage-storage curves provided in Attachment B of the Detailed Plan (USBR 2012b). The results from the initial model output showed higher capacities than specified in the Detailed Plan. Therefore, cross-section elevations upstream of each of the dams were adjusted (shifted up) until the stage-storage relationships in the HEC-RAS model matched the stage-storage curves from the Detailed Plan.

## Inflow Rate

Inflow data based on the Klamath Basin Restoration Agreement (KBRA) flows were used as upstream river flows (Keno flows) [1] for both J.C. Boyle and Copco No. 1. These flows were obtained from the SRH1-D model input files (USBR 2012c). The data were compared to the measured flows at the USGS gage at Keno (gage no. 11509500, Klamath River at Keno, OR). A comparison between the USGS measured data at Keno and the SRH1-D data used in the model is provided in Section 4.4. Flow was increased upstream of Iron Gate dam using the "Copco to Iron Gate Gains" from the SRH1-D input file to account for tributary inflow.

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

Water years 1961 through 2009 were simulated in the model. All simulations started on January 1 with J.C. Boyle at normal maximum operating elevation, Copco Lake at 3.5 feet below the spillway crest, and Iron Gate reservoir full to the spillway crest elevation. It is possible that during construction, water levels could be lower or higher depending upon the hydrologic conditions that occurred in the preceding December.

To be able to compare results for various water-year types, water years were ranked by the maximum 15-day flow volume between January and May. These are shown in Table F-1.

### Table F-1. Water Years between 1961 and 2009 ranked by SRH1-D Keno Flow Volume

| Water Year | Maximum 15-day Flow Volume between January and May (acre-feet) | Rank |
|---|---|---|
| 1966* | 5,194,887 | 1 |
| 1997 | 4,572,024 | 2 |
| 1972 | 4,529,358 | 3 |
| 2006 | 4,138,916 | 4 |
| 1996 | 3,965,633 | 5 |
| 1983 | 3,940,625 | 6 |
| 1986 | 3,239,955 | 7 |
| 1974 | 3,166,176 | 8 |
| 1999 | 3,061,339 | 9 |
| 1982 | 2,927,194 | 10 |
| 1970 | 2,897,662 | 11 |
| 1971 | 2,845,658 | 12 |
| 1989 | 2,813,797 | 13 |
| 1978 | 2,723,380 | 14 |
| 1969 | 2,563,472 | 15 |
| 1984 | 2,516,746 | 16 |
| 1998 | 2,471,870 | 17 |
| 1993 | 2,384,182 | 18 |
| 1975 | 2,361,555 | 19 |
| 1985 | 1,710,804 | 20 |
| 2000 | 1,633,487 | 21 |
| 1968 | 1,622,059 | 22 |
| 1995 | 1,540,547 | 23 |
| 1980 | 1,394,132 | 24 |
| 1973 | 1,390,825 | 25 |
| 1964 | 1,294,327 | 26 |
| 2008 | 1,194,776 | 27 |
| 1976 | 1,177,407 | 28 |

| Water Year | Maximum 15-day Flow Volume between January and May (acre-feet) | Rank |
|---|---|---|
| 2004 | 1,075,804 | 29 |
| 1963 | 1,054,977 | 30 |
| 2007 | 1,054,187 | 31 |
| 1962 | 1,044,193 | 32 |
| 1987 | 1,019,283 | 33 |
| 1967 | 948,459 | 34 |
| 1988 | 900,774 | 35 |
| 1965 | 874,920 | 36 |
| 2003 | 801,979 | 37 |
| 1979 | 772,021 | 38 |
| 1990 | 711,287 | 39 |
| 1981 | 695,542 | 40 |
| 2002 | 674,728 | 41 |
| 2001 | 634,014 | 42 |
| 2009 | 627,011 | 43 |
| 1961 | 620,286 | 44 |
| 1977 | 586,748 | 45 |
| 1994 | 416,661 | 46 |
| 1991 | 396,980 | 47 |
| 2005 | 377,839 | 48 |
| 1992 | 370,748 | 49 |

** Corresponds to water year 1965 in historical flow record.*

# F2. J.C. Boyle Reservoir

The drawdown procedure included in the HEC-RAS model for J.C. Boyle is summarized below:

1. Simulations started on January 1 of the drawdown year, by making releases through the gated spillway (crest elevation 3785.2) and the power intake (invert elevation 3771.7). The three spillway gates and the gate for the power intake were set fully open. The maximum flow through the power intake is about 2,800 cubic feet per second (cfs). About 25 percent of years have an average flow in January greater than 2,800 cfs and almost 40 percent have a maximum flow greater than 2,800 cfs. Flows above about 2,800 cfs go over the spillway.
2. After two weeks (set to January 14), it was assumed that the concrete stoplogs on the first 9.5- by 10-foot diversion culvert would be removed and the culvert was opened.
3. Drawdown would continue using the single diversion culvert until the end of January.
4. On February 1, the second 9.5- by 10-foot diversion culvert would be opened by removing the concrete stoplogs.
5. The power intake gate was closed once the reservoir was drawn down below the power intake invert or when the second bay of the diversion culvert was opened, whichever was earlier.

## Results

Results from the simulations of J.C. Boyle are shown in Figures F2-1 through F2-49. Because of the small size of the J.C. Boyle Reservoir, the reservoir will refill partially or completely during a storm until dam removal is complete. The capacity of the two diversion culverts for water levels below the spillway elevation is about 5,700 cfs. About 15 percent of the years are expected to have a maximum January or February flow that exceeds 5,000 cfs and will result in reservoir refilling and associated flows over the spillway.

During representative drier years (for example 1973 and 1979), the reservoir was easily drawn down in January, and it did not refill after that point.

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

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

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

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

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

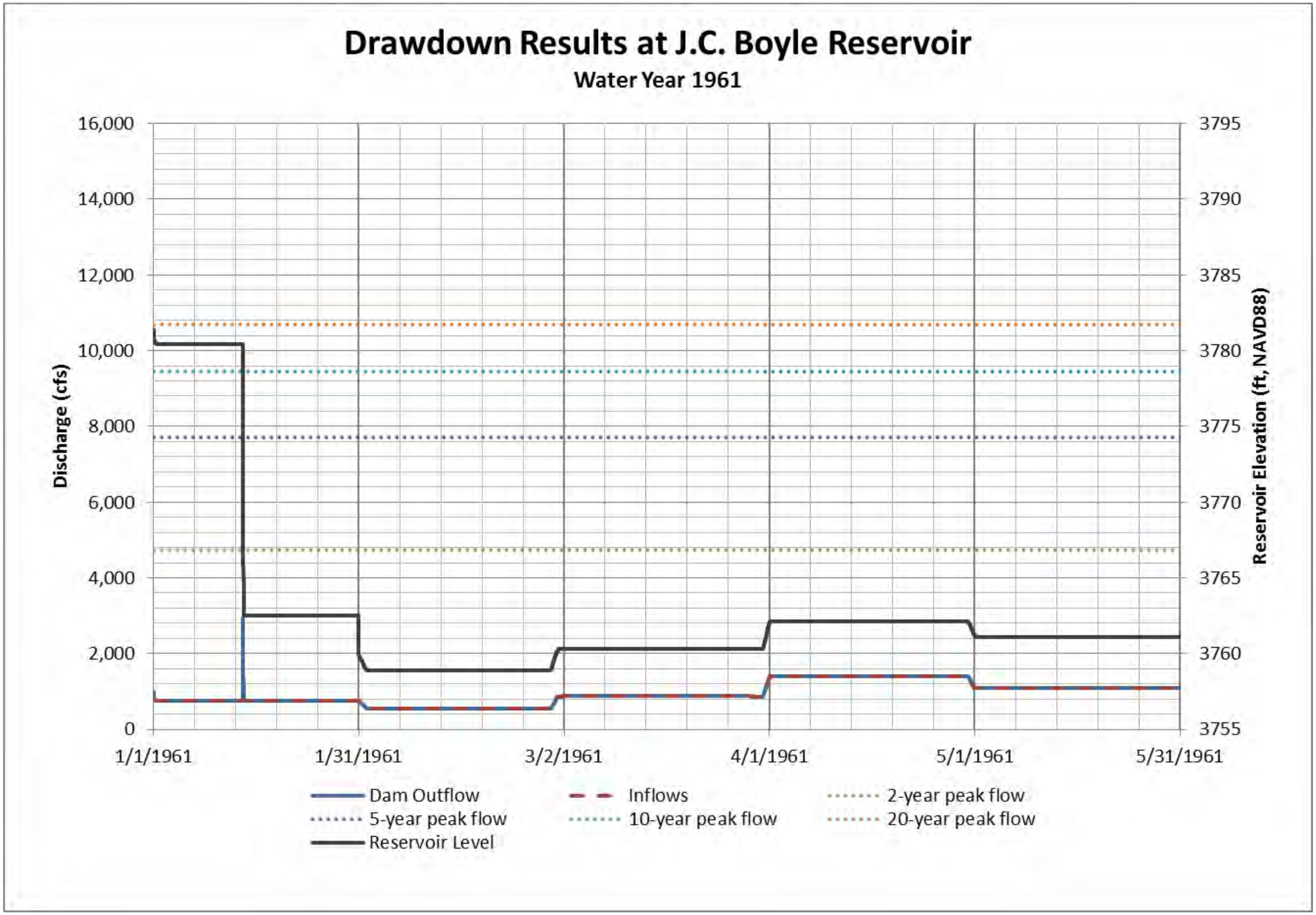



Figure F2-1 J.C. Boyle Reservoir Drawdown, Water Year 1961

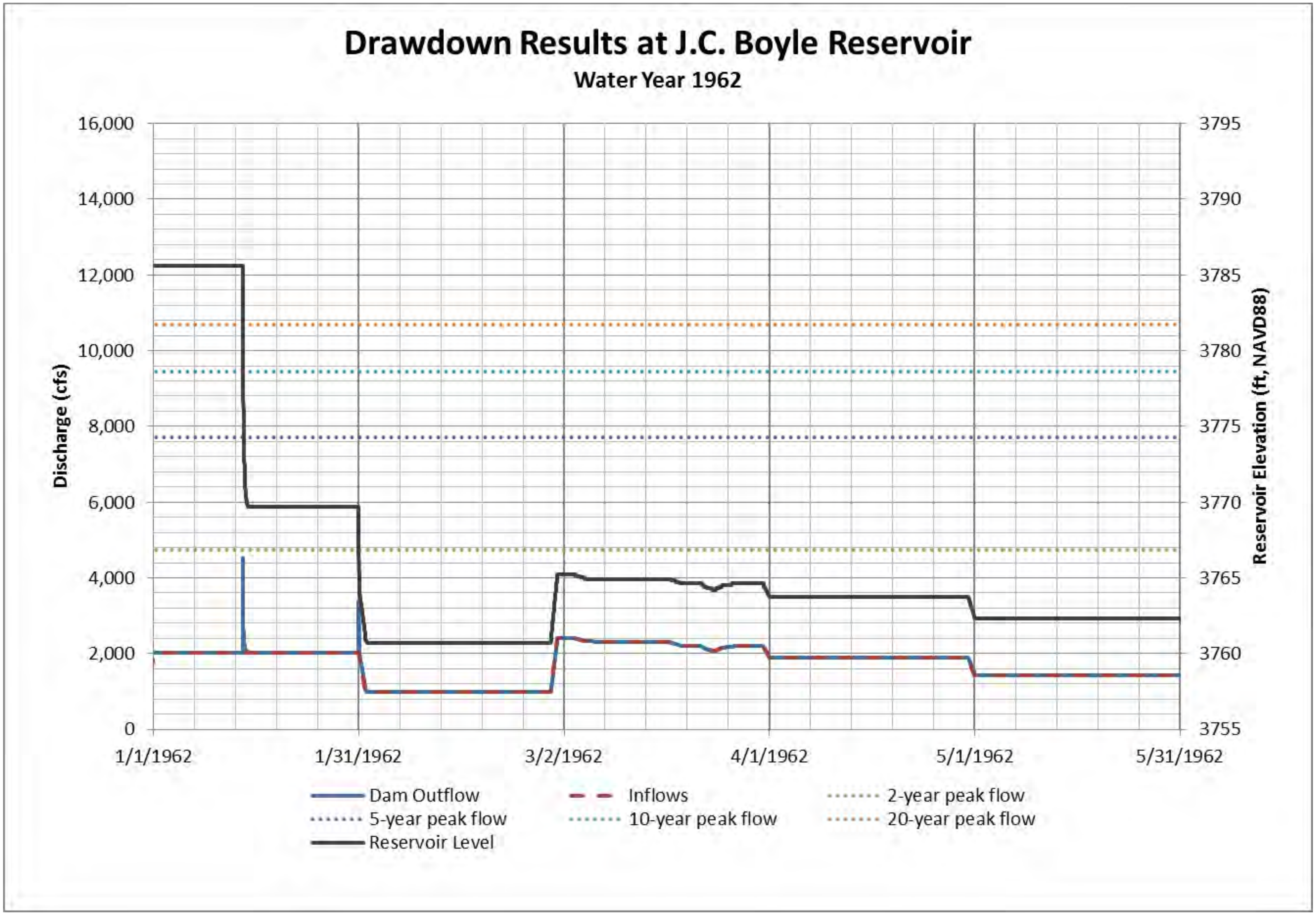



**Figure F2-2 J.C. Boyle Reservoir Drawdown, Water Year 1962**

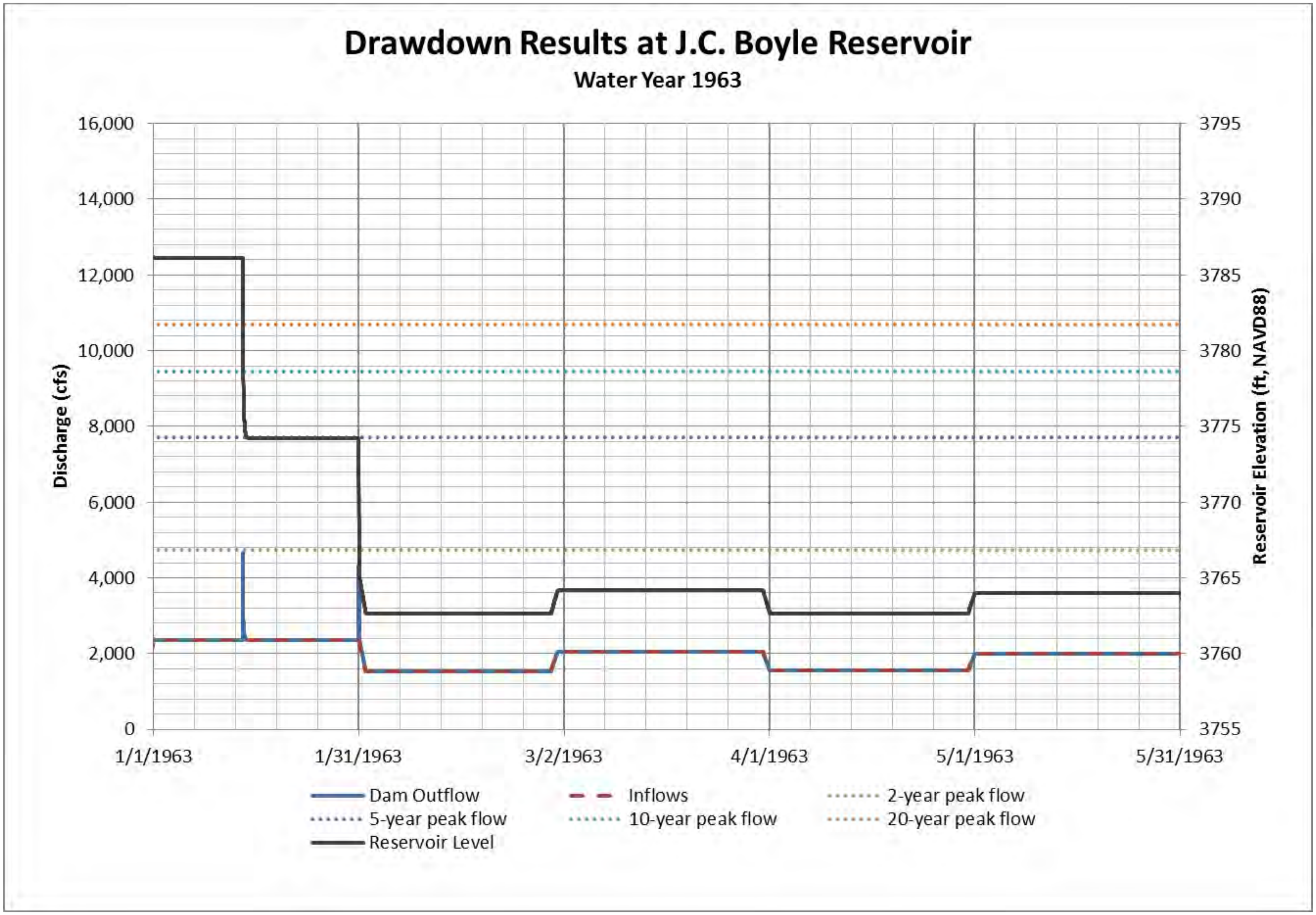



**Figure F2-3 J.C. Boyle Reservoir Drawdown, Water Year 1963**

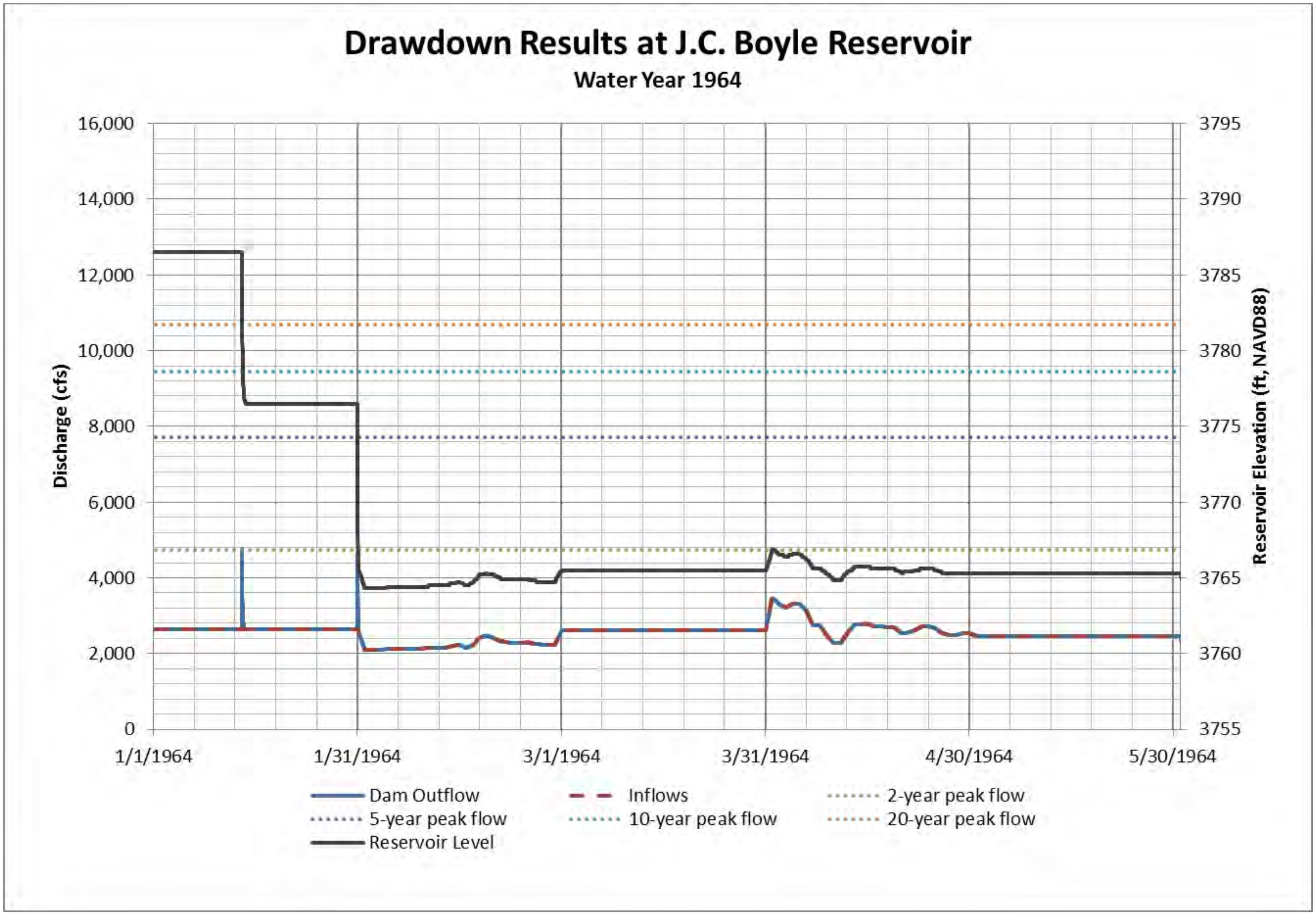



**Figure F2-4 J.C. Boyle Reservoir Drawdown, Water Year 1964**

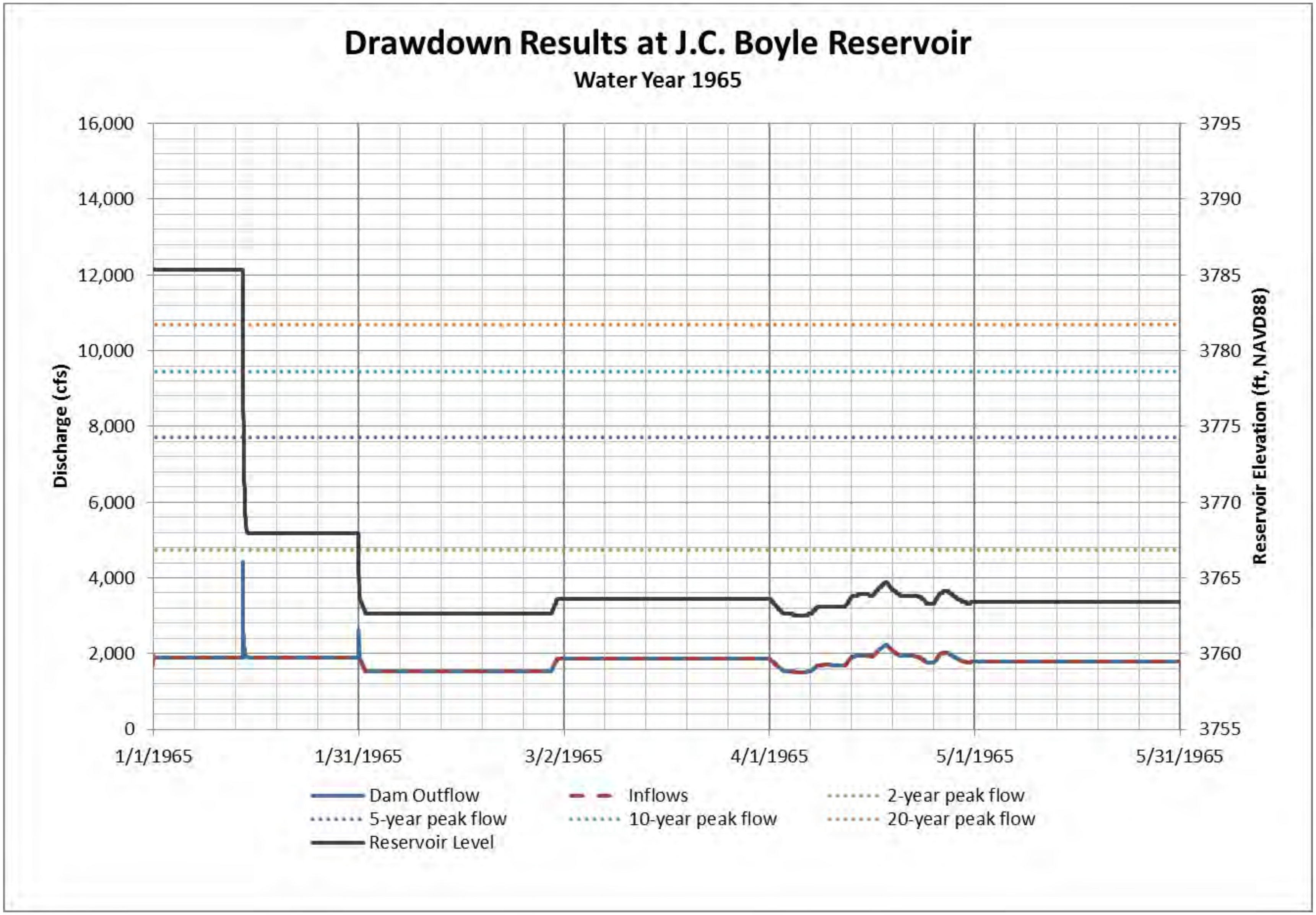



**Figure F2-5 J.C. Boyle Reservoir Drawdown, Water Year 1965**

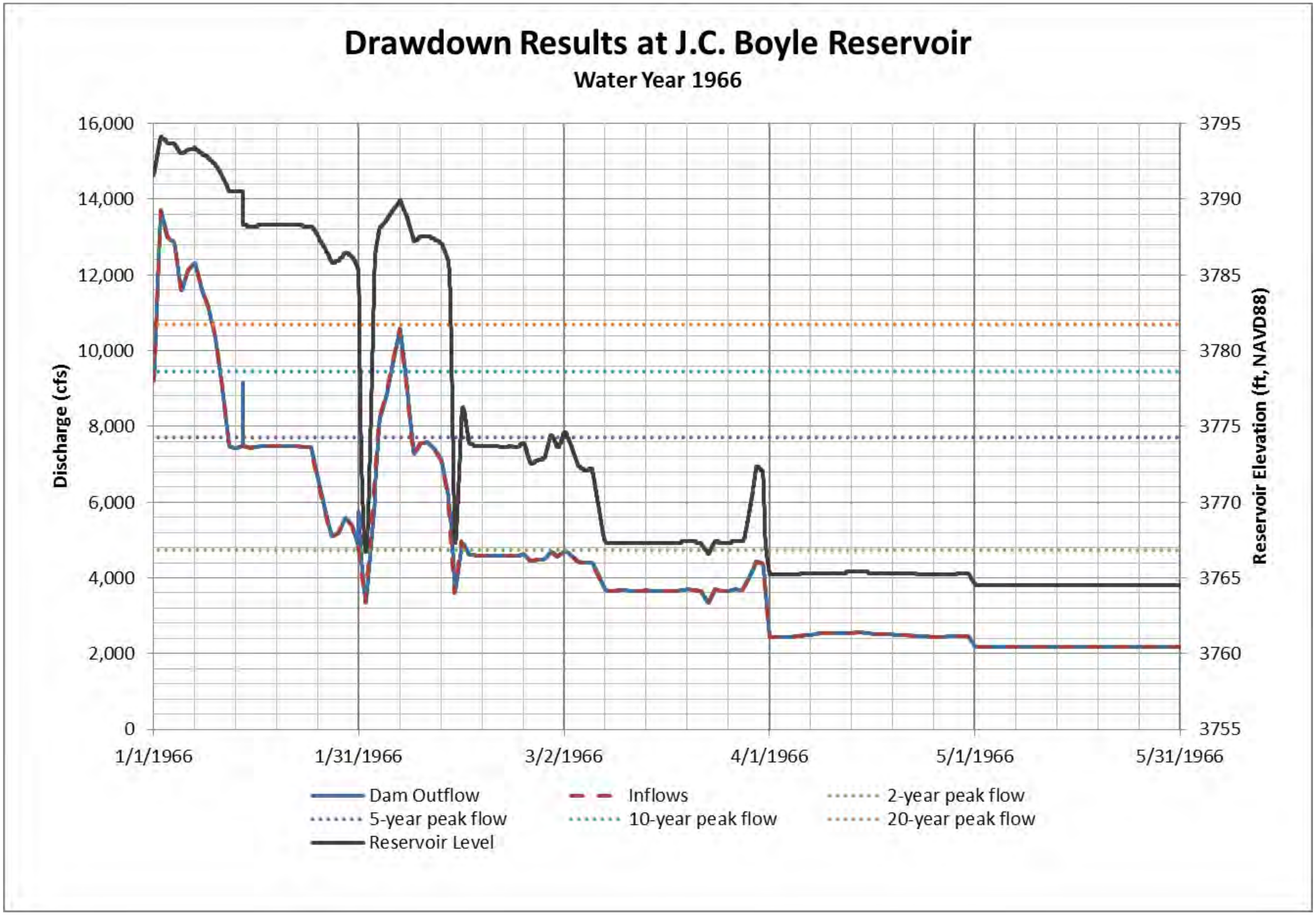



**Figure F2-6 J.C. Boyle Reservoir Drawdown, Water Year 1966 (Wettest Year)**

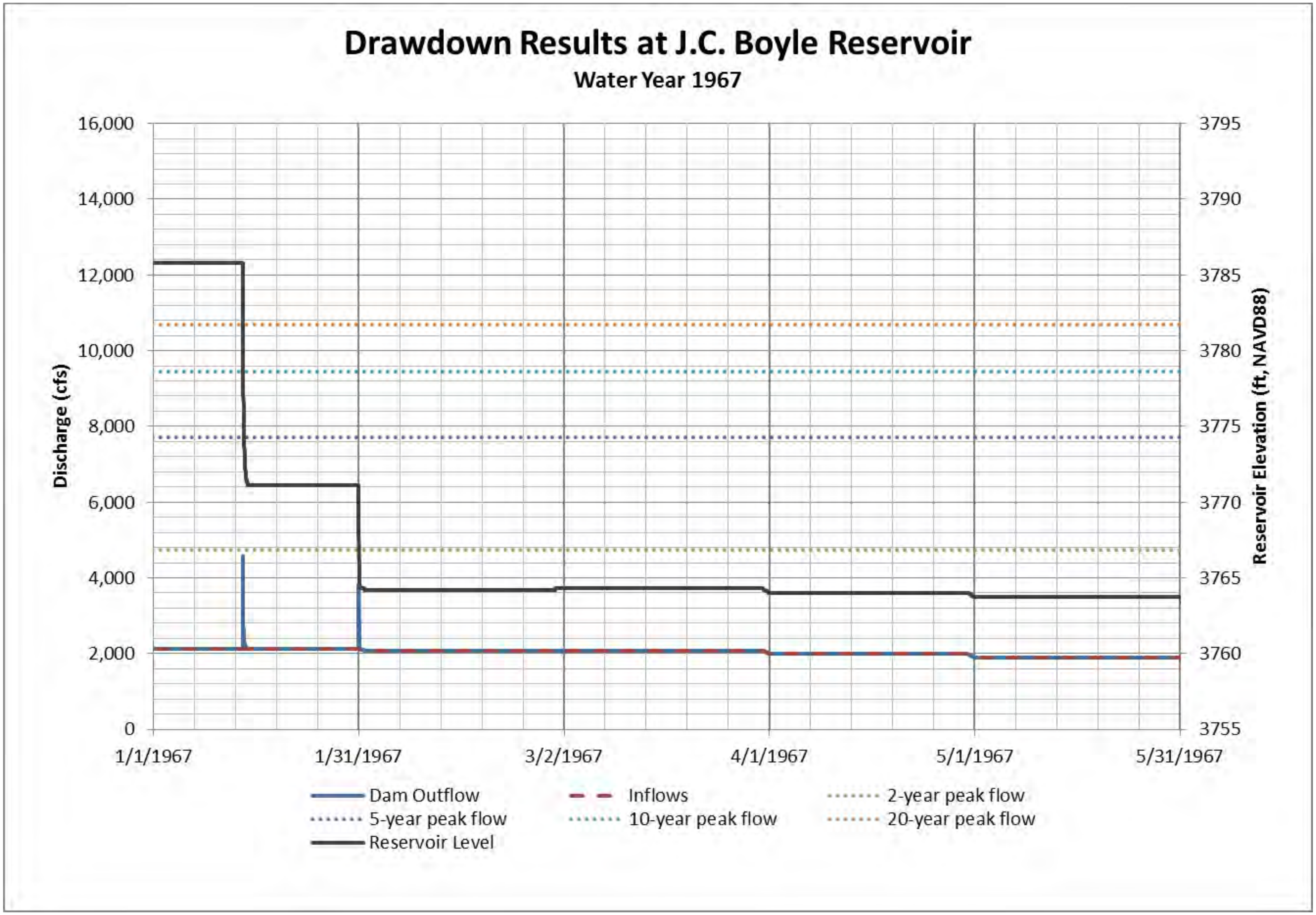
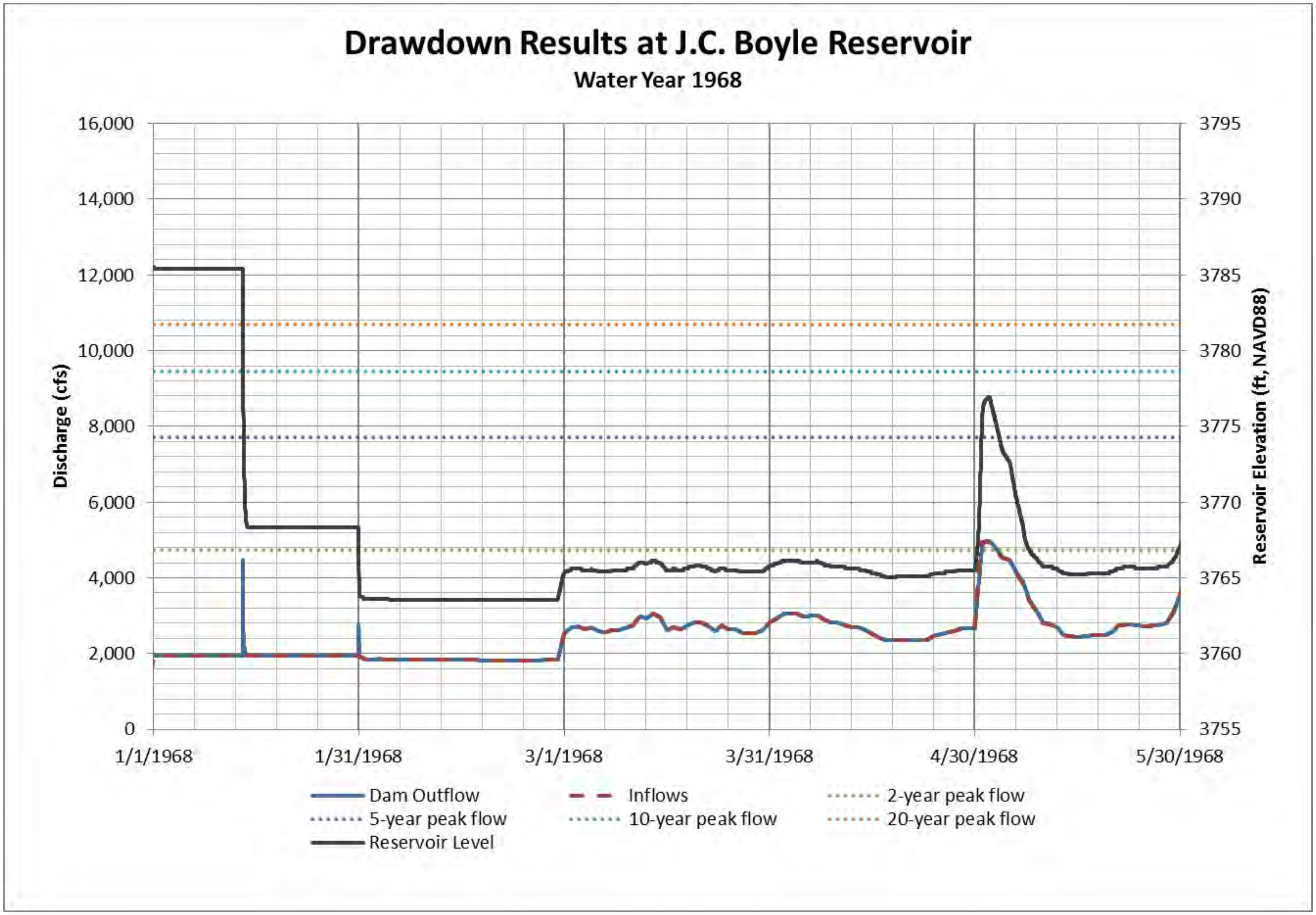



**Figure F2-7 J.C. Boyle Reservoir Drawdown, Water Year 1967**




## Figure F2-8 J.C. Boyle Reservoir Drawdown, Water Year 1968

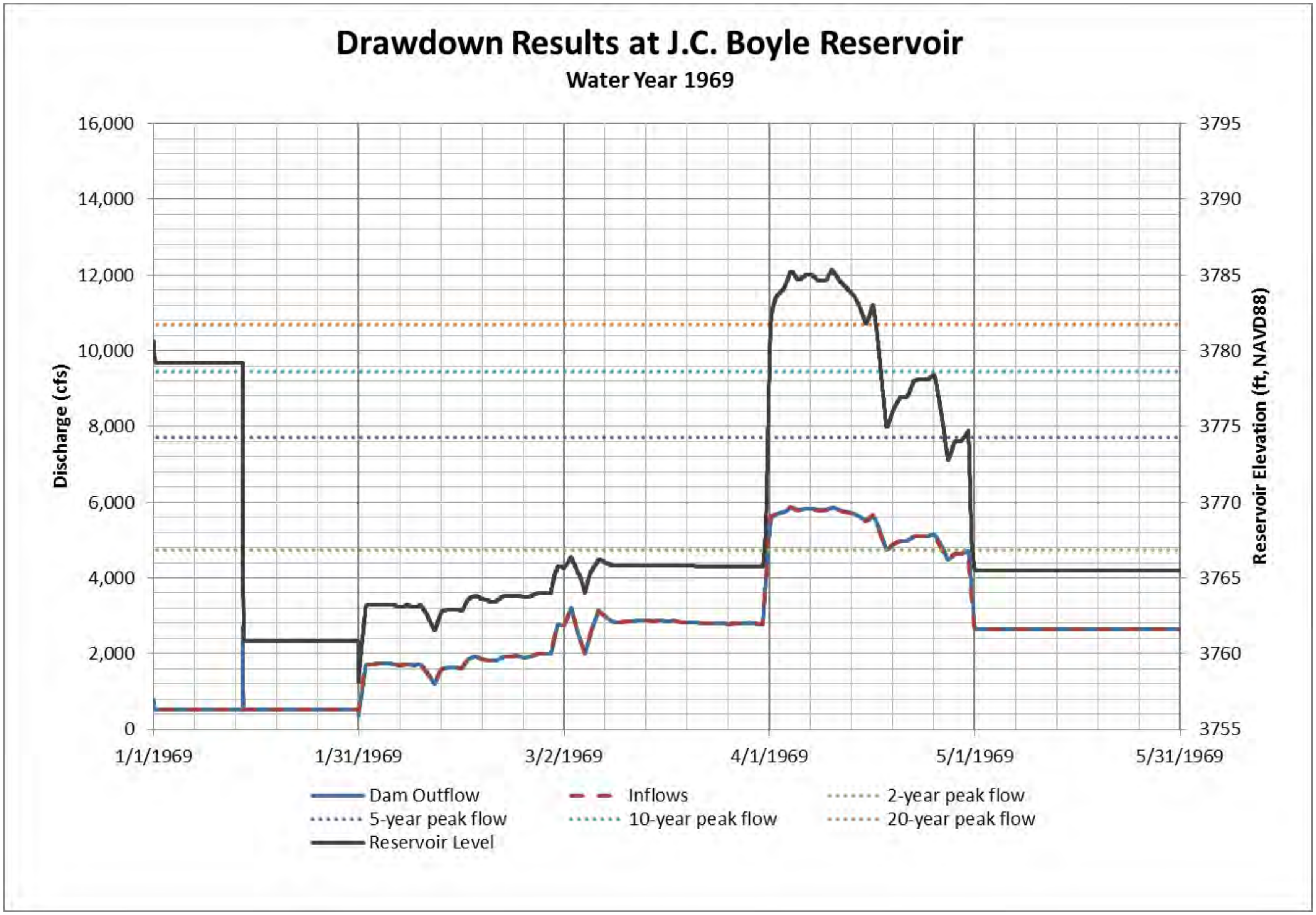



**Figure F2-9 J.C. Boyle Reservoir Drawdown, Water Year 1969**

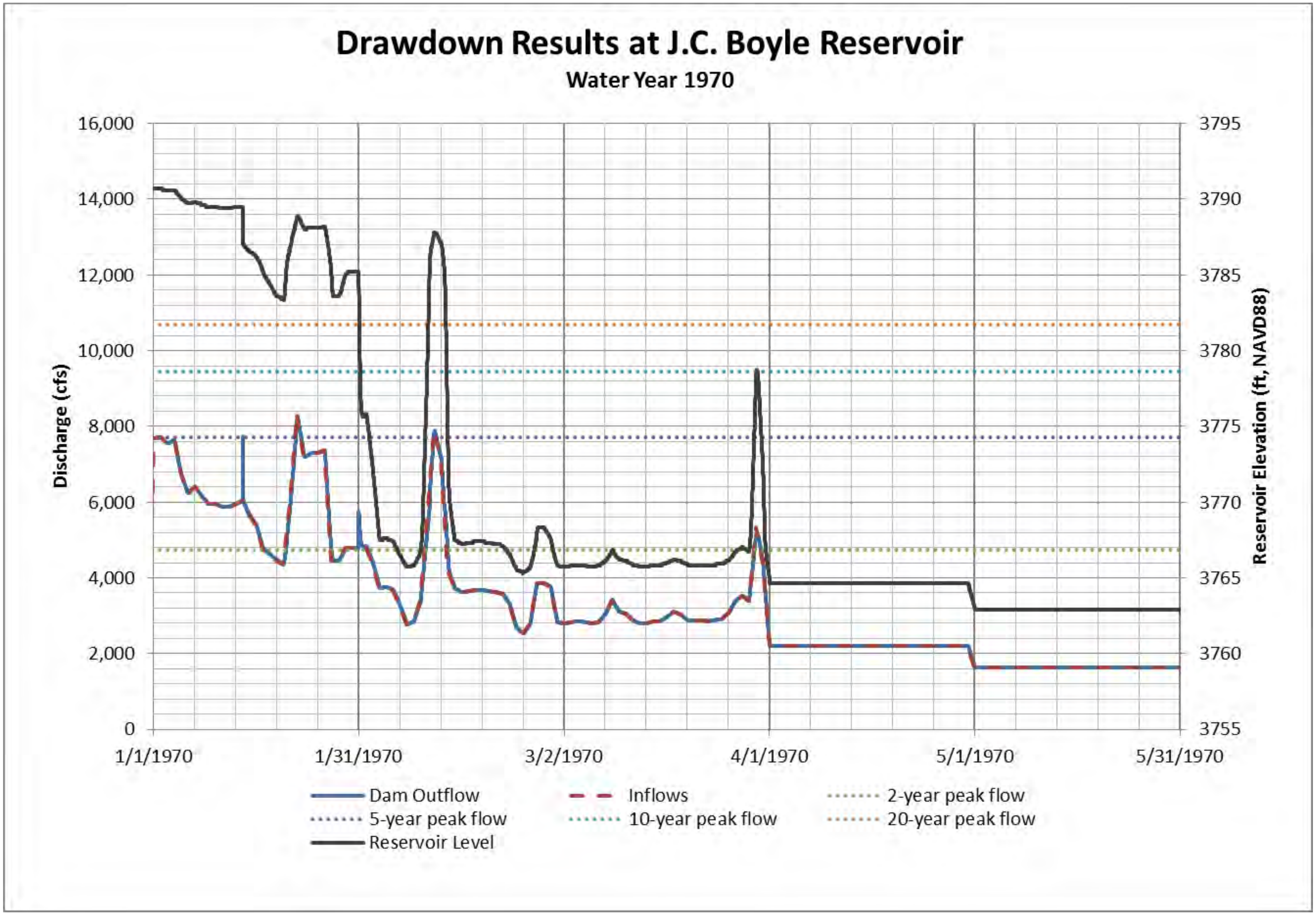



**Figure F2-10 J.C. Boyle Reservoir Drawdown, Water Year 1970 (Above Normal Year)**

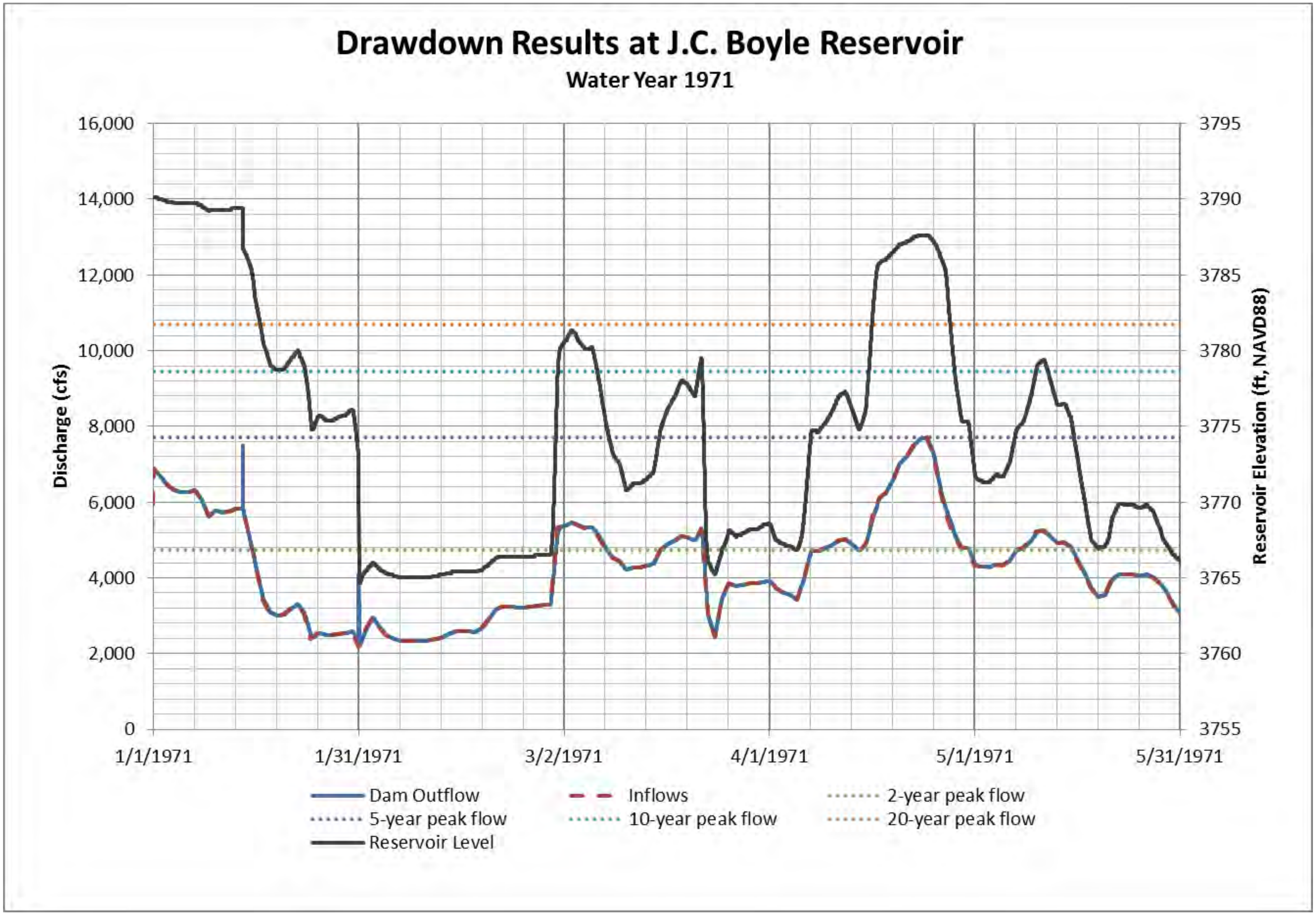



**Figure F2-11 J.C. Boyle Reservoir Drawdown, Water Year 1971**

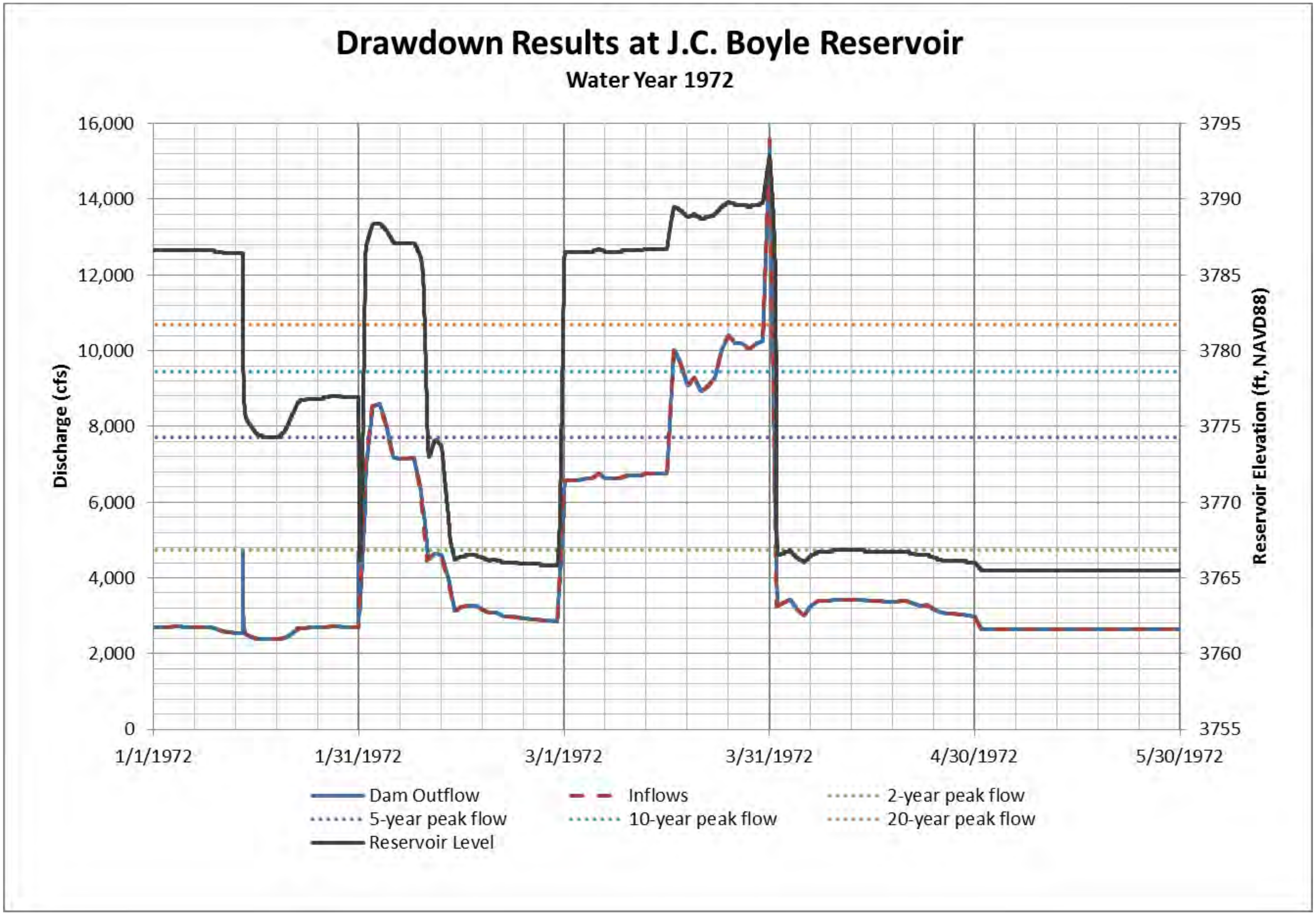



**Figure F2-12 J.C. Boyle Reservoir Drawdown, Water Year 1972**

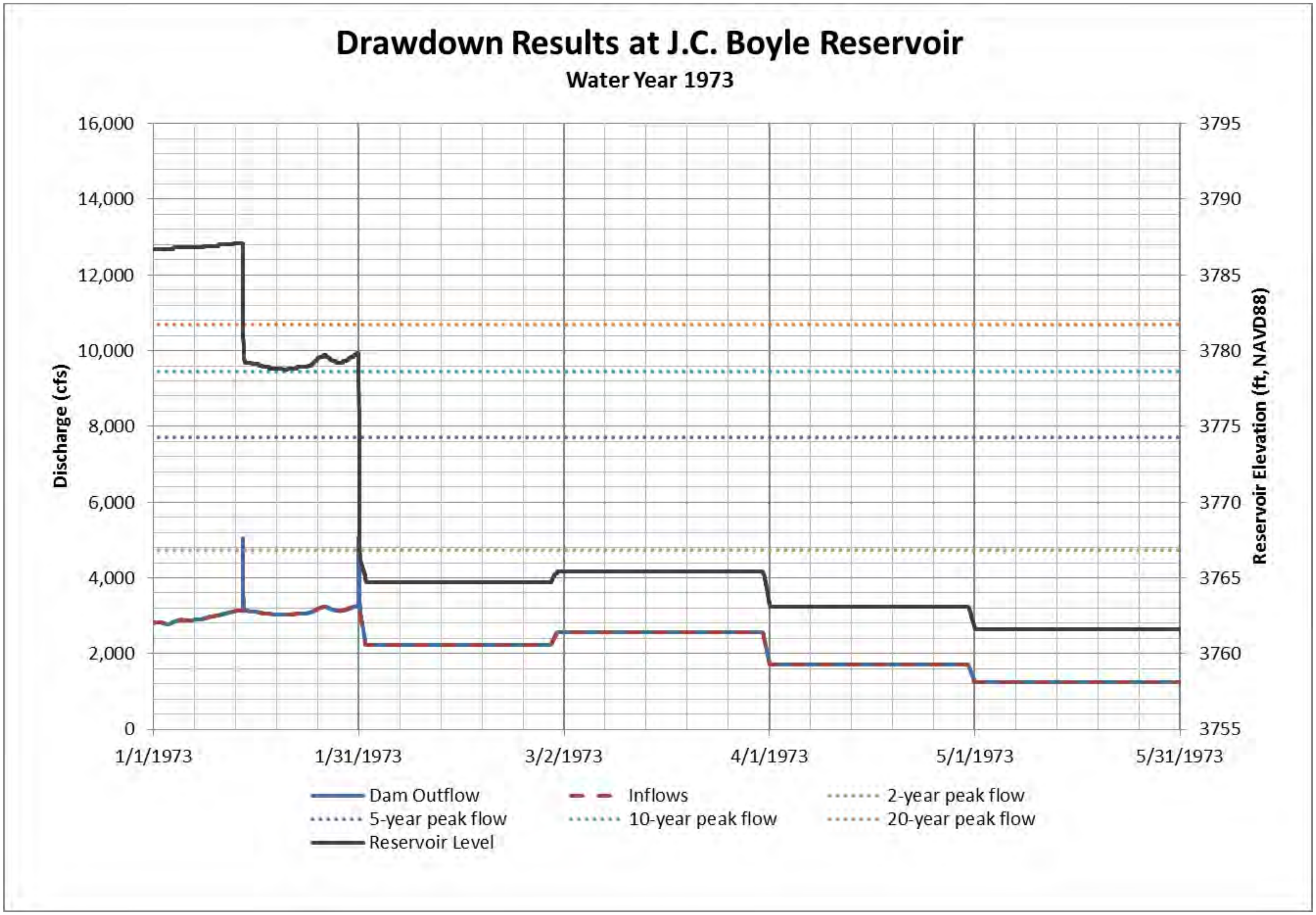



**Figure F2-13 J.C. Boyle Reservoir Drawdown, Water Year 1973 (Median Year)**

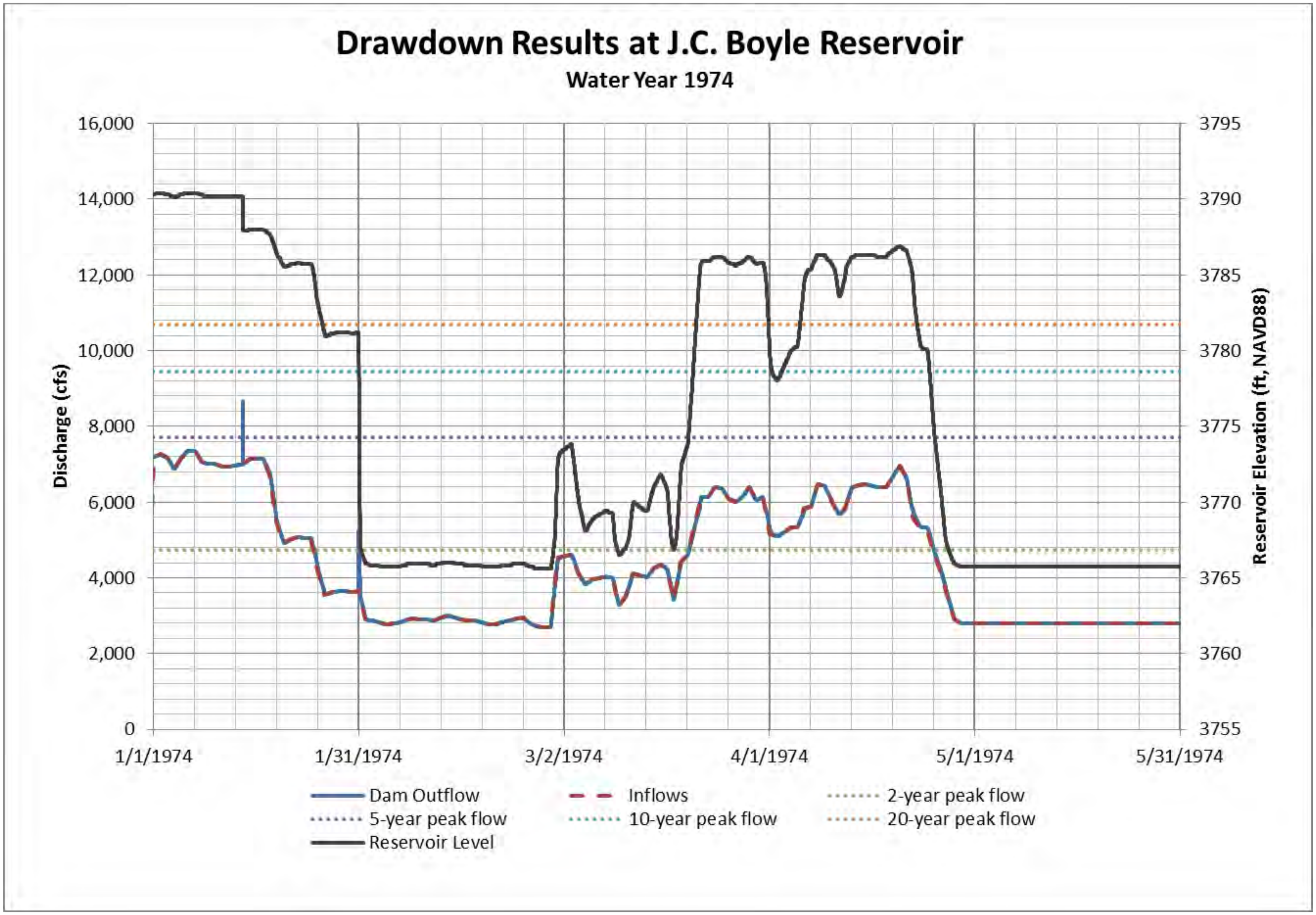



**Figure F2-14 J.C. Boyle Reservoir Drawdown, Water Year 1974**

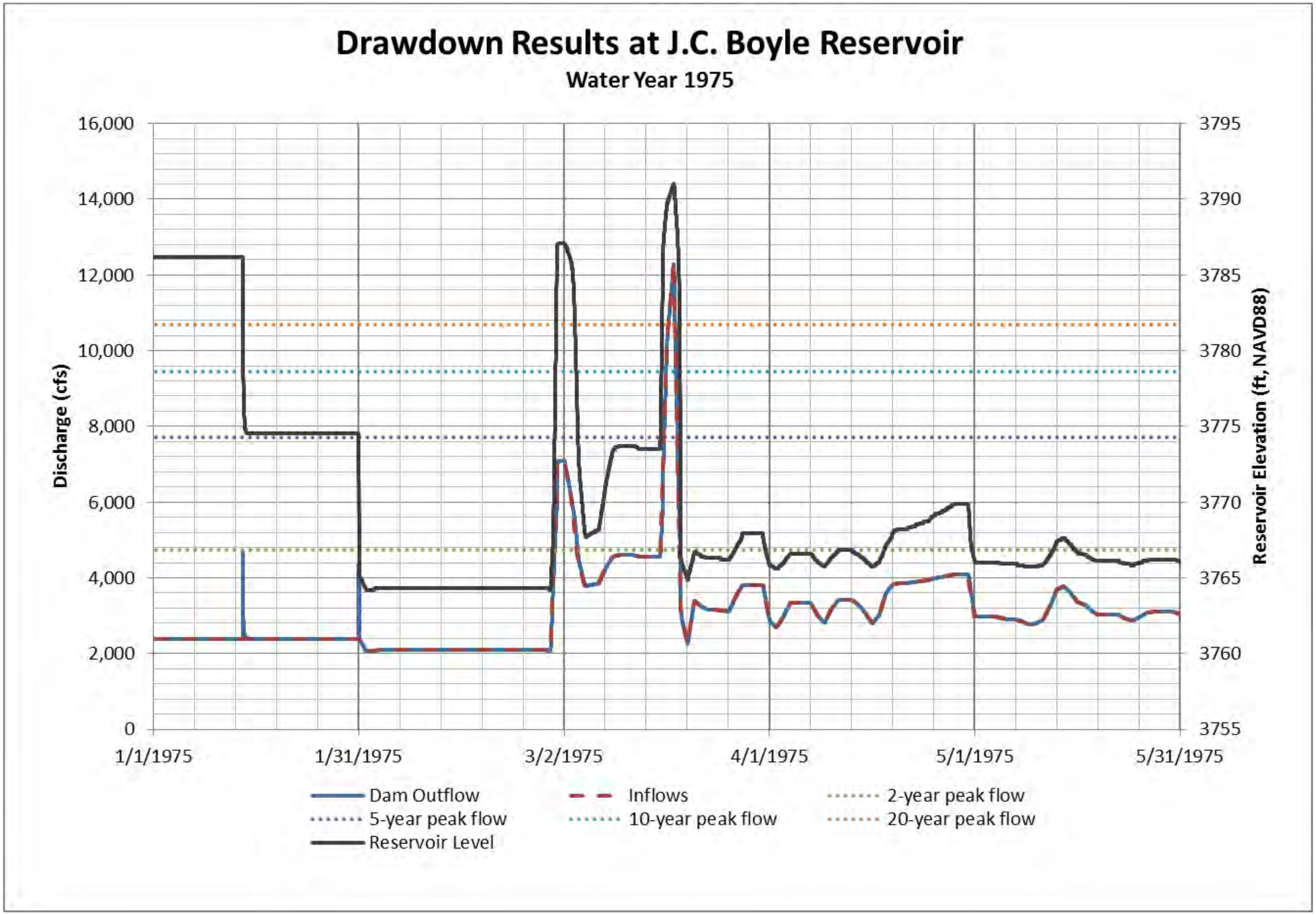



**Figure F2-15 J.C. Boyle Reservoir Drawdown, Water Year 1975**

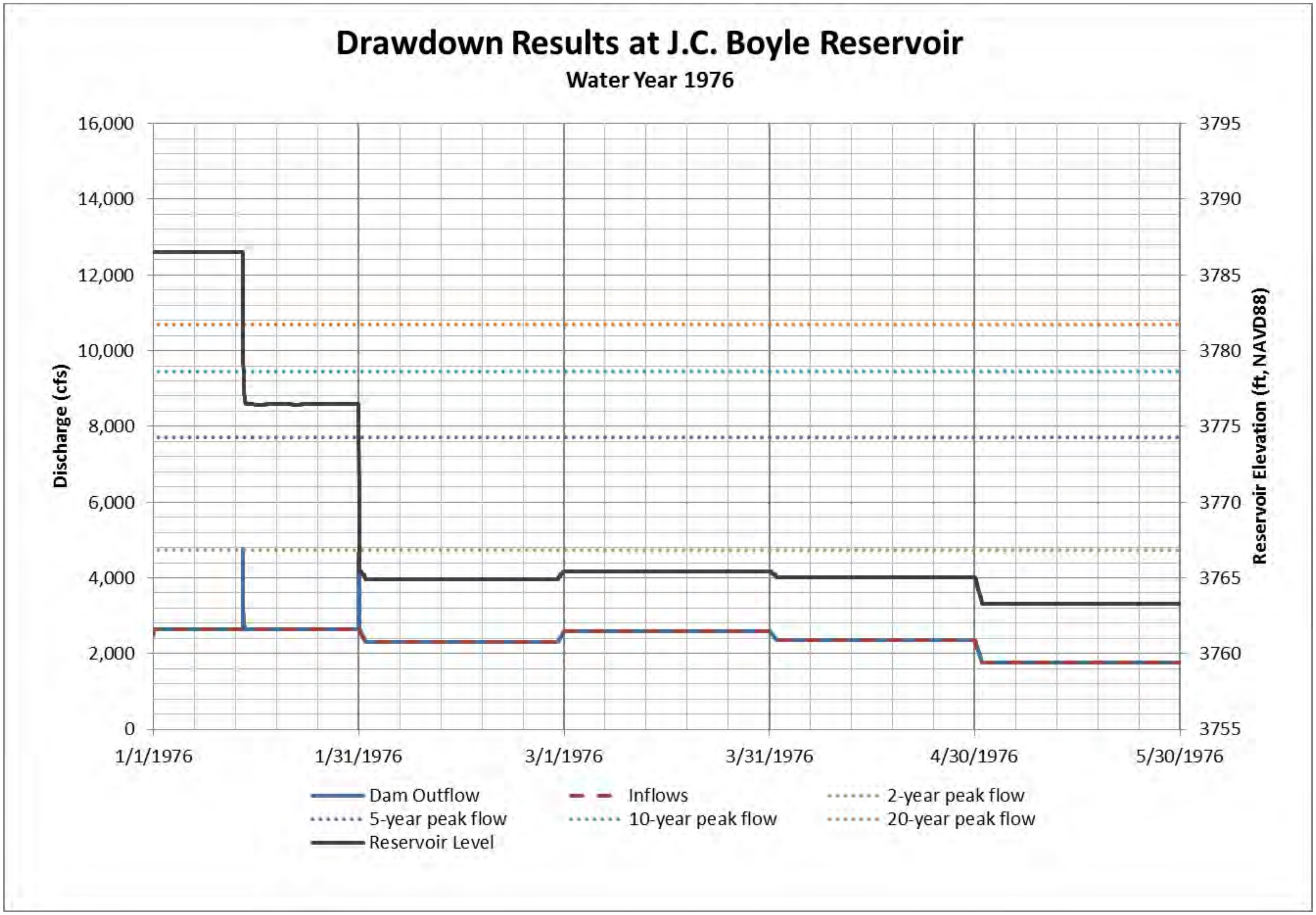



Figure F2-16 J.C. Boyle Reservoir Drawdown, Water Year 1976

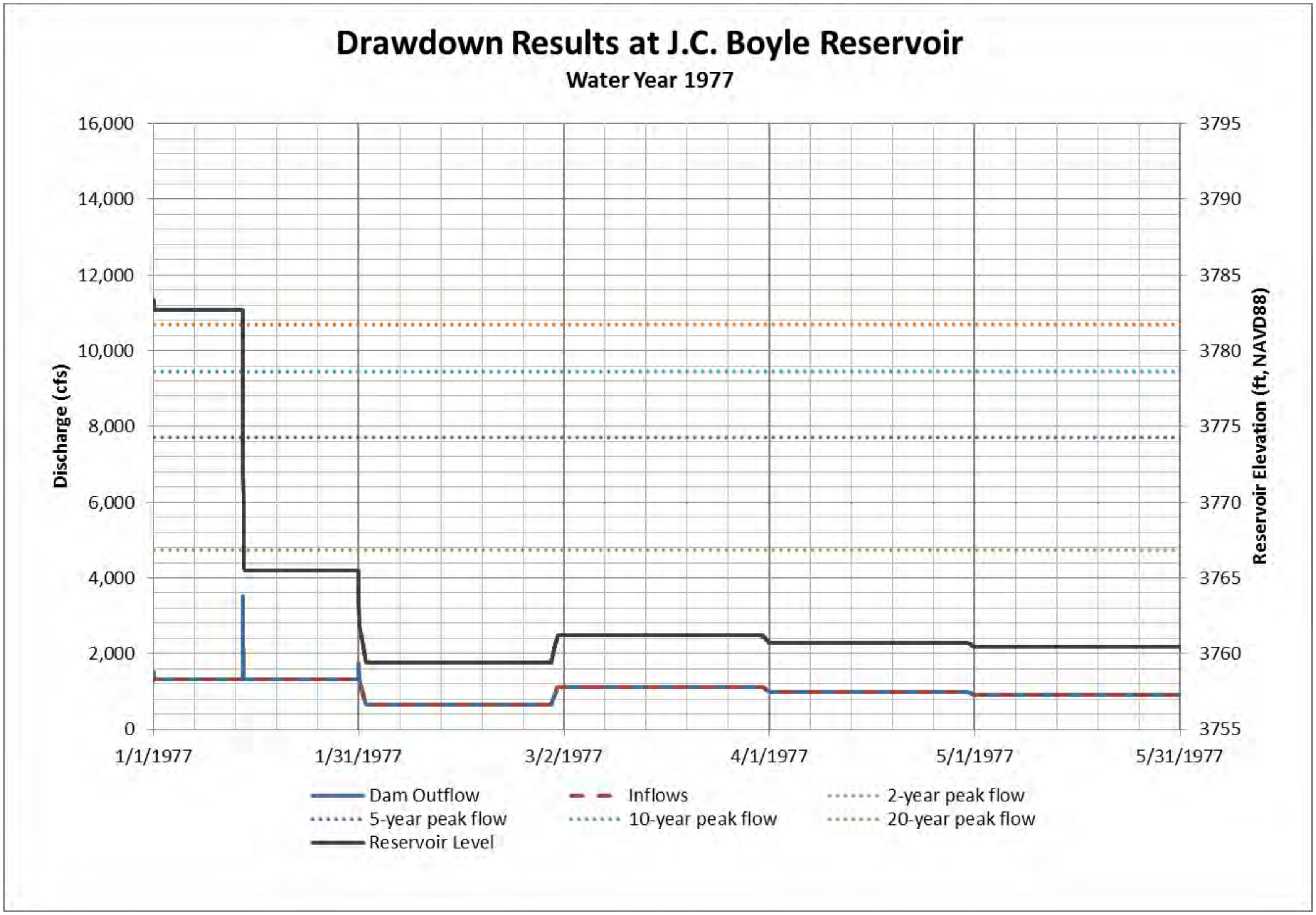



**Figure F2-17 J.C. Boyle Reservoir Drawdown, Water Year 1977**

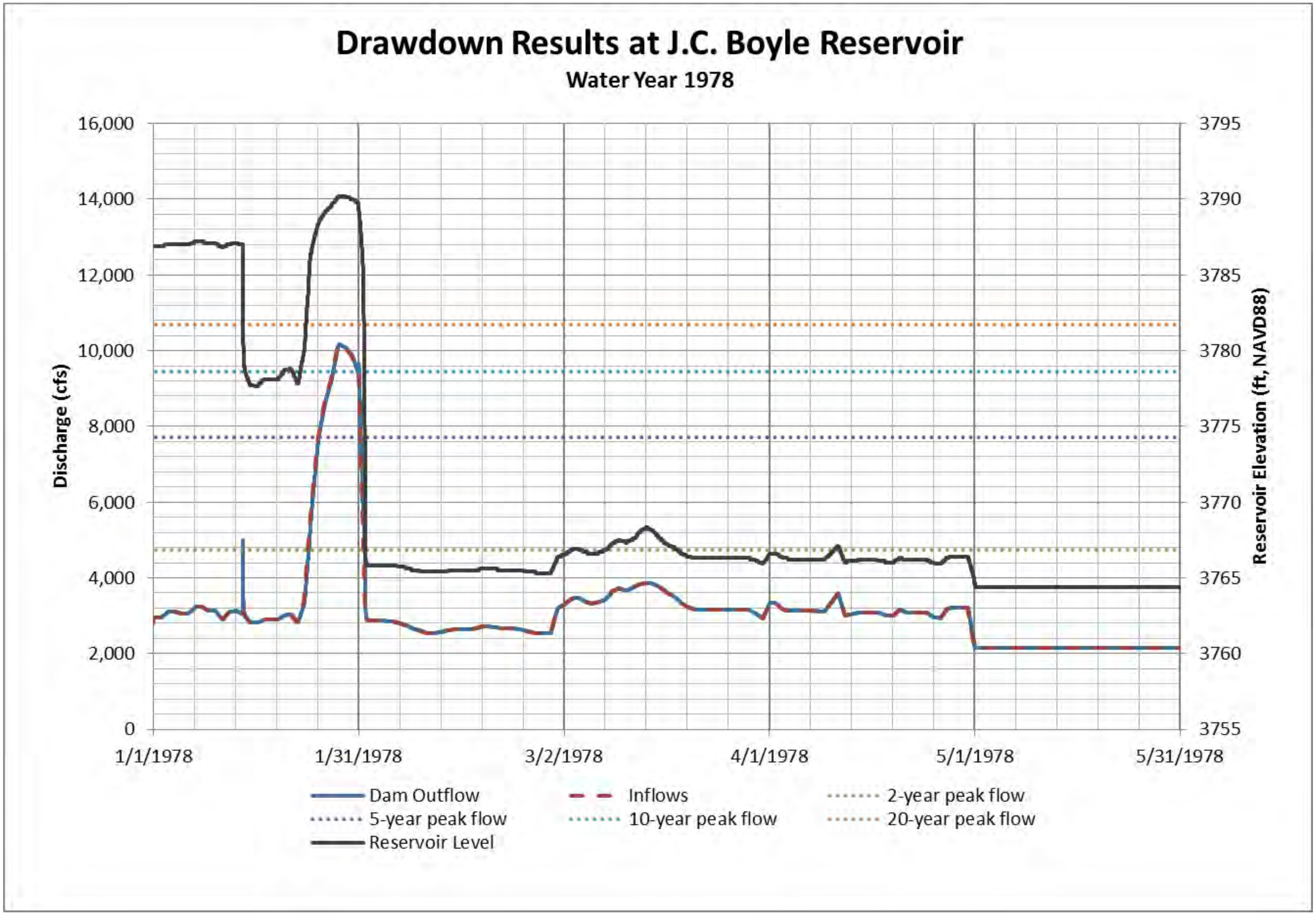



**Figure F2-18 J.C. Boyle Reservoir Drawdown, Water Year 1978**

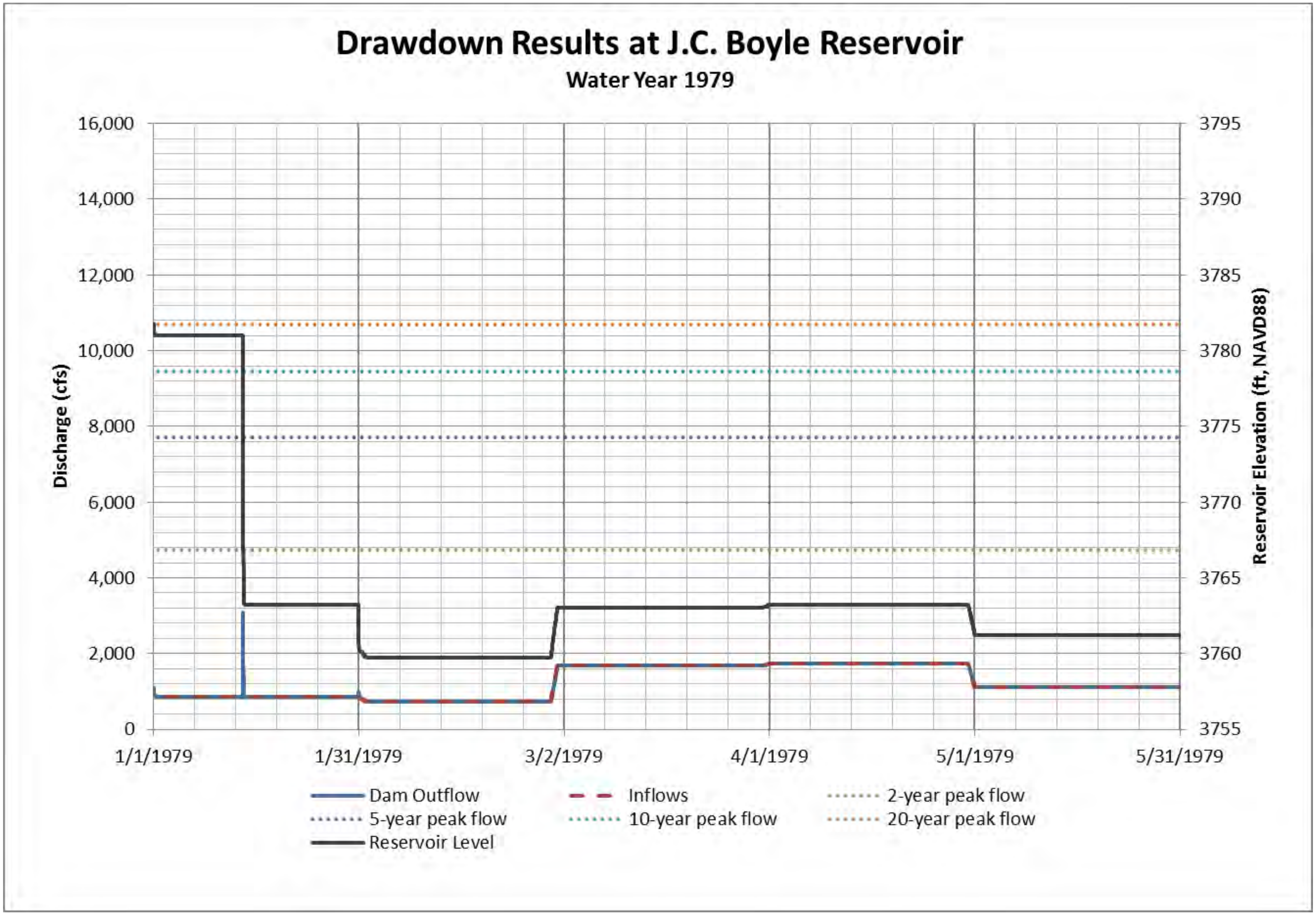



**Figure F2-19 J.C. Boyle Reservoir Drawdown, Water Year 1979 (Dry Year)**

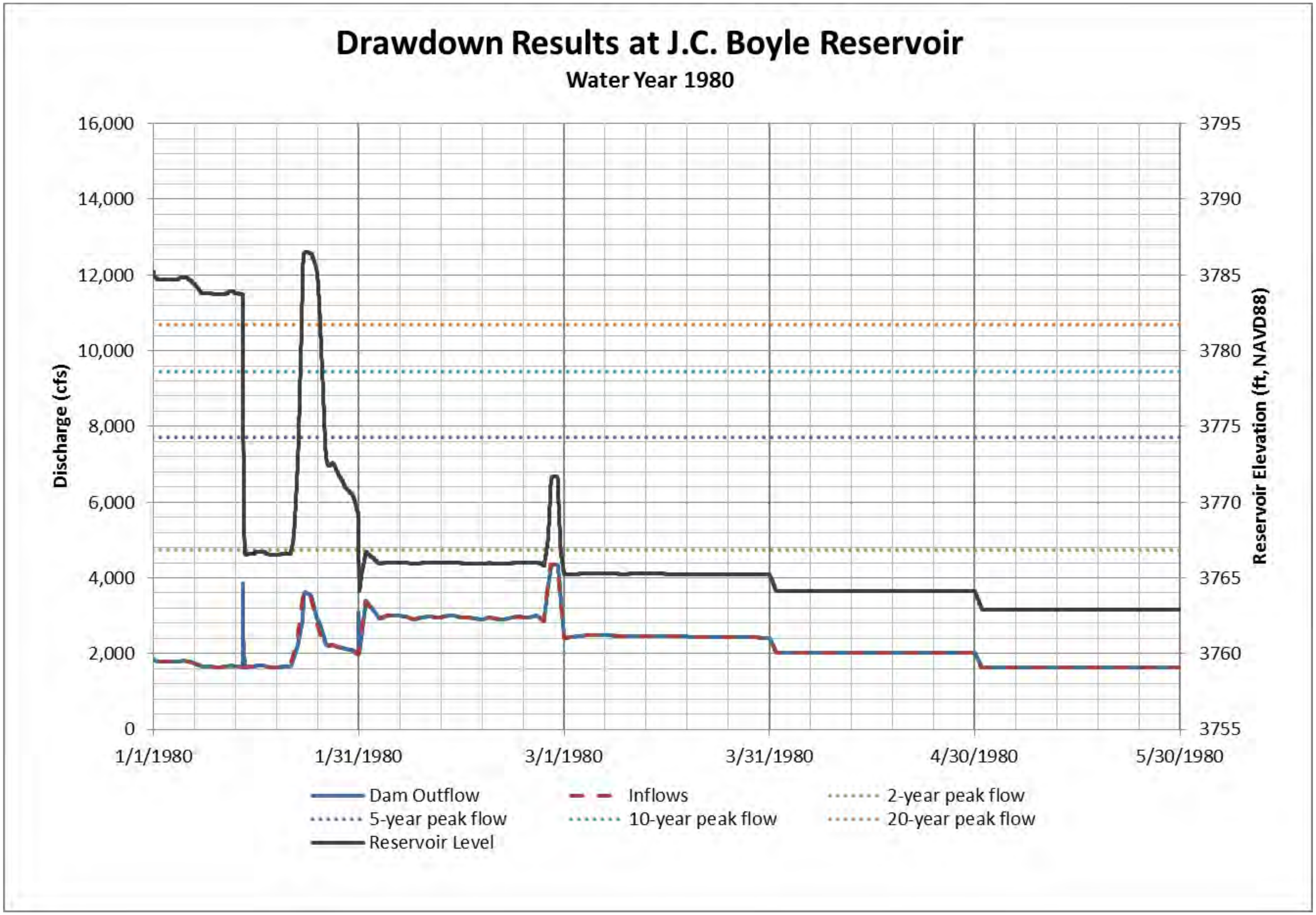



**Figure F2-20 J.C. Boyle Reservoir Drawdown, Water Year 1980**

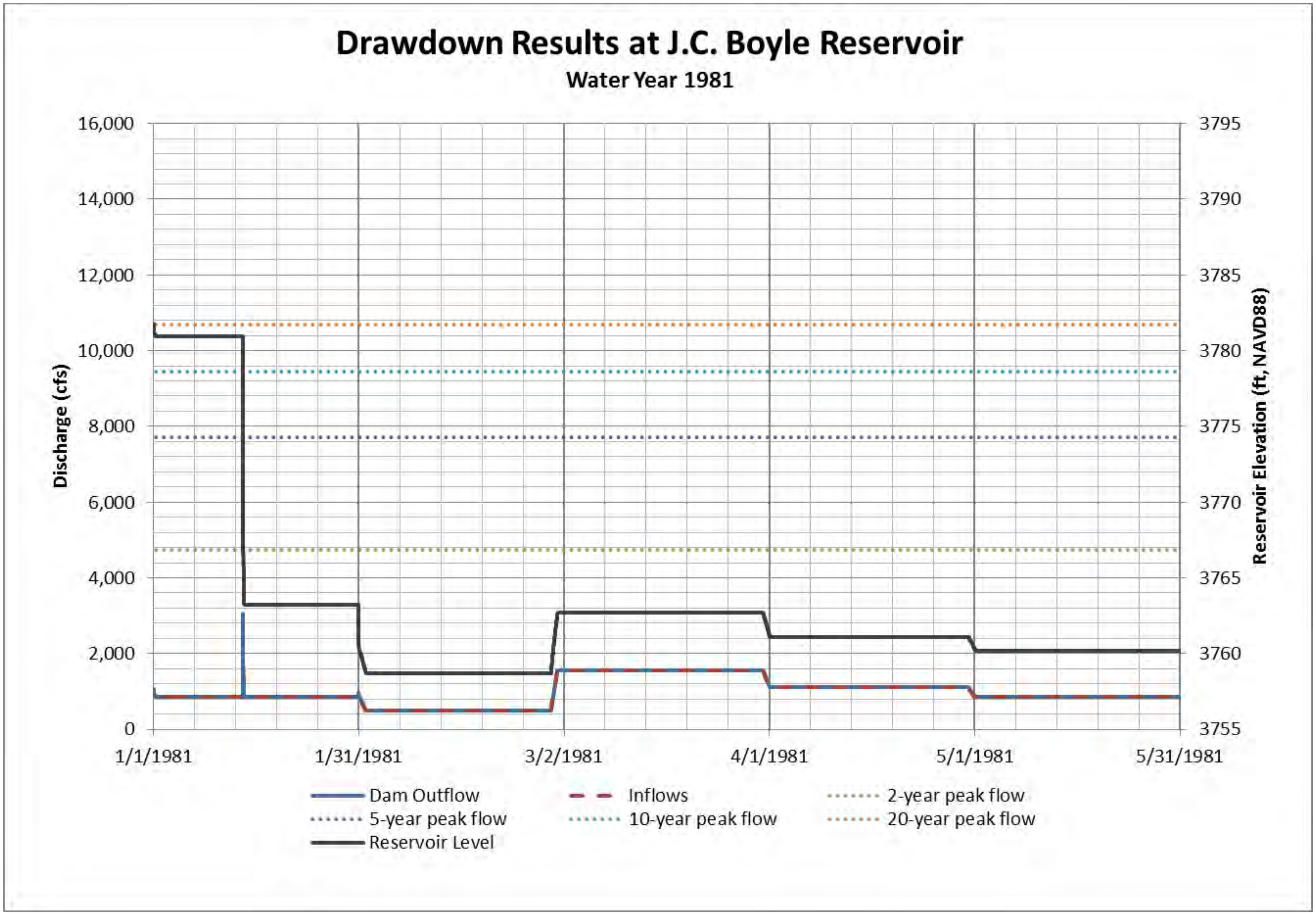



**Figure F2-21 J.C. Boyle Reservoir Drawdown, Water Year 1981**

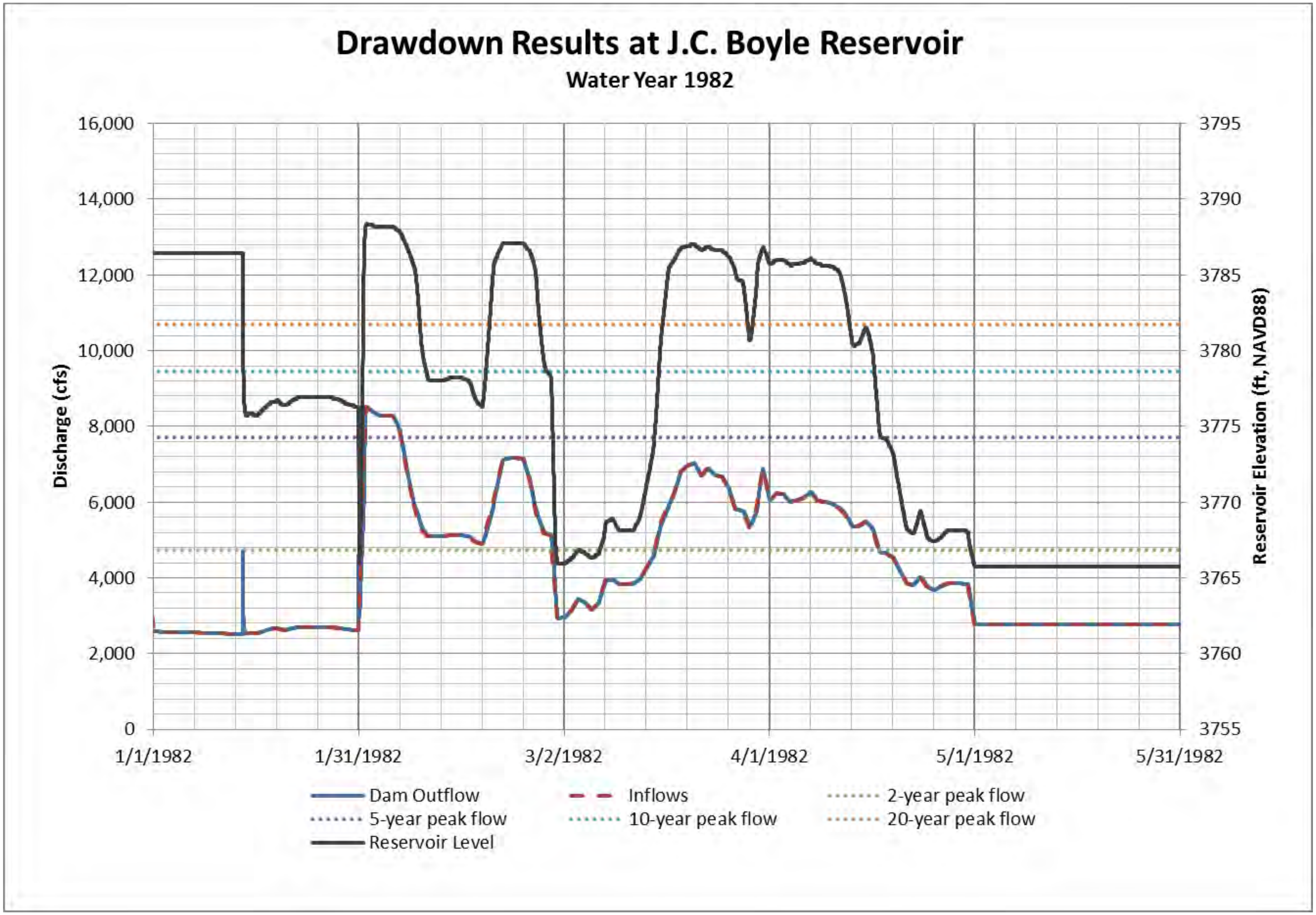



Figure F2-22 J.C. Boyle Reservoir Drawdown, Water Year 1982

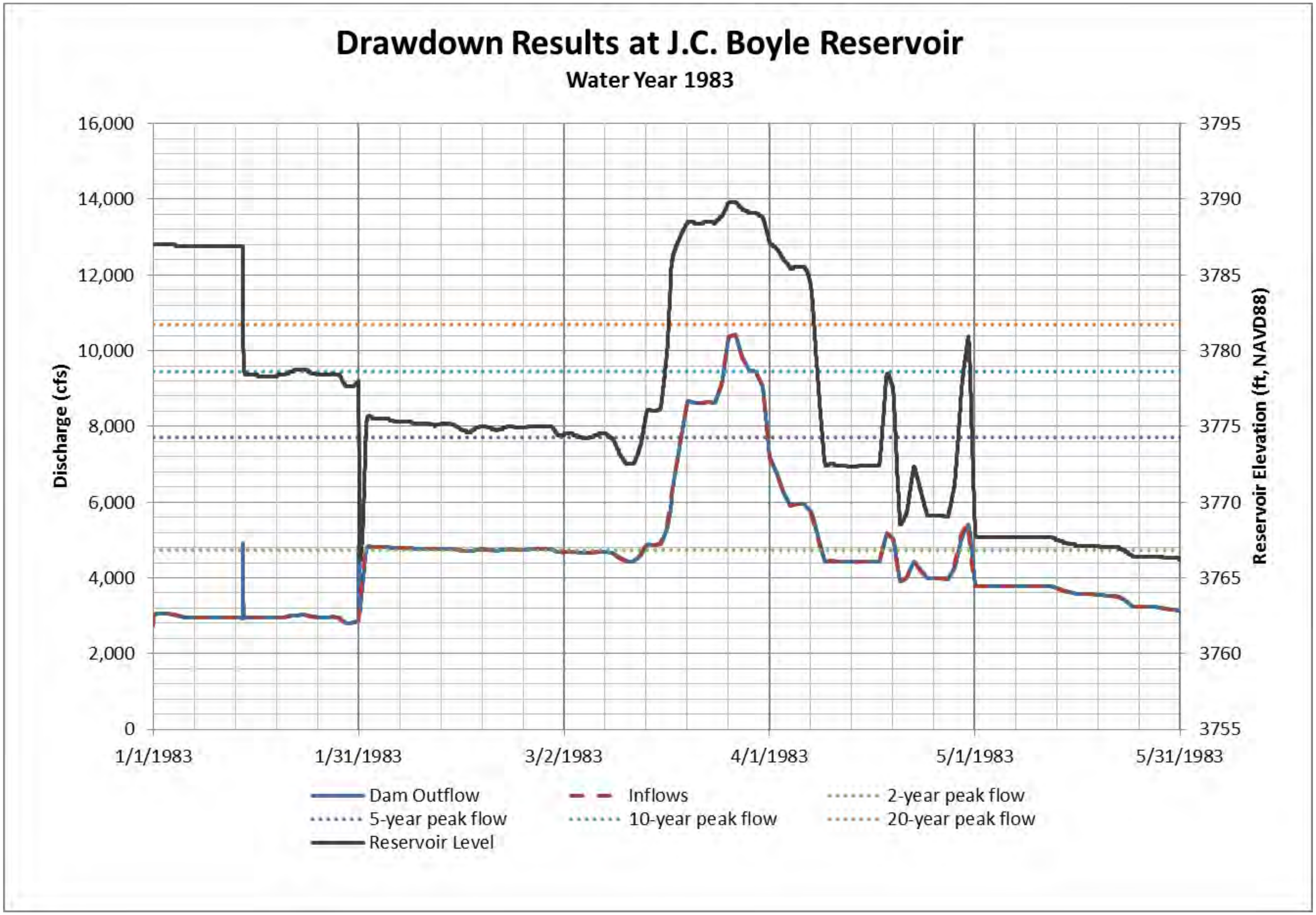



Figure F2-23 J.C. Boyle Reservoir Drawdown, Water Year 1983

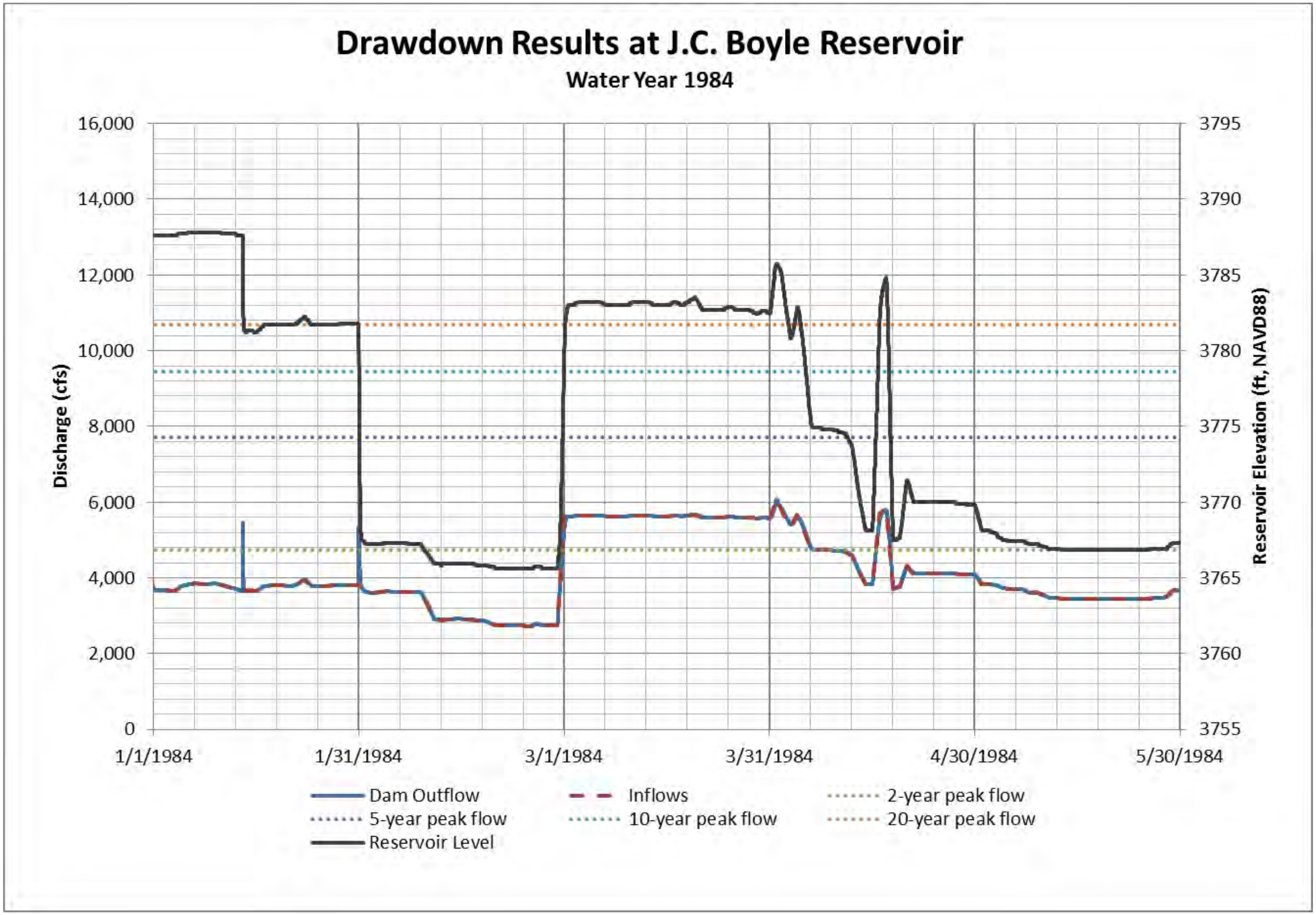



**Figure F2-24 J.C. Boyle Reservoir Drawdown, Water Year 1984**

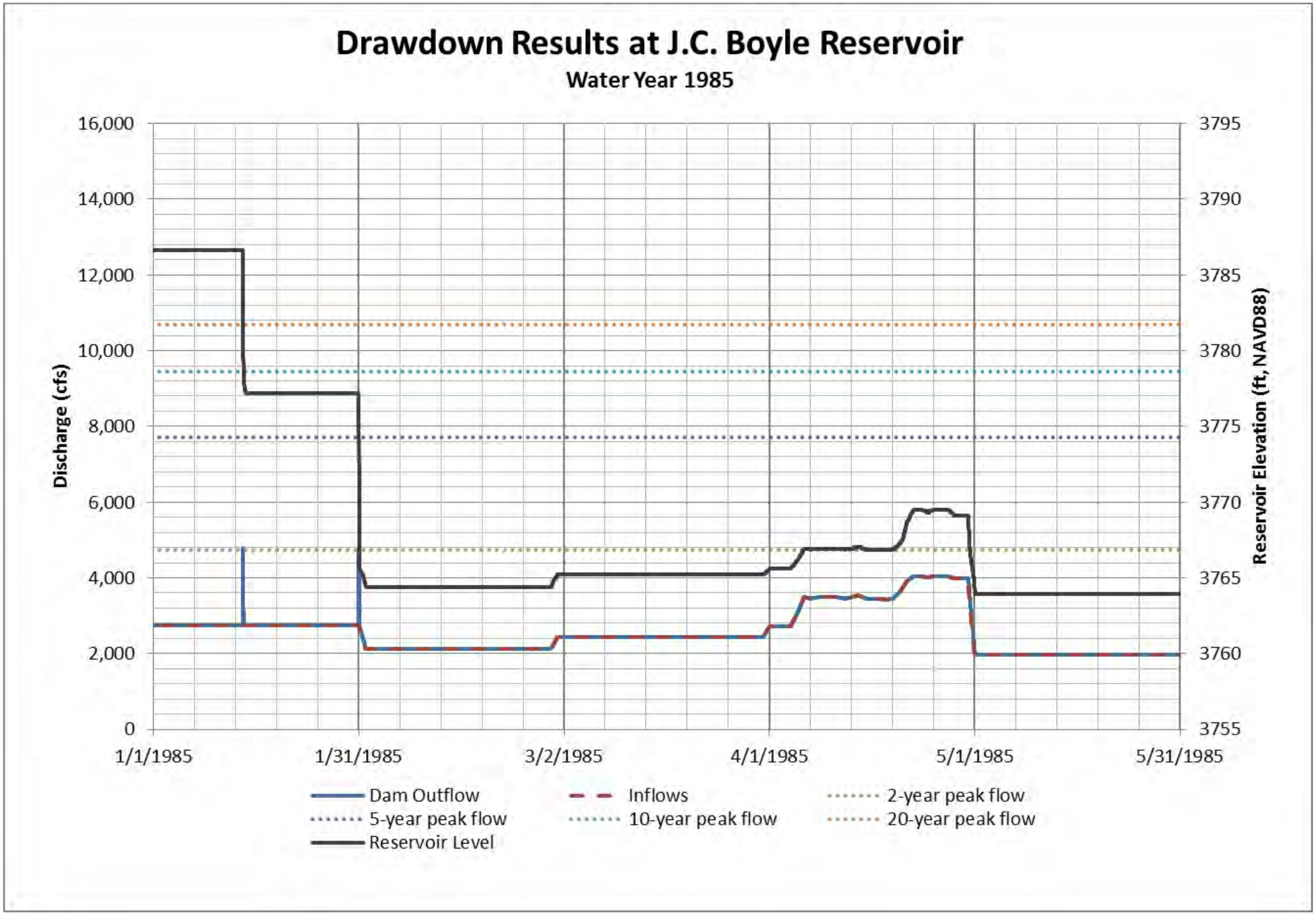



**Figure F2-25 J.C. Boyle Reservoir Drawdown, Water Year 1985**

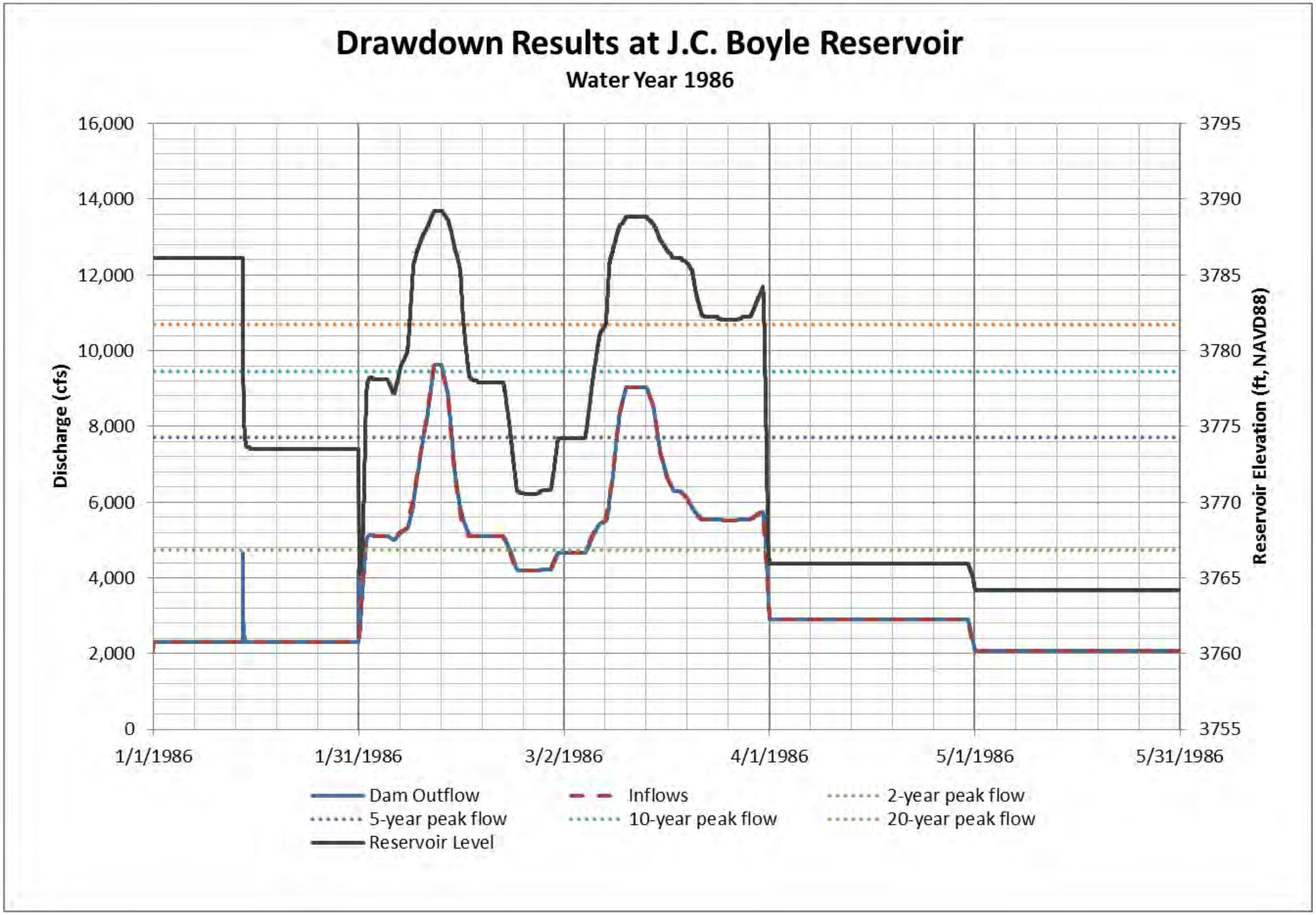



**Figure F2-26 J.C. Boyle Reservoir Drawdown, Water Year 1986 (Wet Year)**

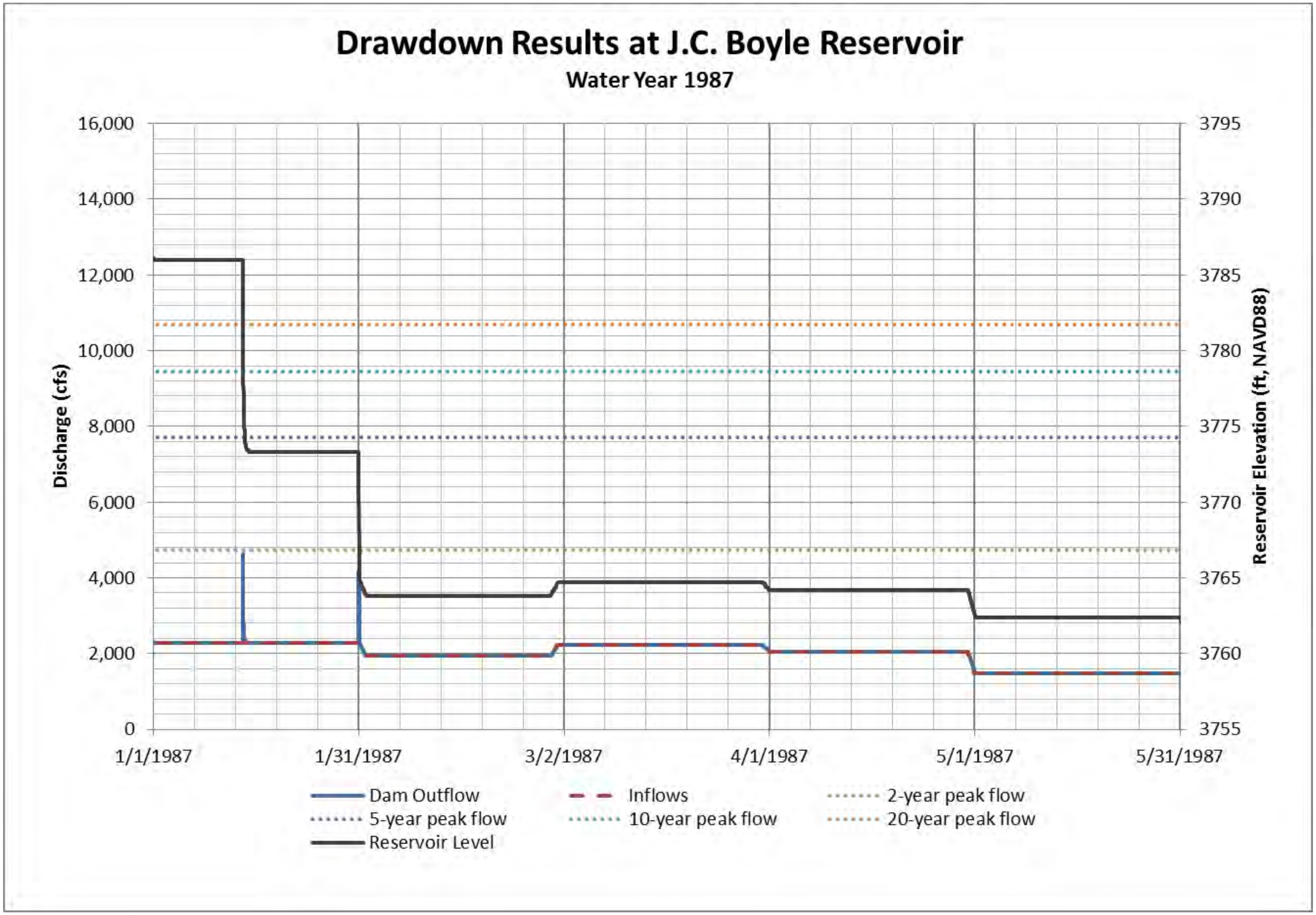



**Figure F2-27 J.C. Boyle Reservoir Drawdown, Water Year 1987**

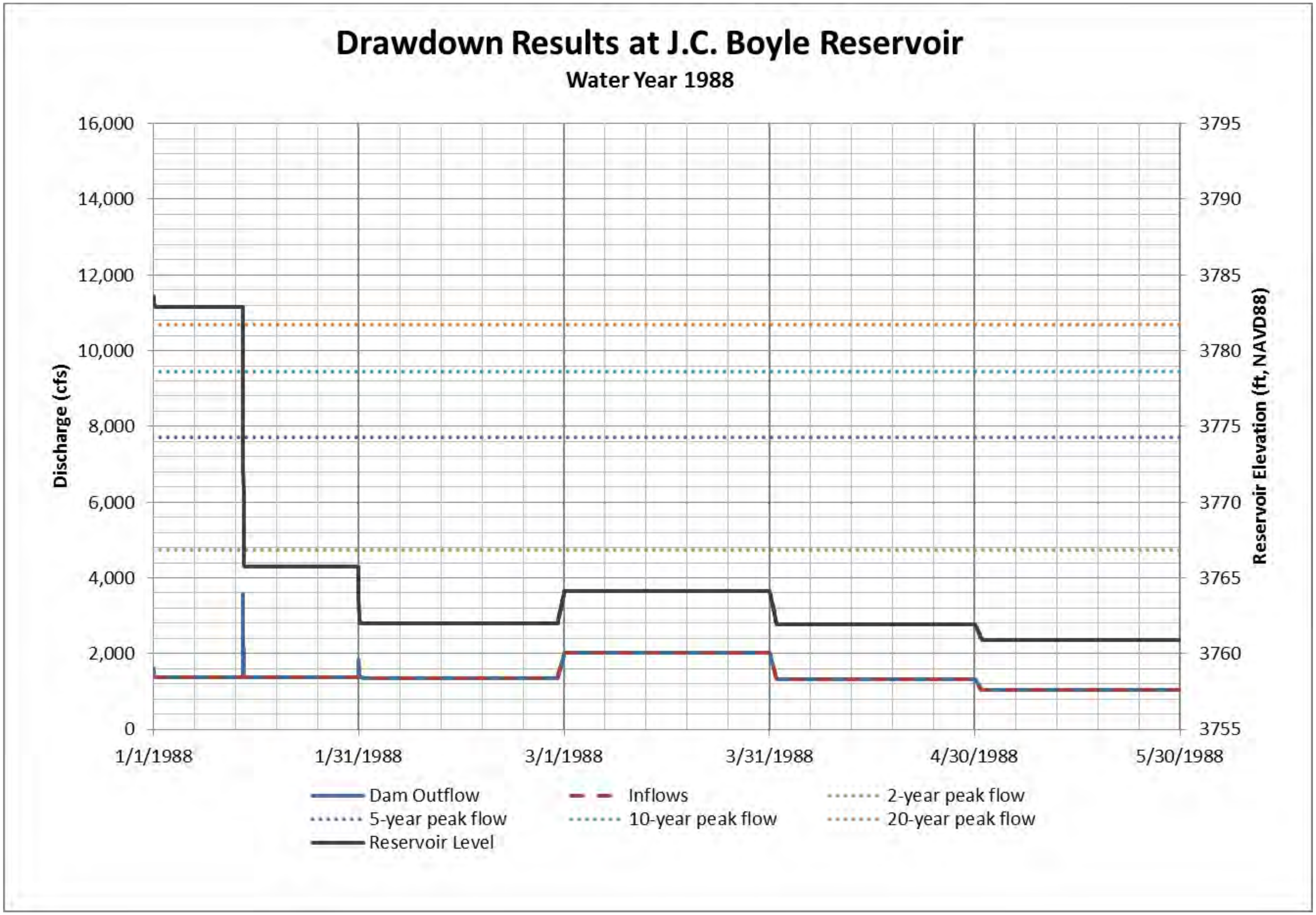



**Figure F2-28 J.C. Boyle Reservoir Drawdown, Water Year 1988**

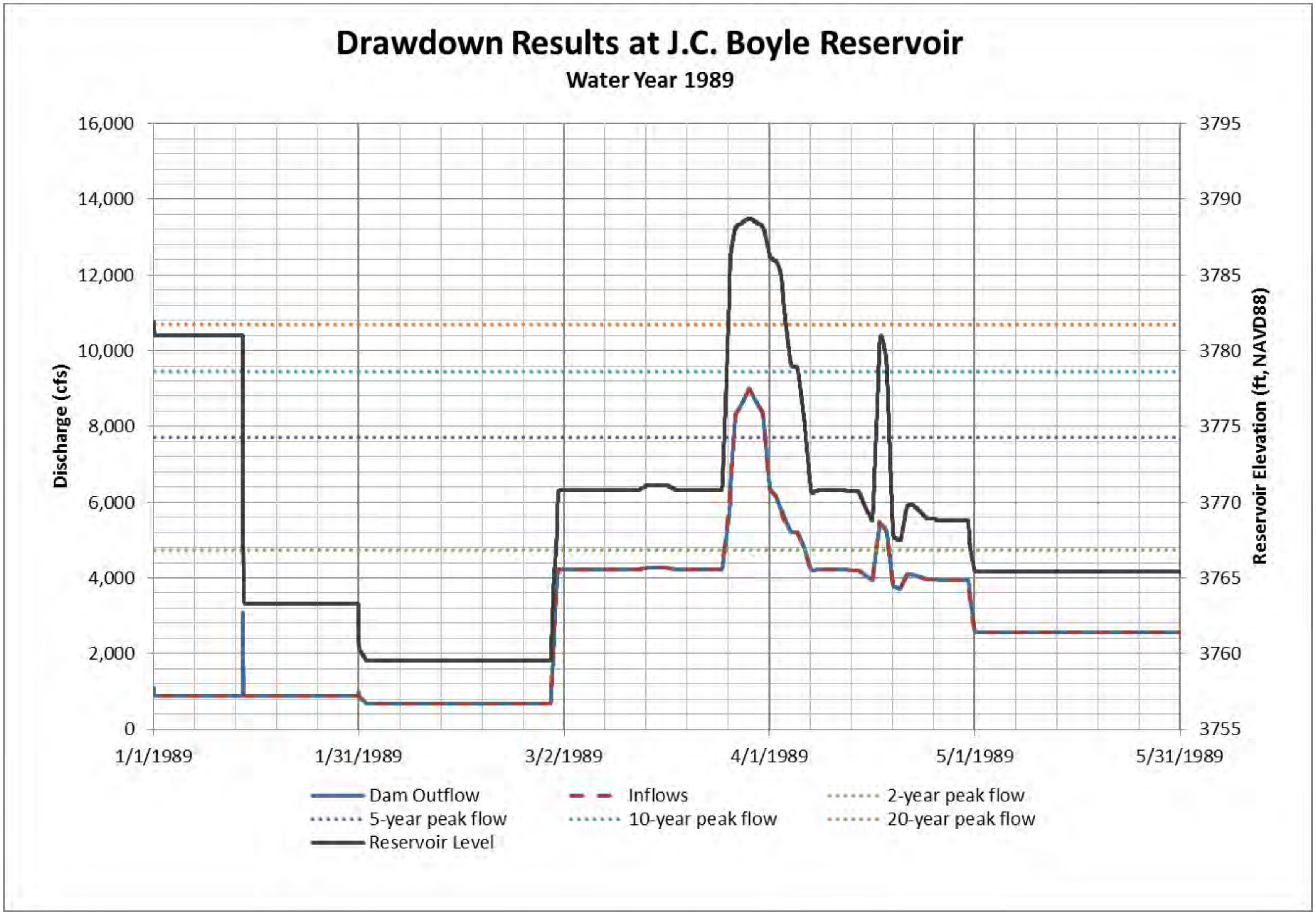



**Figure F2-29 J.C. Boyle Reservoir Drawdown, Water Year 1989**

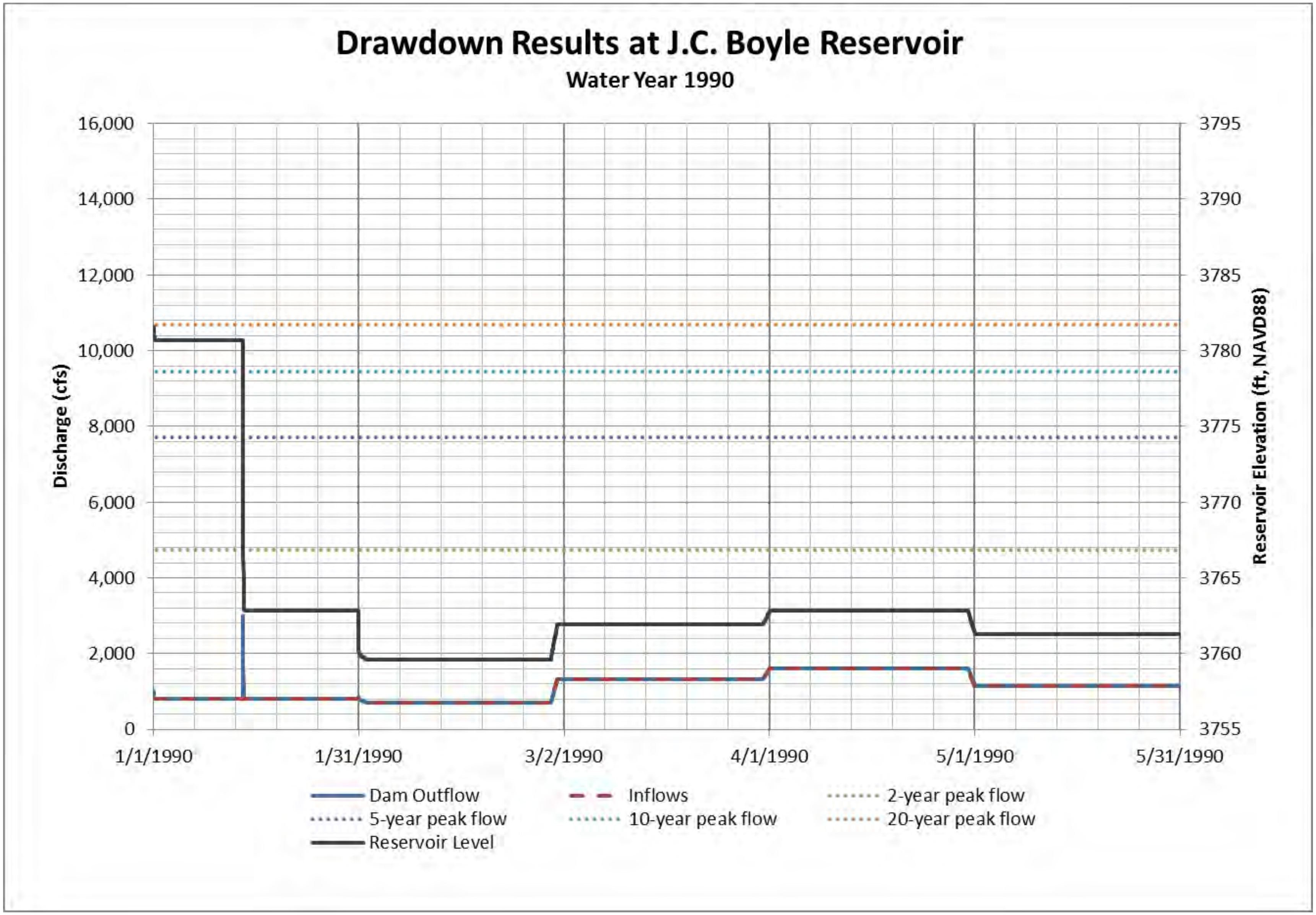



Figure F2-30 J.C. Boyle Reservoir Drawdown, Water Year 1990

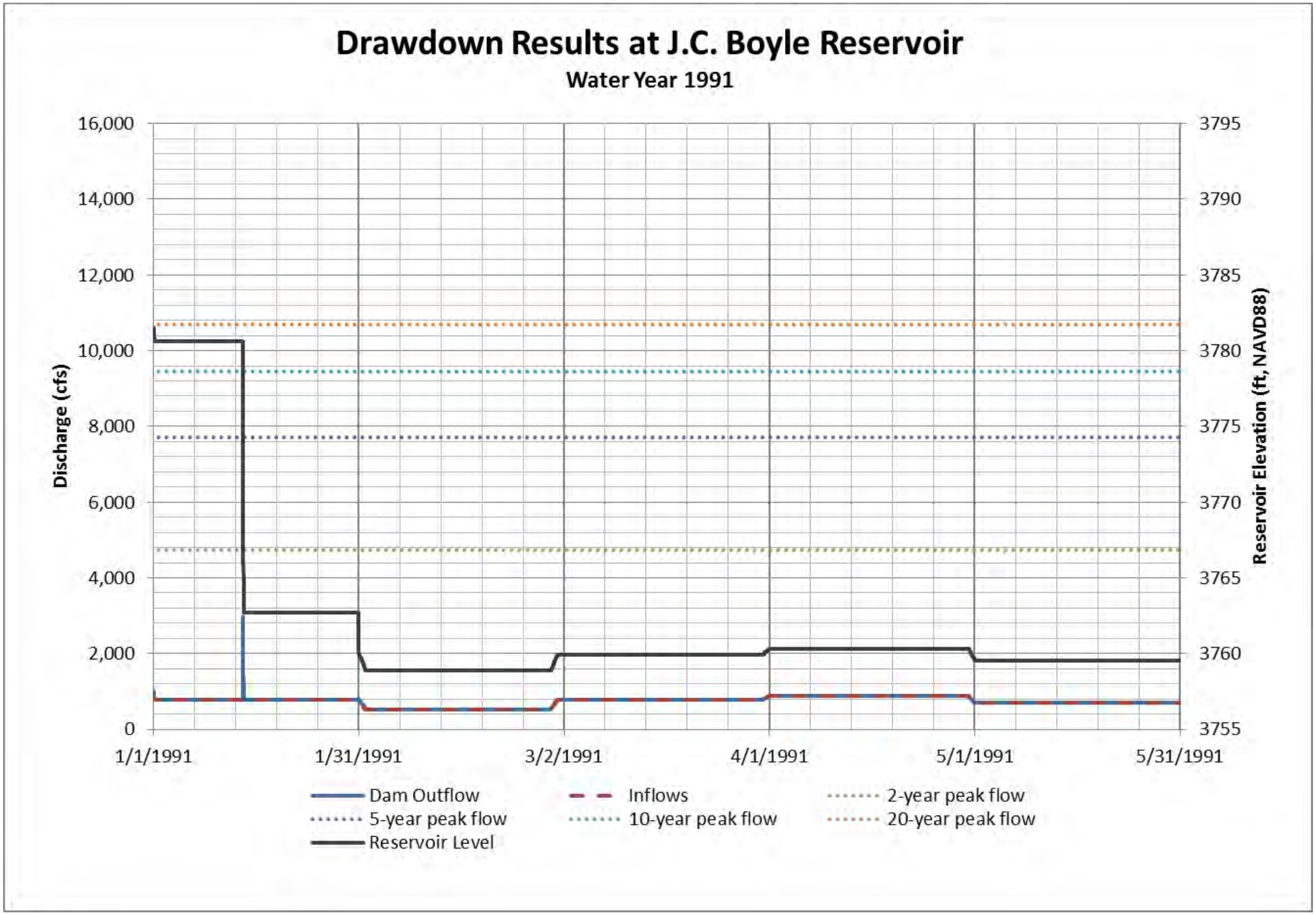



**Figure F2-31 J.C. Boyle Reservoir Drawdown, Water Year 1991**

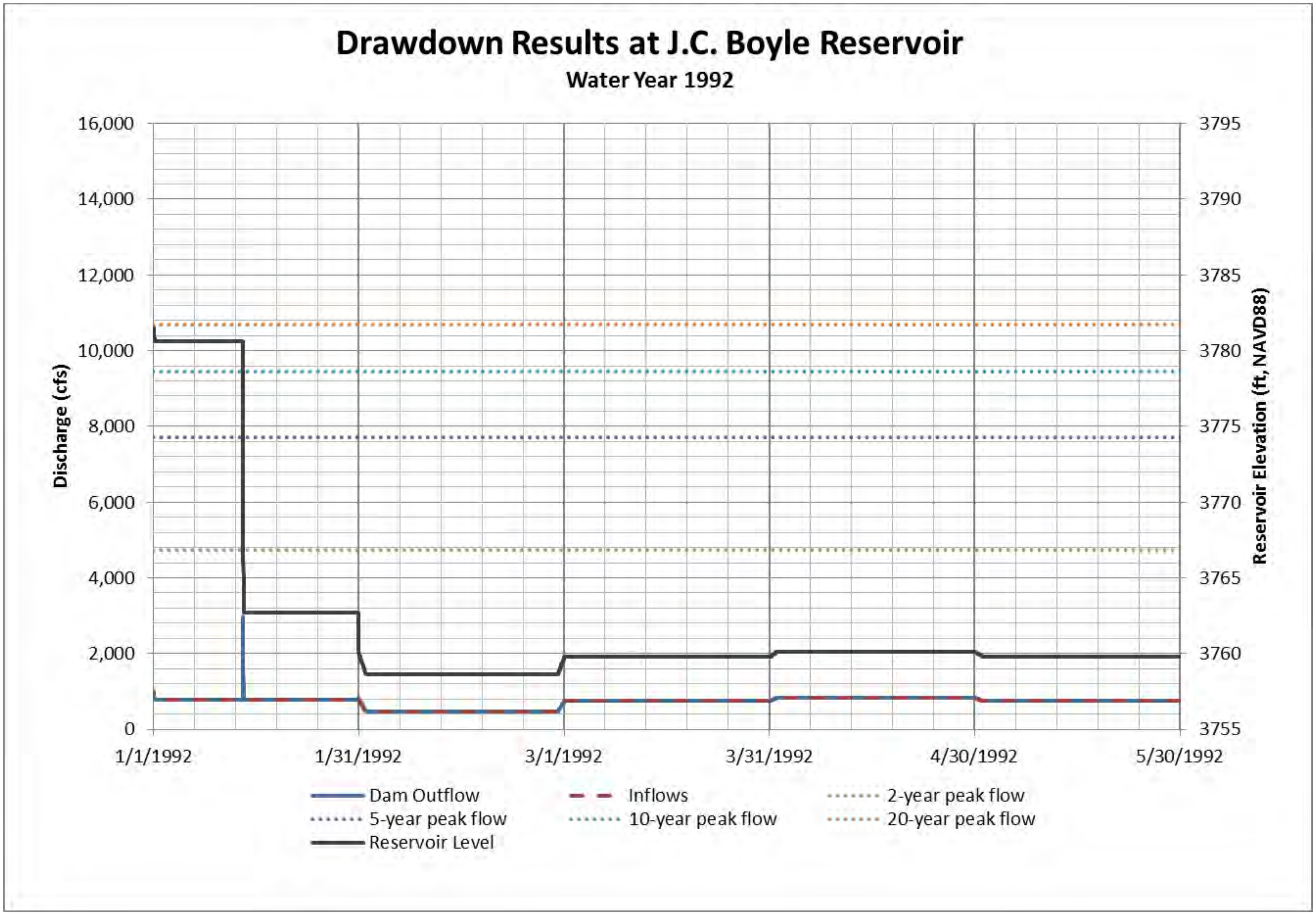



**Figure F2-32 J.C. Boyle Reservoir Drawdown, Water Year 1992**

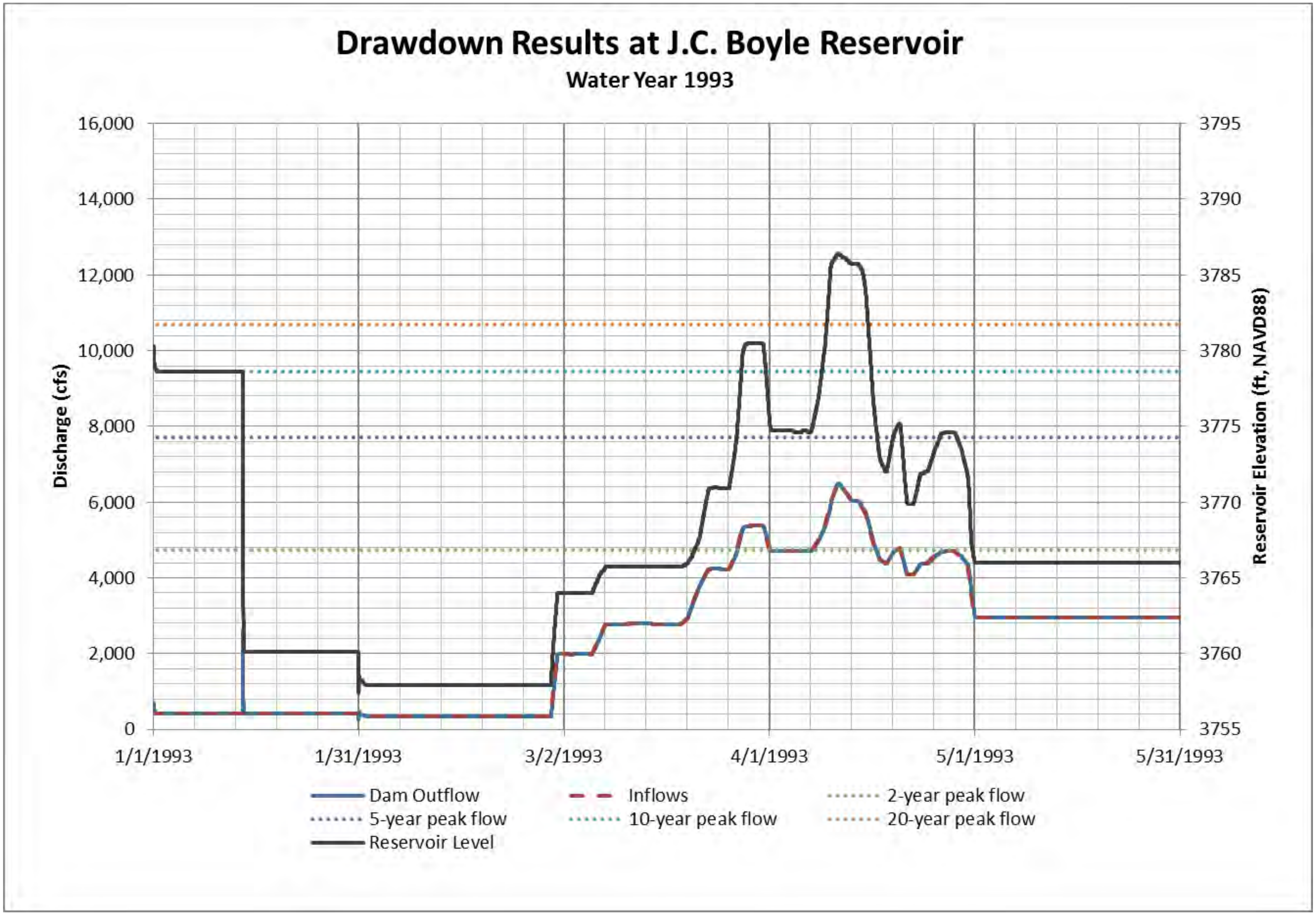



Figure F2-33 J.C. Boyle Reservoir Drawdown, Water Year 1993

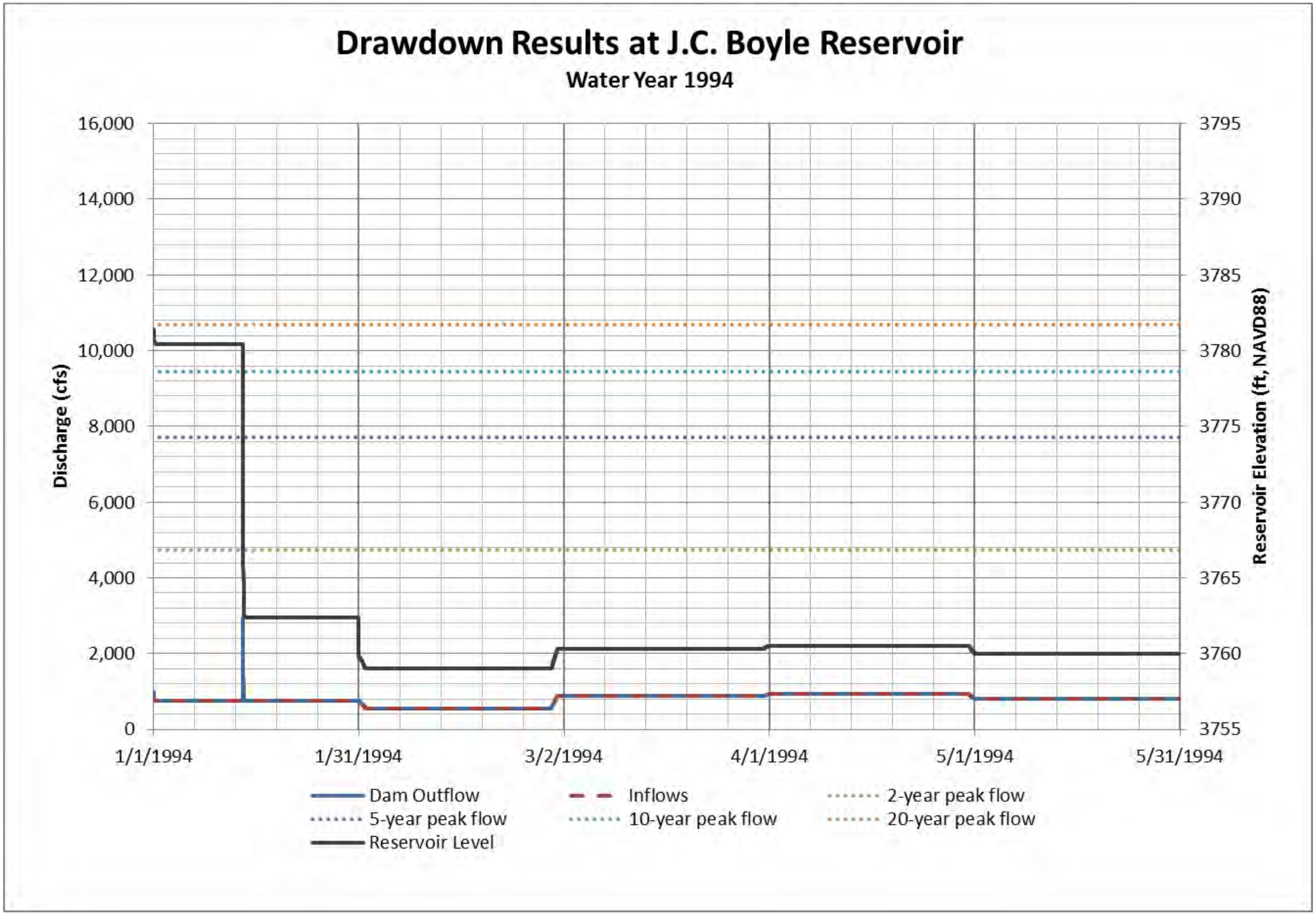



**Figure F2-34 J.C. Boyle Reservoir Drawdown, Water Year 1994**

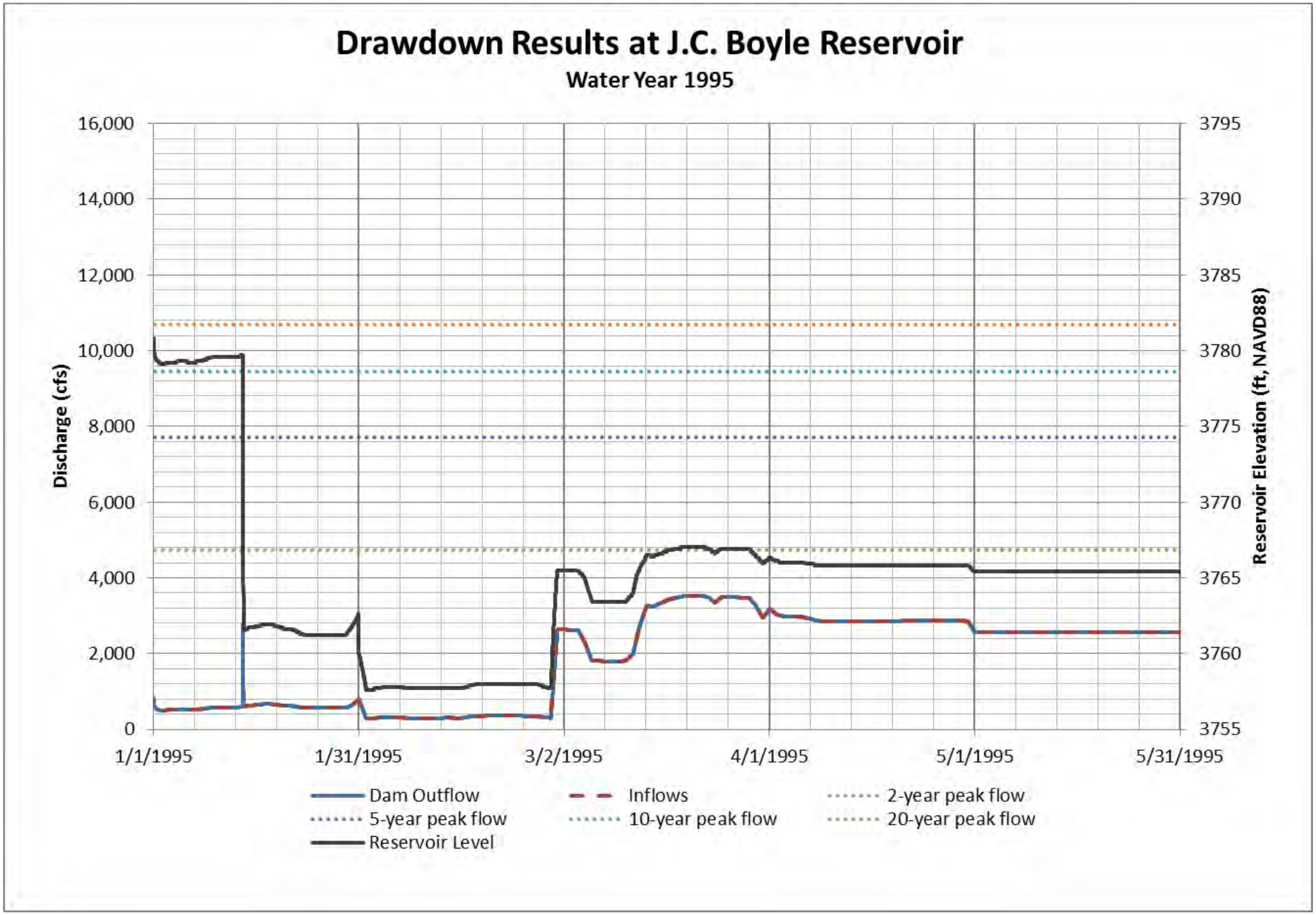



Figure F2-35 J.C. Boyle Reservoir Drawdown, Water Year 1995

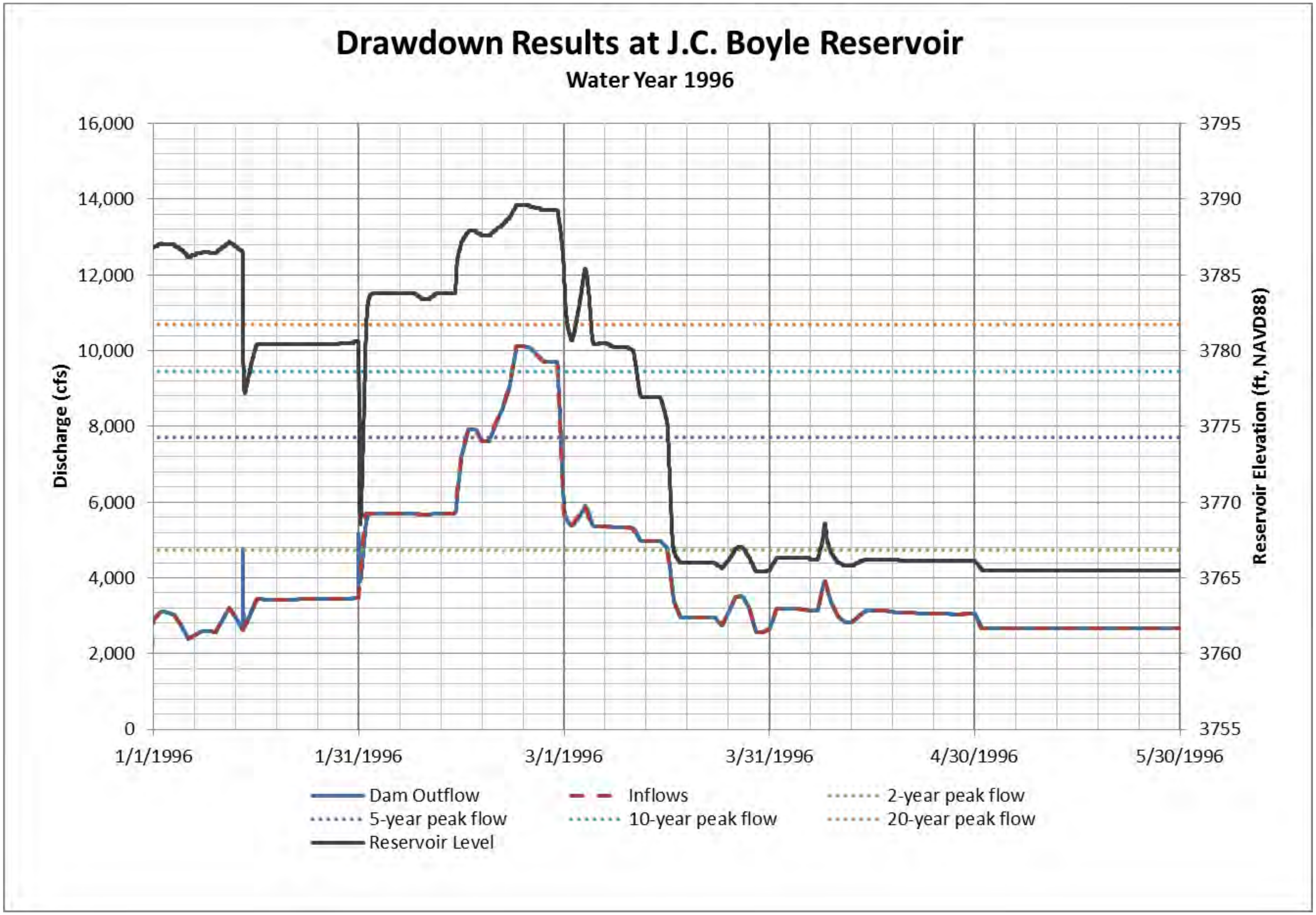



**Figure F2-36 J.C. Boyle Reservoir Drawdown, Water Year 1996**

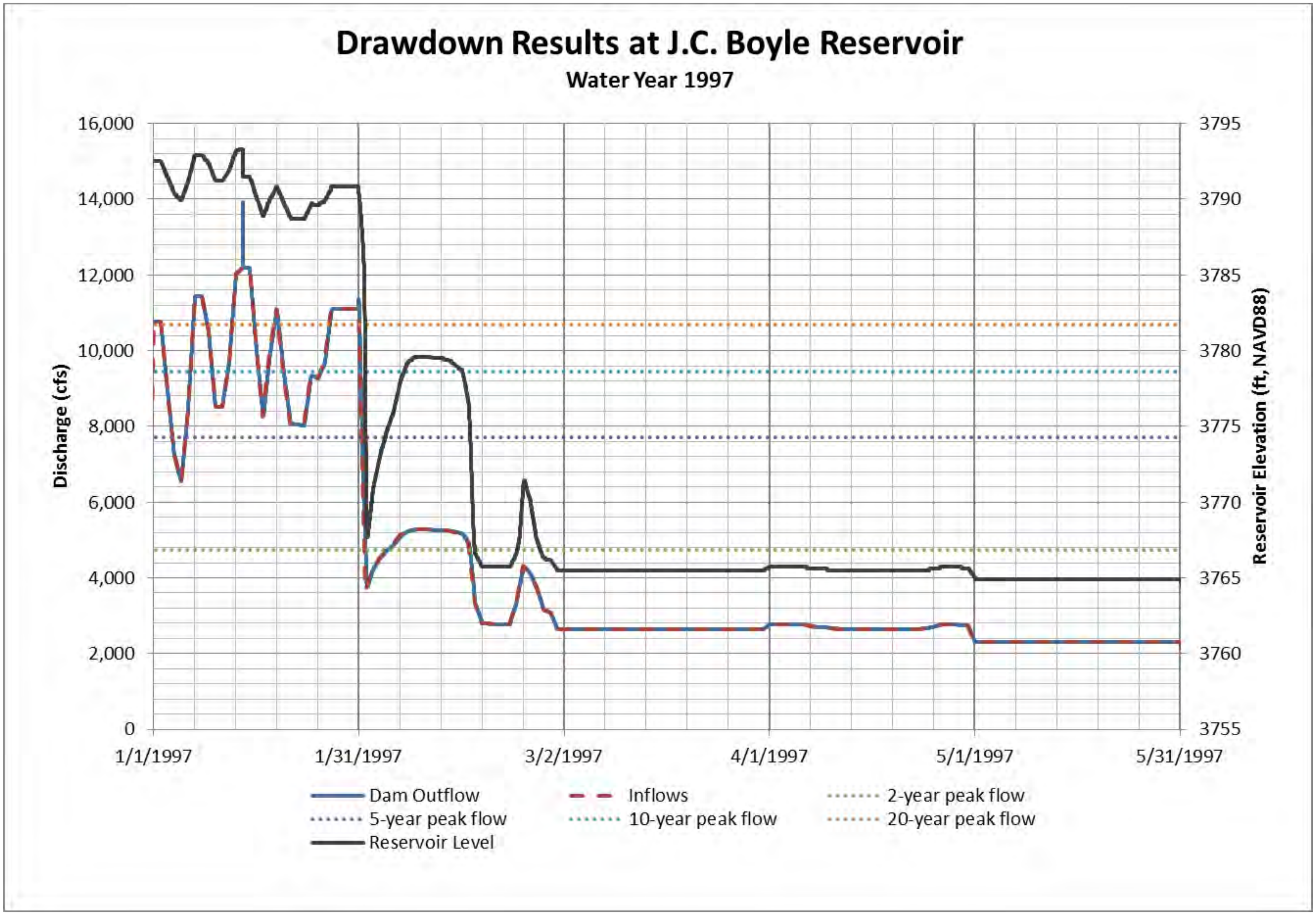



**Figure F2-37 J.C. Boyle Reservoir Drawdown, Water Year 1997**

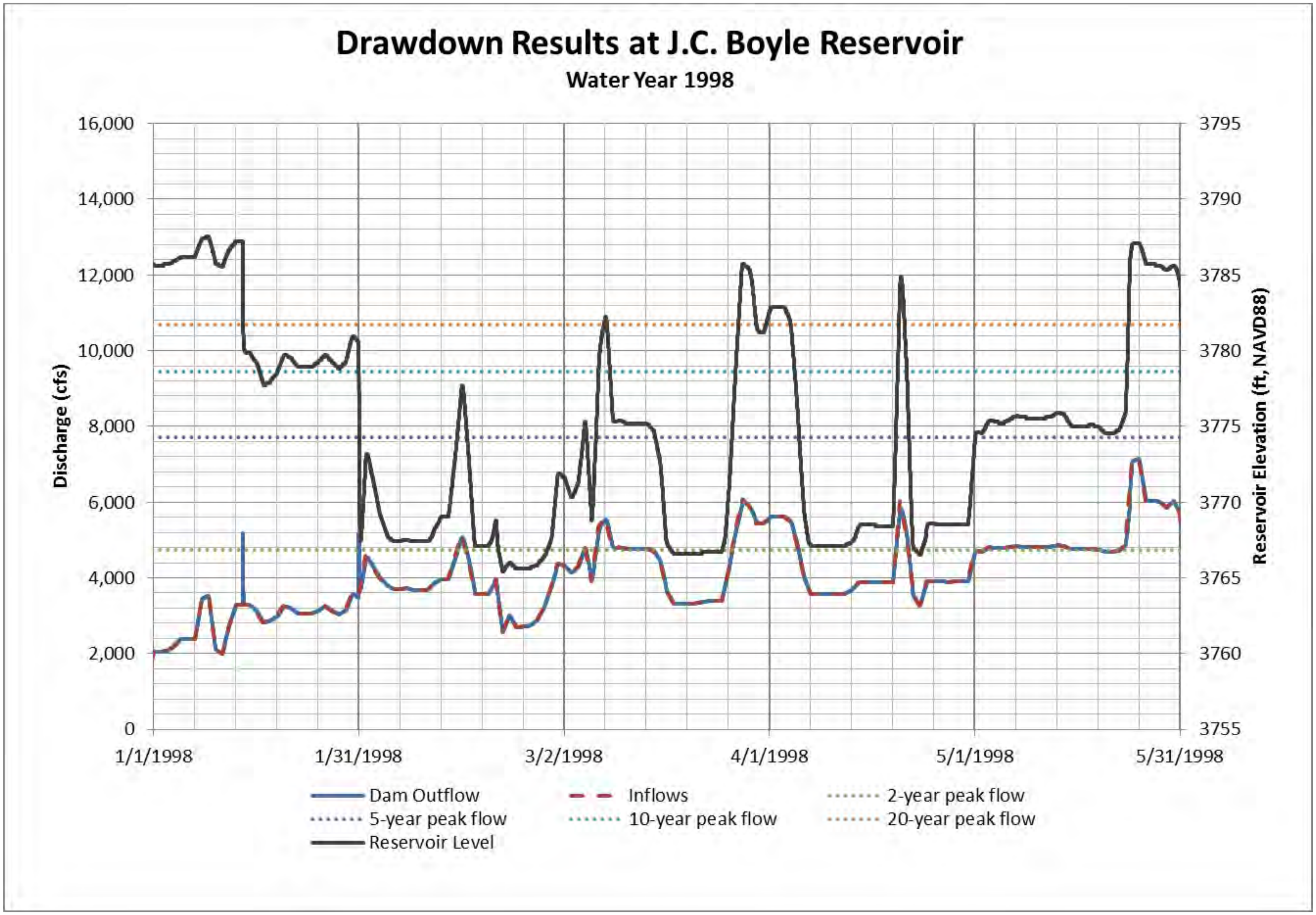



Figure F2-38 J.C. Boyle Reservoir Drawdown, Water Year 1998

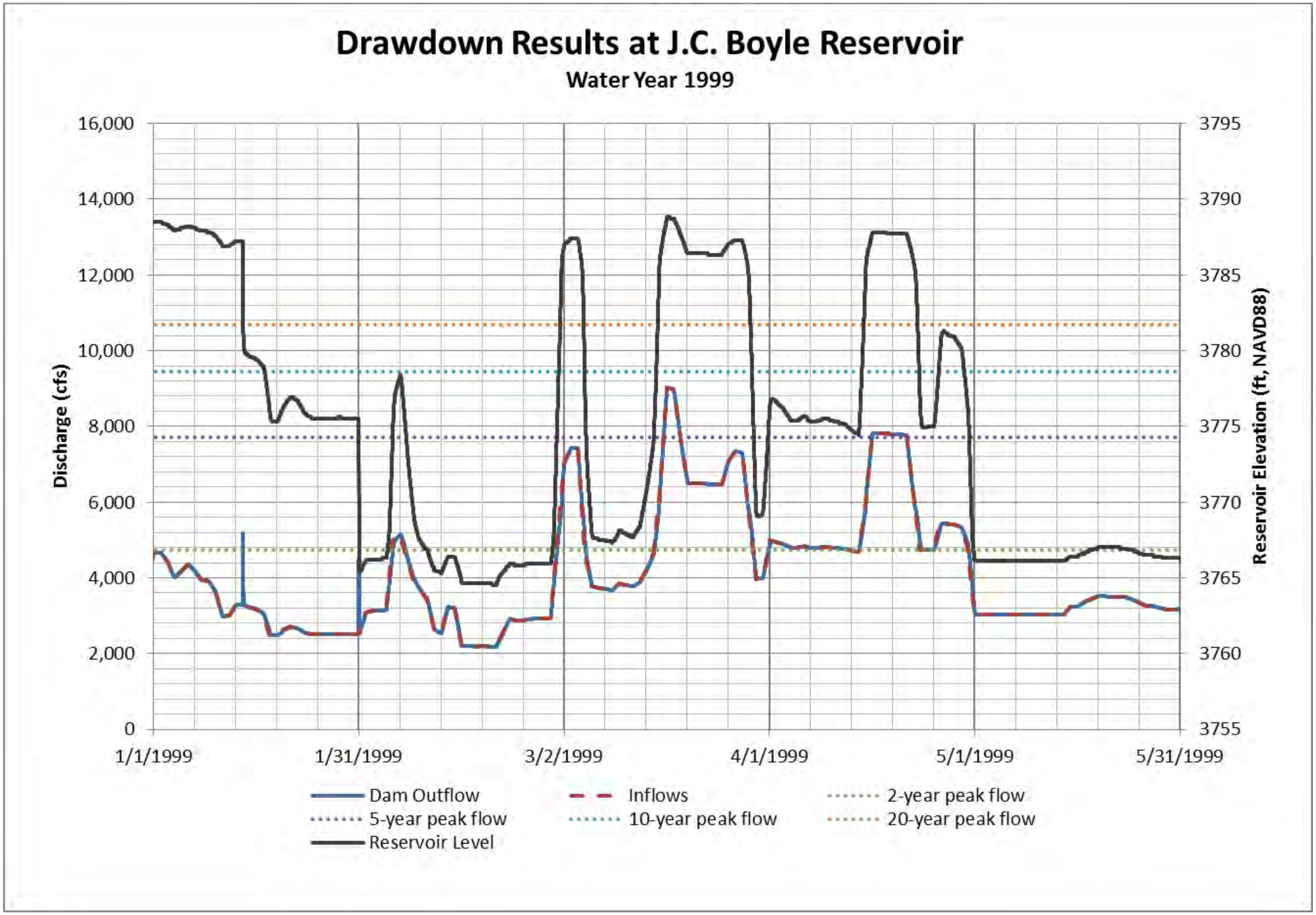



**Figure F2-39 J.C. Boyle Reservoir Drawdown, Water Year 1999**

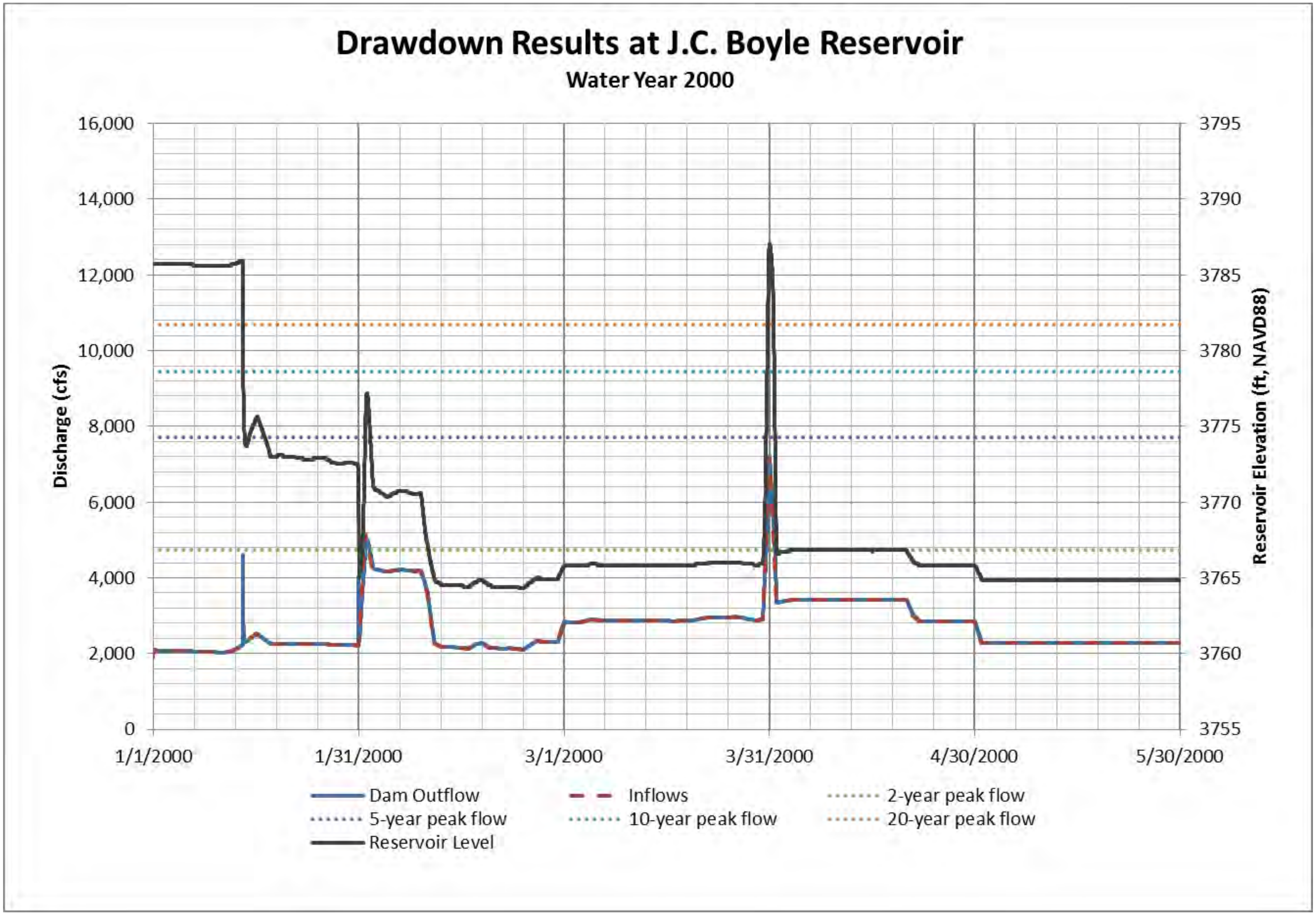



**Figure F2-40 J.C. Boyle Reservoir Drawdown, Water Year 2000**

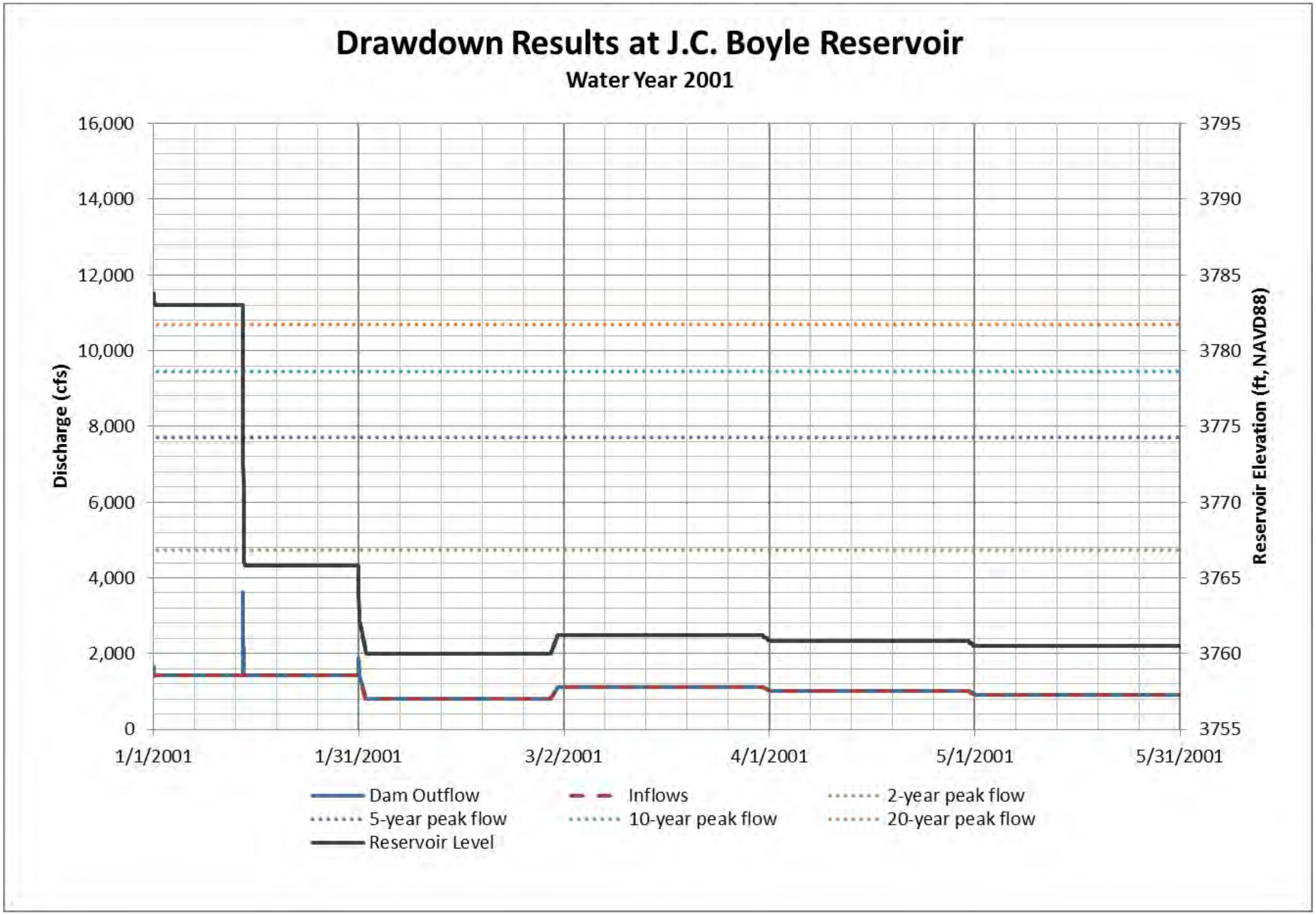



**Figure F2-41 J.C. Boyle Reservoir Drawdown, Water Year 2001**

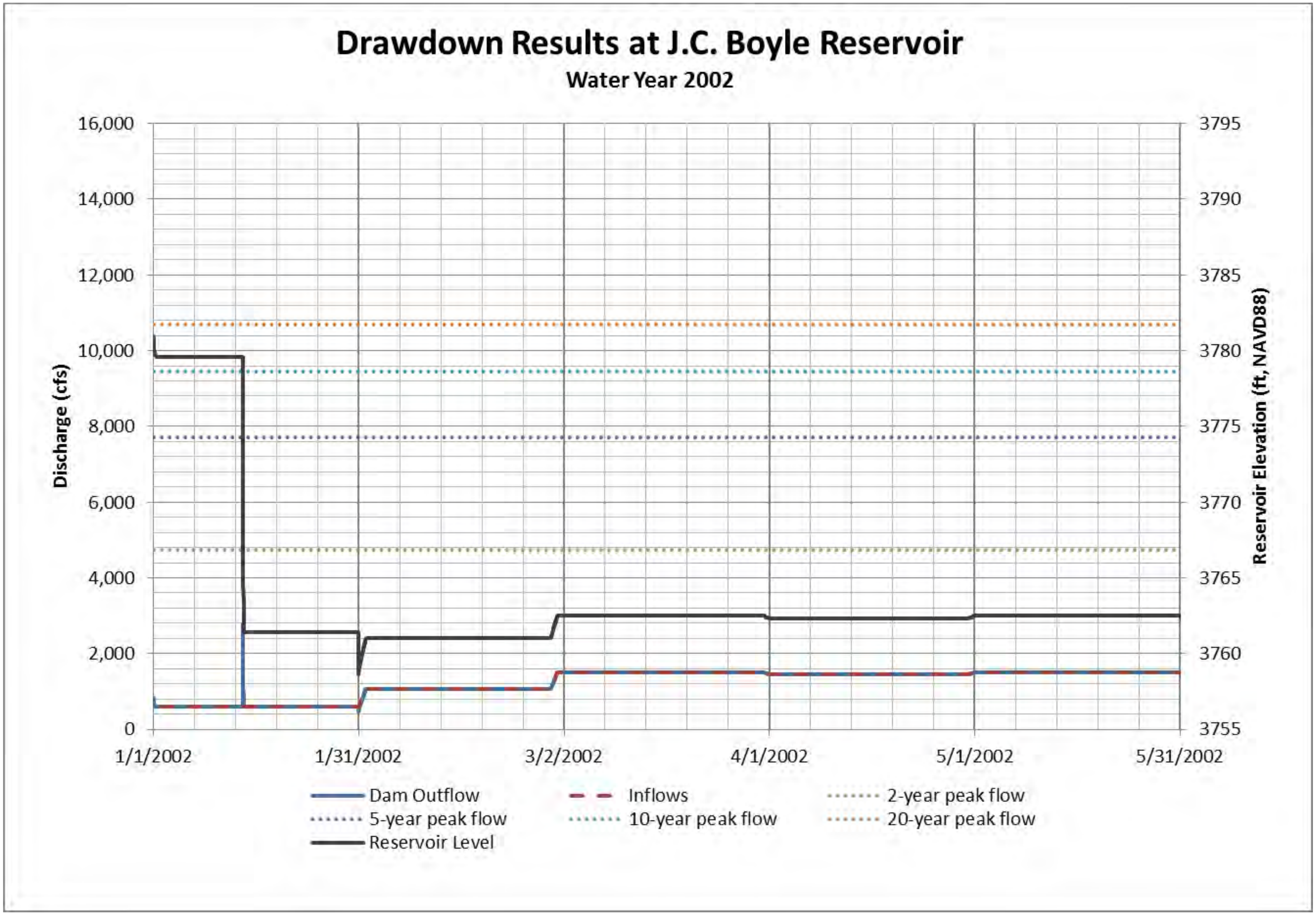



**Figure F2-42 J.C. Boyle Reservoir Drawdown, Water Year 2002**

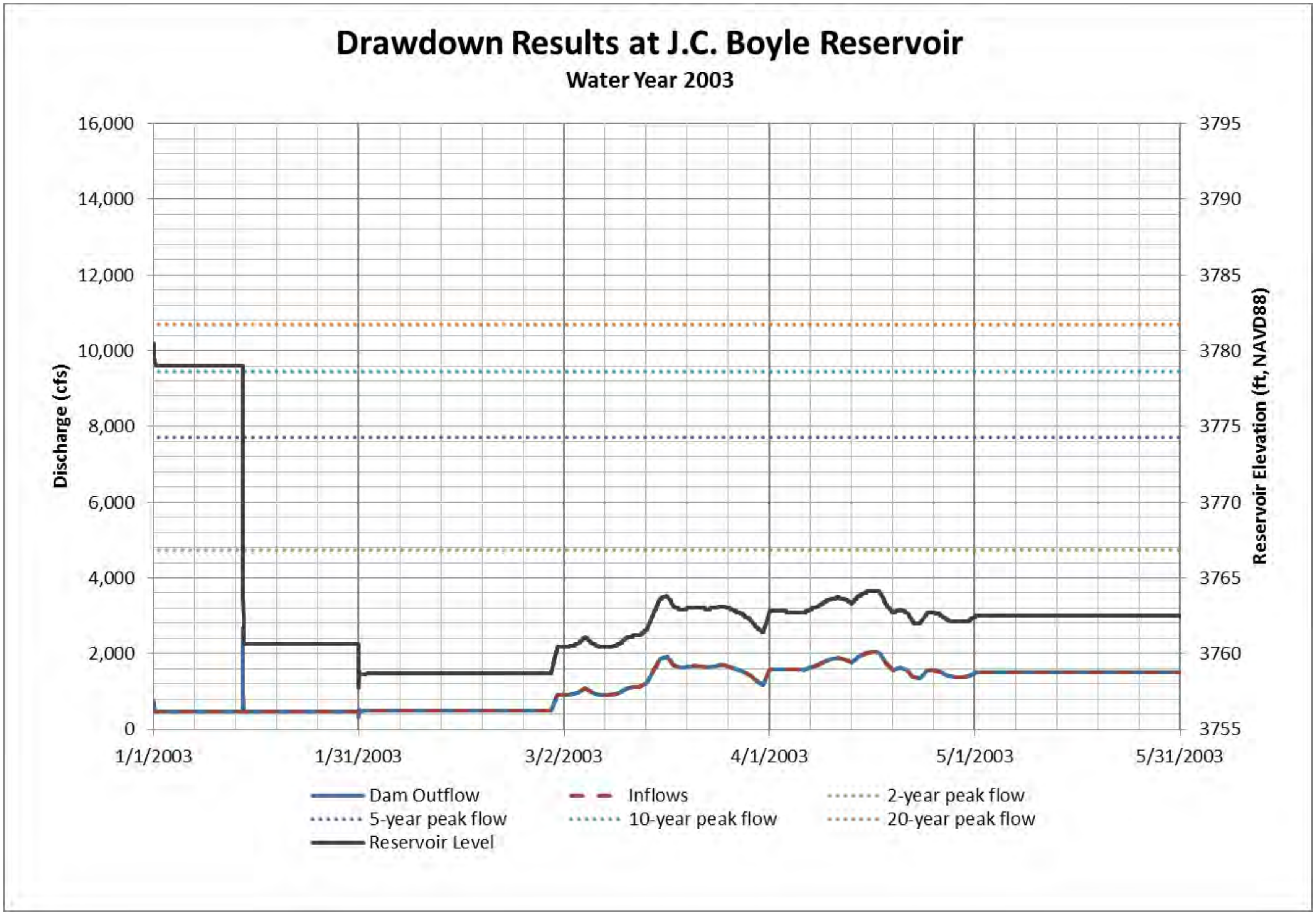



**Figure F2-43 J.C. Boyle Reservoir Drawdown, Water Year 2003**

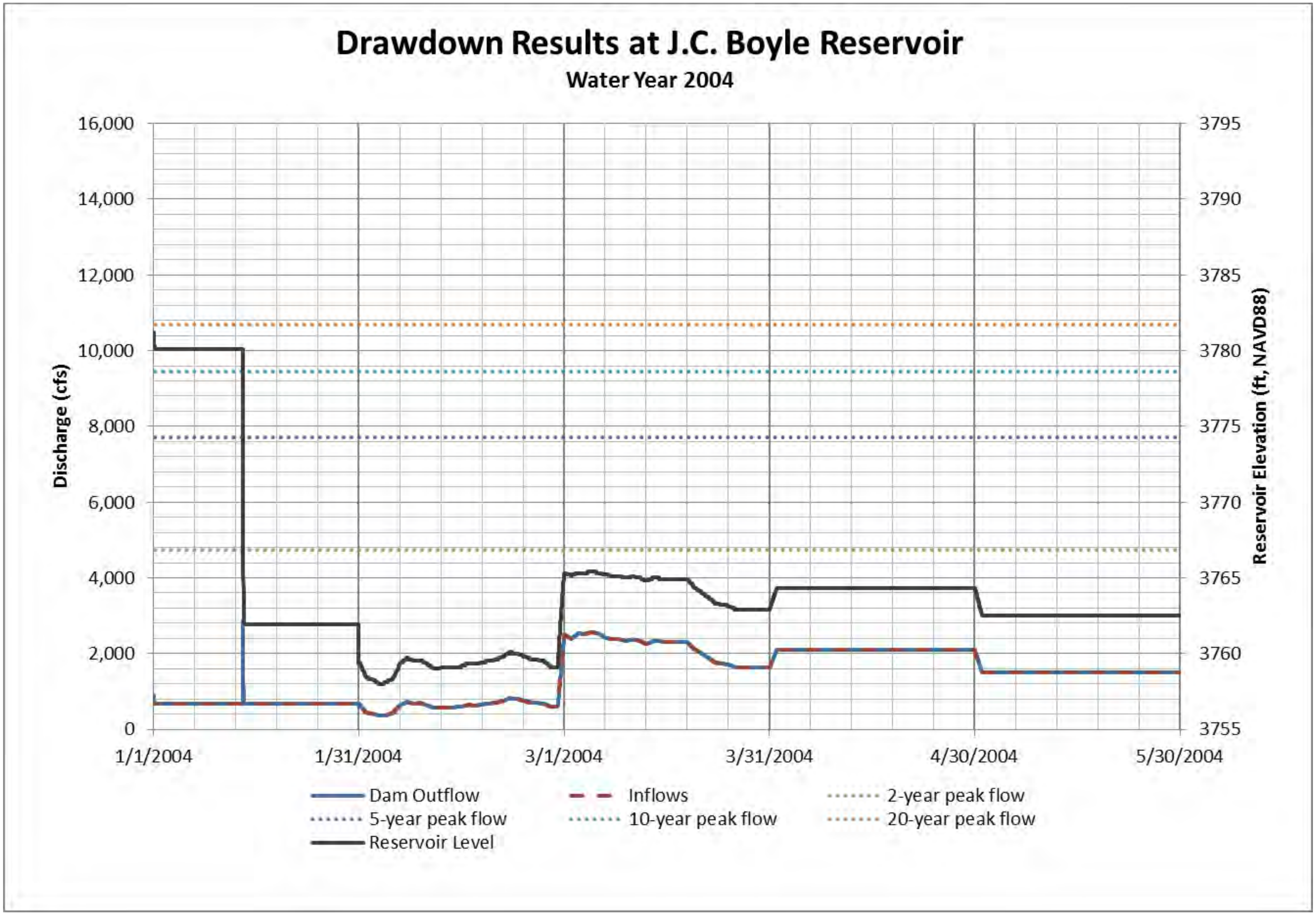



**Figure F2-44 J.C. Boyle Reservoir Drawdown, Water Year 2004**

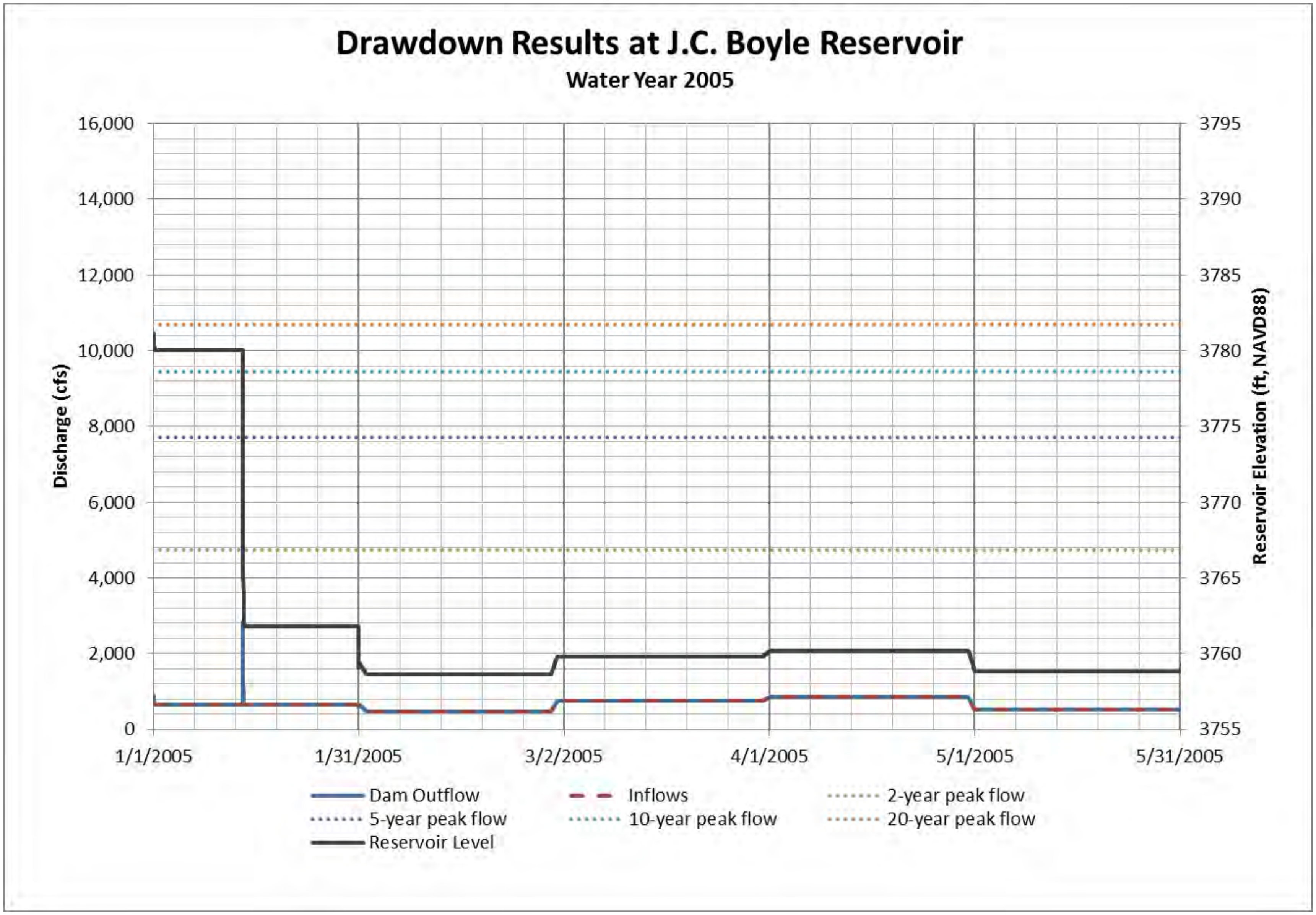



**Figure F2-45 J.C. Boyle Reservoir Drawdown, Water Year 2005**

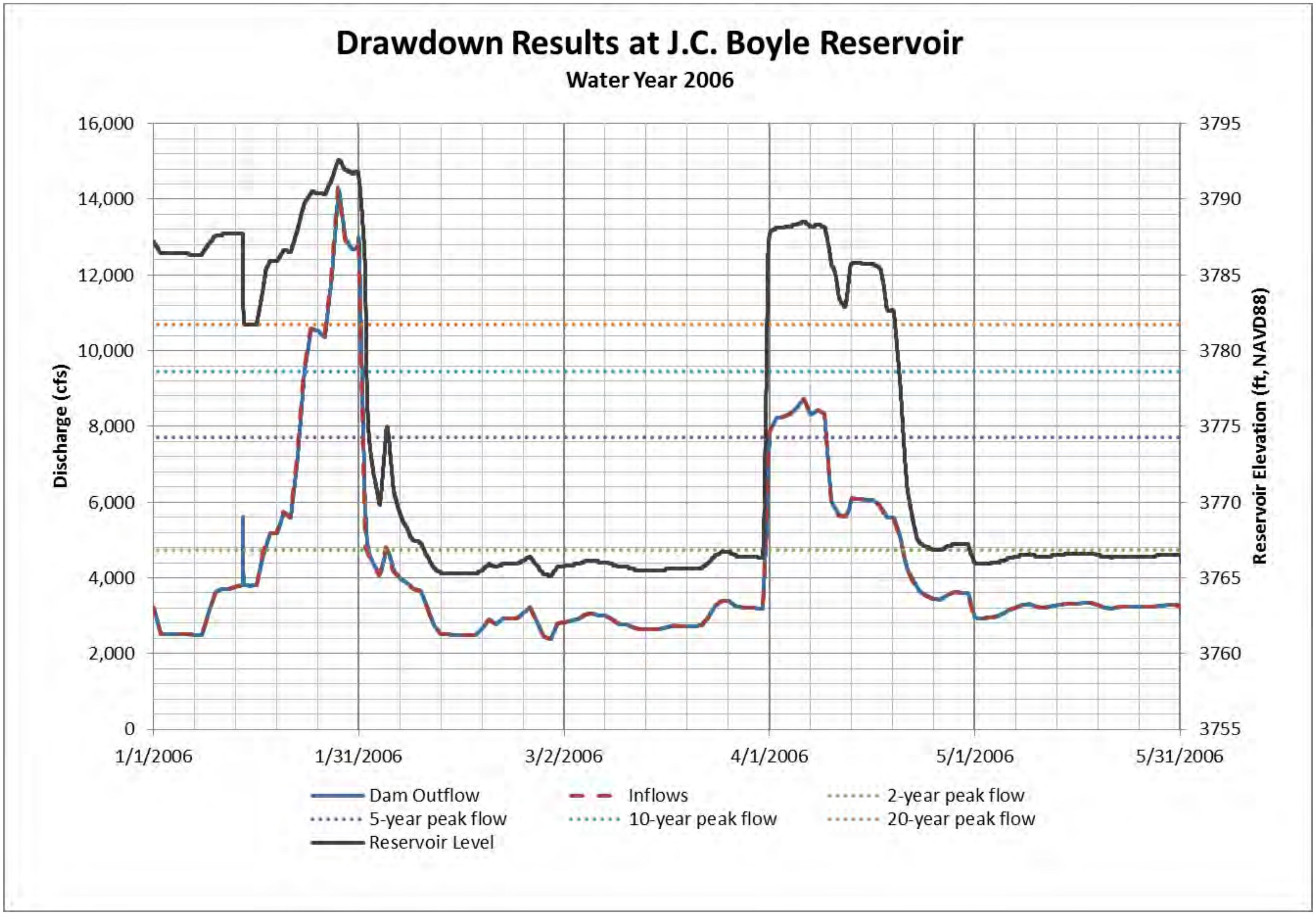
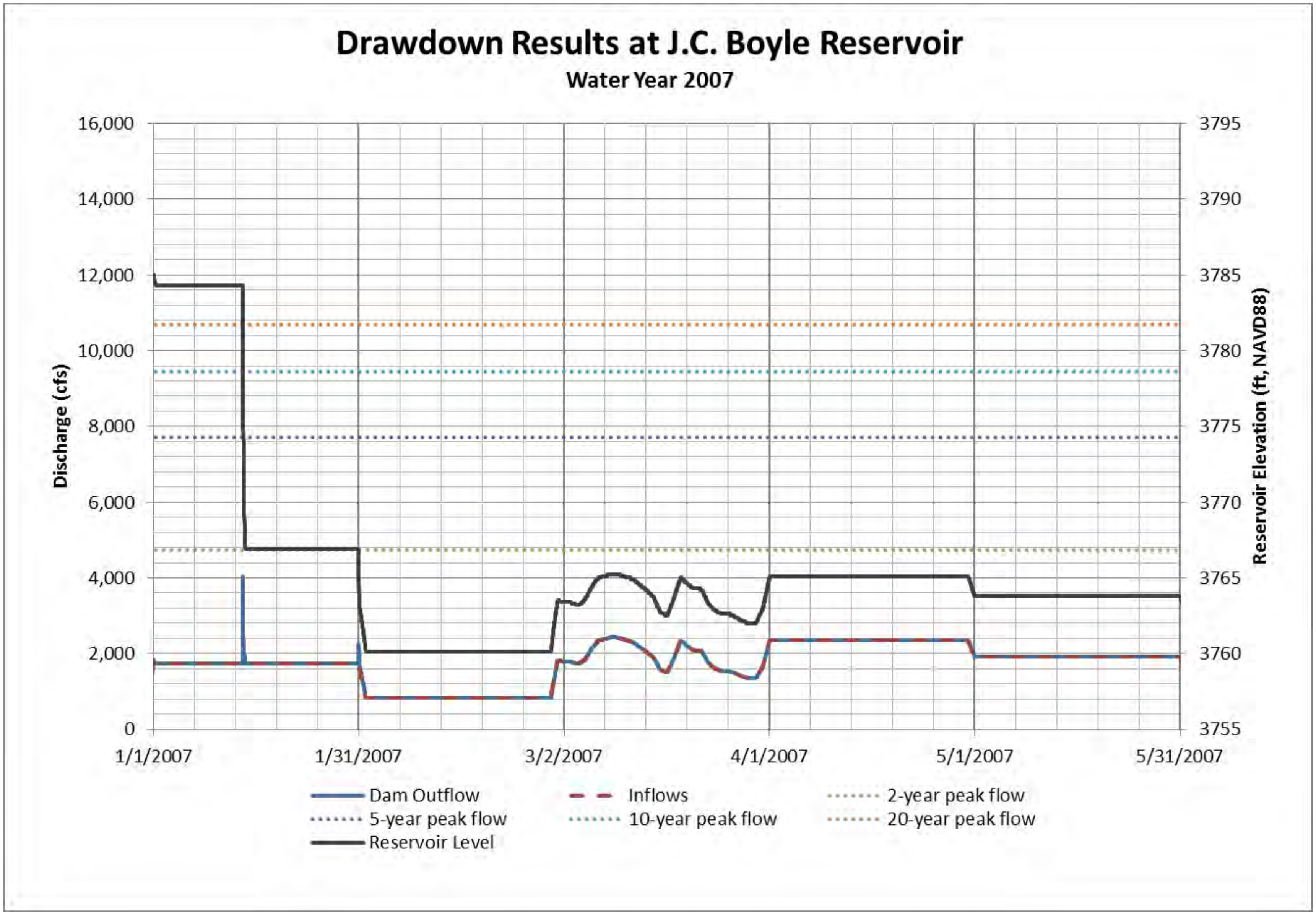



**Figure F2-46 J.C. Boyle Reservoir Drawdown, Water Year 2006 (Wet Year)**




## Figure F2-47 J.C. Boyle Reservoir Drawdown, Water Year 2007

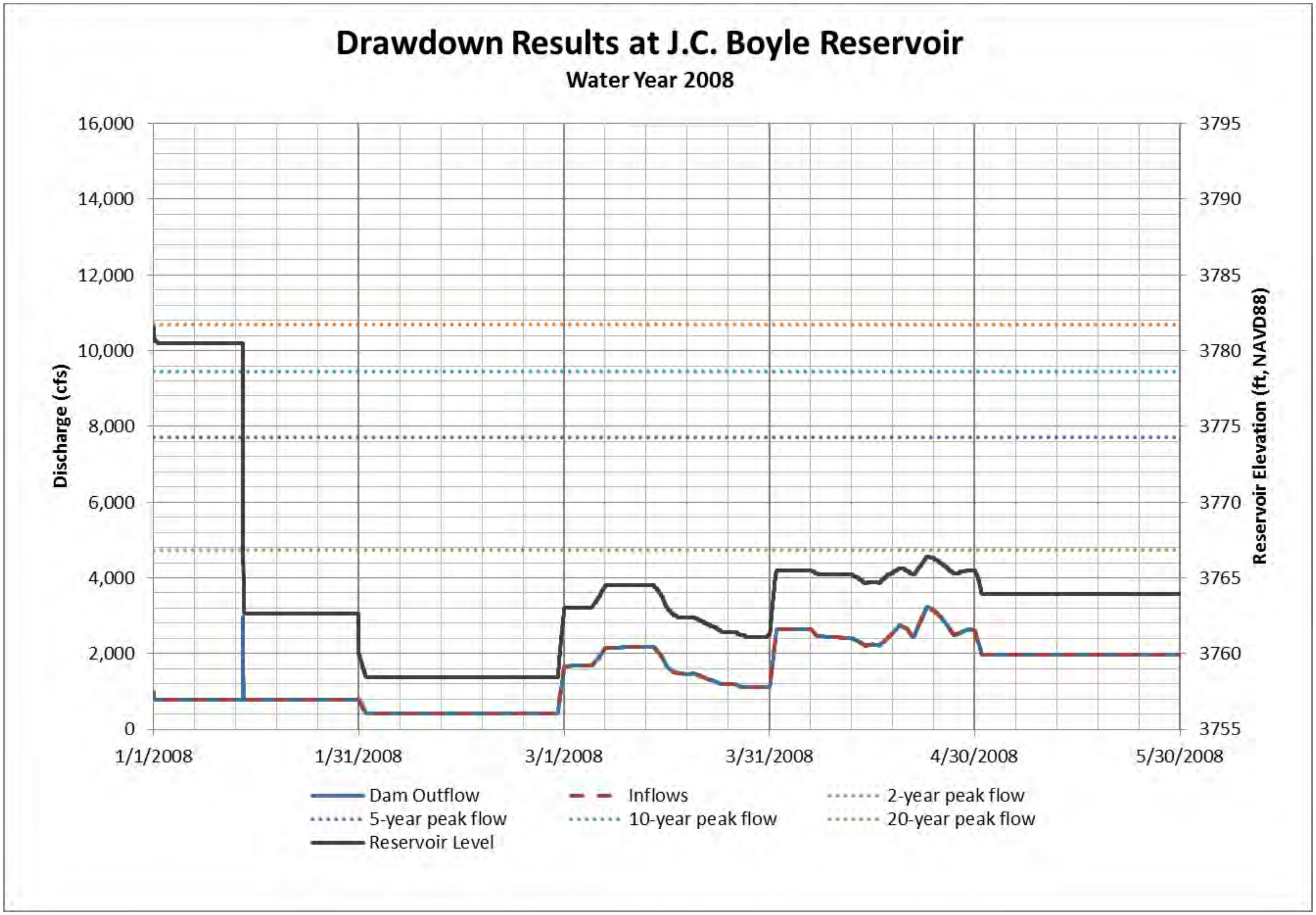



**Figure F2-48 J.C. Boyle Reservoir Drawdown, Water Year 2008**

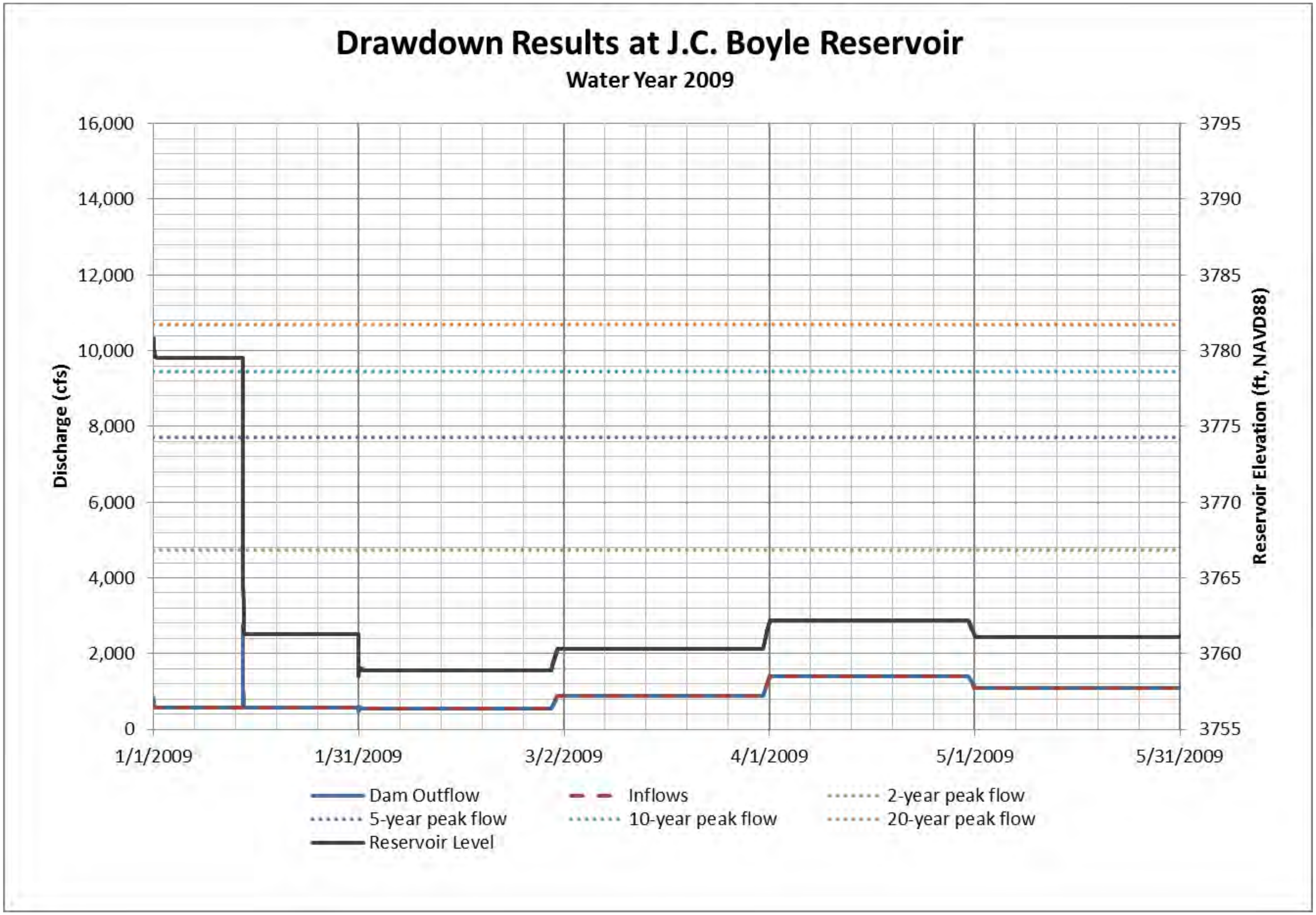



**Figure F2-49 J.C. Boyle Reservoir Drawdown, Water Year 2009**

# F3. Copco 1 Reservoir

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

### Option 1 – Diversion Tunnel Modified to Restore Capacity and Dam Notching:

The drawdown procedure at Copco Lake for Option 1 is summarized below:

1. For modeling purposes, it was assumed that by January 1 (the start of the simulation), following the two-month initial drawdown period beginning November 1, the water level would be 3.5 feet below the spillway crest.
2. The three 6-foot gates on the diversion tunnel were assumed to be open at the start of the simulation.
3. Until completion of the last notch, it was assumed that the 6-foot gates would be closed down to limit the maximum rate of drawdown to 5 feet per day. Once the last notch was complete, it was assumed that the 6-foot gates would be left open.
4. In order to fully draw down the reservoir, the concrete dam was notched with a series of 13 notches: an initial 24.5-foot notch, followed by 11 18-foot deep notches (measured from lowered dam crest to notch elevation; sequentially lowering the notches in 6 foot increments), then a final notch of 22 feet down to the channel bed elevation. The dam crest was lowered in 6 foot lifts as the notching progressed. The bottom width of all notches was 8 feet. The elevation of the first notch was at 2572.5 feet. The elevation of the final notch was at elevation 2484.5 (regardless of water year) with the lowered dam crest at elevation 2518.5.
5. To simplify the model, it was assumed that the dam crest would be lowered at the same time as the completion of the notch. Construction of the notch did not begin until the water level dropped to the level of where the dam crest would be once the lowering was complete (18 feet above the notch elevation). It was assumed that the lowered crest would need to be above the water level for construction to continue. The minimum time needed before starting the next notch was assumed to be 5 days. This would allow for completion of 13 notches by March 1, assuming construction was not delayed.
6. Maximum additional discharge downstream of the dam due to drawdown activities is about 7,700 cfs with about 2,800 cfs through the notch (assuming an 18-foot-deep notch with a bottom width of 8 feet adjacent to the 2 previous notches 12 feet and 6 feet deep) and the rest through the diversion tunnel. The additional flow due to drawdown decreases as the reservoir level drops in the notch. For reference, the 10-year, 20-year, 50-year, and 100-year flow events downstream of Copco No. 1 are about 11,300 cfs, 13,500 cfs, 16,560 cfs, and 18,950 cfs, respectively.

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

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

1. For modeling purposes, it was assumed that by January 1 (the start of the simulation), following the two-month initial drawdown period beginning November 1, the water level would be 3.5 feet below the spillway crest.
2. It was assumed that the large 16- by 18-foot gate on the diversion tunnel would not be opened until January 15 to allow for drawdown of Iron Gate reservoir prior to making additional releases from Copco Lake. The only releases from Copco Lake between January 1 and January 15 would be over the spillway.
3. On January 15 of the drawdown year, the gate on the diversion tunnel would be opened.
4. It was assumed that the diversion tunnel gate would be closed down to limit the maximum rate of drawdown to 5 feet per day. Once the reservoir level reached the top of the diversion tunnel gate, it was assumed that the drawdown rate would no longer be limited.
5. Maximum additional discharge downstream of the dam due to drawdown activities is about 6,000 cfs when the gate is opened on January 15. During other times the increase is generally 1,000 to 2,000 cfs. The total discharge capacity of the new gate structure with the reservoir at the spillway crest elevation 2597.0 feet is about 16,000 cfs, but would be limited to 13,000 cfs to not cause high water levels that would impact power production at Copco No. 2 powerhouse.
6. For reference, the 10-year, 20-year, 50-year, and 100-year flow events downstream of Copco No. 1 are 11,300 cfs, 13,500 cfs, 16,560 cfs, and 18,950 cfs, respectively.

### Results

Figures F3-2 through F3-50 show the drawdown results for Copco No. 1 for both drawdown options.

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

As discussed above construction of a notch did not begin until the water surface elevation was at the elevation of the next notch crest (18 feet above the current notch invert). The next notch could be started at a higher elevation (for example, 1 foot below the notch crest being constructed). However, if a higher water surface elevation was used the notch crest could not be lowered 6 feet unless the water surface elevation dropped. Figure F3-1 shows the length of time the first and last notch were delayed because the water level was too high. There is a 30 percent chance that the last notch would be delayed at least one week and a 10 percent chance that it would be delayed 7 weeks or more. The delay is usually caused by storms that occur after most of the notches have been constructed and result in an overtopping of the notch crest.

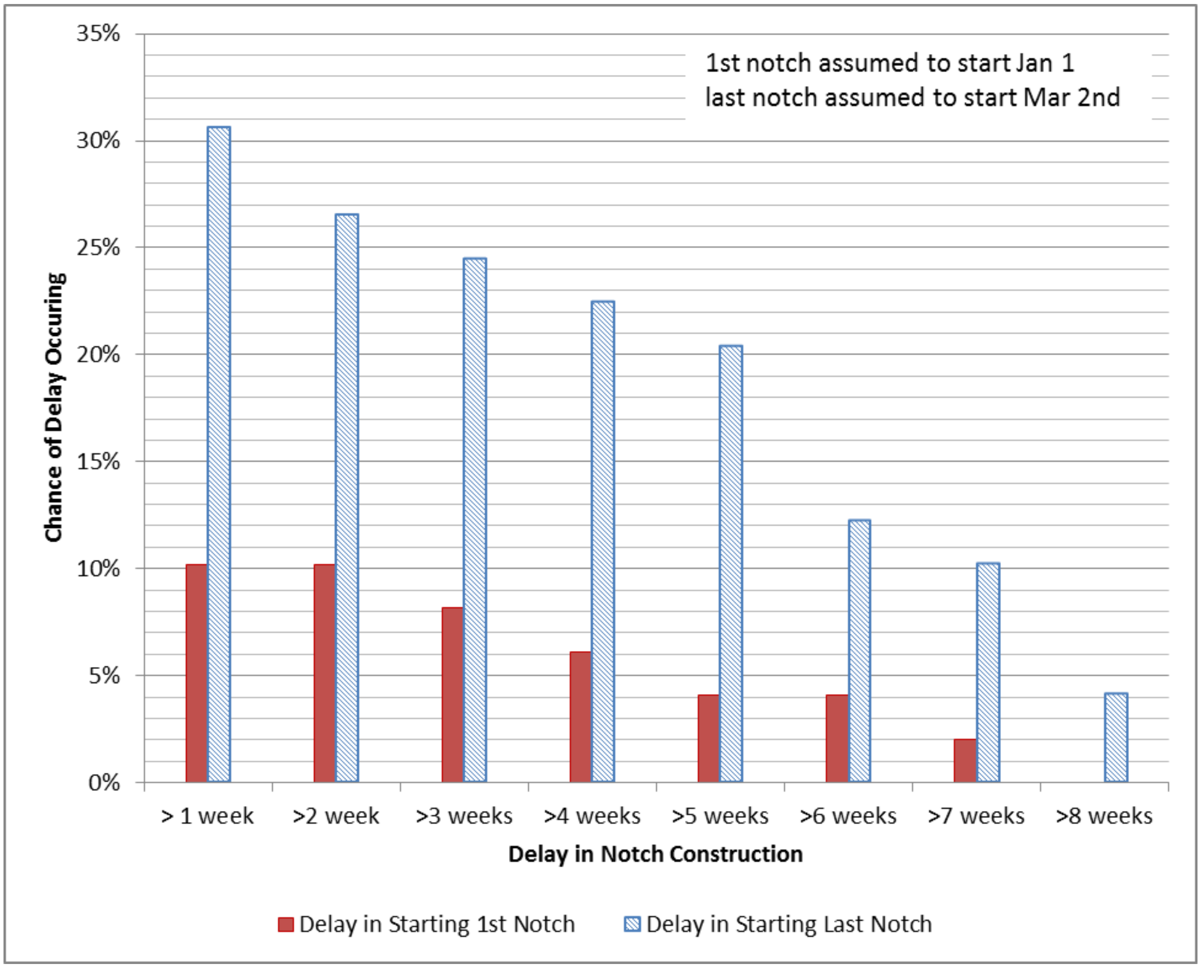



**Figure F3-1. Graph Showing the Chance of a Delay in the Construction of the First and Last Notches in Copco No. 1 Dam**

During representative dry years (e.g., 1973 and 1979), the reservoir was easily drawn down before March 1, and does not refill after that point.

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

Also during the wetter years, flows are higher than what would be expected via the spillway alone (i.e., without drawdown), but the increases are limited to those periods when flows are below the 10-year flood elevation.

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

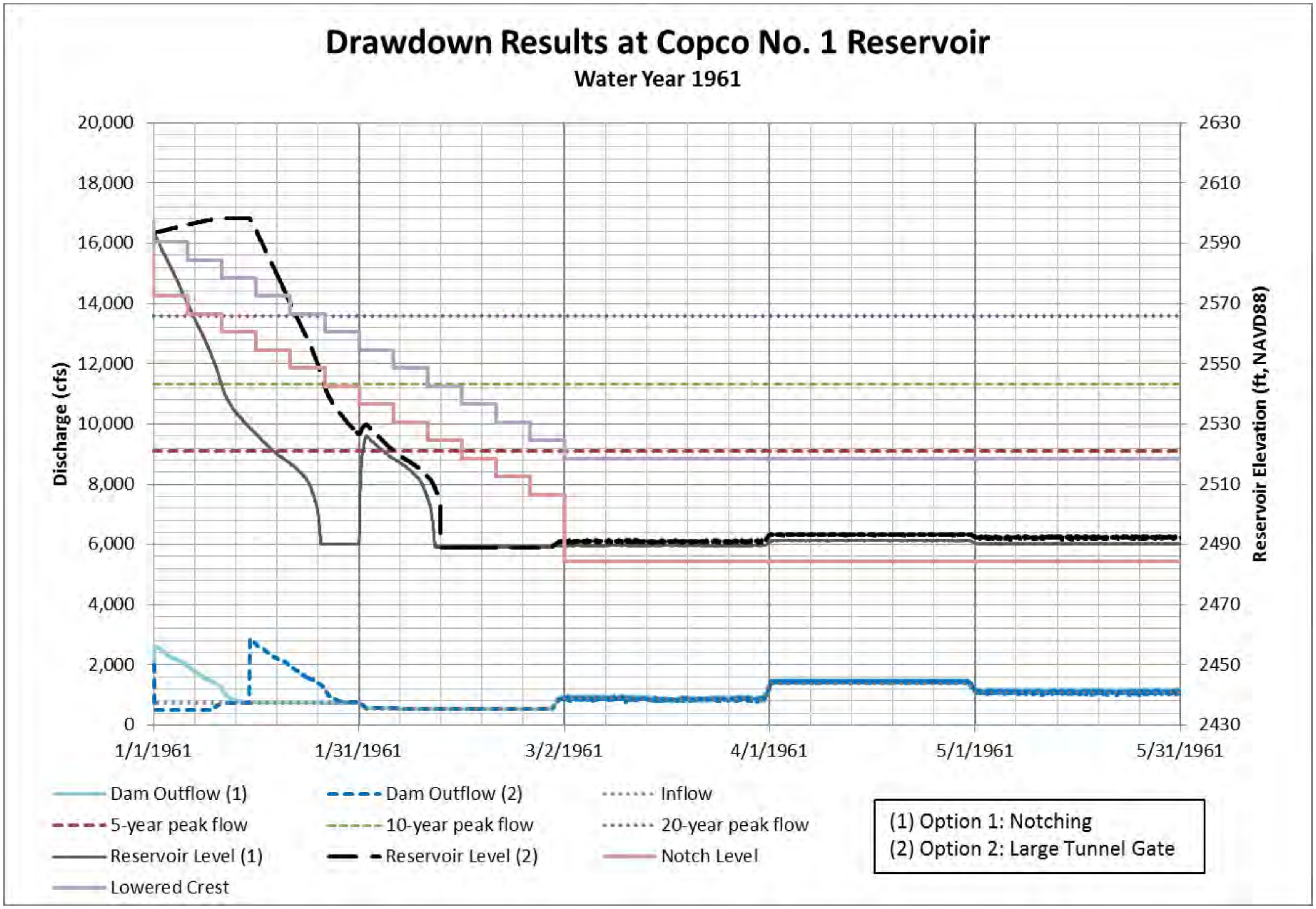



**Figure F3-2 Copco No. 1 Reservoir Drawdown, Water Year 1961**

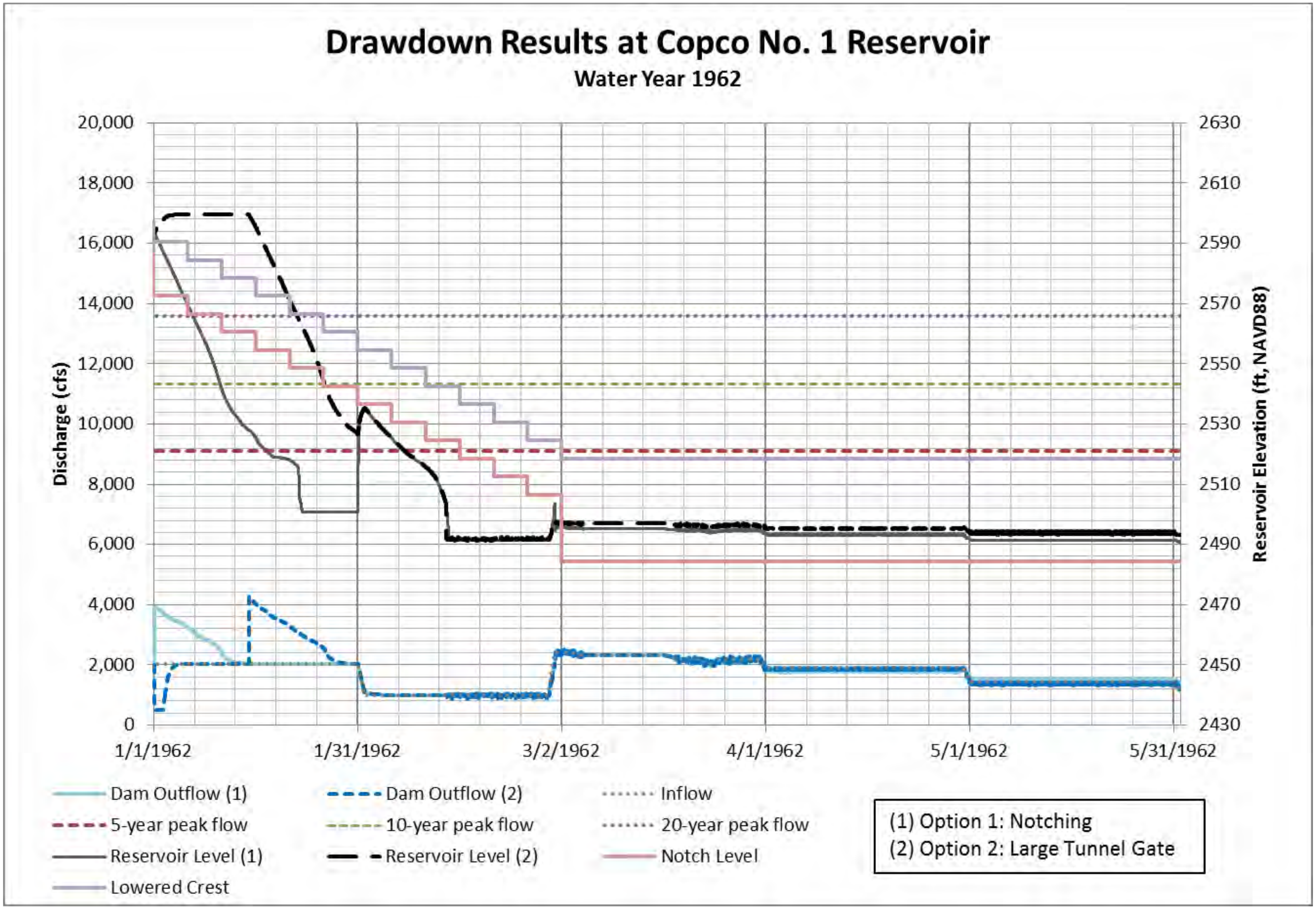



**Figure F3-3 Copco No. 1 Reservoir Drawdown, Water Year 1962**

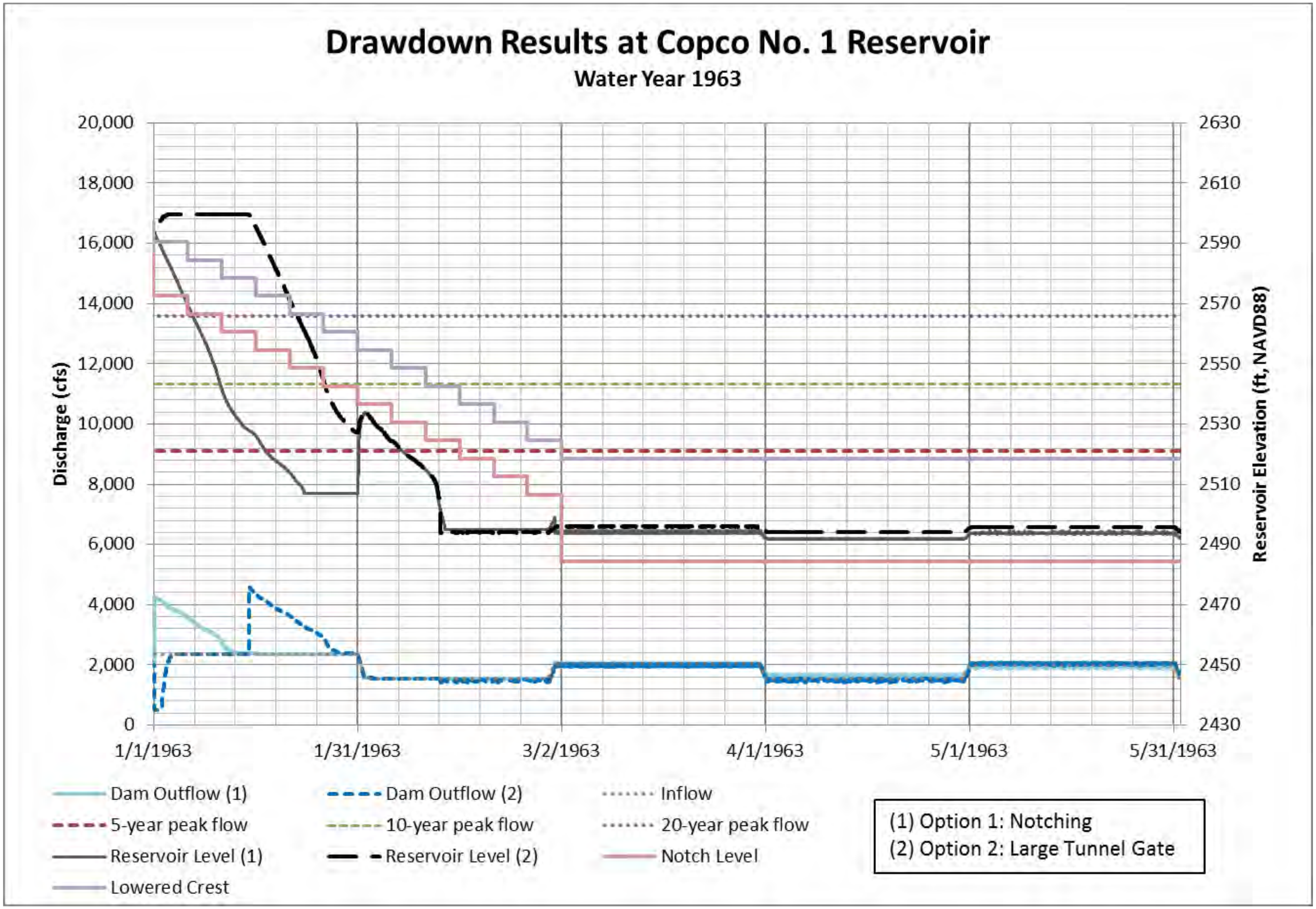



**Figure F3-4 Copco No. 1 Reservoir Drawdown, Water Year 1963**

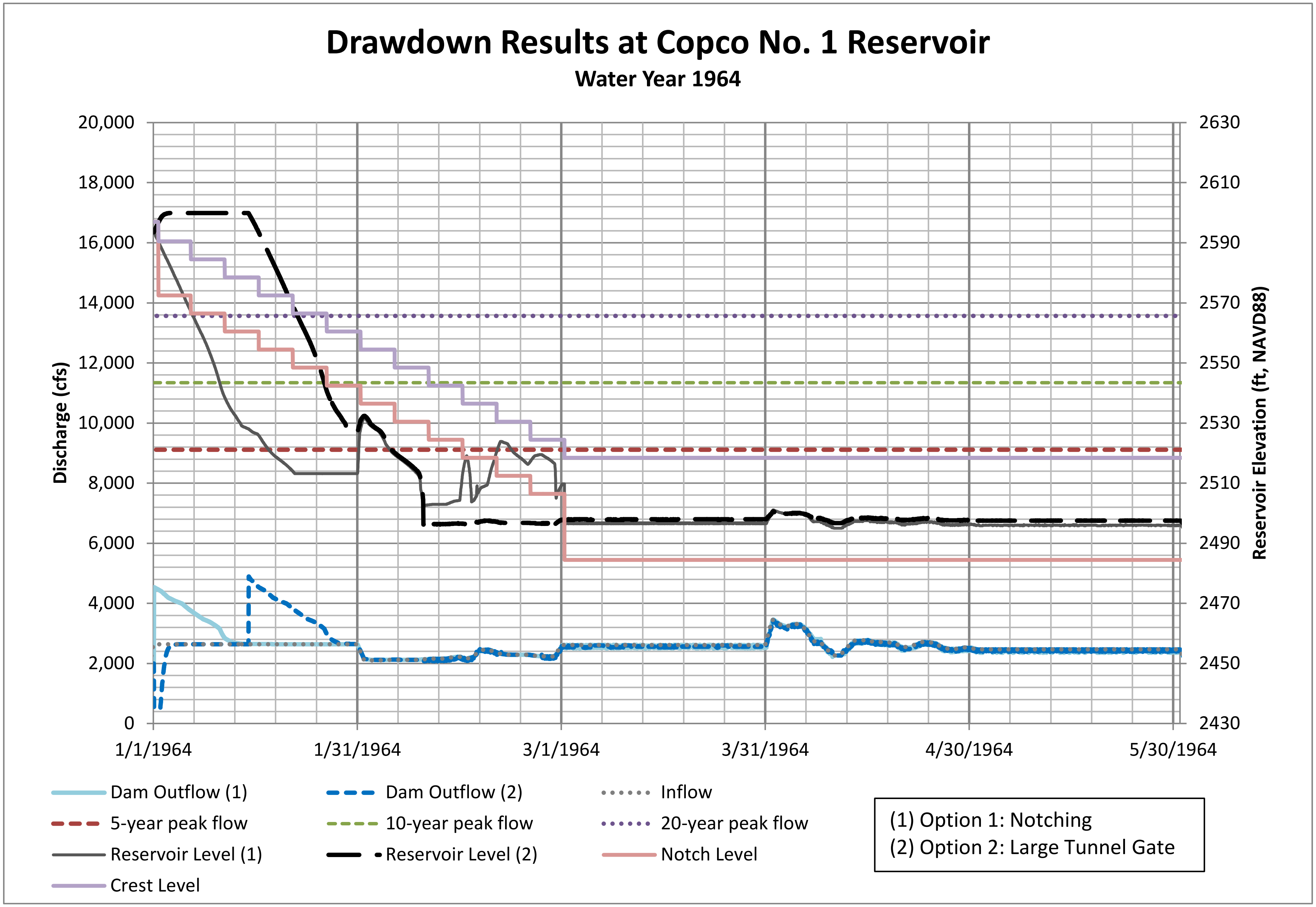



**Figure F3-5 Copco No. 1 Reservoir Drawdown, Water Year 1964**

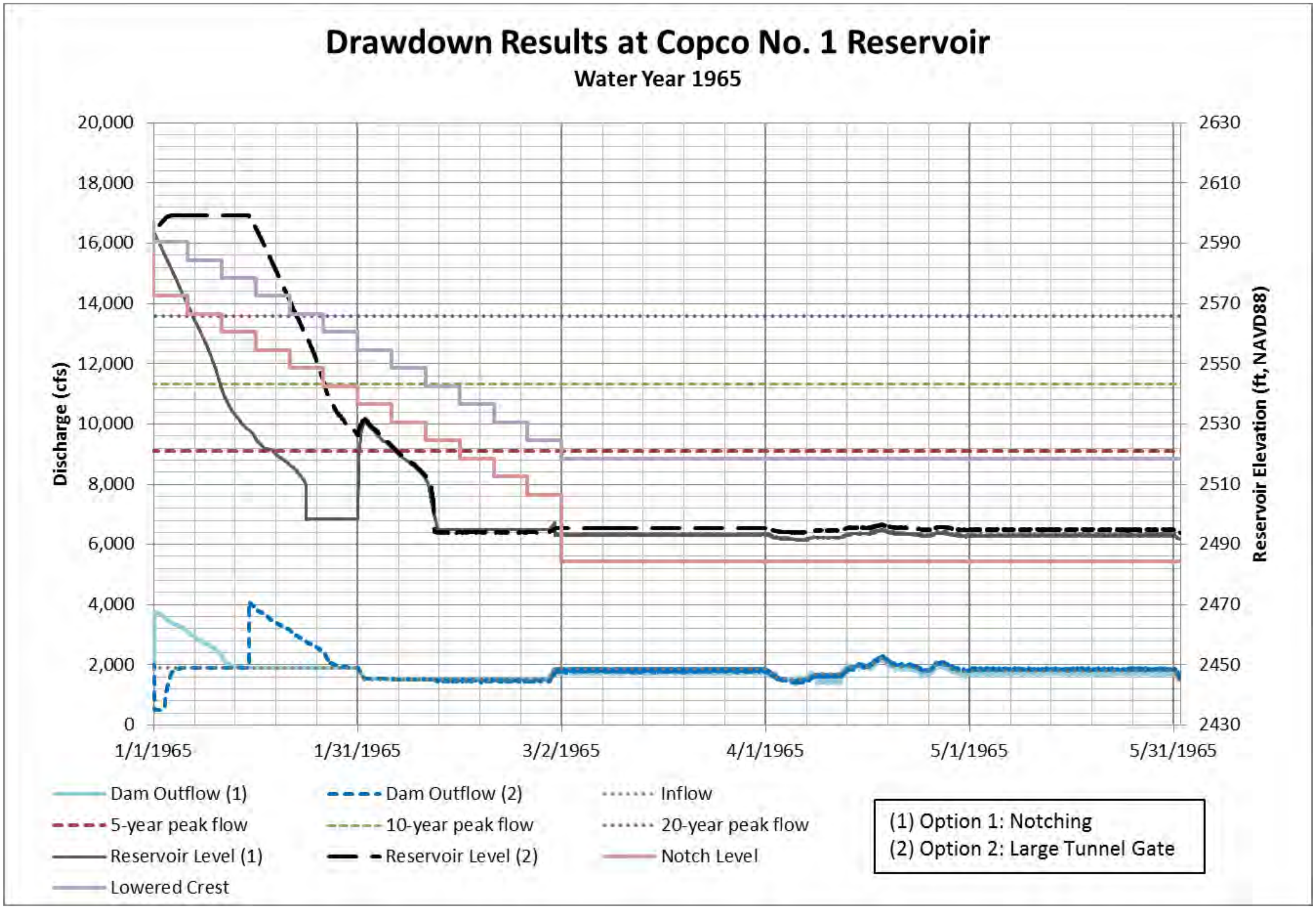



Figure F3-6 Copco No. 1 Reservoir Drawdown, Water Year 1965

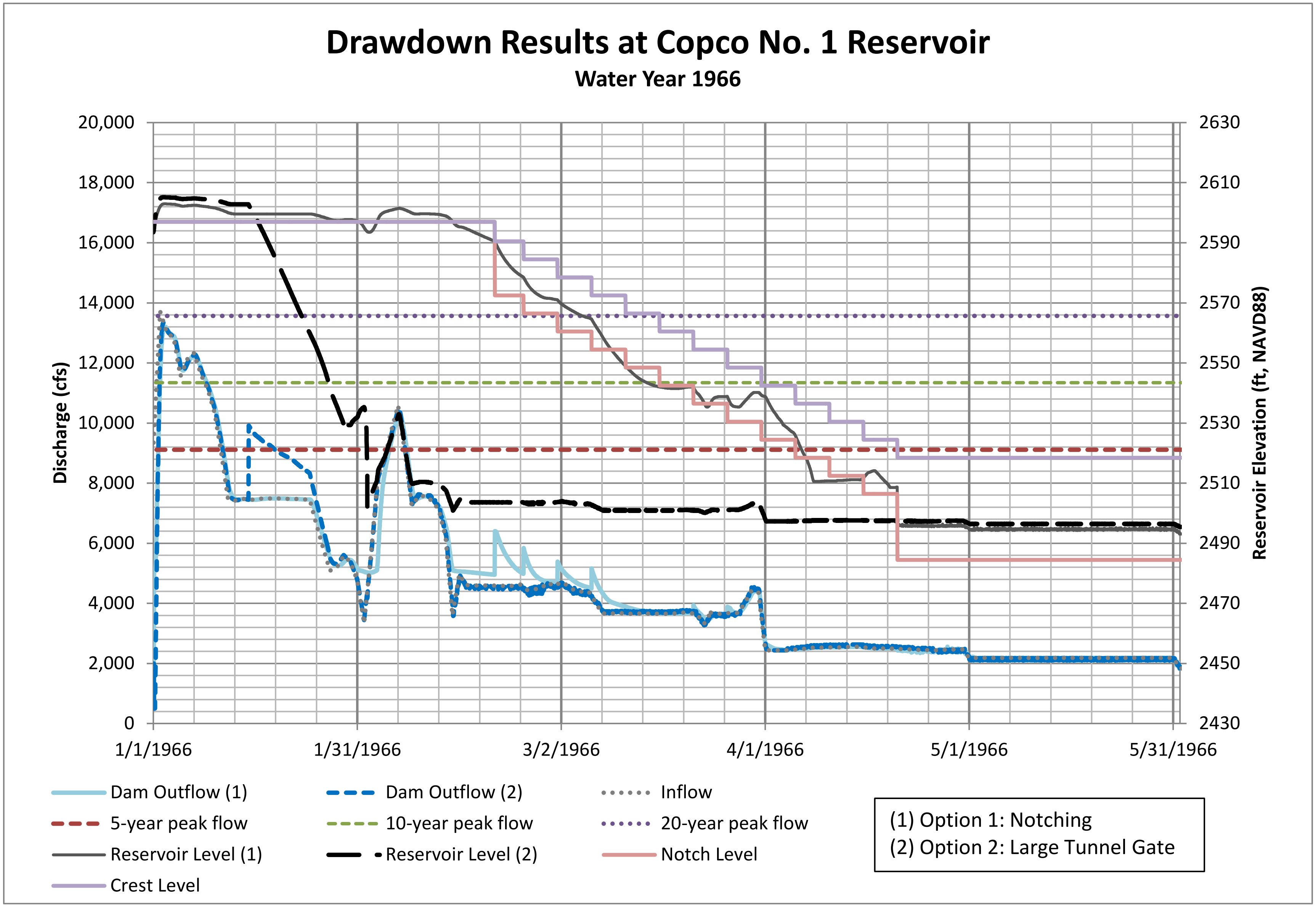



**Figure F3-7 Copco No. 1 Reservoir Drawdown, Water Year 1966**

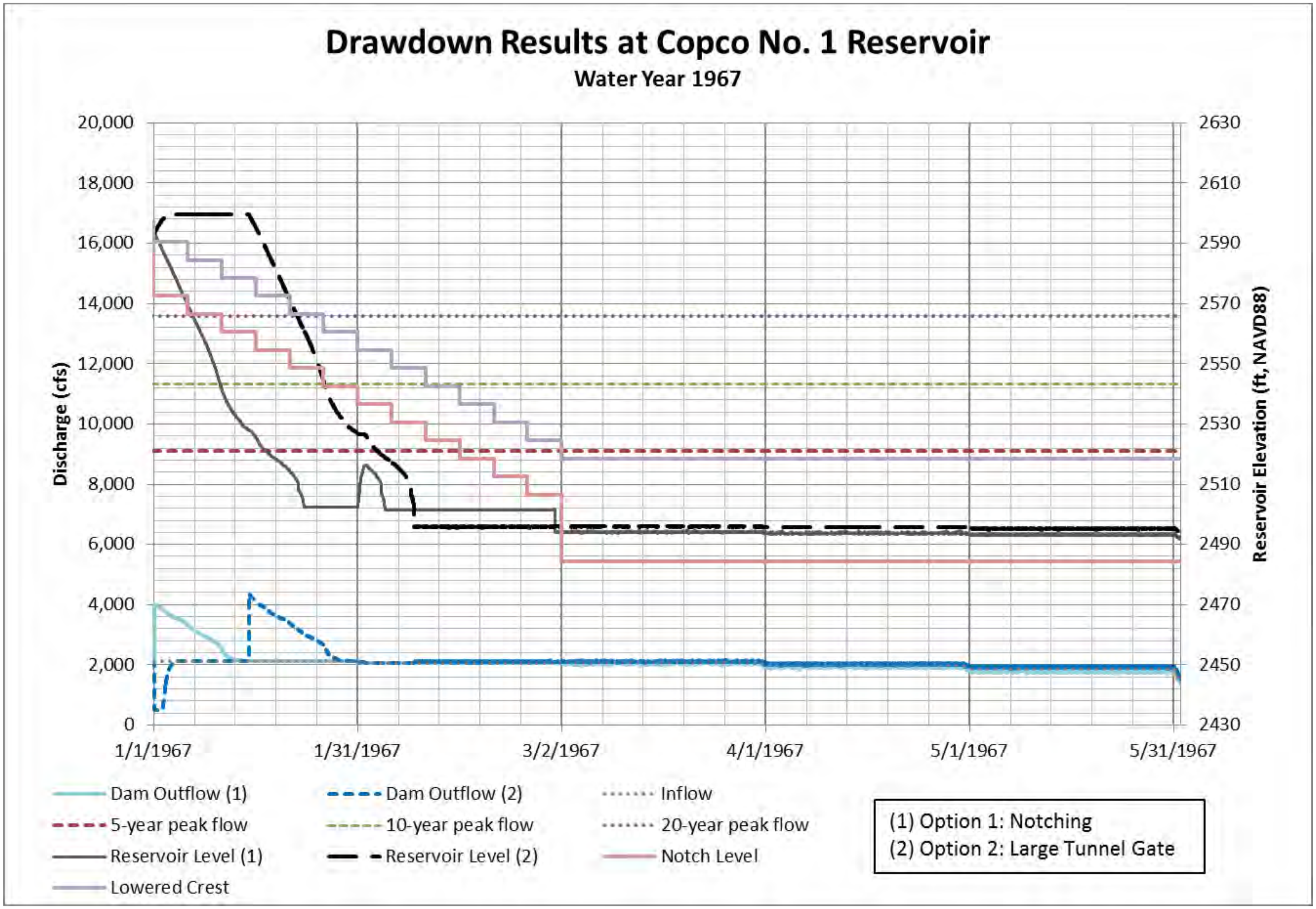



**Figure F3-8 Copco No. 1 Reservoir Drawdown, Water Year 1967**

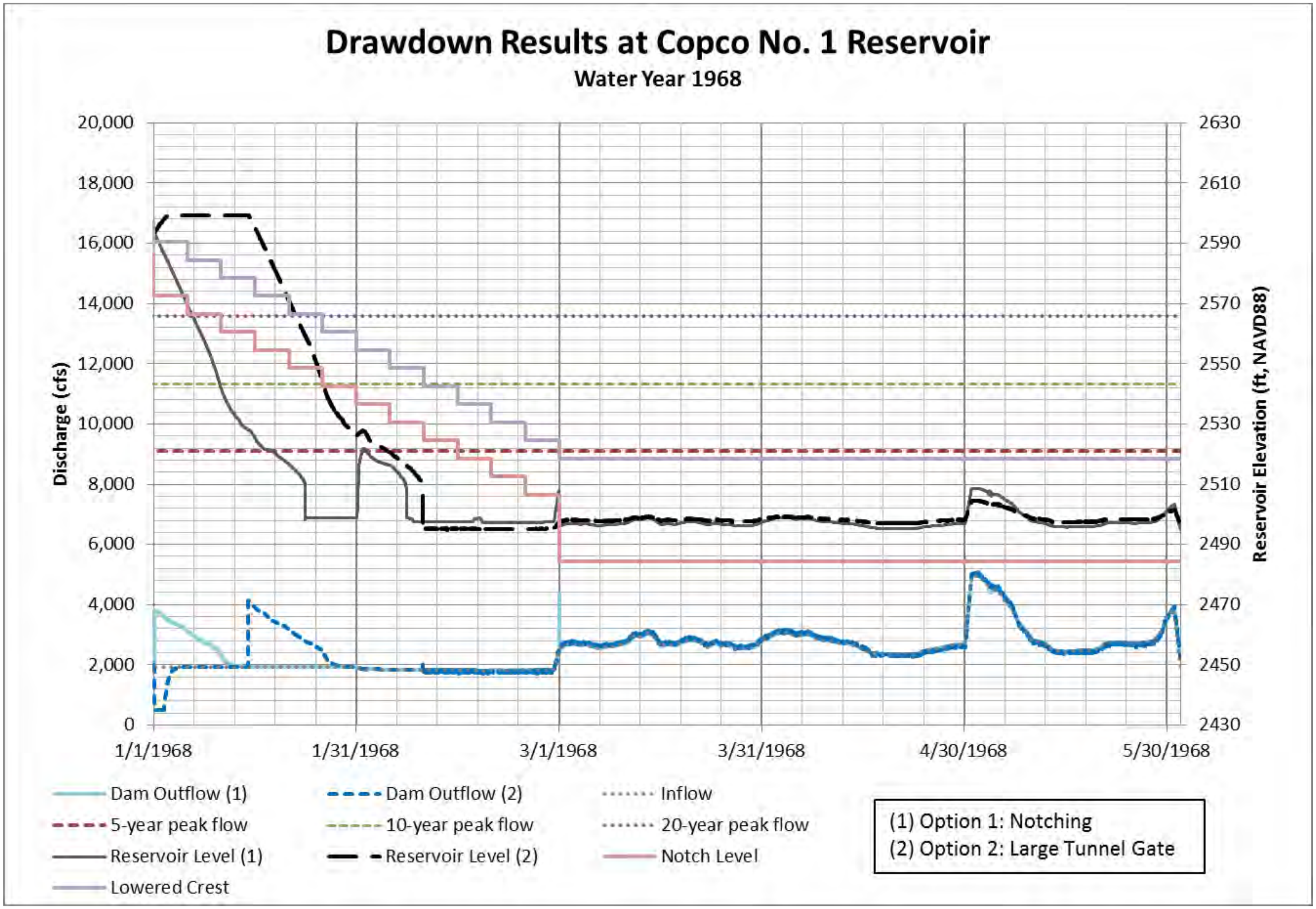



**Figure F3-9 Copco No. 1 Reservoir Drawdown, Water Year 1968**

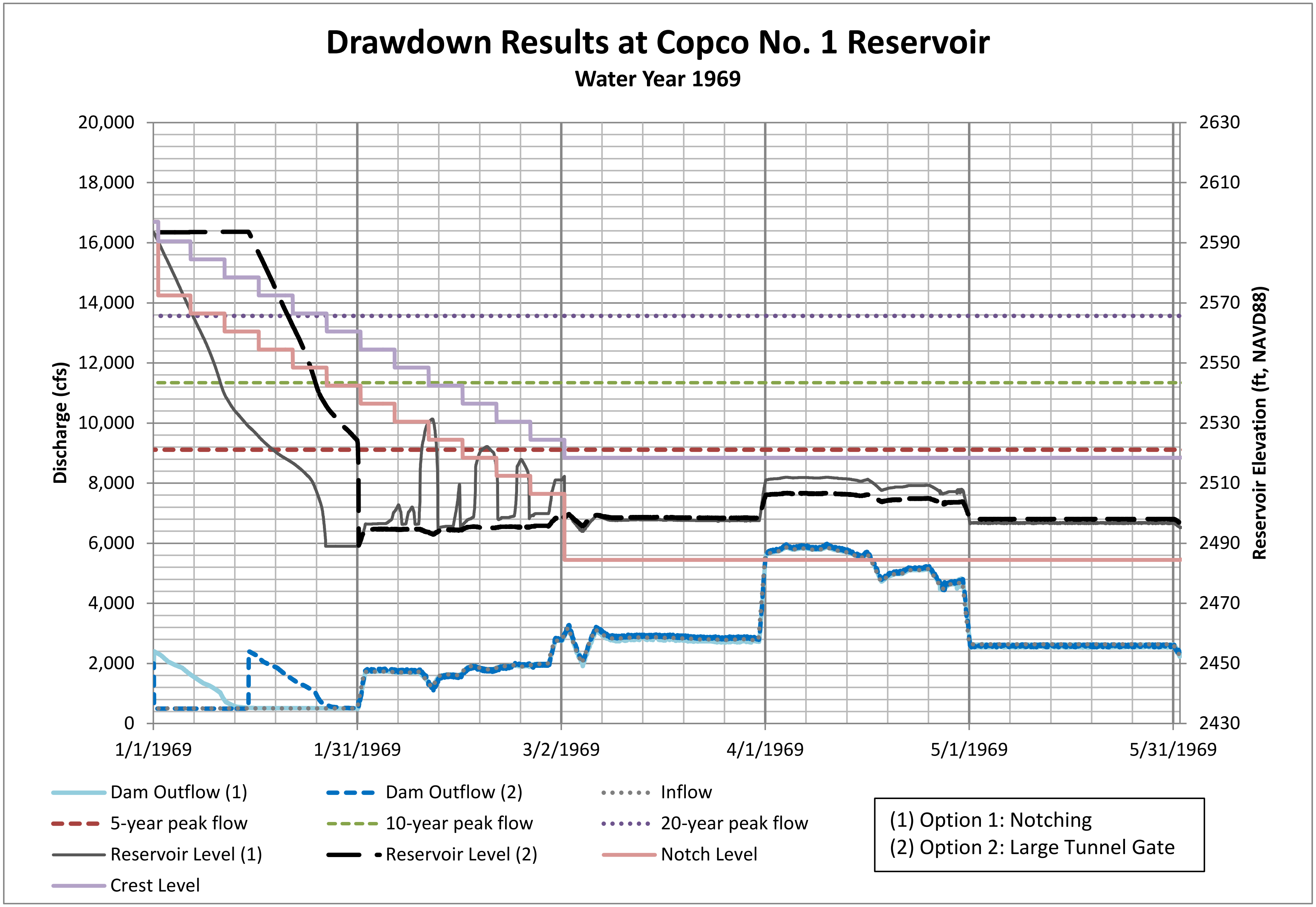



**Figure F3-10 Copco No. 1 Reservoir Drawdown, Water Year 1969**

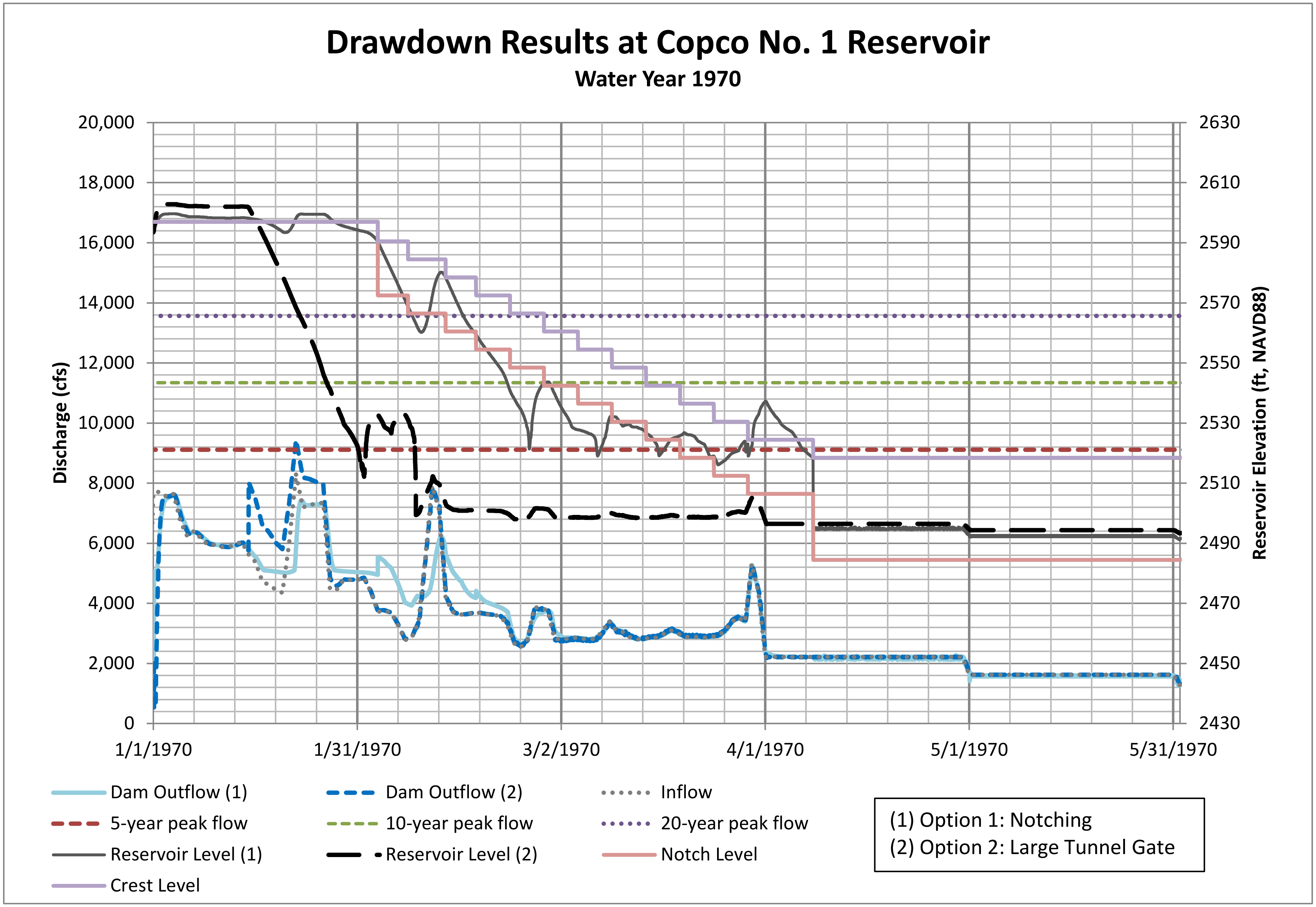



**Figure F3-11 Copco No. 1 Reservoir Drawdown, Water Year 1970**

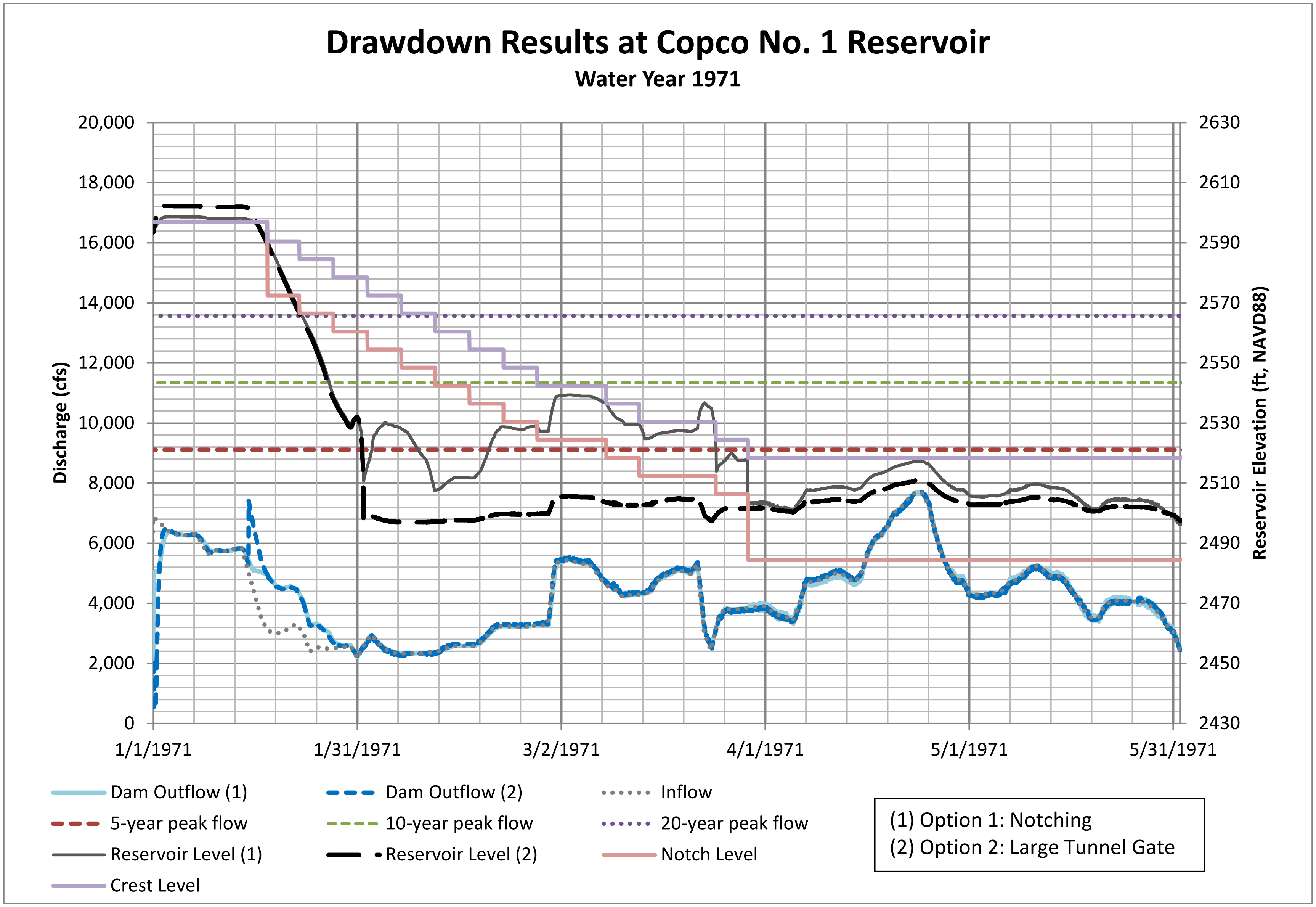



Figure F3-12 Copco No. 1 Reservoir Drawdown, Water Year 1971

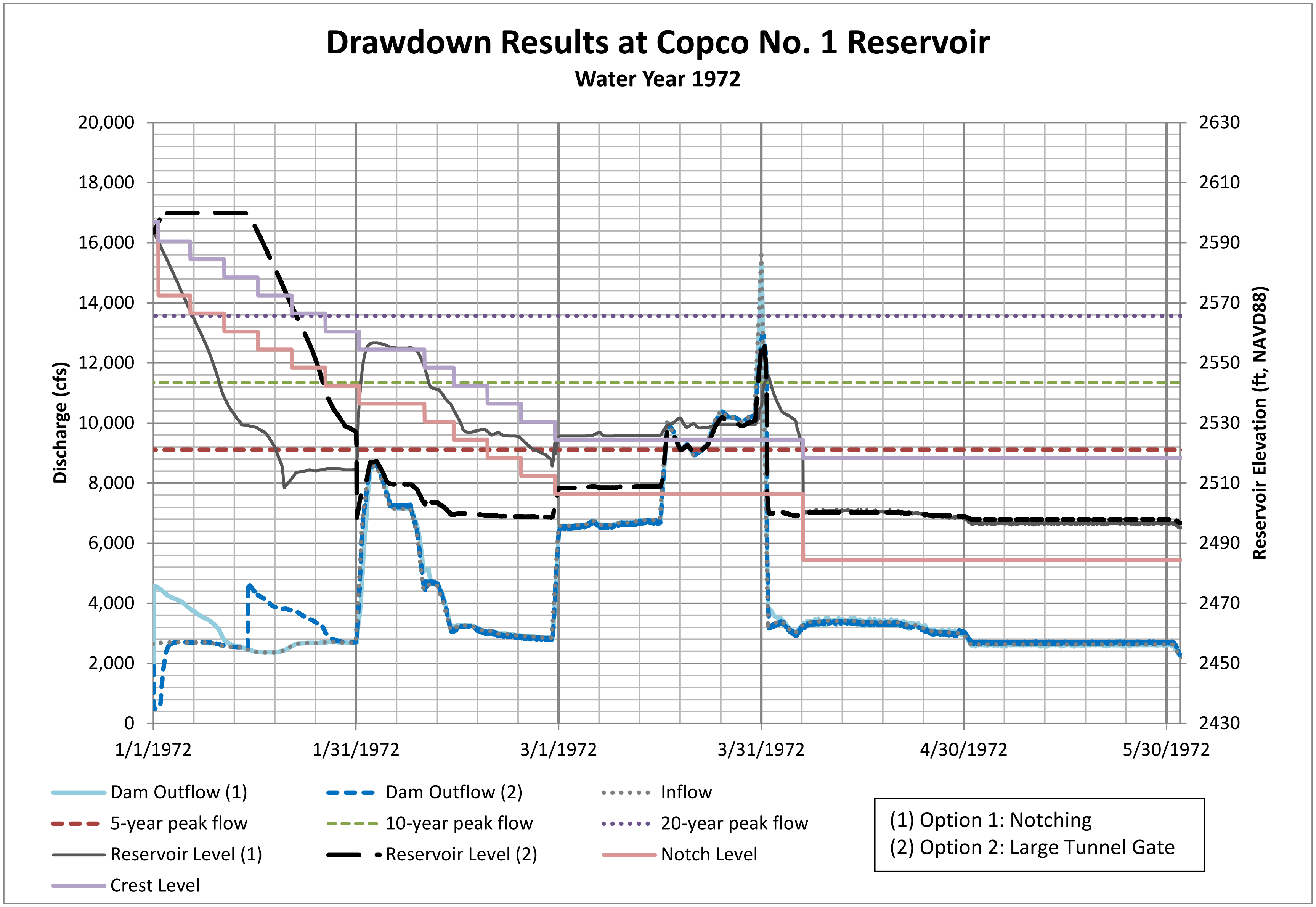



Figure F3-13 Copco No. 1 Reservoir Drawdown, Water Year 1972

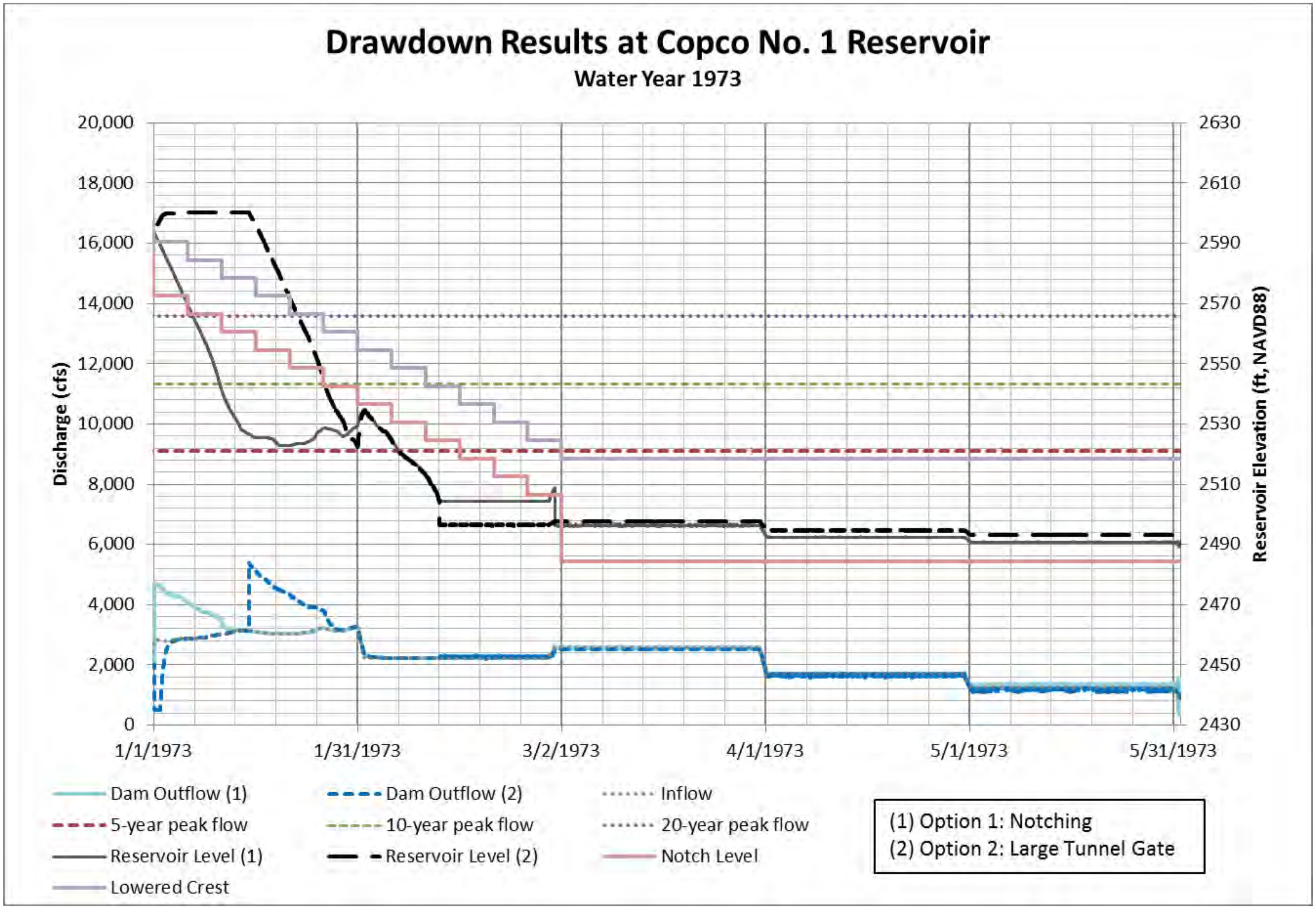



**Figure F3-14 Copco No. 1 Reservoir Drawdown, Water Year 1973**

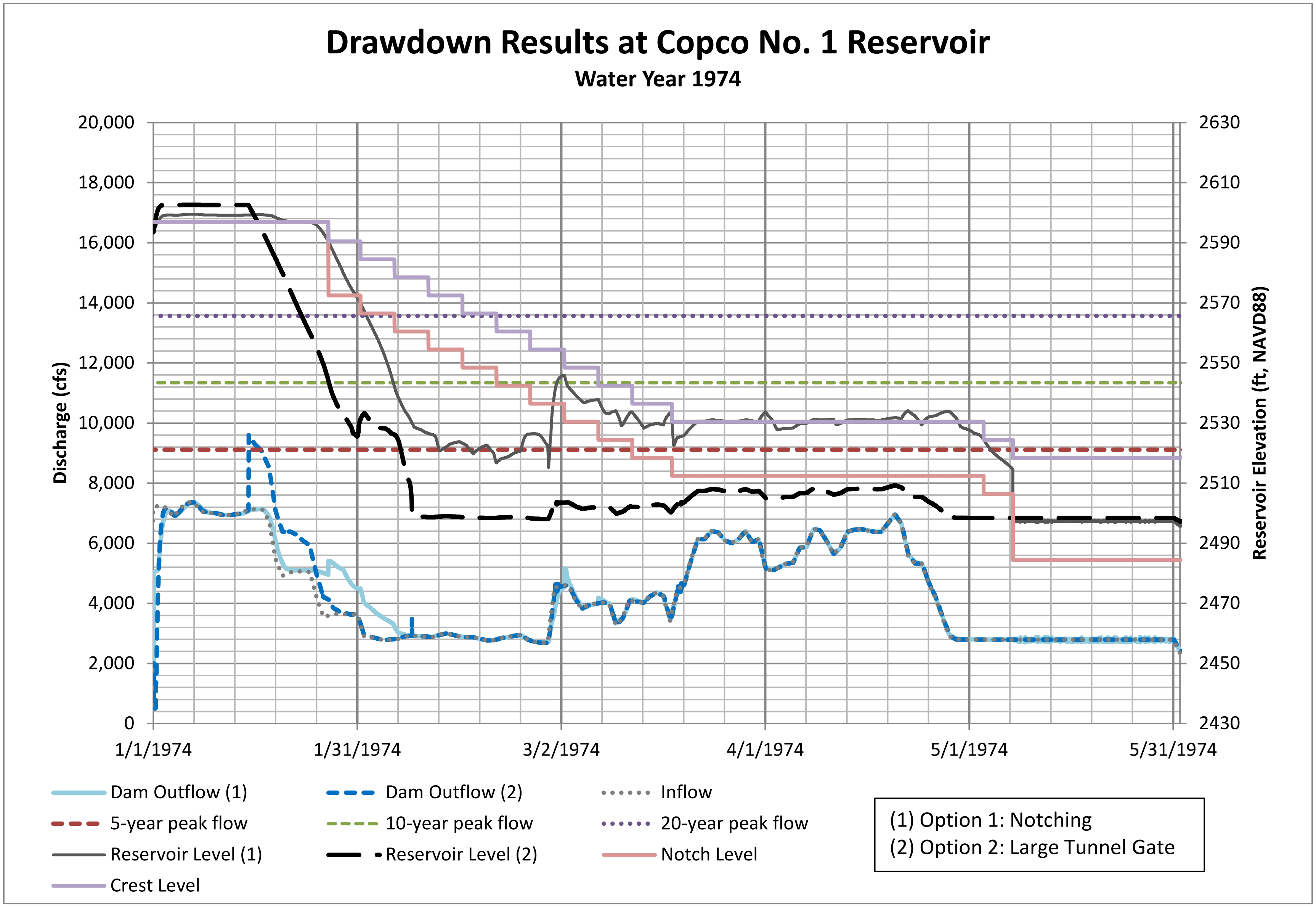



Figure F3-15 Copco No. 1 Reservoir Drawdown, Water Year 1974

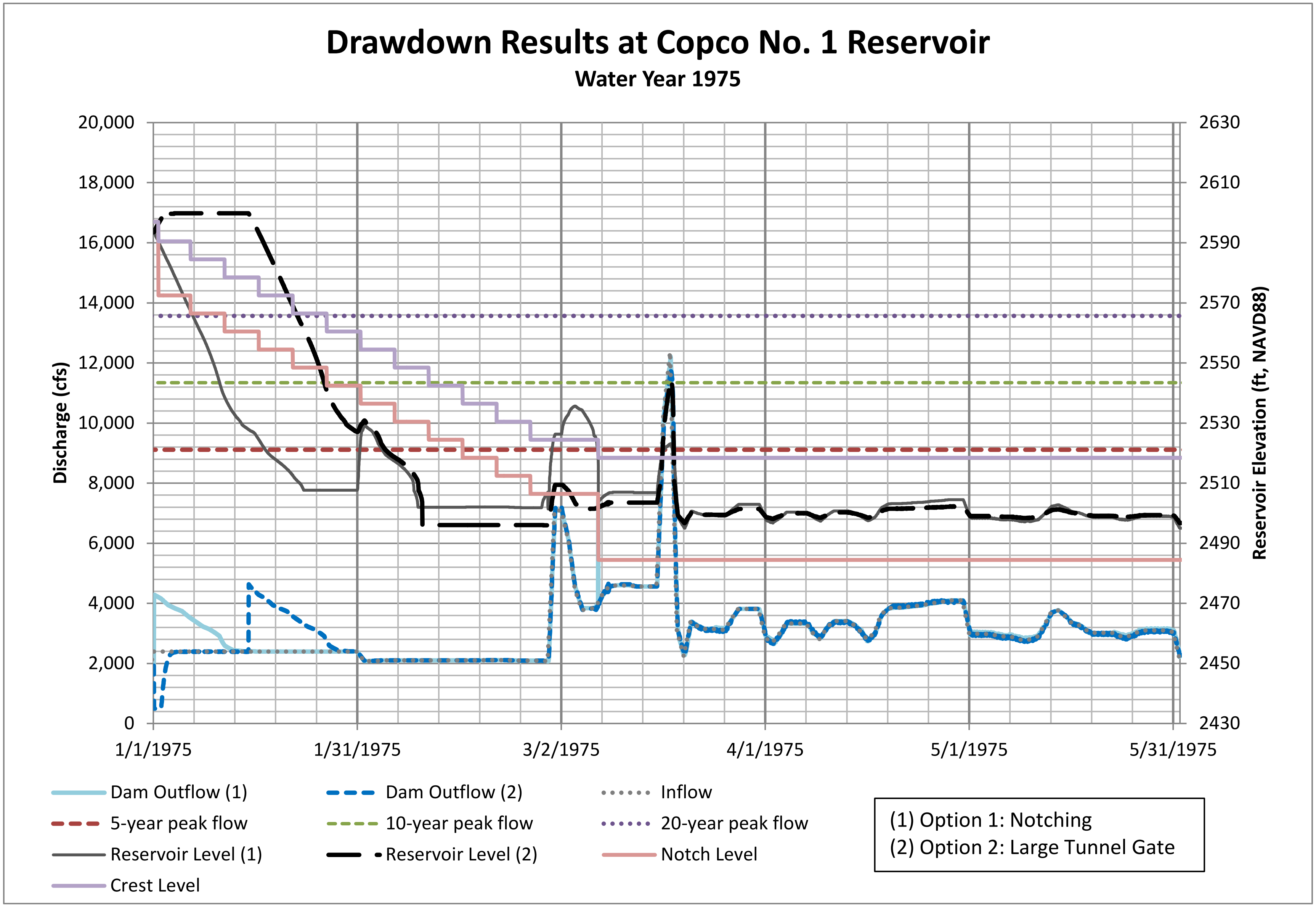



**Figure F3-16 Copco No. 1 Reservoir Drawdown, Water Year 1975**

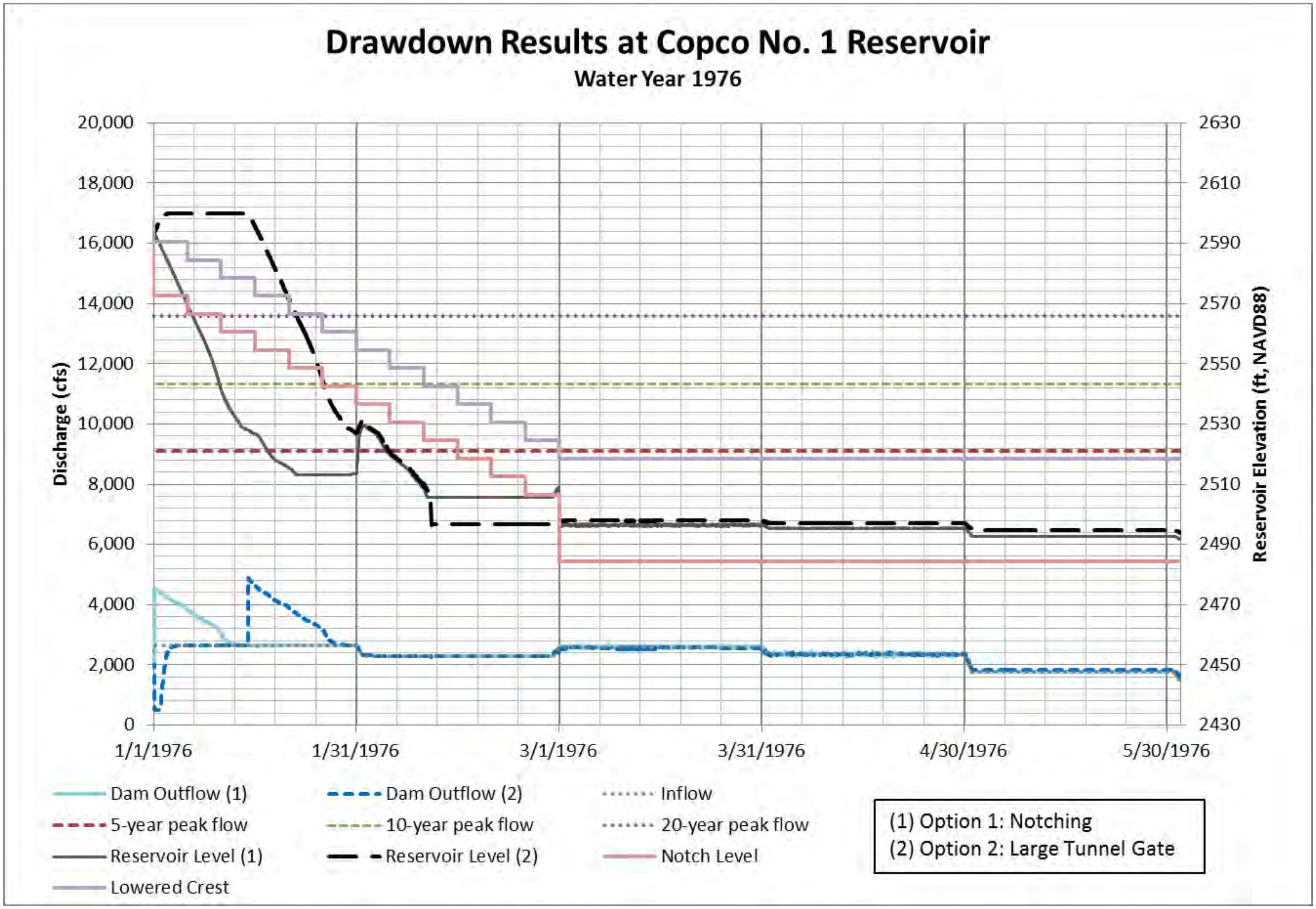



**Figure F3-17 Copco No. 1 Reservoir Drawdown, Water Year 1976**

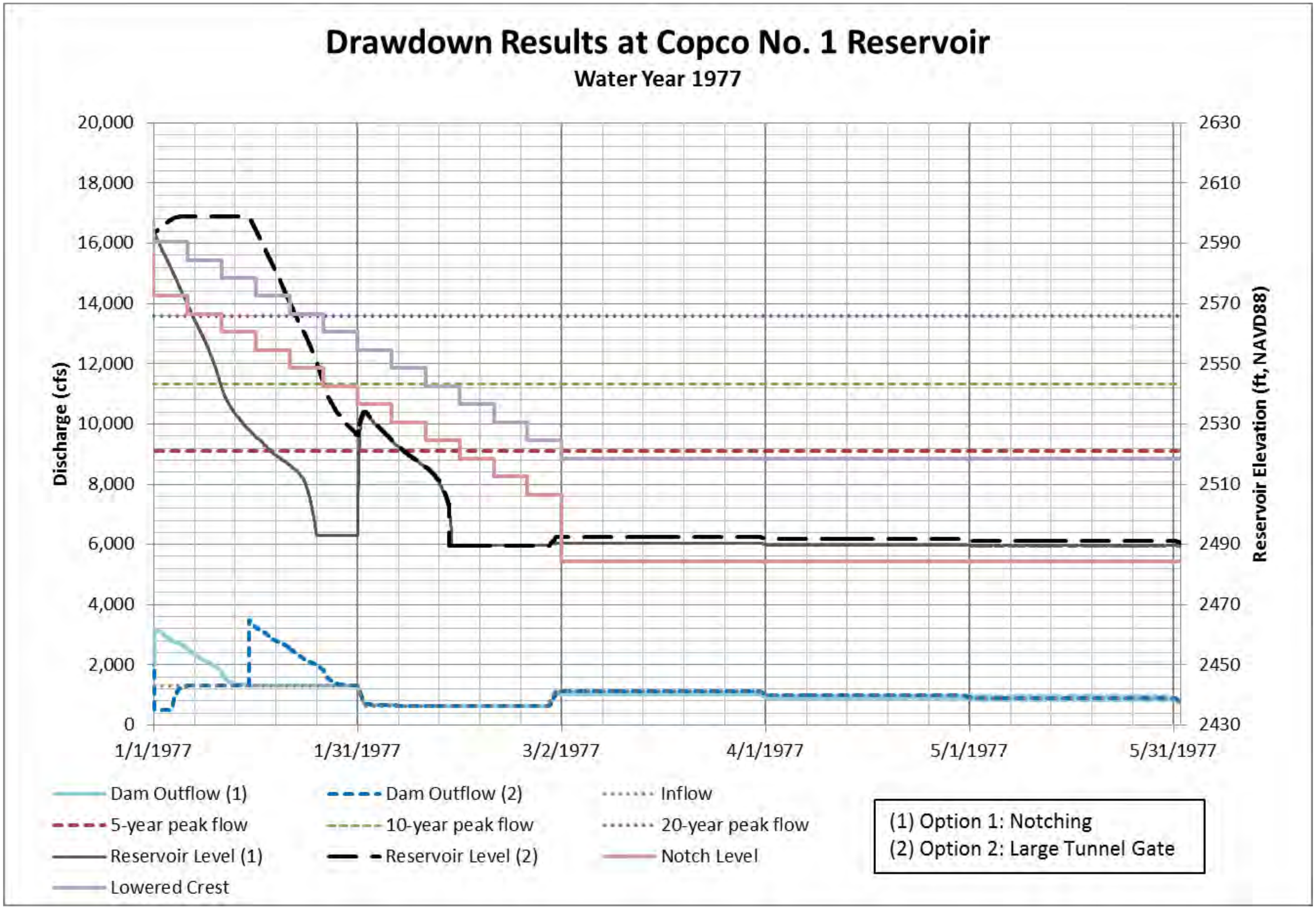



**Figure F3-18 Copco No. 1 Reservoir Drawdown, Water Year 1977**

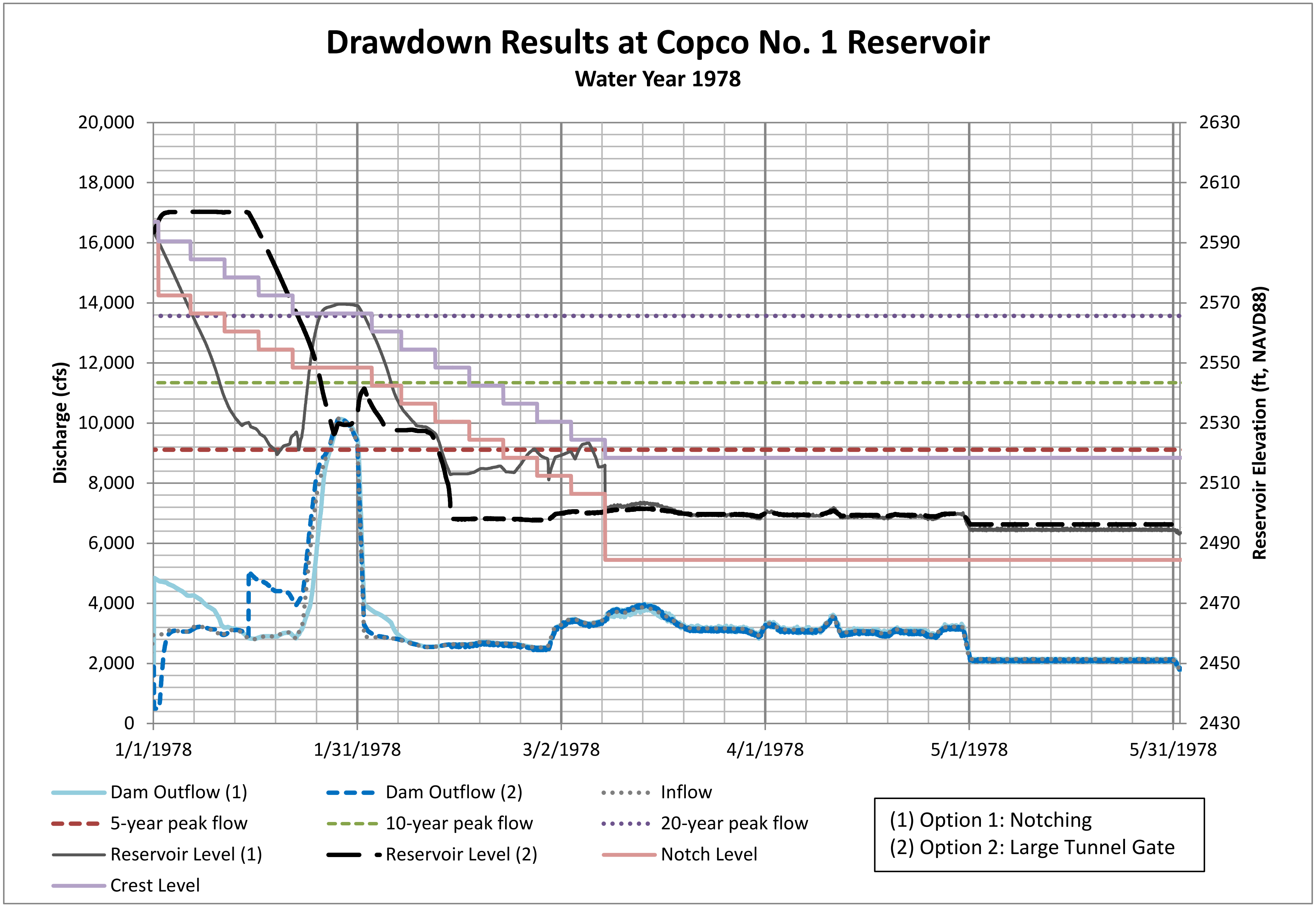



**Figure F3-19 Copco No. 1 Reservoir Drawdown, Water Year 1978**

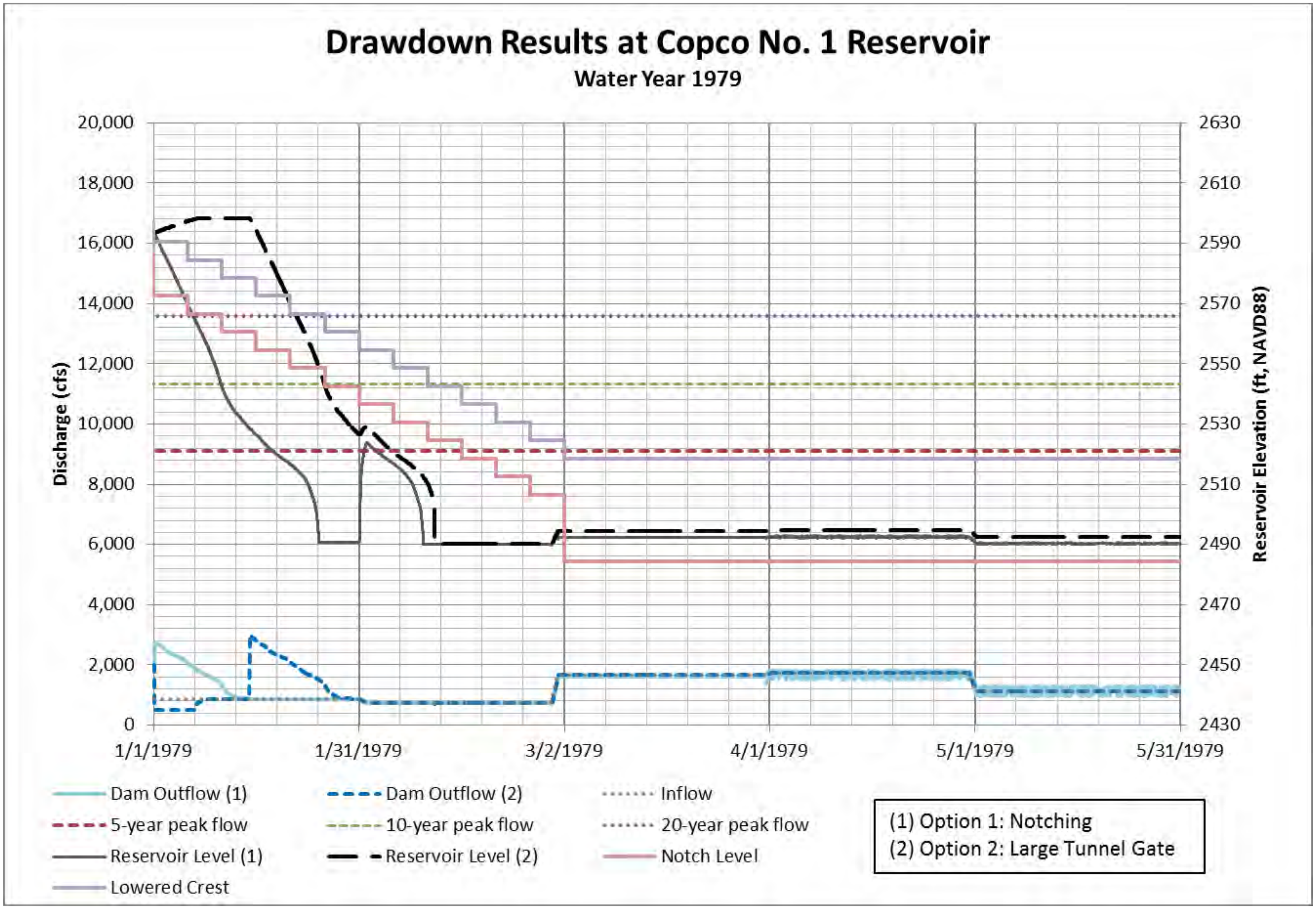



**Figure F3-20 Copco No. 1 Reservoir Drawdown, Water Year 1979**

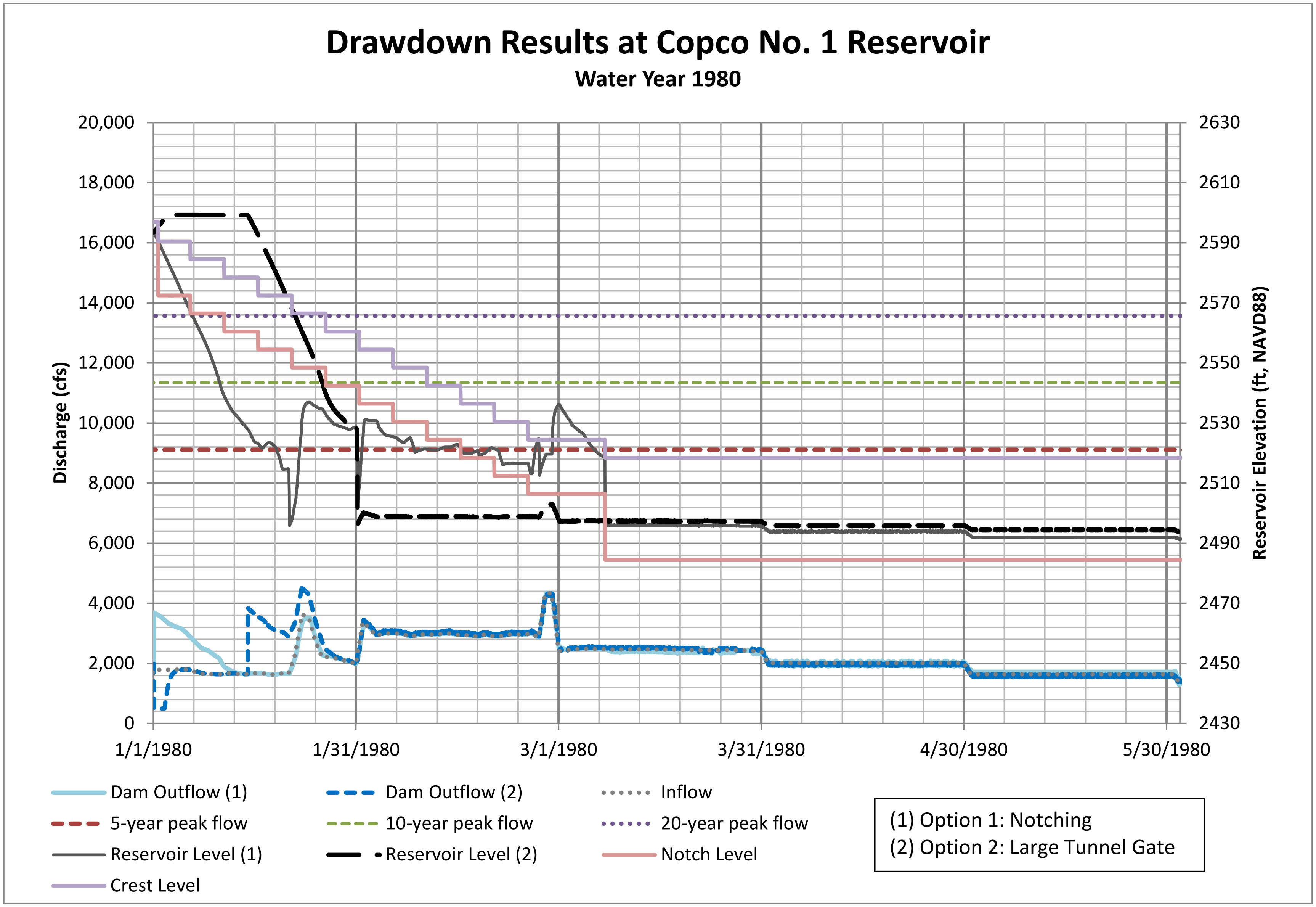



**Figure F3-21 Copco No. 1 Reservoir Drawdown, Water Year 1980**

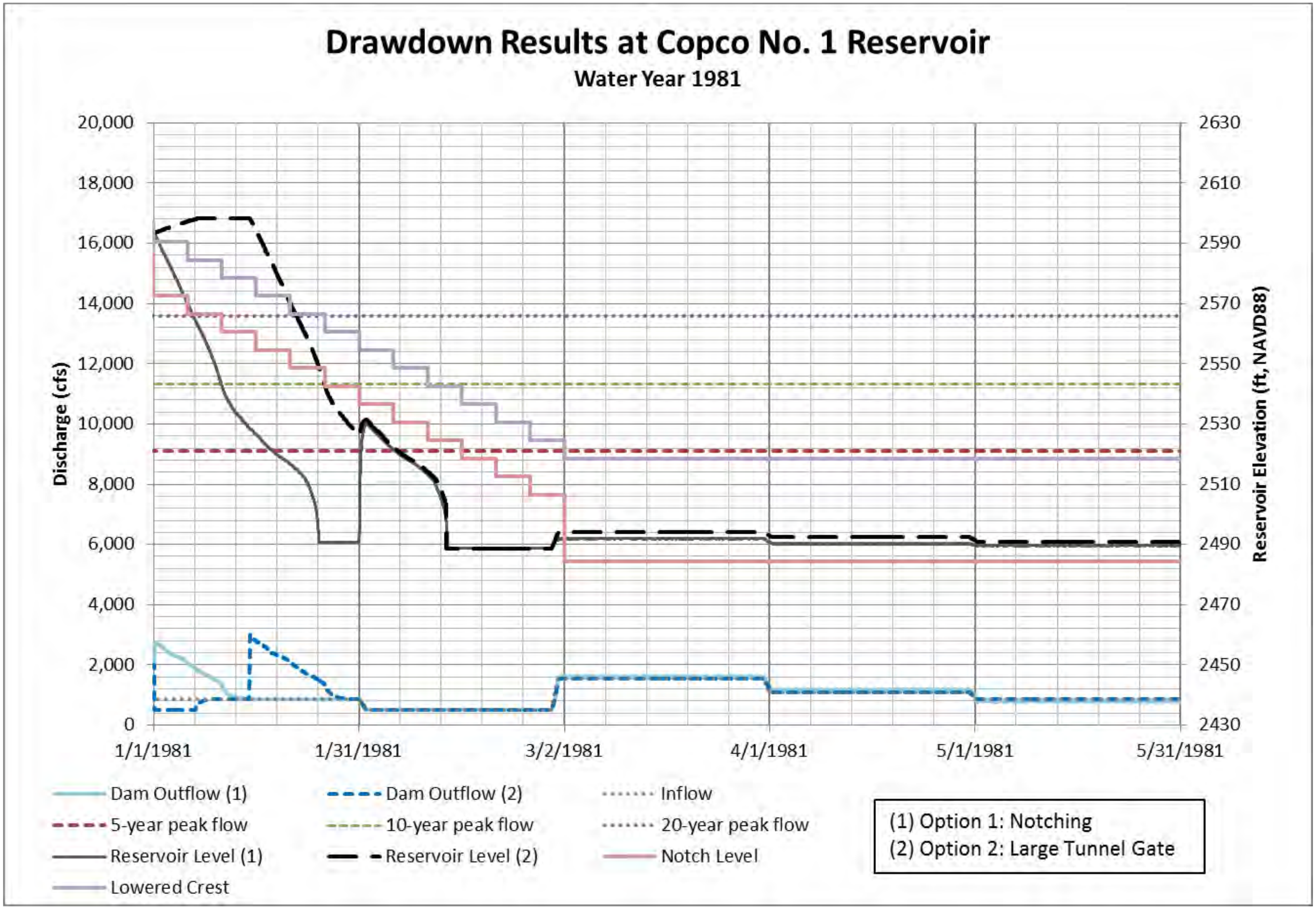



**Figure F3-22 Copco No. 1 Reservoir Drawdown, Water Year 1981**

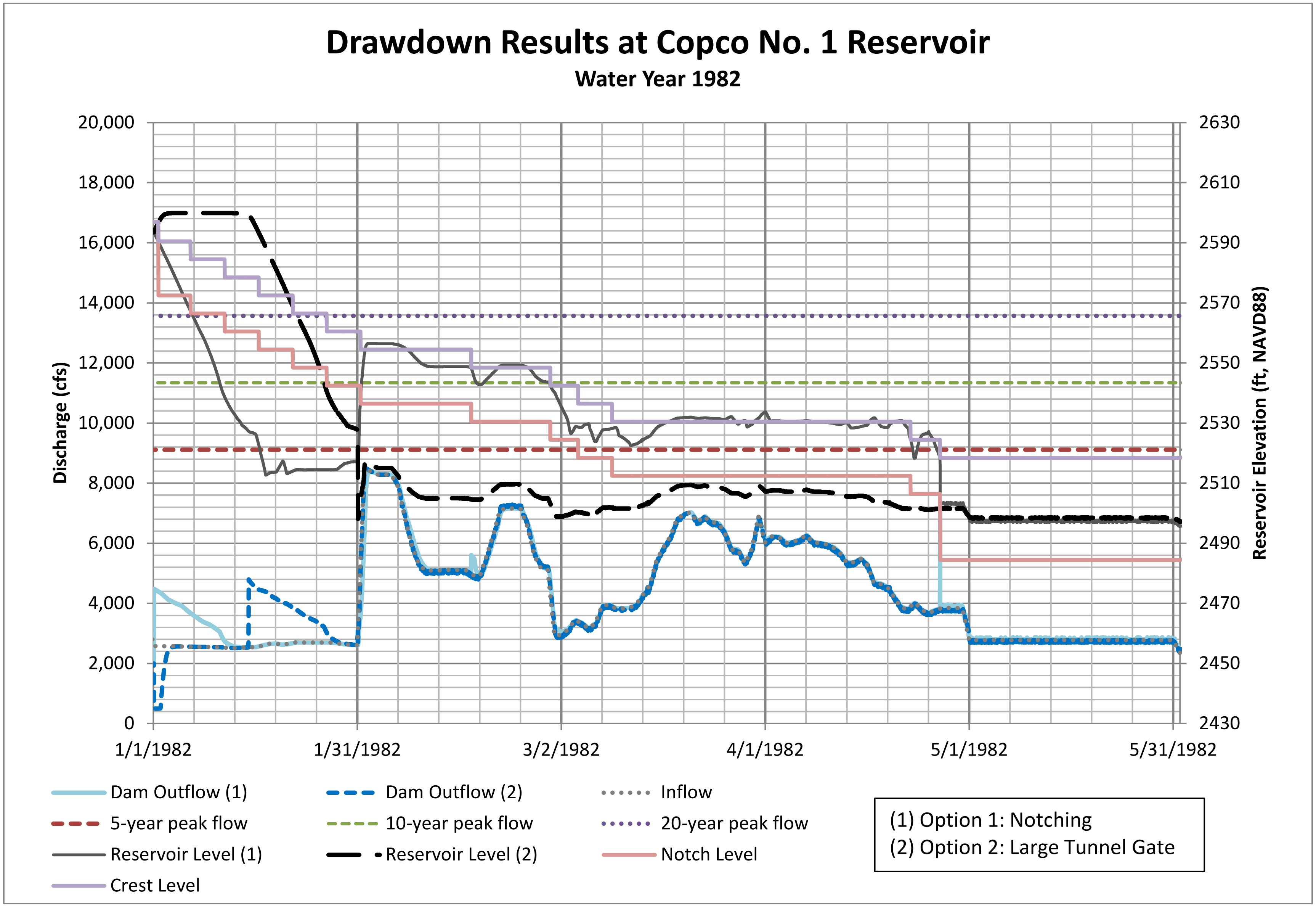



Figure F3-23 Copco No. 1 Reservoir Drawdown, Water Year 1982

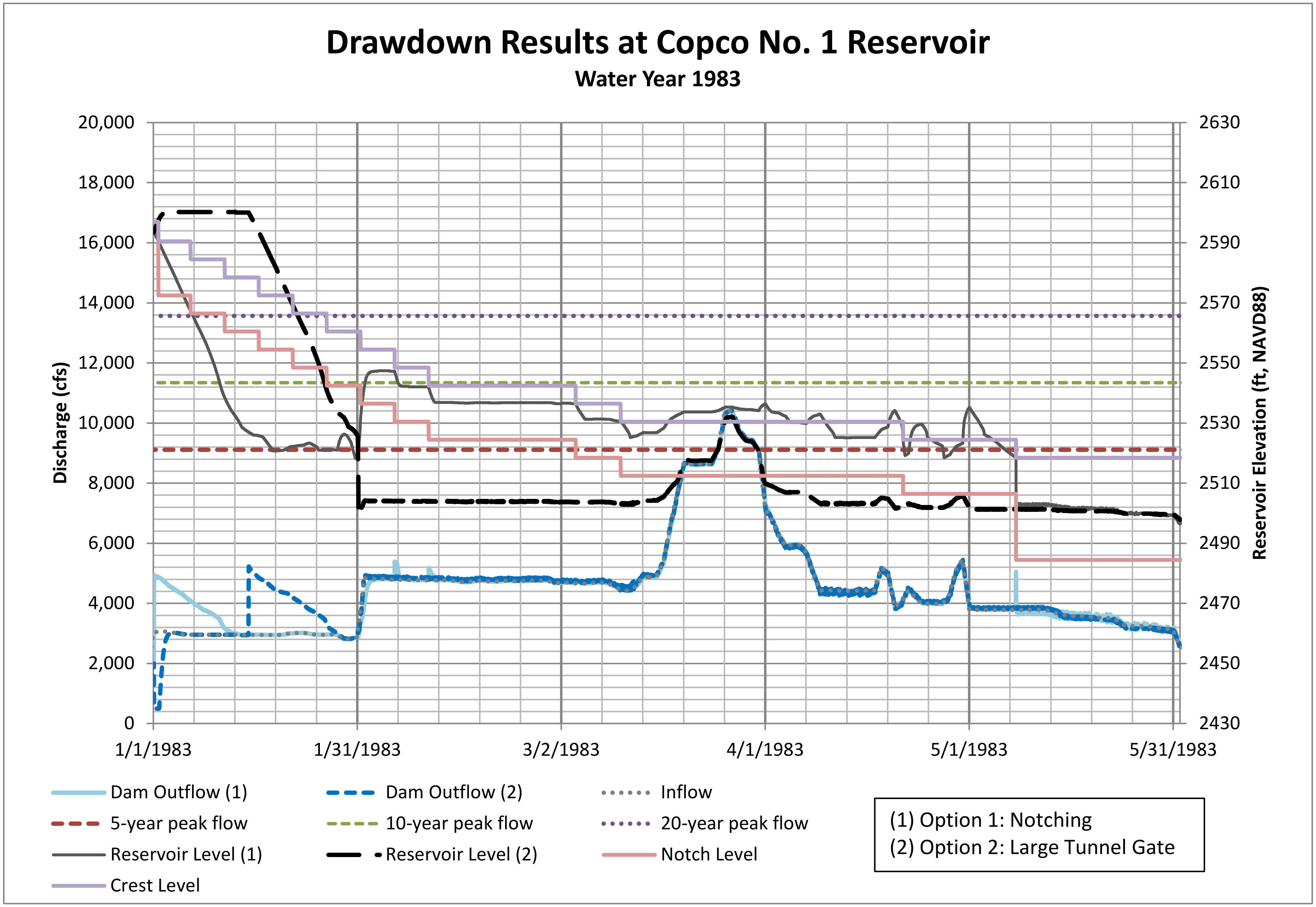



**Figure F3-24 Copco No. 1 Reservoir Drawdown, Water Year 1983**

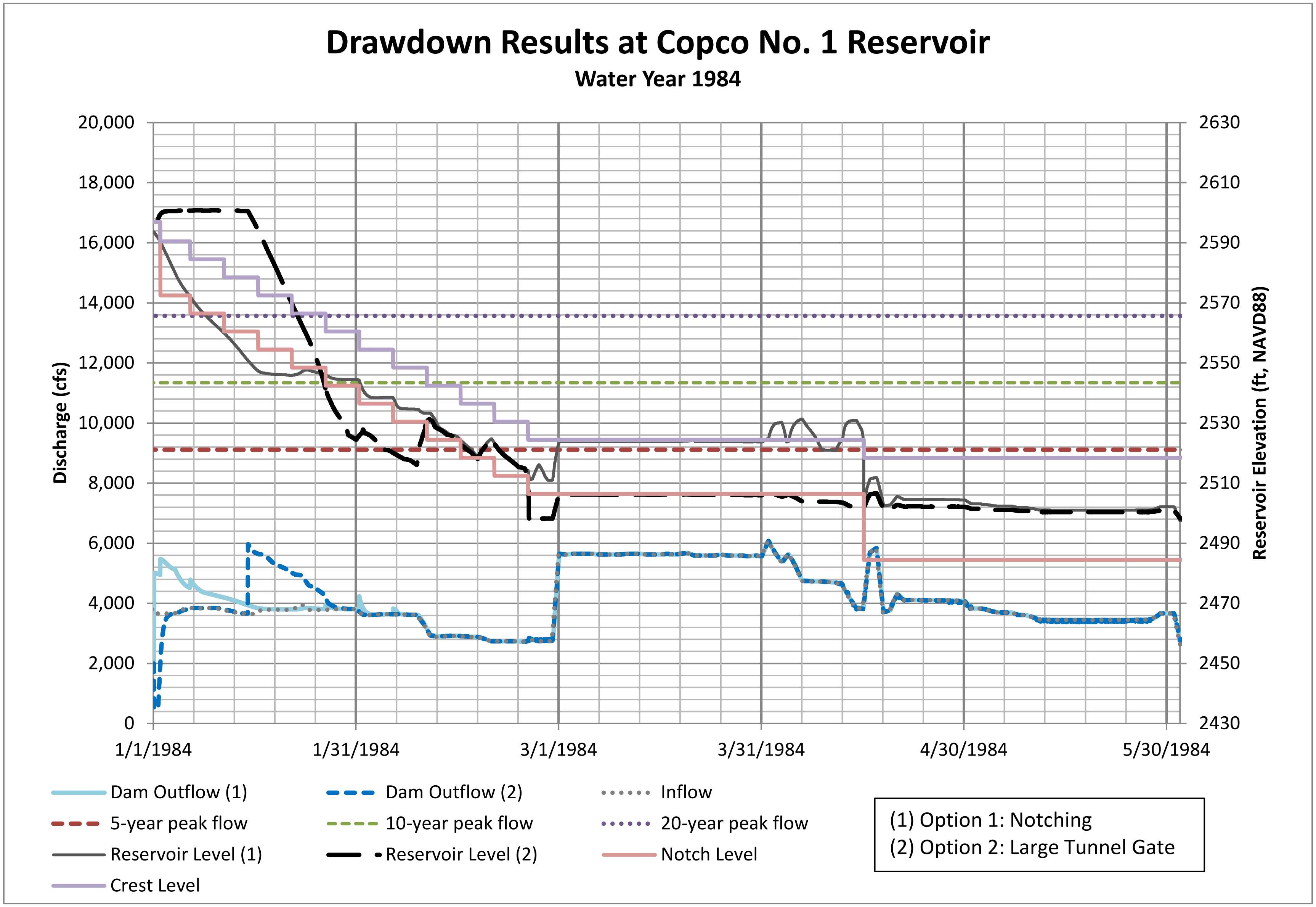



**Figure F3-25 Copco No. 1 Reservoir Drawdown, Water Year 1984**

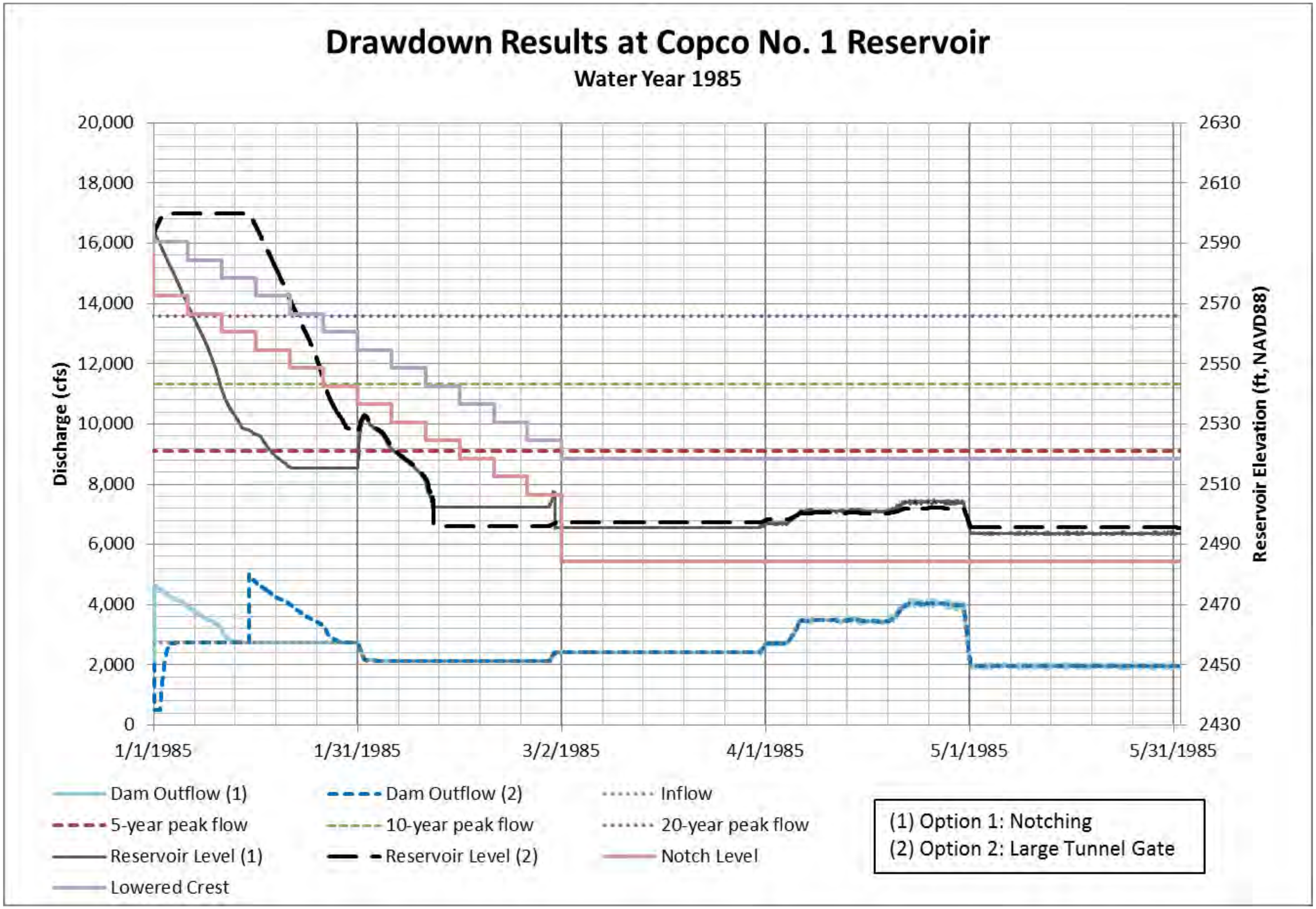



Figure F3-26 Copco No. 1 Reservoir Drawdown, Water Year 1985

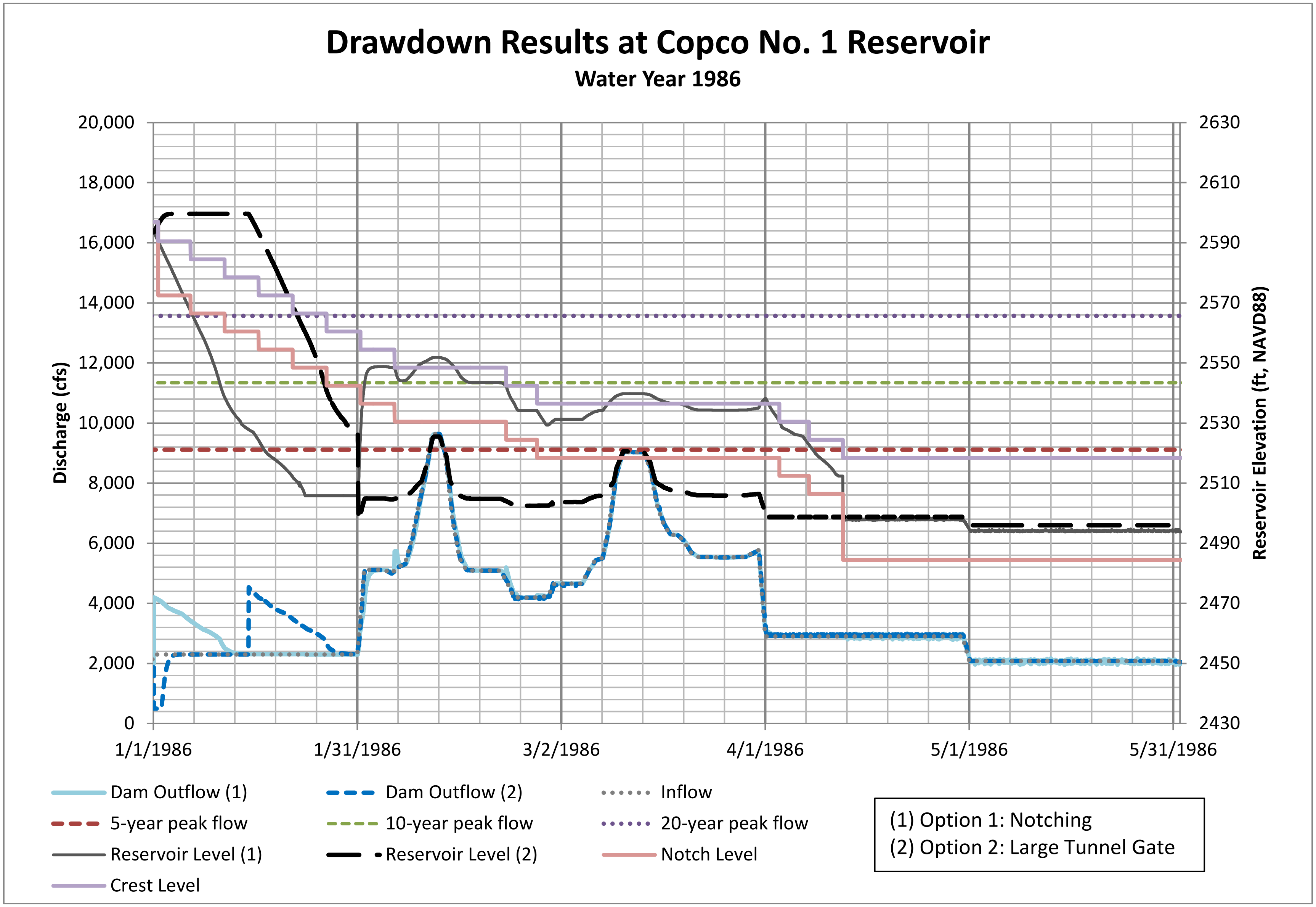



Figure F3-27 Copco No. 1 Reservoir Drawdown, Water Year 1986

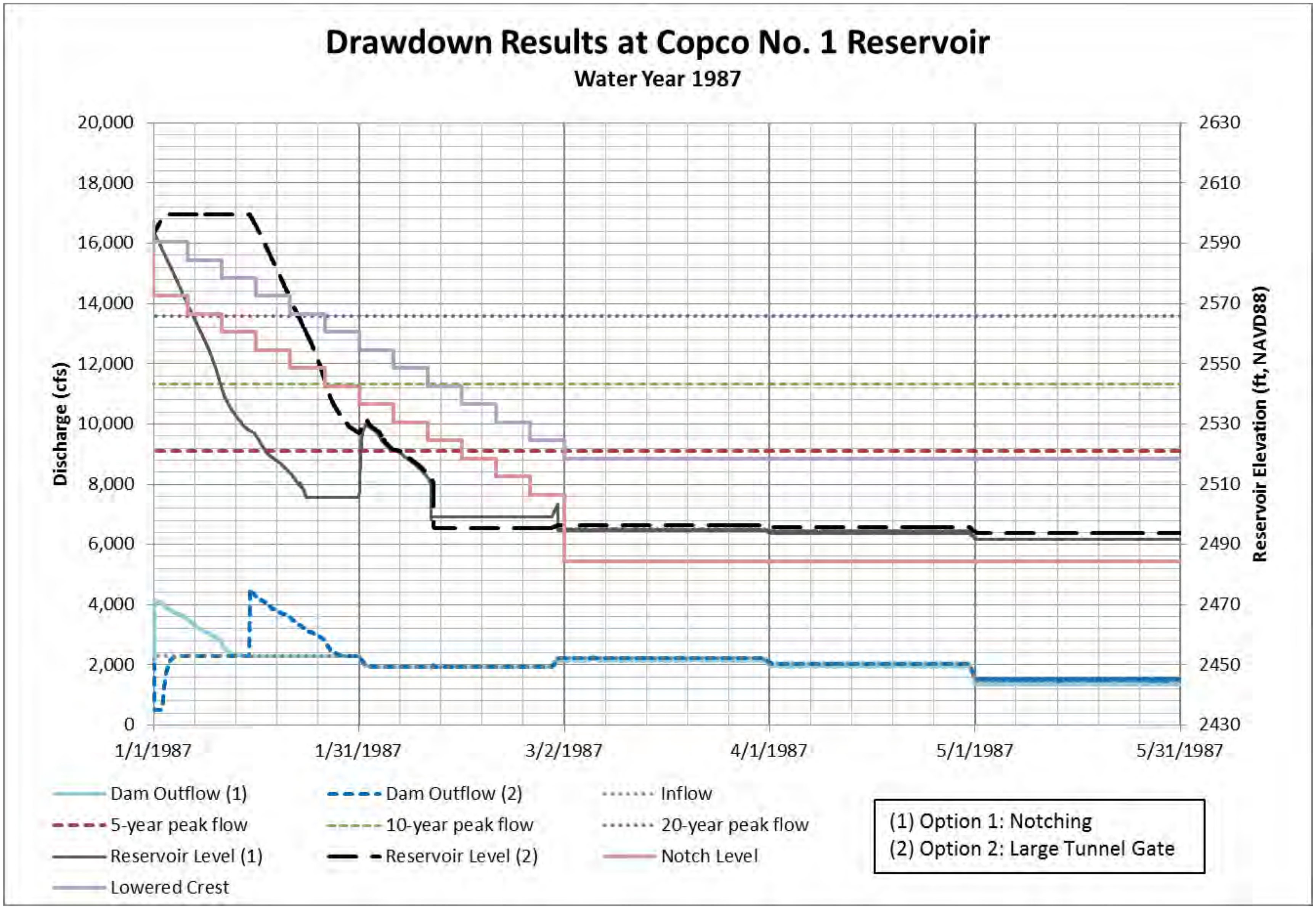



Figure F3-28 Copco No. 1 Reservoir Drawdown, Water Year 1987

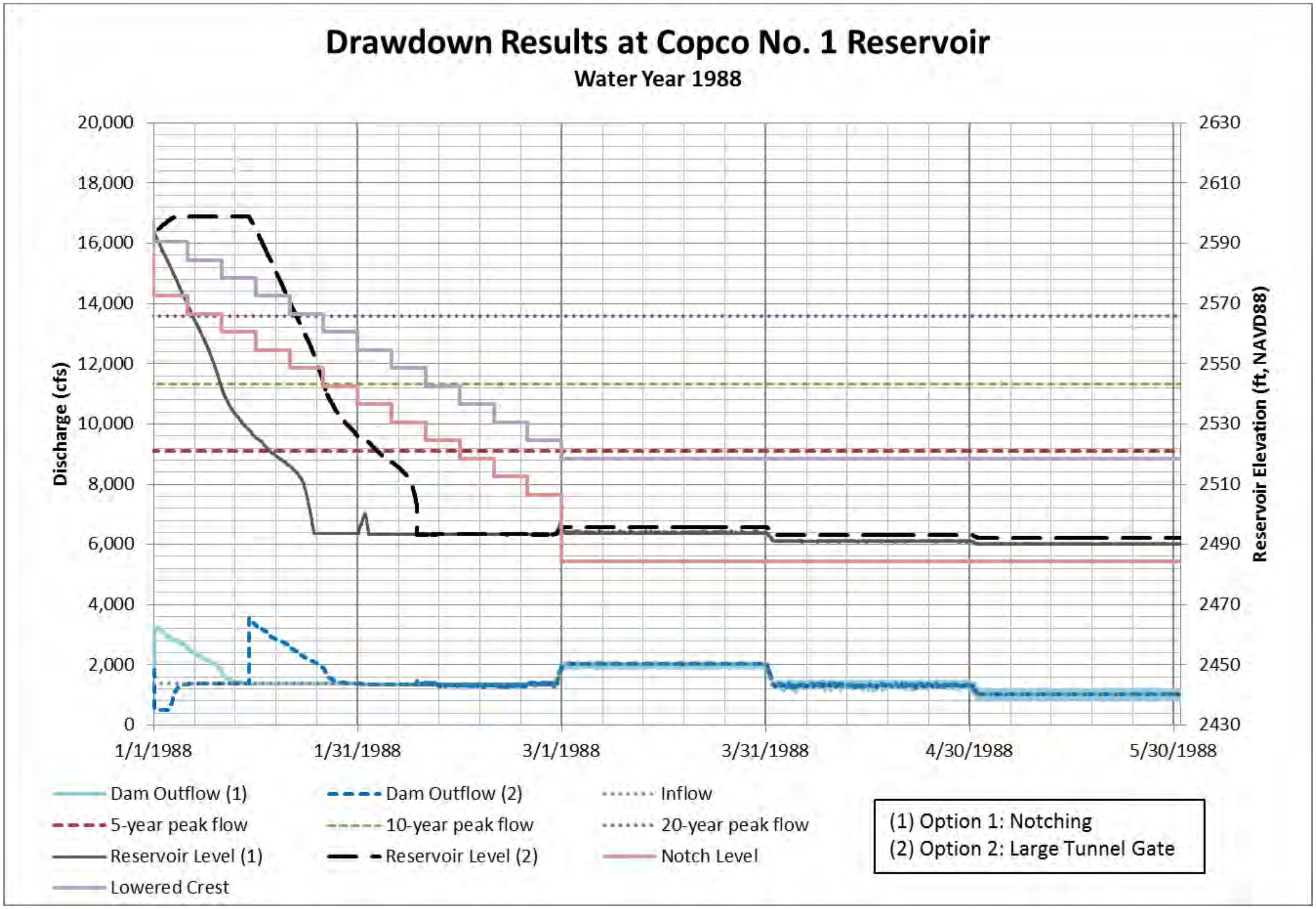



Figure F3-29 Copco No. 1 Reservoir Drawdown, Water Year 1988

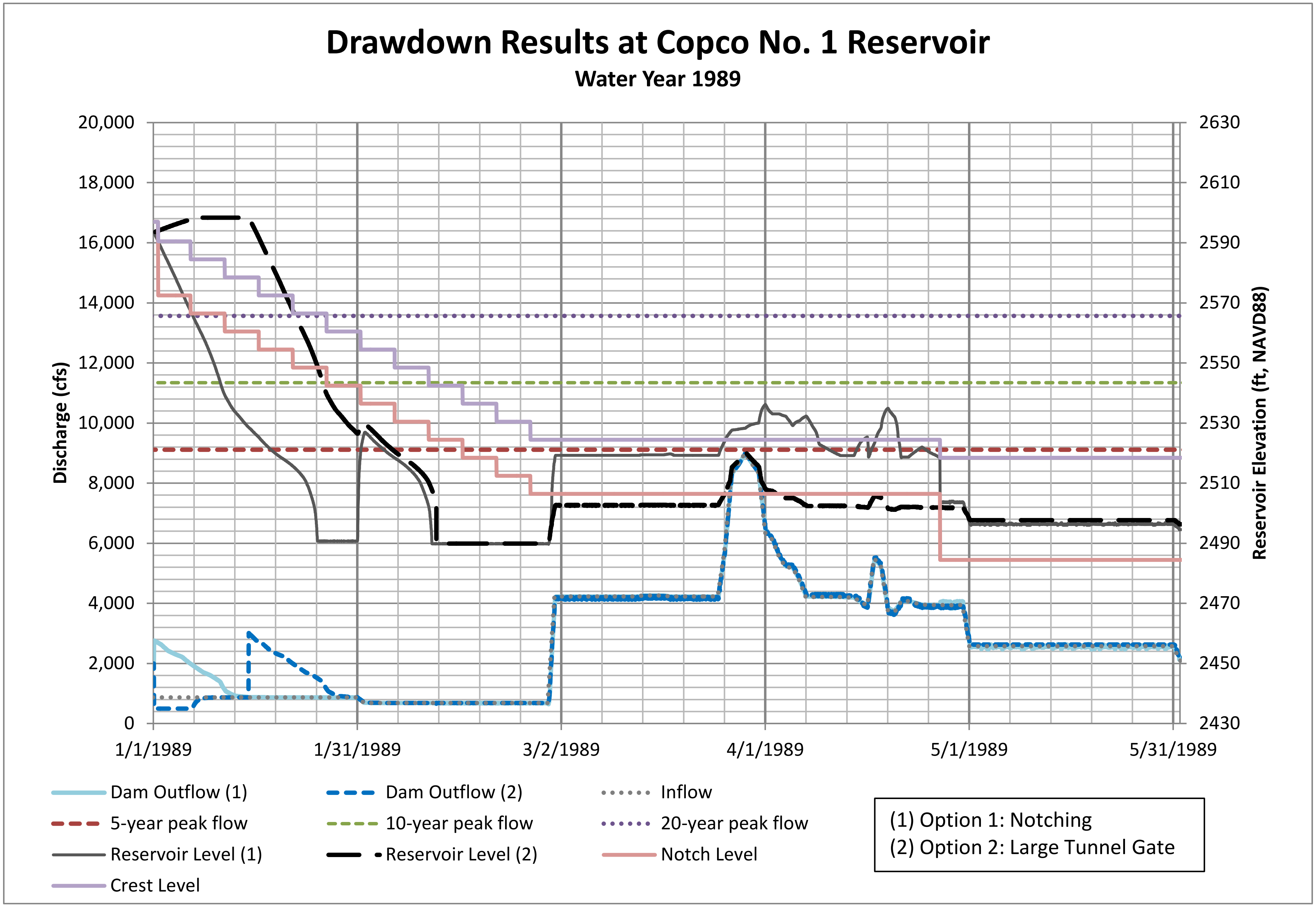



Figure F3-30 Copco No. 1 Reservoir Drawdown, Water Year 1989

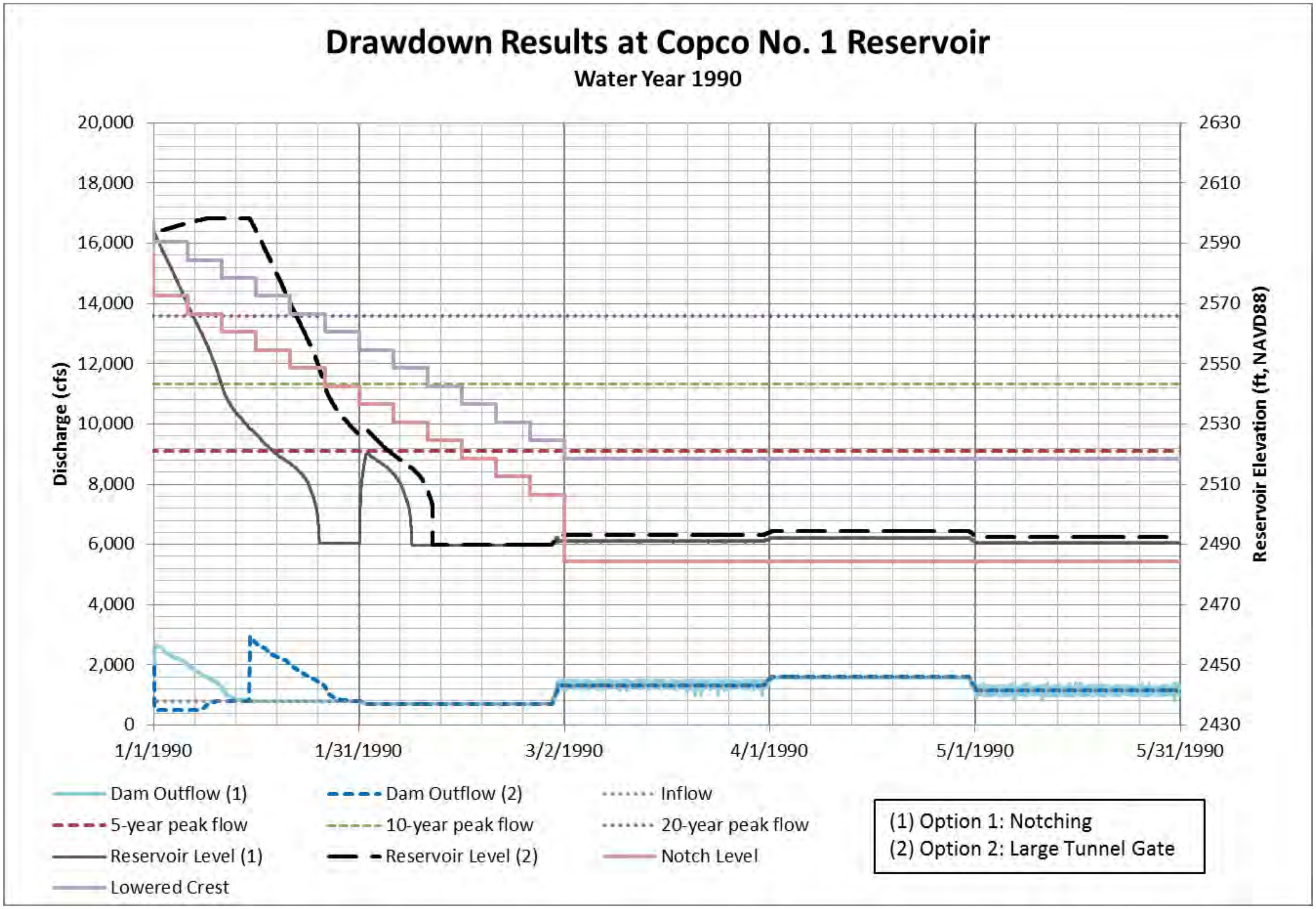



**Figure F3-31 Copco No. 1 Reservoir Drawdown, Water Year 1990**

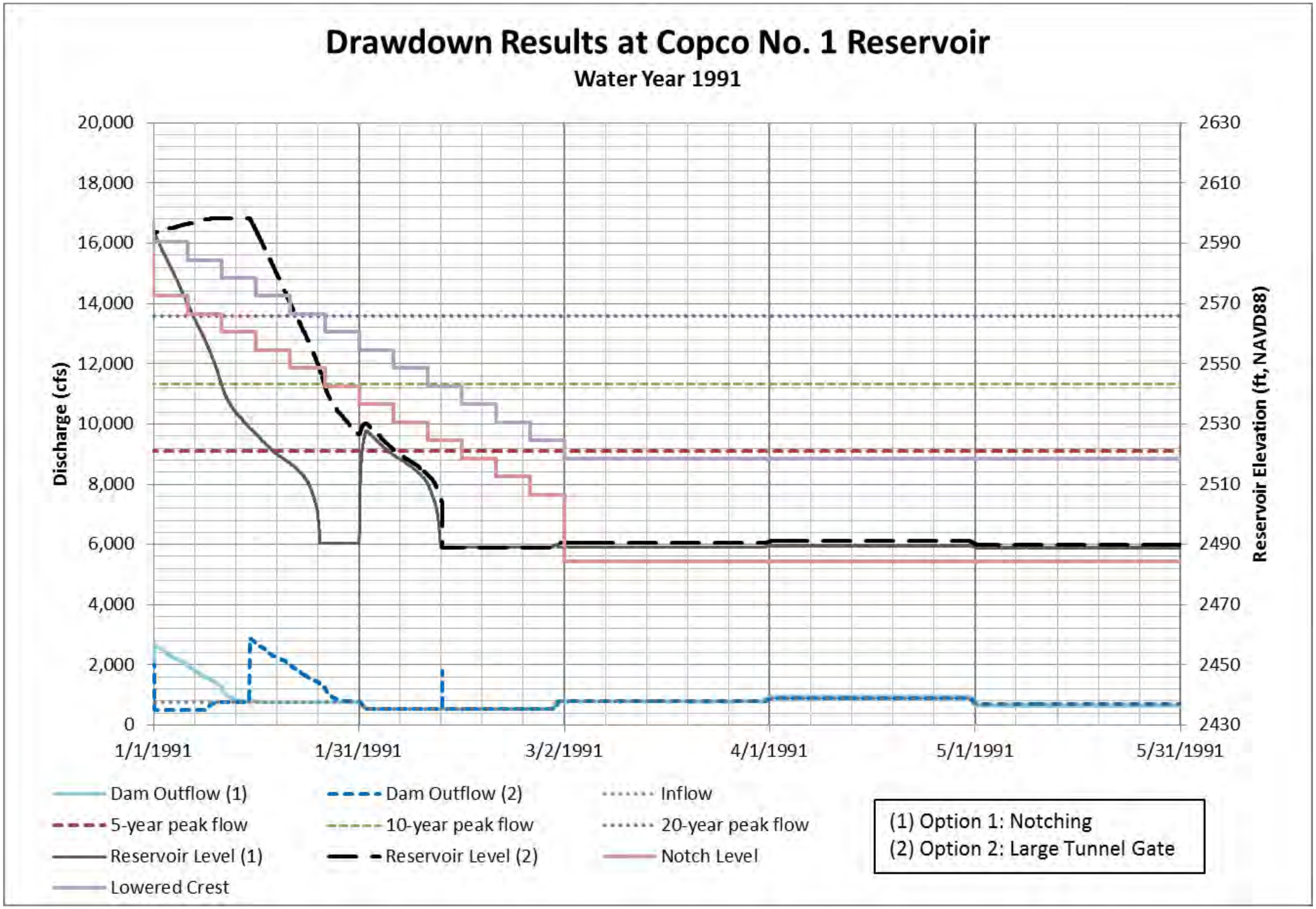



**Figure F3-32 Copco No. 1 Reservoir Drawdown, Water Year 1991**

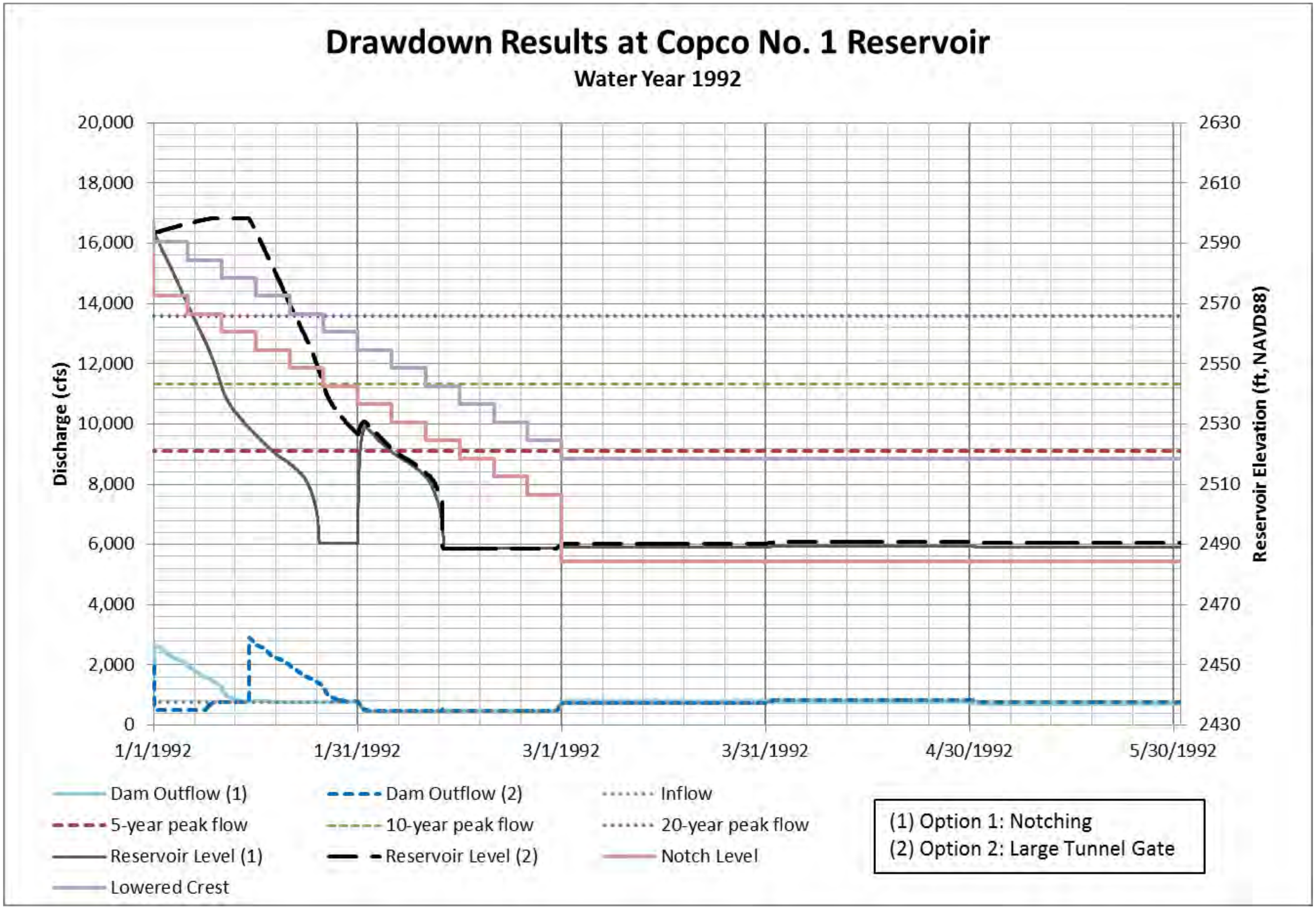



**Figure F3-33 Copco No. 1 Reservoir Drawdown, Water Year 1992**

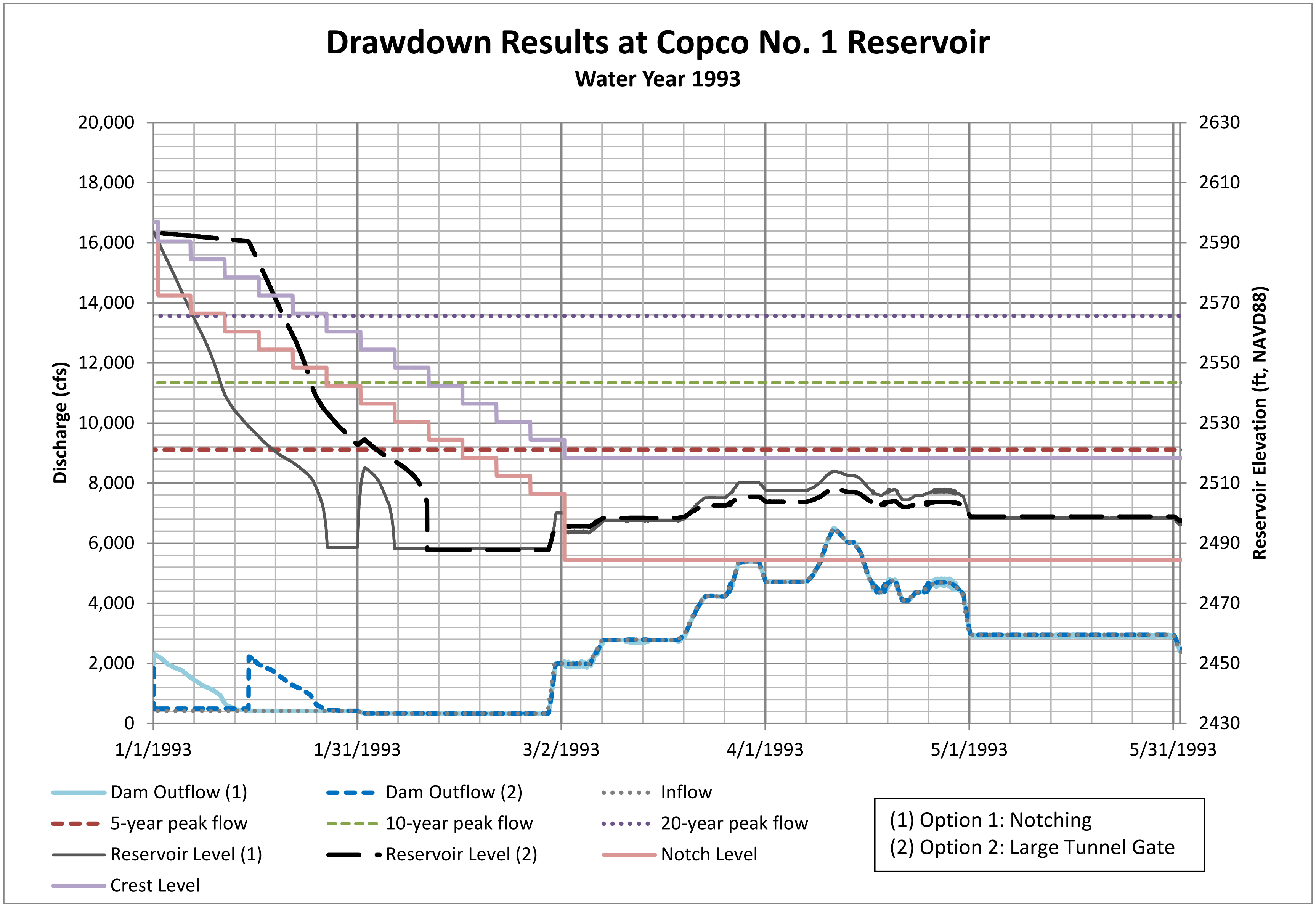



**Figure F3-34 Copco No. 1 Reservoir Drawdown, Water Year 1993**

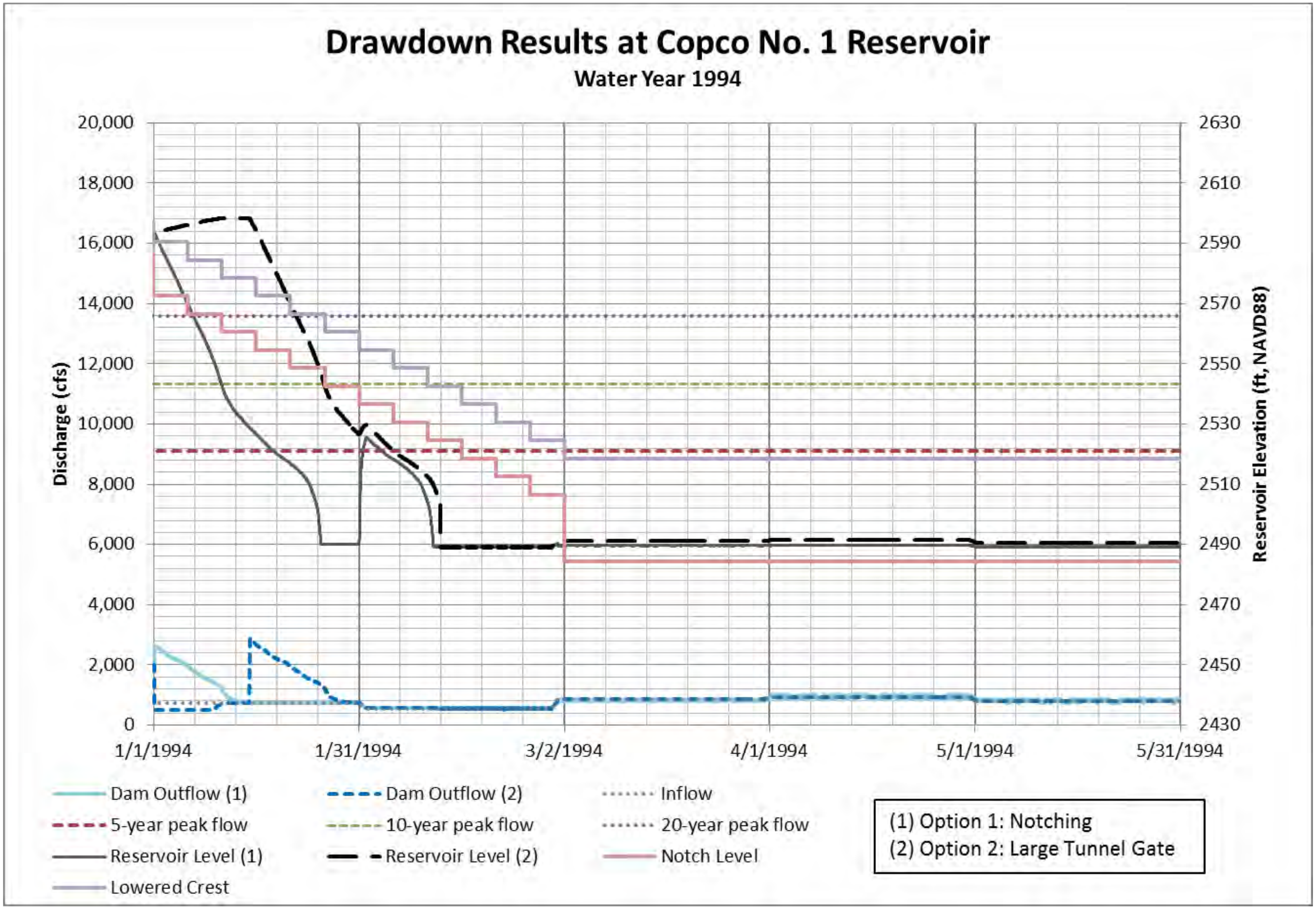



**Figure F3-35 Copco No. 1 Reservoir Drawdown, Water Year 1994**

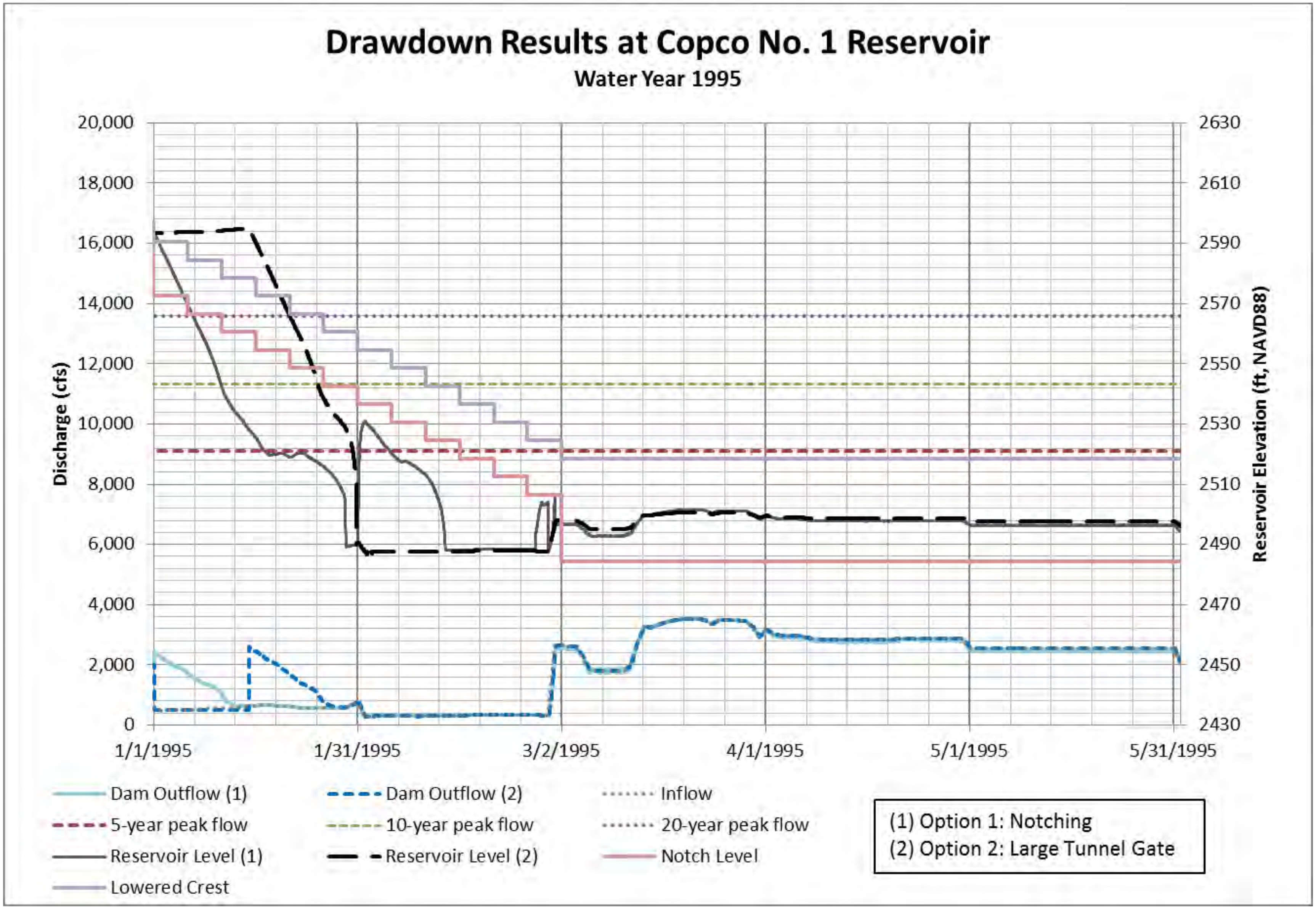



**Figure F3-36 Copco No. 1 Reservoir Drawdown, Water Year 1995**

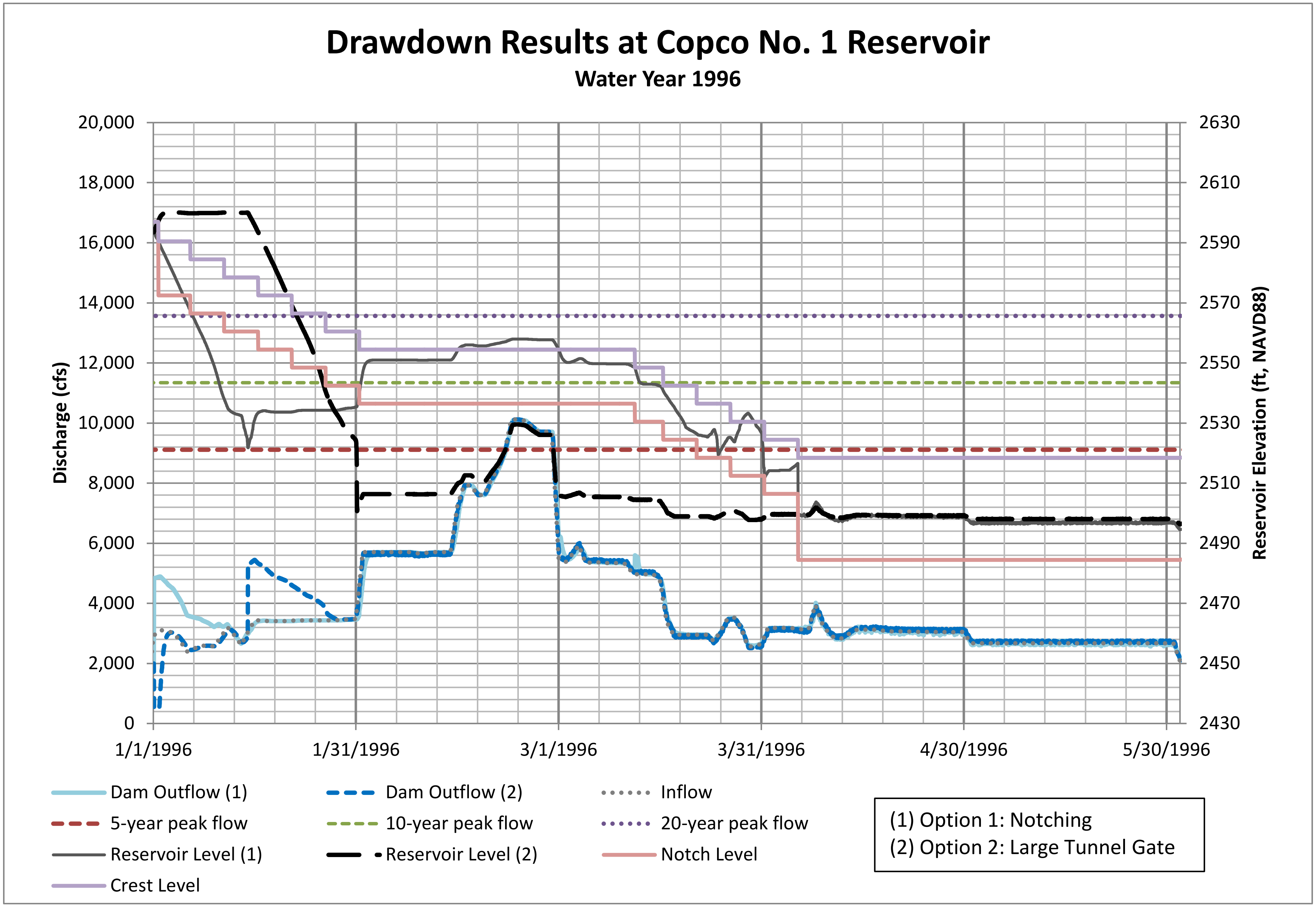



Figure F3-37 Copco No. 1 Reservoir Drawdown, Water Year 1996

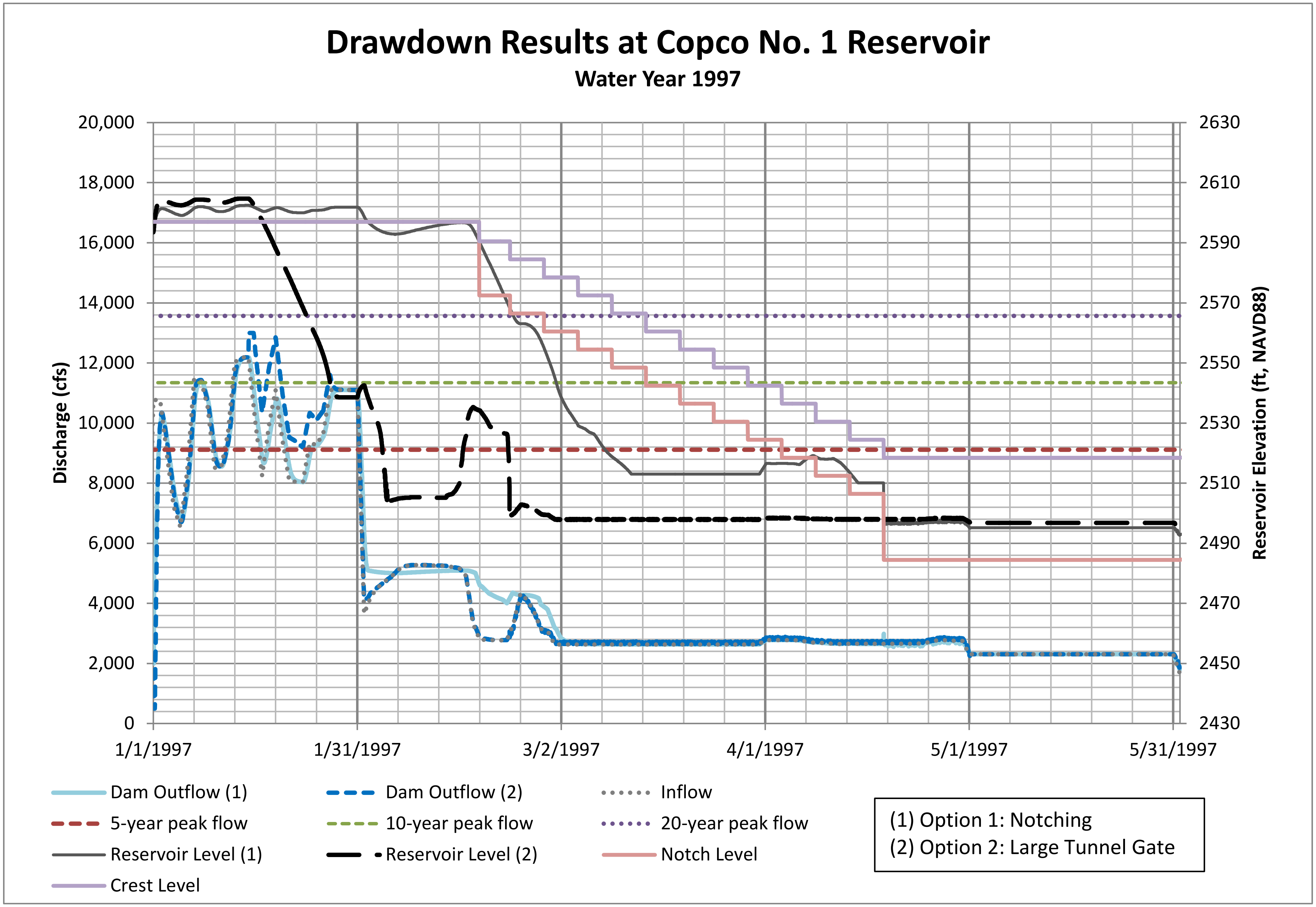



Figure F3-38 Copco No. 1 Reservoir Drawdown, Water Year 1997

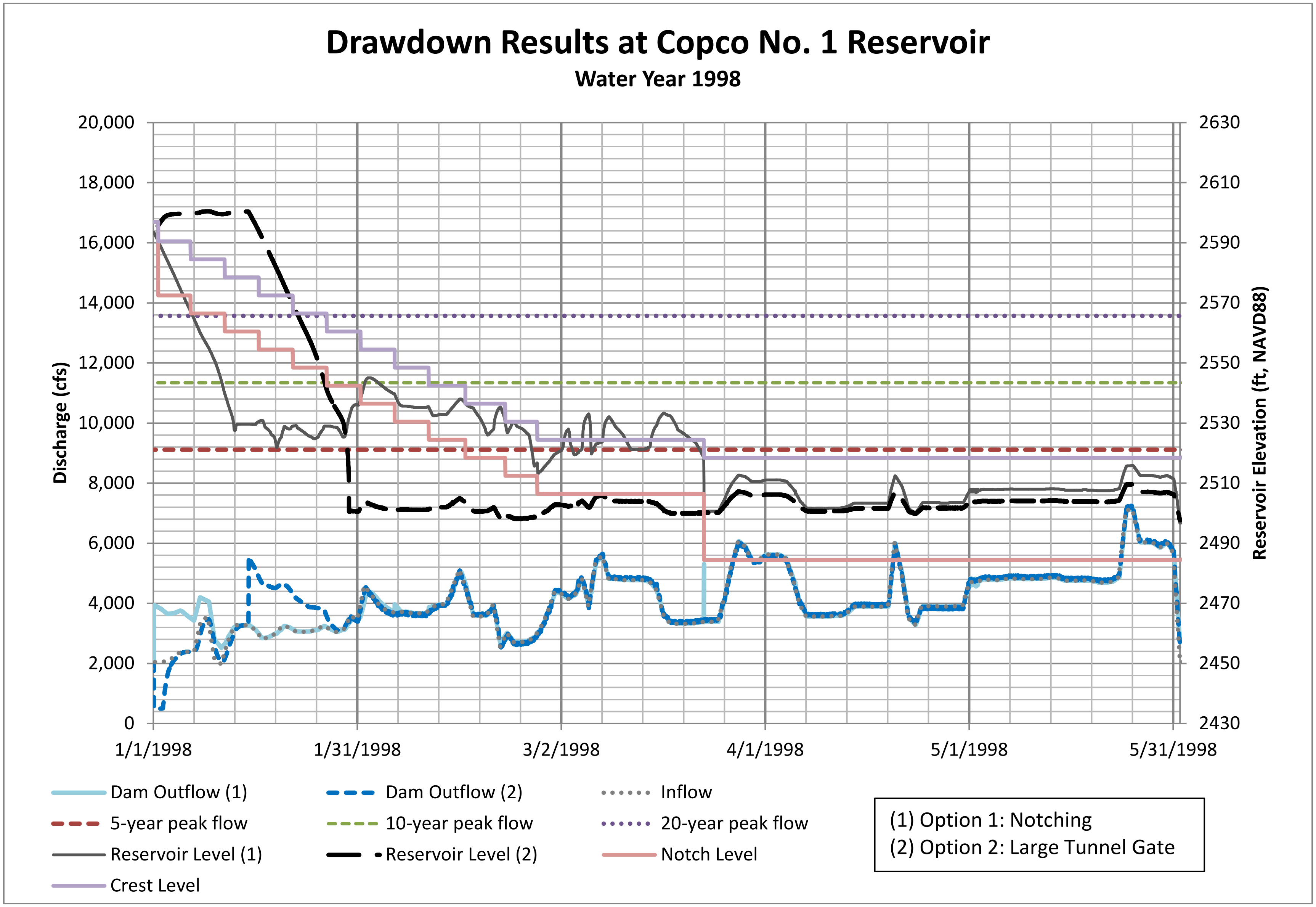



**Figure F3-39 Copco No. 1 Reservoir Drawdown, Water Year 1998**

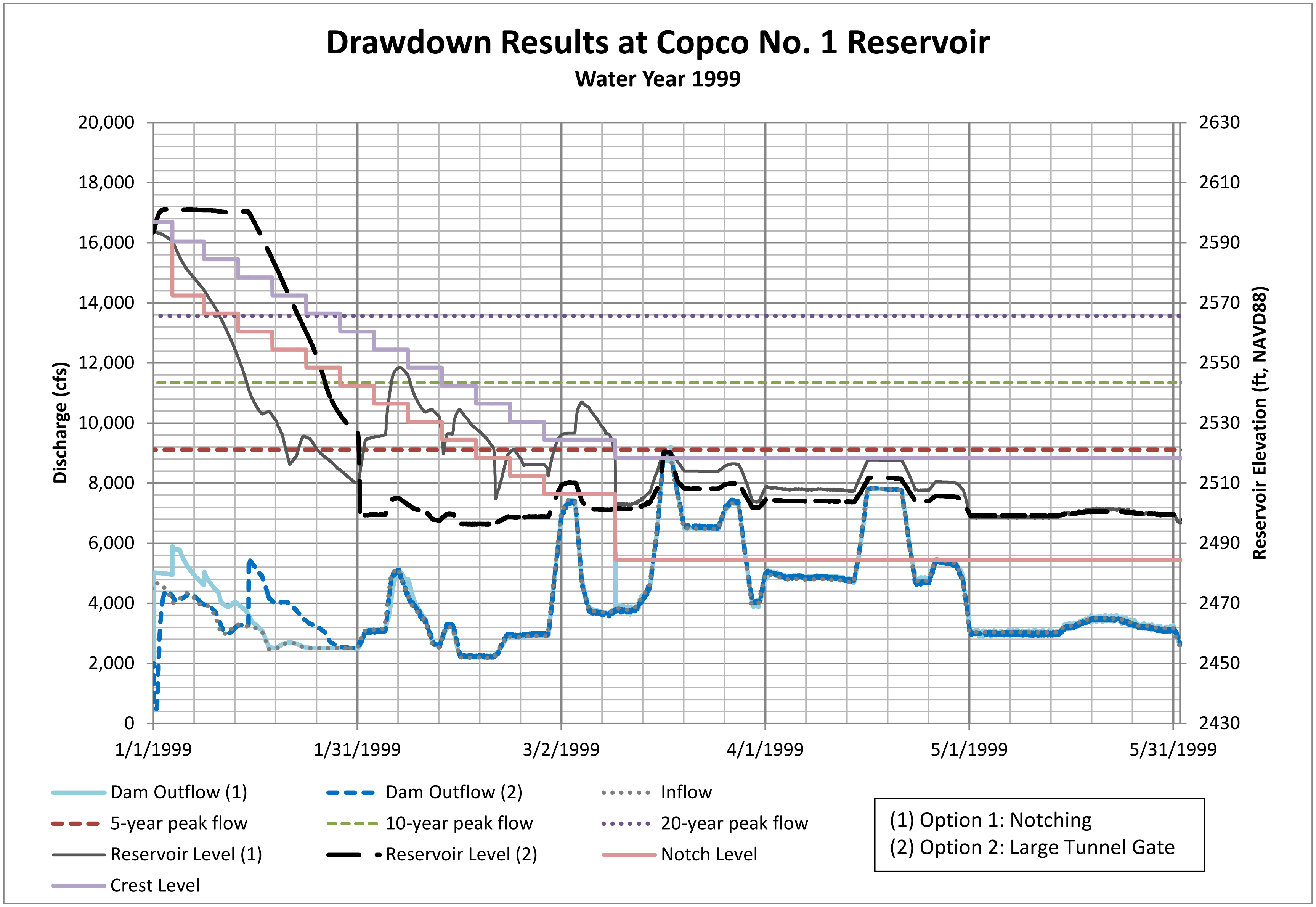



**Figure F3-40 Copco No. 1 Reservoir Drawdown, Water Year 1999**

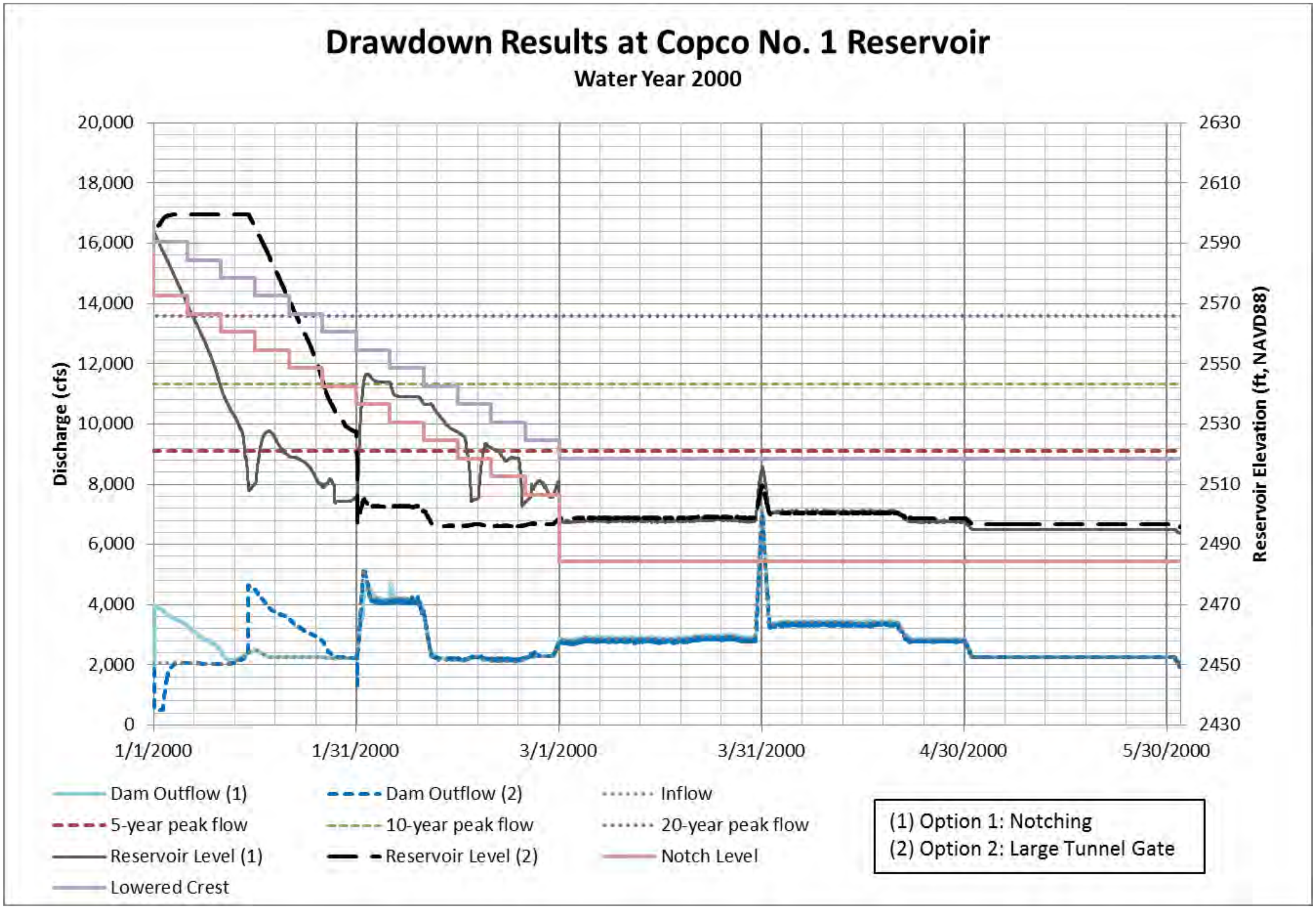



**Figure F3-41 Copco No. 1 Reservoir Drawdown, Water Year 2000**

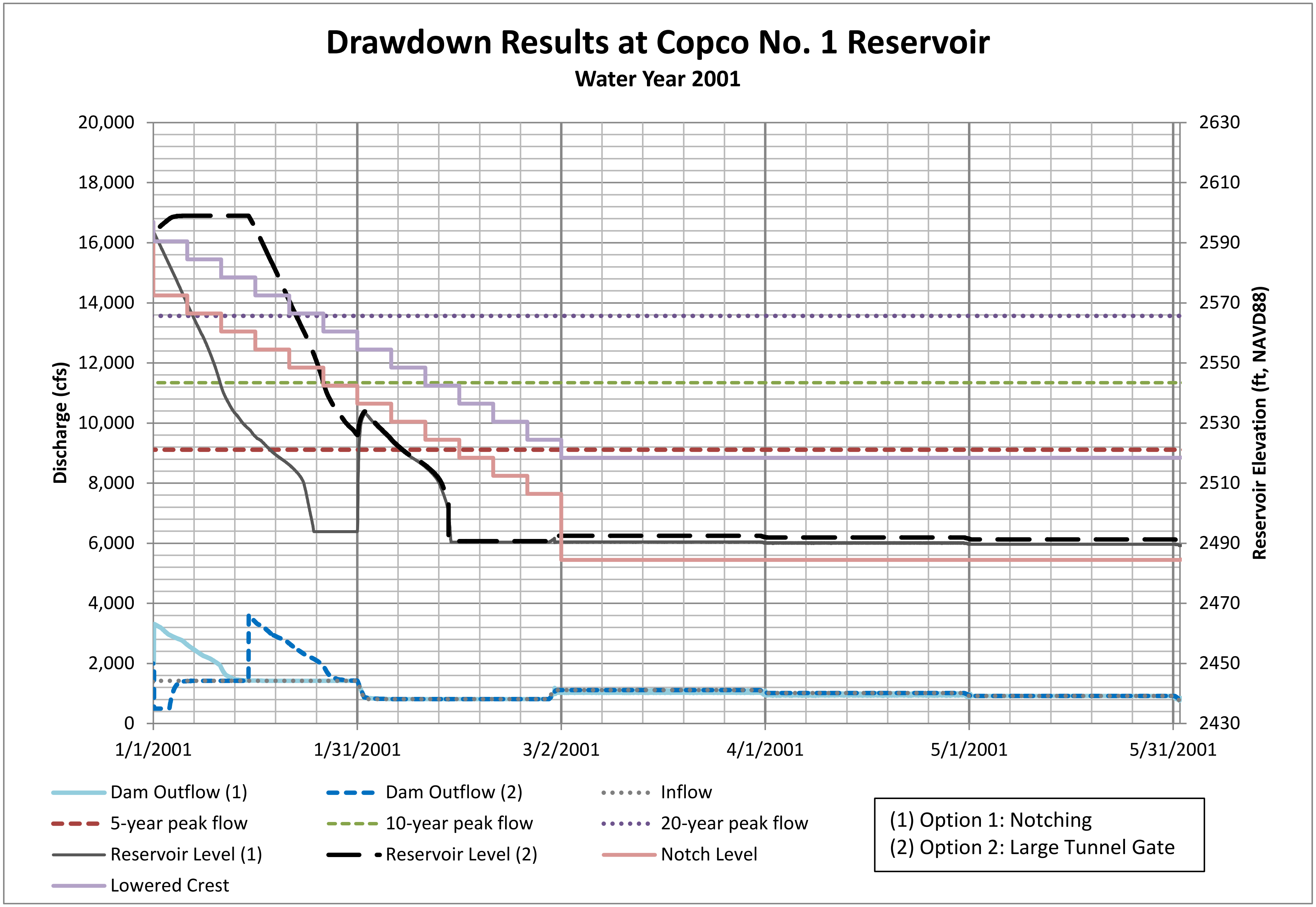



**Figure F3-42 Copco No. 1 Reservoir Drawdown, Water Year 2001**

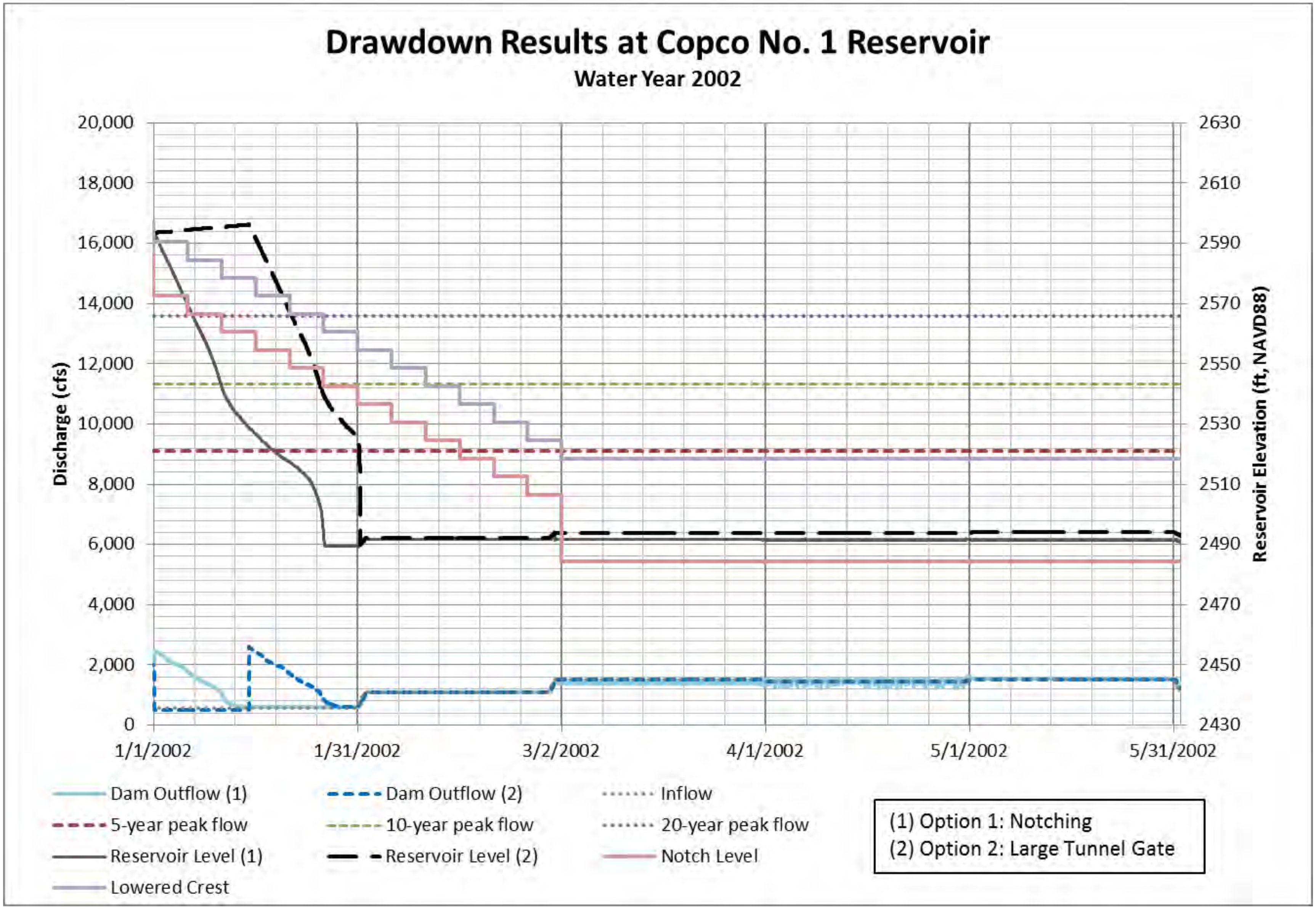



**Figure F3-43 Copco No. 1 Reservoir Drawdown, Water Year 2002**

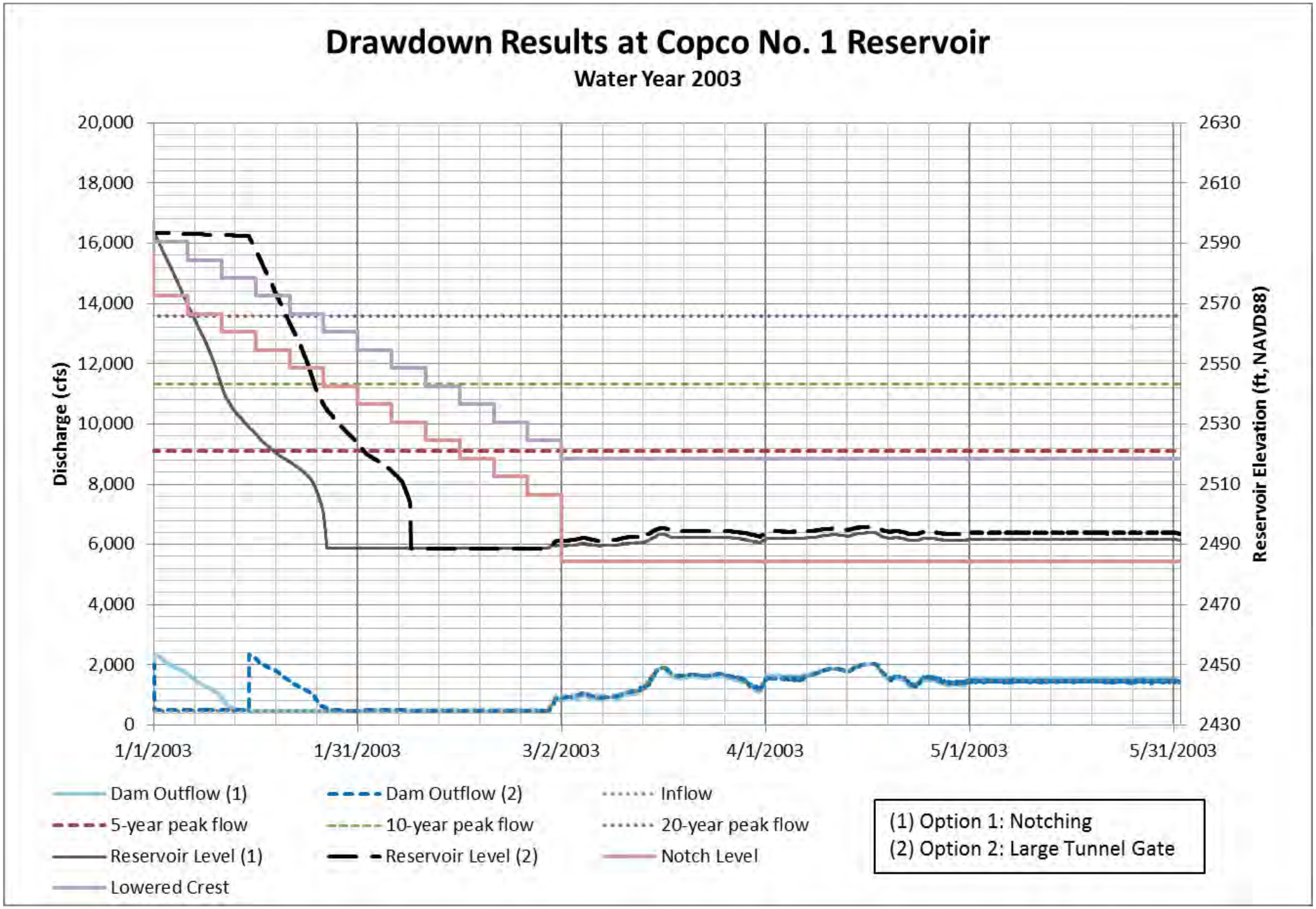



Figure F3-44 Copco No. 1 Reservoir Drawdown, Water Year 2003

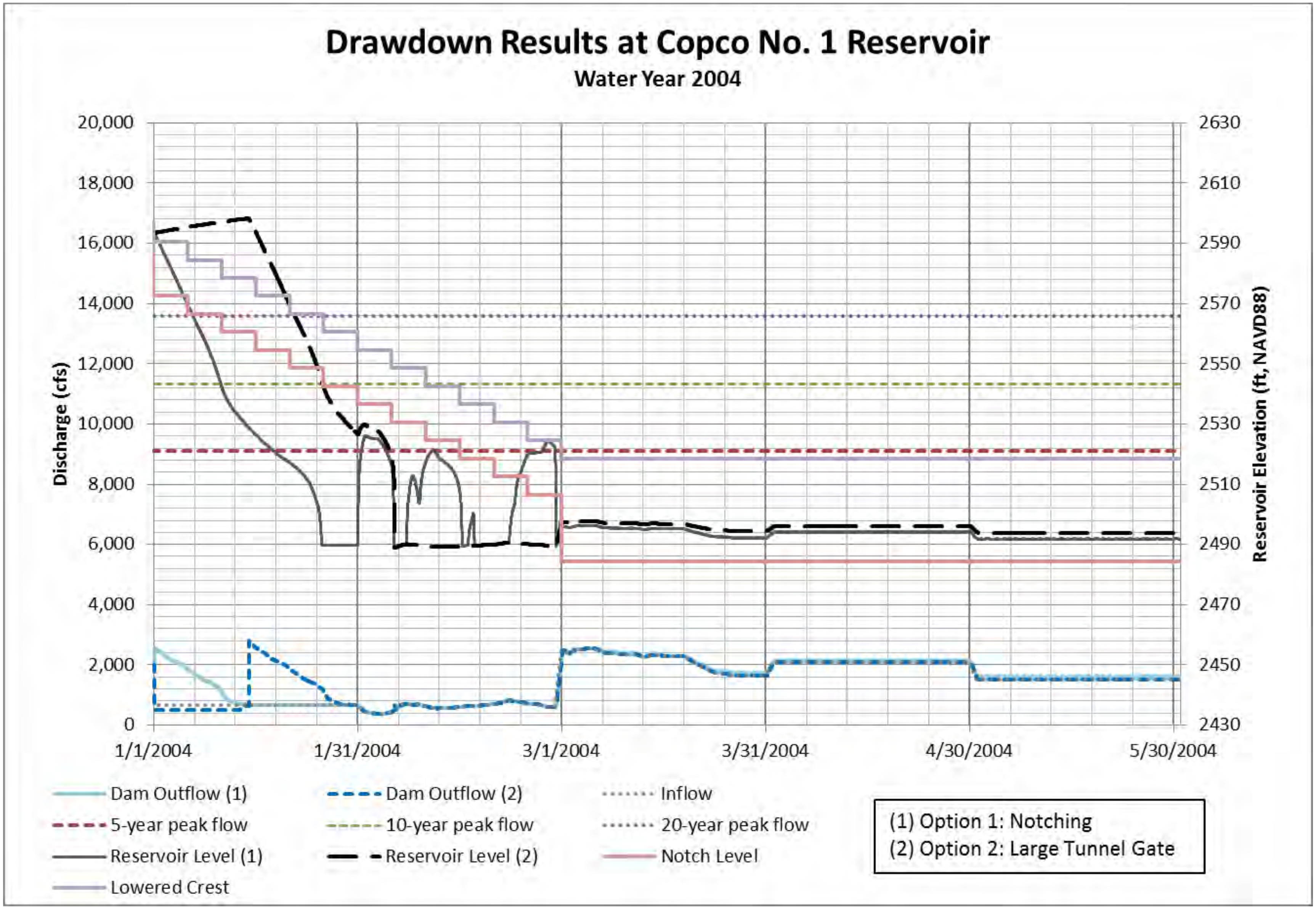



**Figure F3-45 Copco No. 1 Reservoir Drawdown, Water Year 2004**

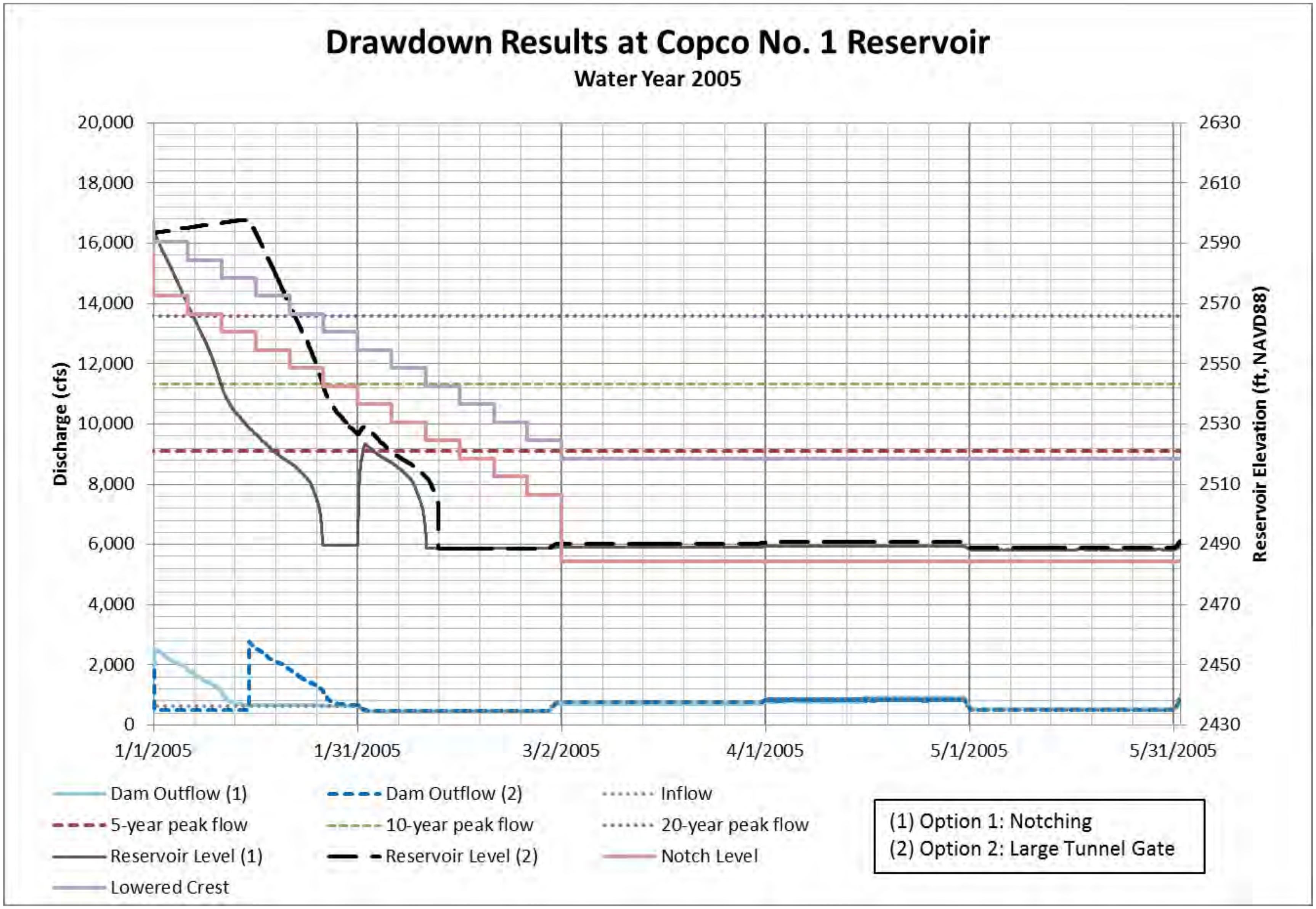



Figure F3-46 Copco No. 1 Reservoir Drawdown, Water Year 2005

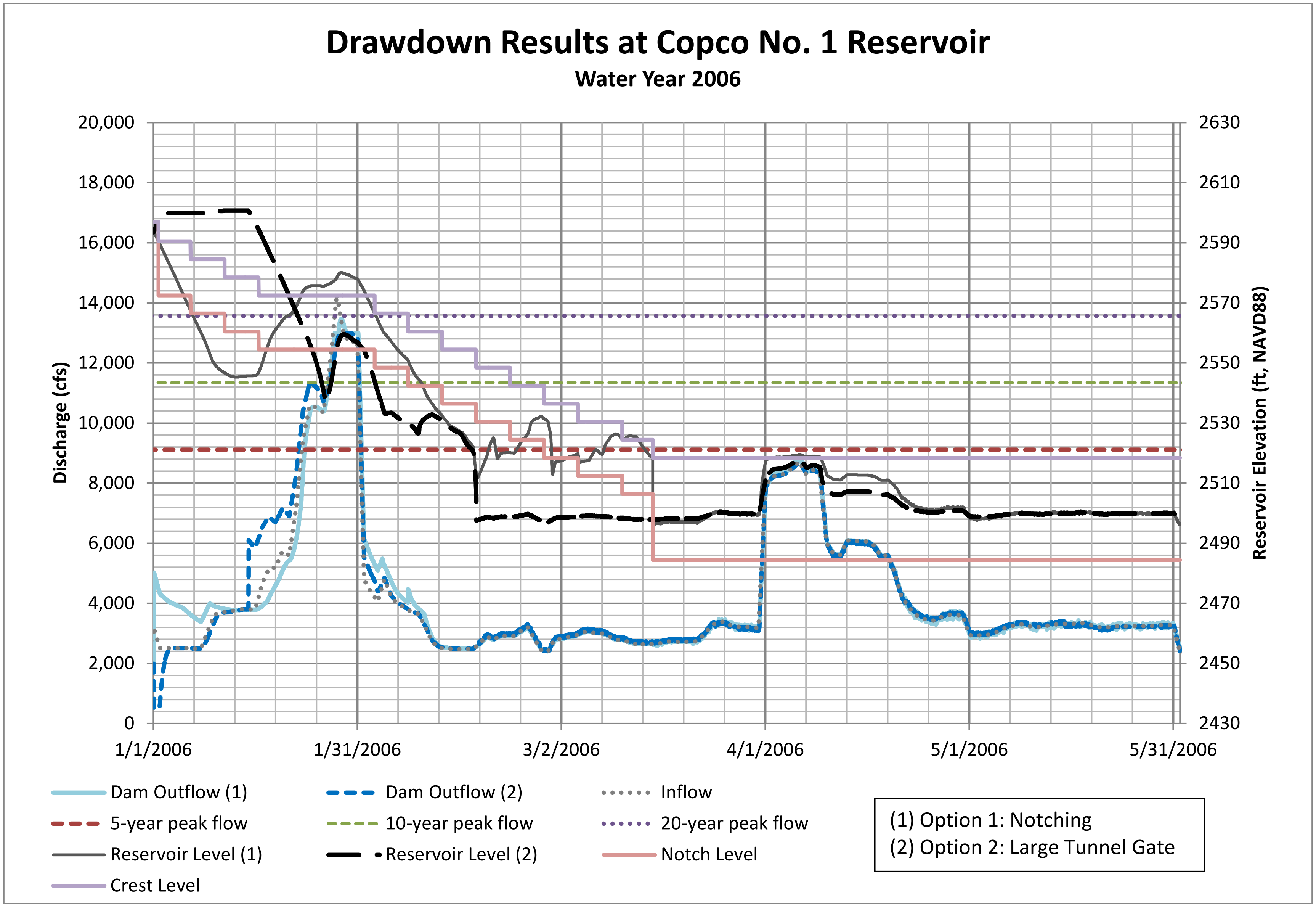



**Figure F3-47 Copco No. 1 Reservoir Drawdown, Water Year 2006**

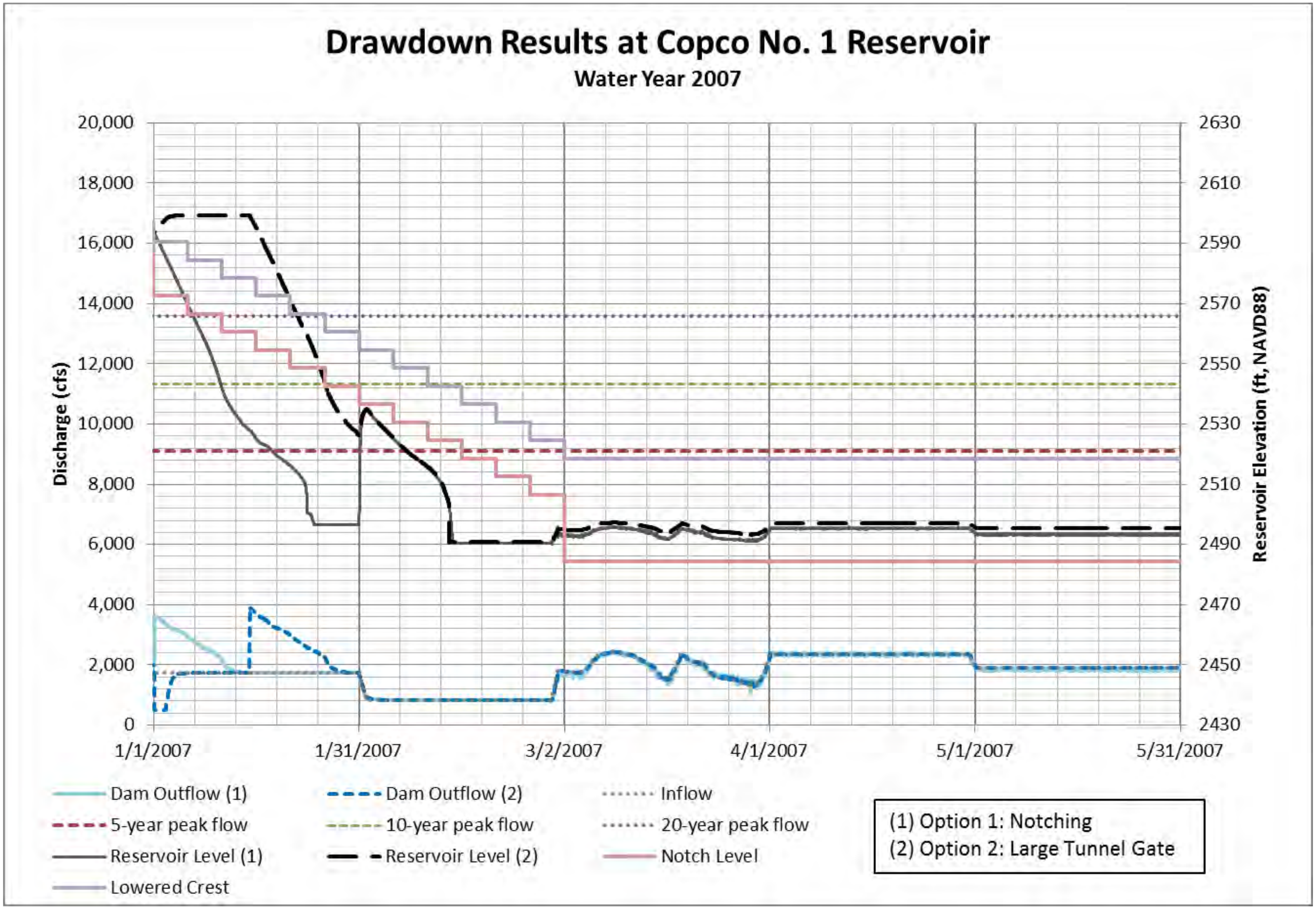



**Figure F3-48 Copco No. 1 Reservoir Drawdown, Water Year 2007**

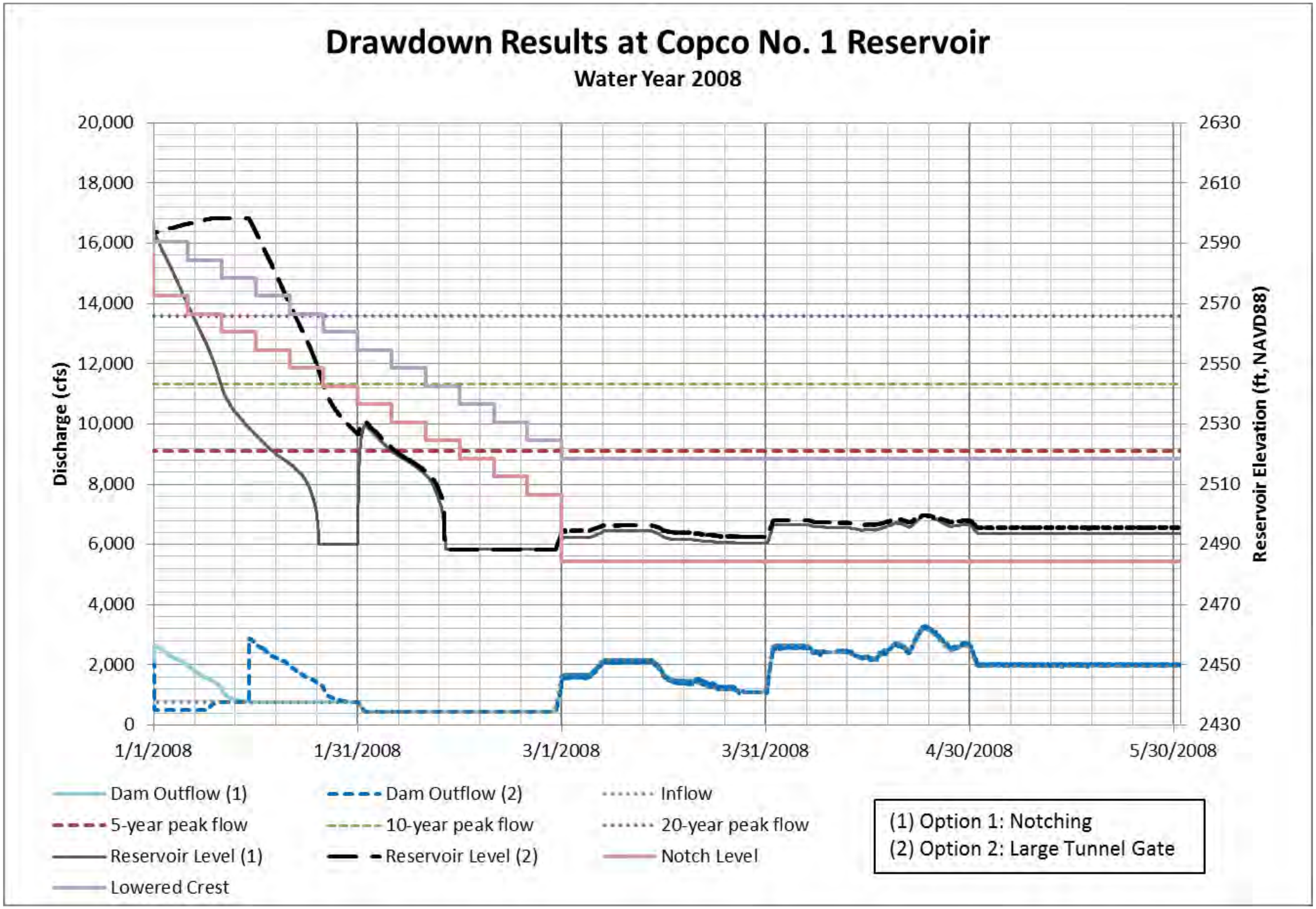



**Figure F3-49 Copco No. 1 Reservoir Drawdown, Water Year 2008**

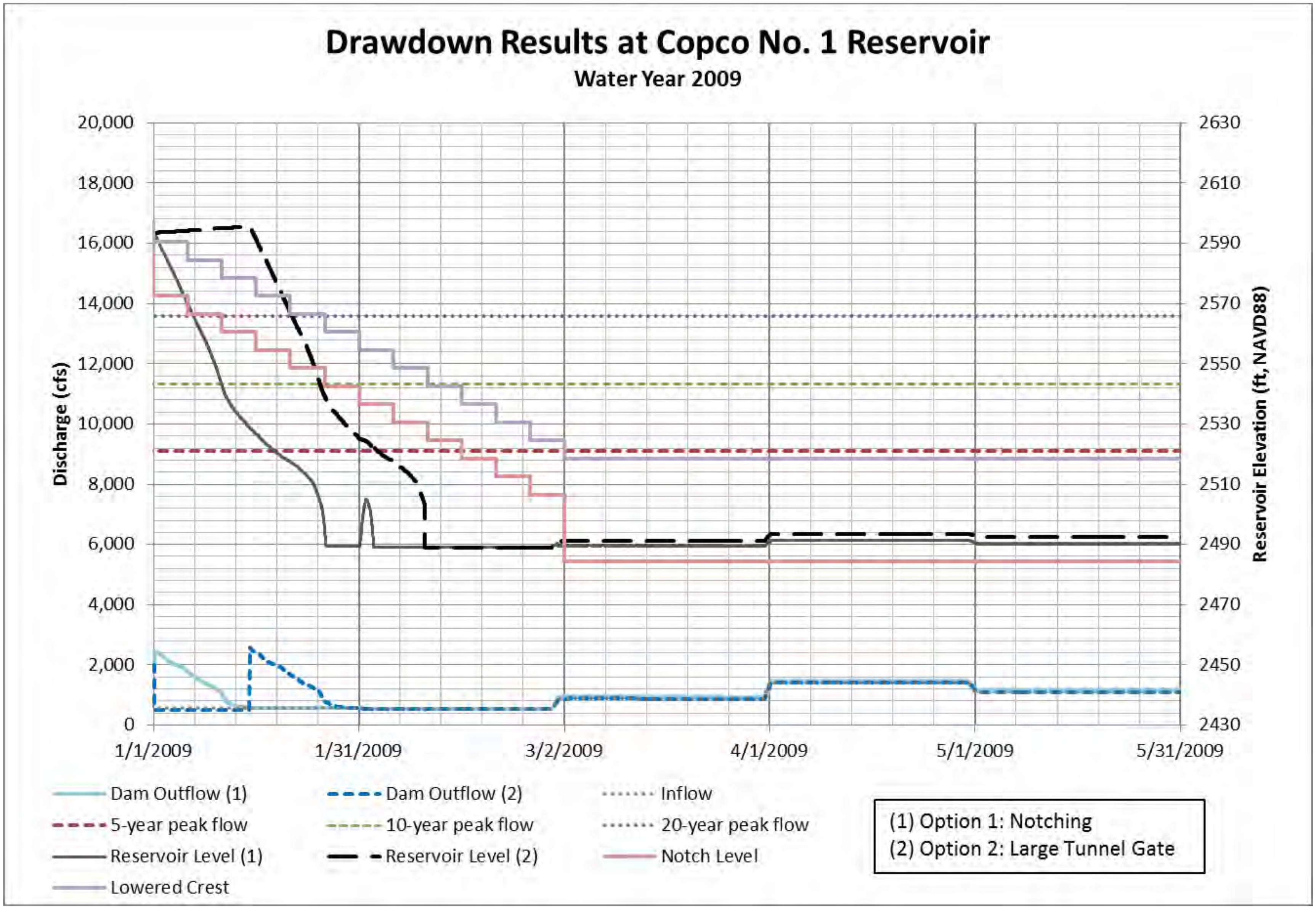



**Figure F3-50 Copco No. 1 Reservoir Drawdown, Water Year 2009**

# F4. Iron Gate Reservoir

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

## Results

Results for drawdown in Iron Gate Reservoir are shown in Figures F3-1 through F3-49. Due to their close proximity, the Iron Gate Reservoir drawdown was modeled in conjunction with the Copco Lake drawdown. There are different results at Iron Gate Reservoir depending on which drawdown option at Copco No. 1 Dam is chosen. References to Options 1 and 2 in the plots are the resulting effects at Iron Gate based on either Option 1 or 2 being implemented at Copco No. 1 Dam.

During representative drier years (for example1973 and 1979), the reservoir was easily drawn down by early February, and it did not refill after that point.

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

For the wettest year, 1966, the reservoir was mostly drawn down by March 1, but did not completely drain until mid-March.

During the wetter years (for example 1966, 2006, 1986, and 1970), flows are higher than what would be expected via the spillway alone (i.e., without drawdown), but the increases are limited to those periods when flows are below the 10-year flood elevation. It is not anticipated that sediment concentrations resulting from the proposed drawdown procedure and associated hydraulics, would differ from those previously estimated (USBR 2012c).

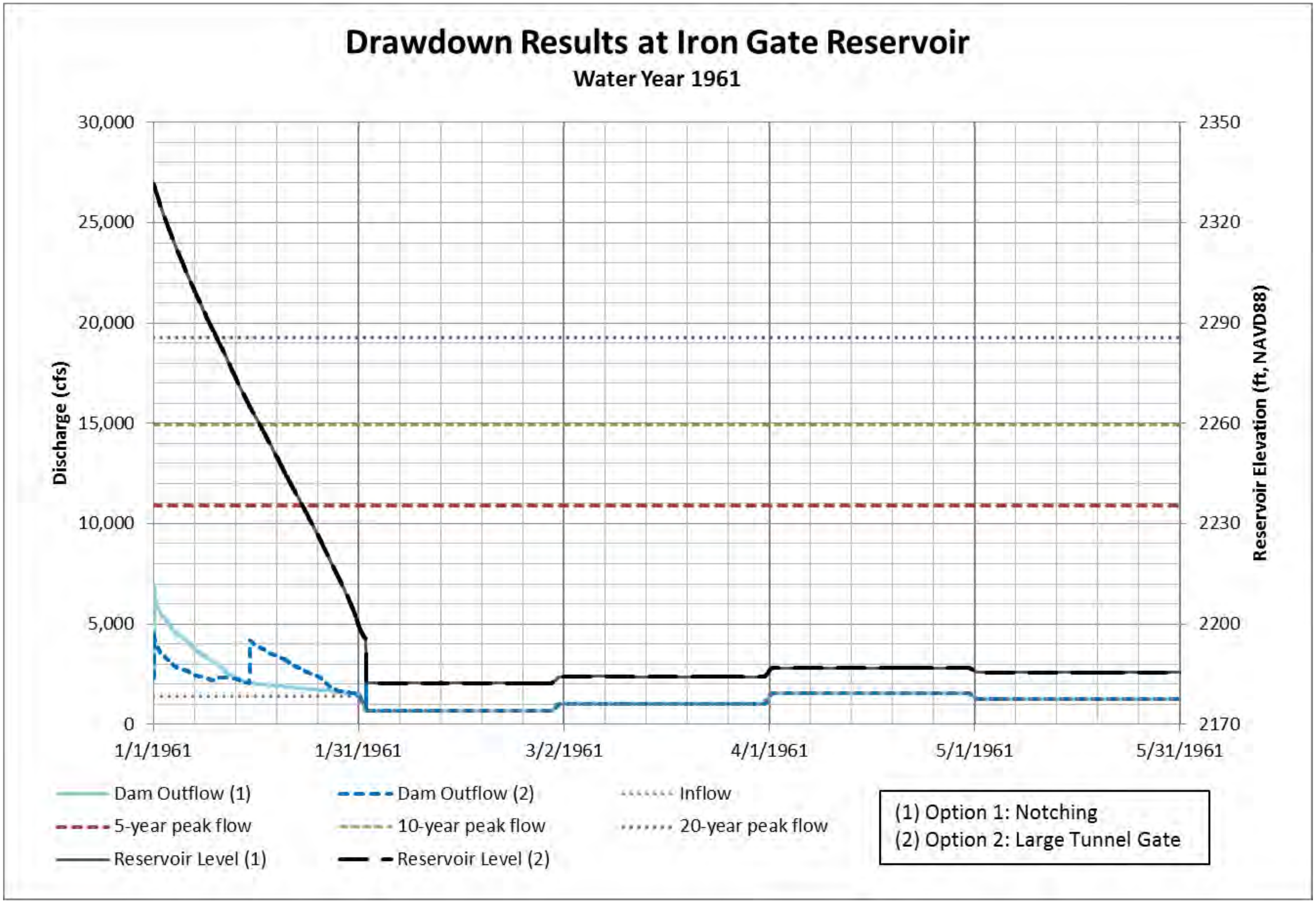



**Figure F4-1 Iron Gate Reservoir Drawdown, Water Year 1961**

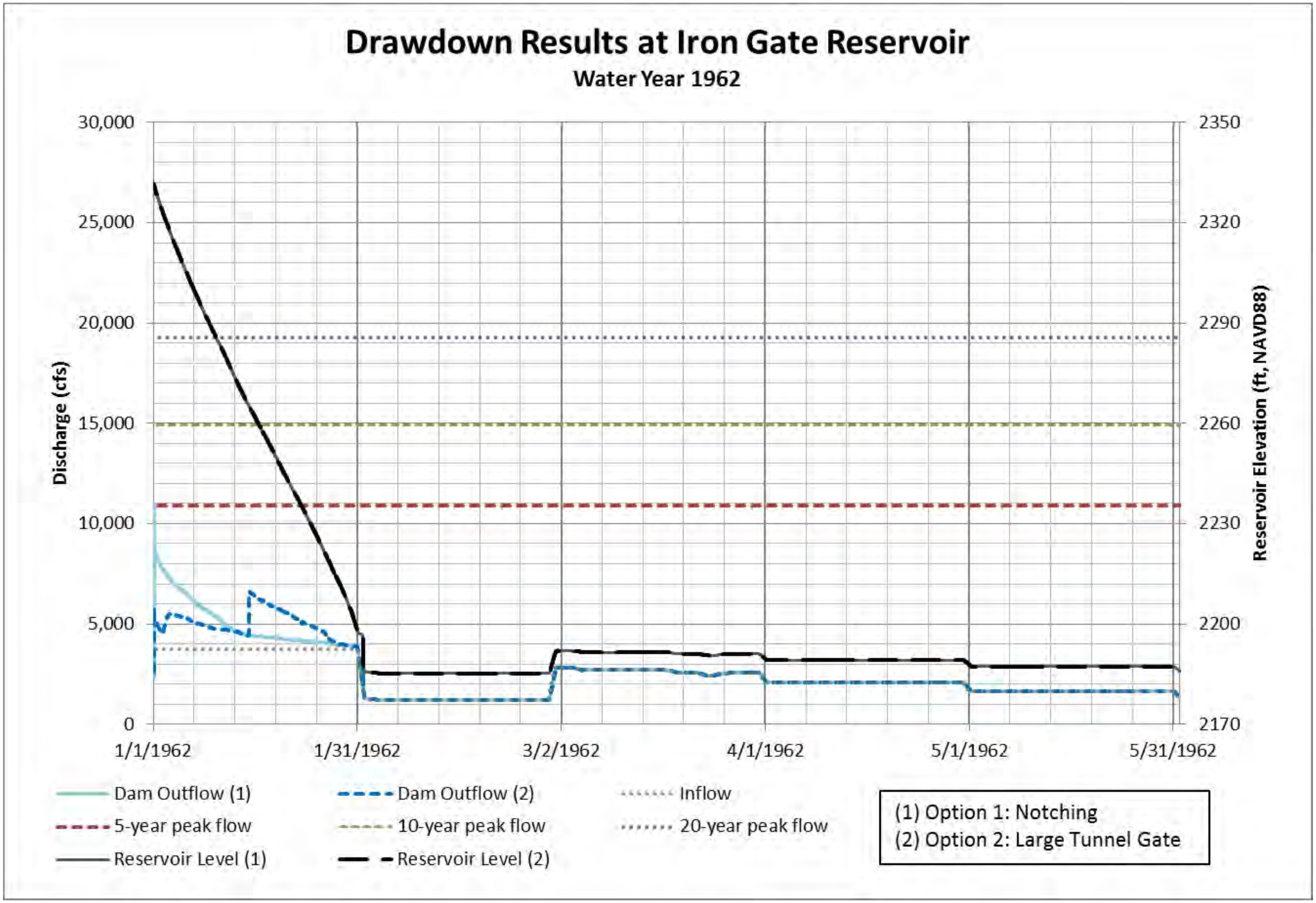



**Figure F4-2 Iron Gate Reservoir Drawdown, Water Year 1962**

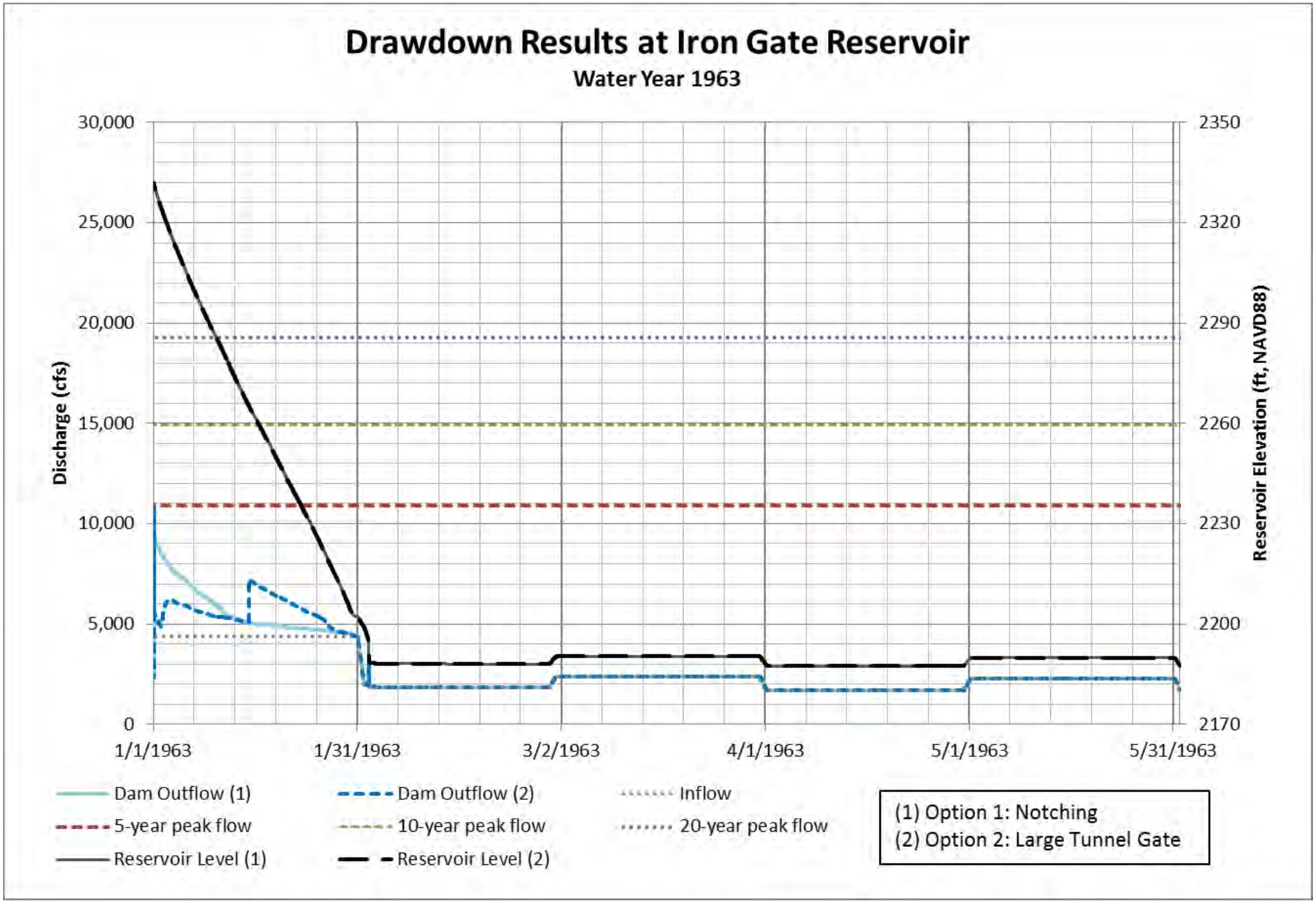



**Figure F4-3 Iron Gate Reservoir Drawdown, Water Year 1963**

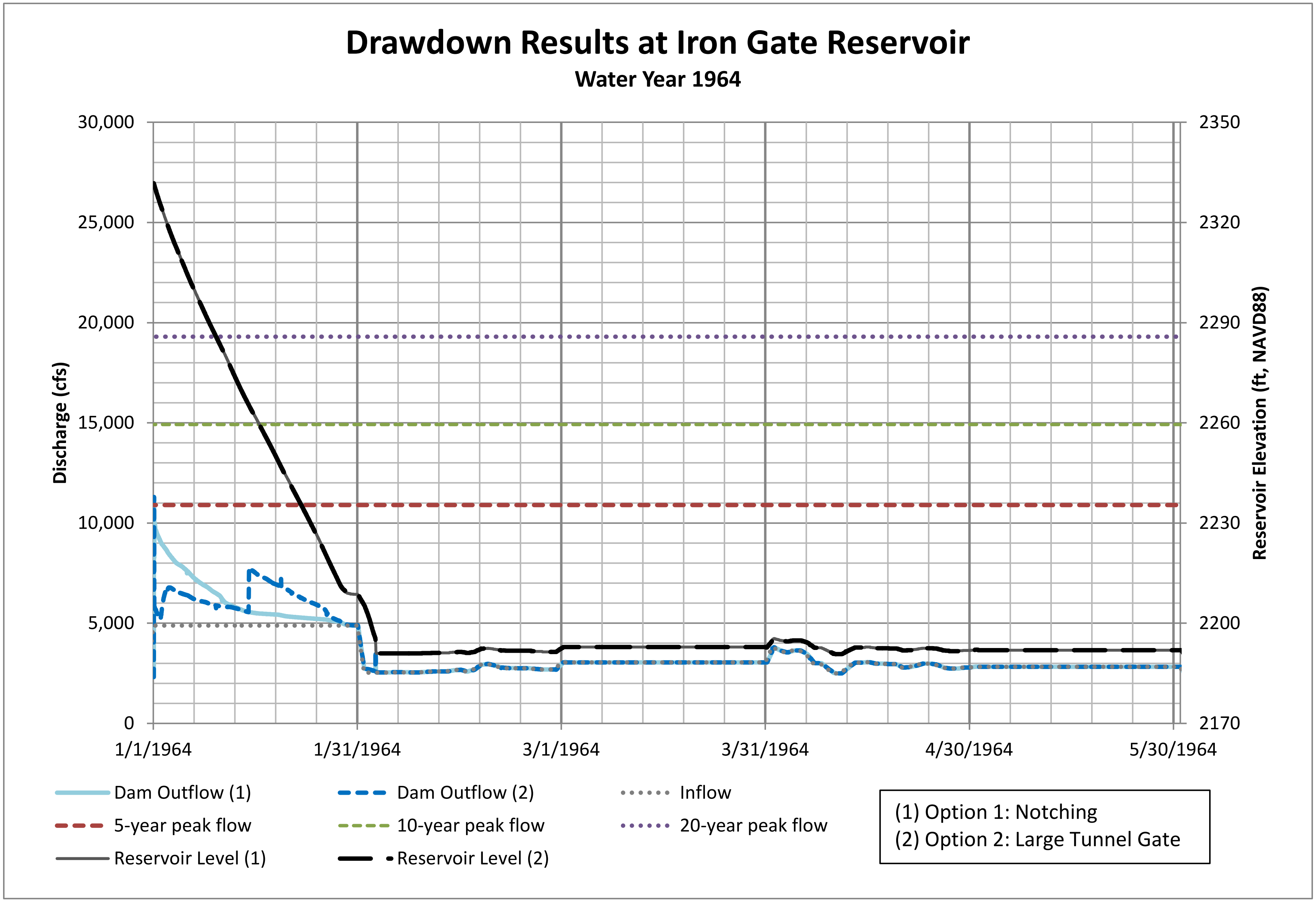



**Figure F4-4 Iron Gate Reservoir Drawdown, Water Year 1964**

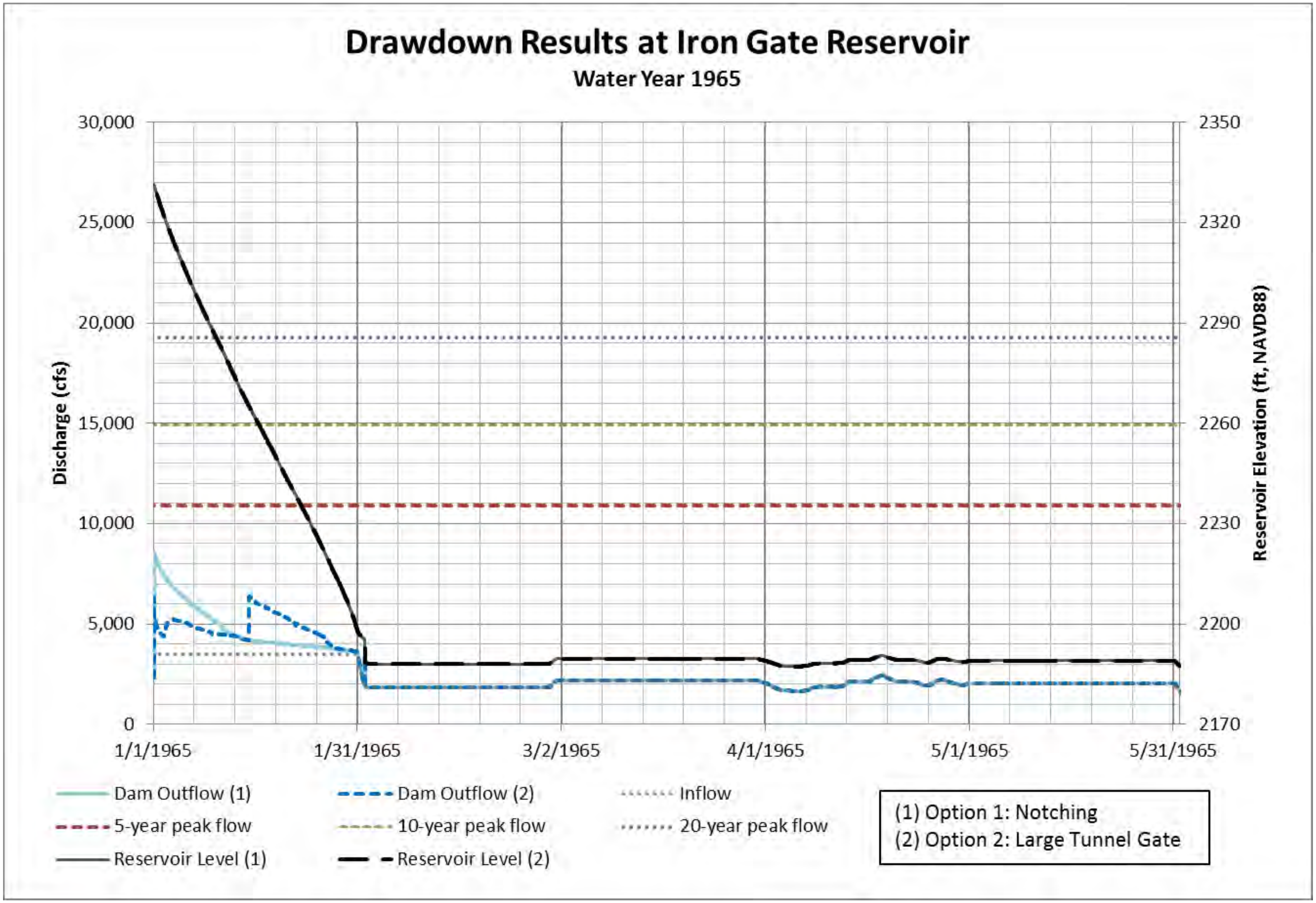



**Figure F4-5 Iron Gate Reservoir Drawdown, Water Year 1965**

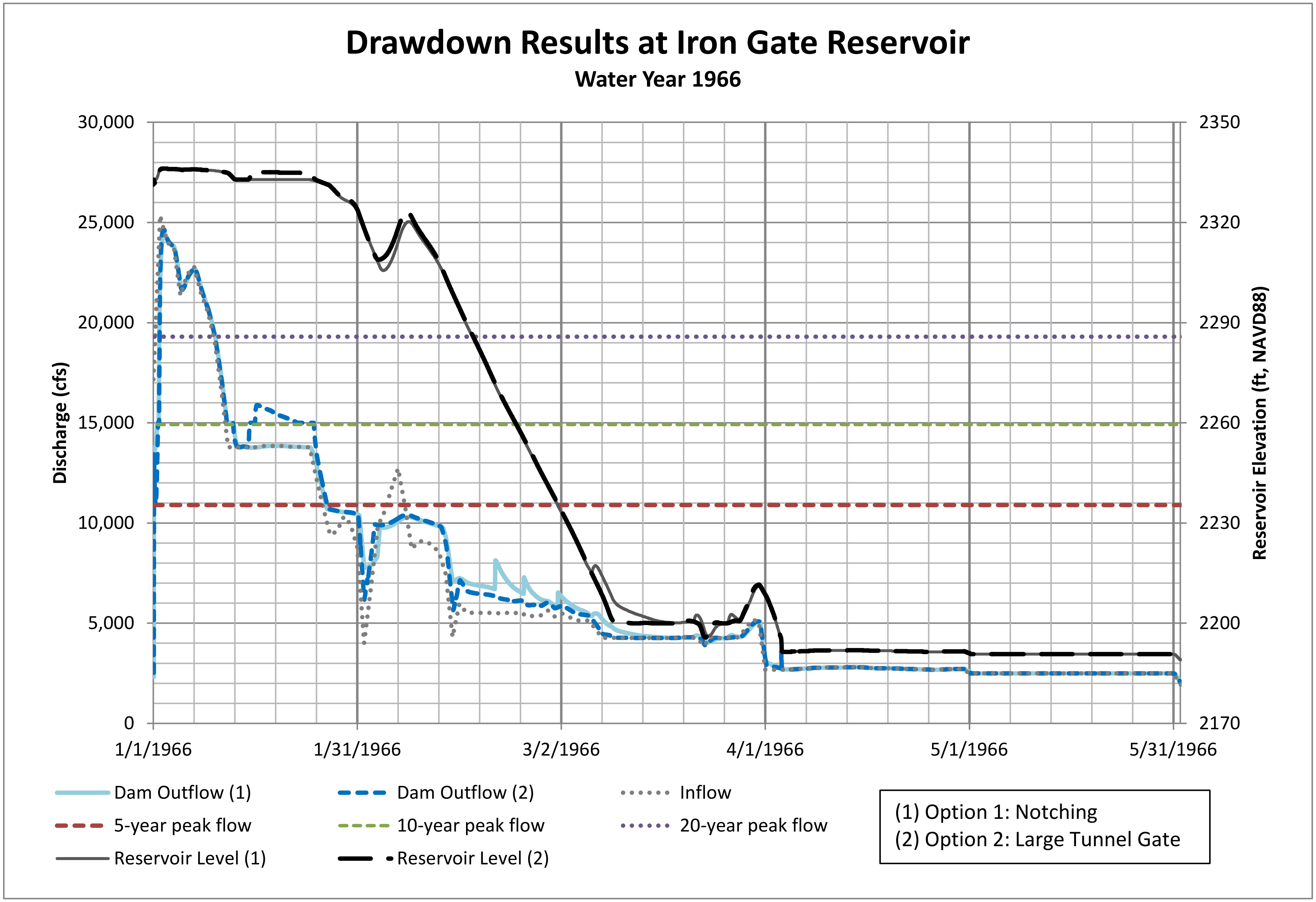



**Figure F4-6 Iron Gate Reservoir Drawdown, Water Year 1966**

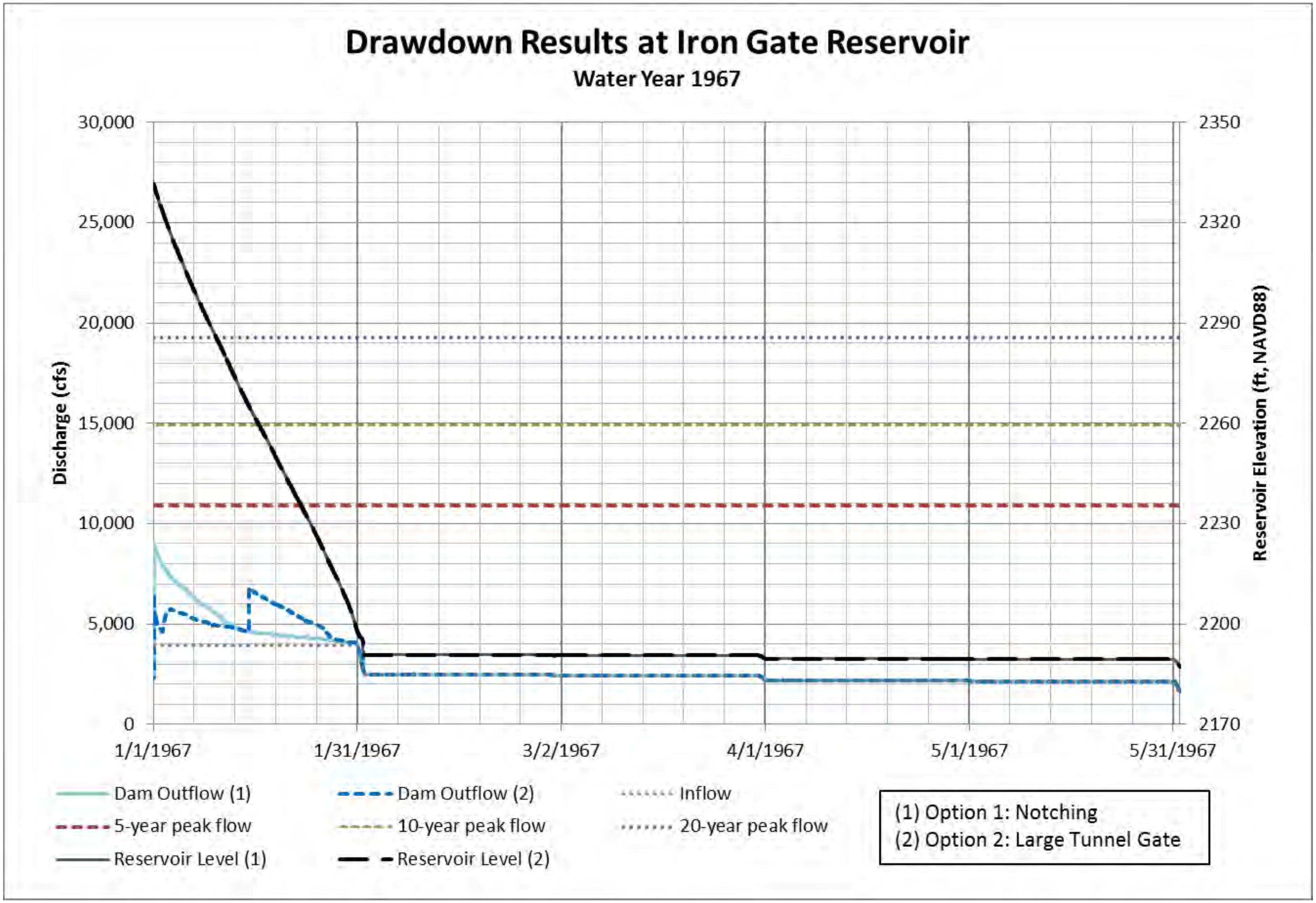



**Figure F4-7 Iron Gate Reservoir Drawdown, Water Year 1967**

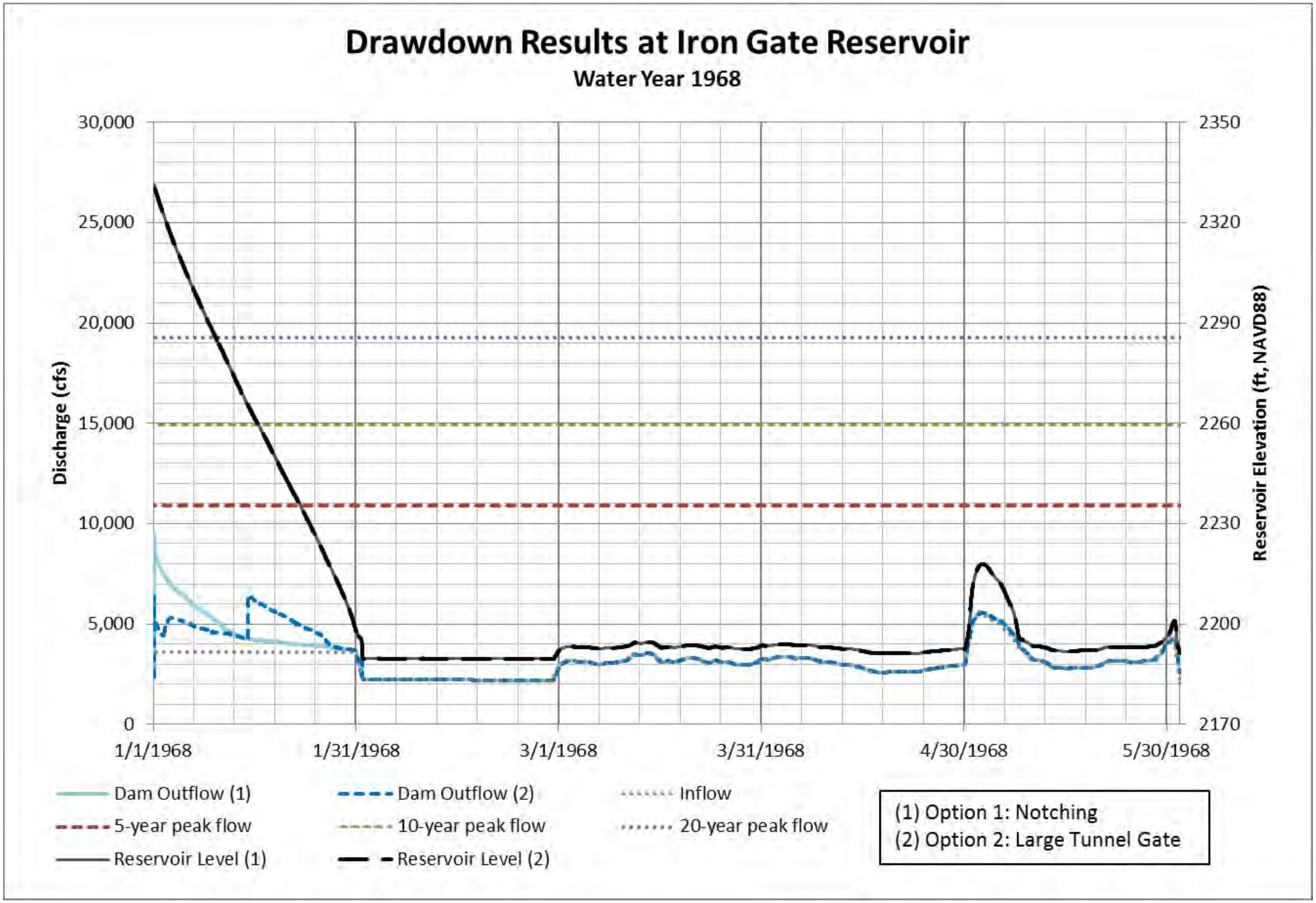



**Figure F4-8 Iron Gate Reservoir Drawdown, Water Year 1968**

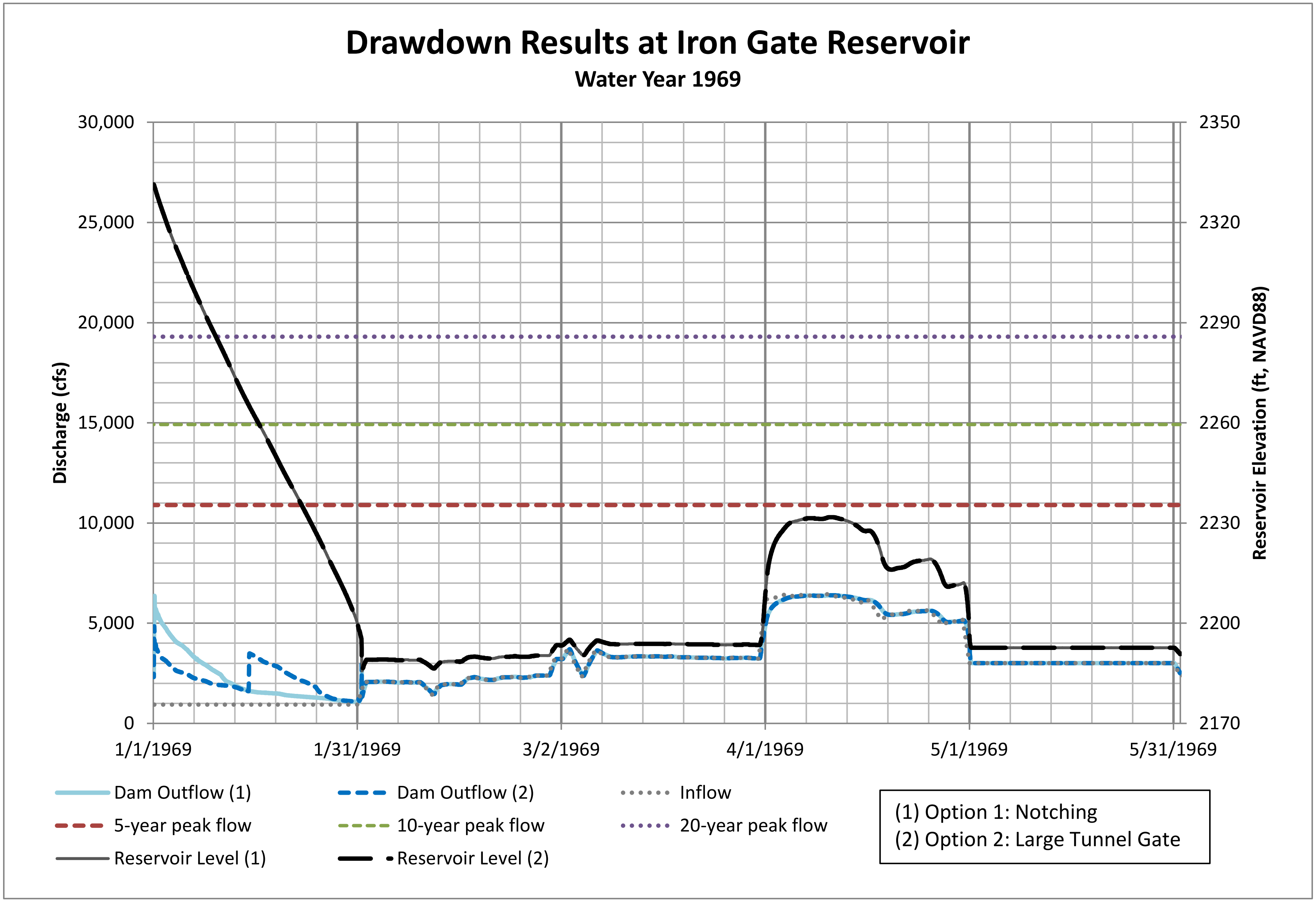



Figure F4-9 Iron Gate Reservoir Drawdown, Water Year 1969

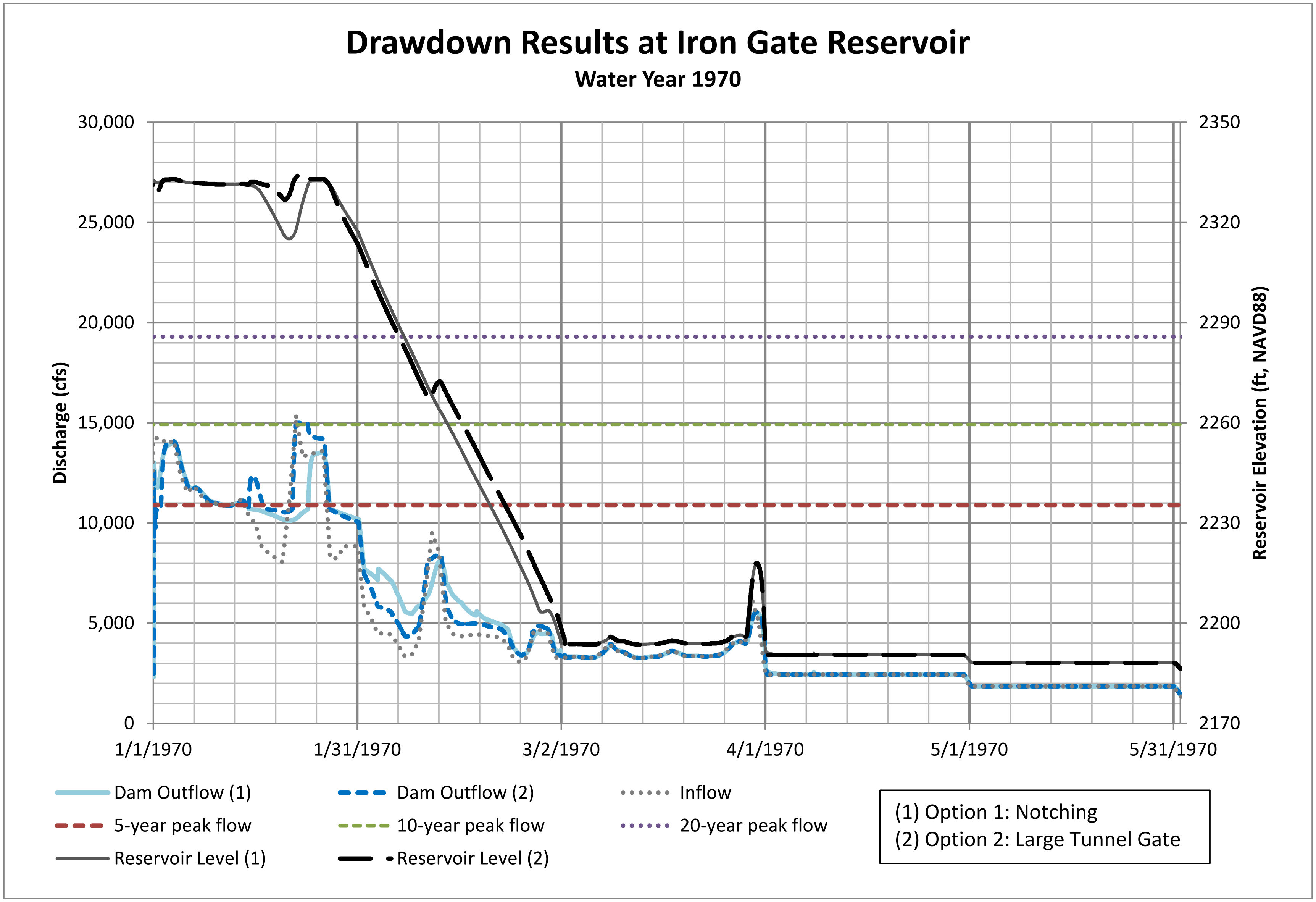



**Figure F4-10 Iron Gate Reservoir Drawdown, Water Year 1970**

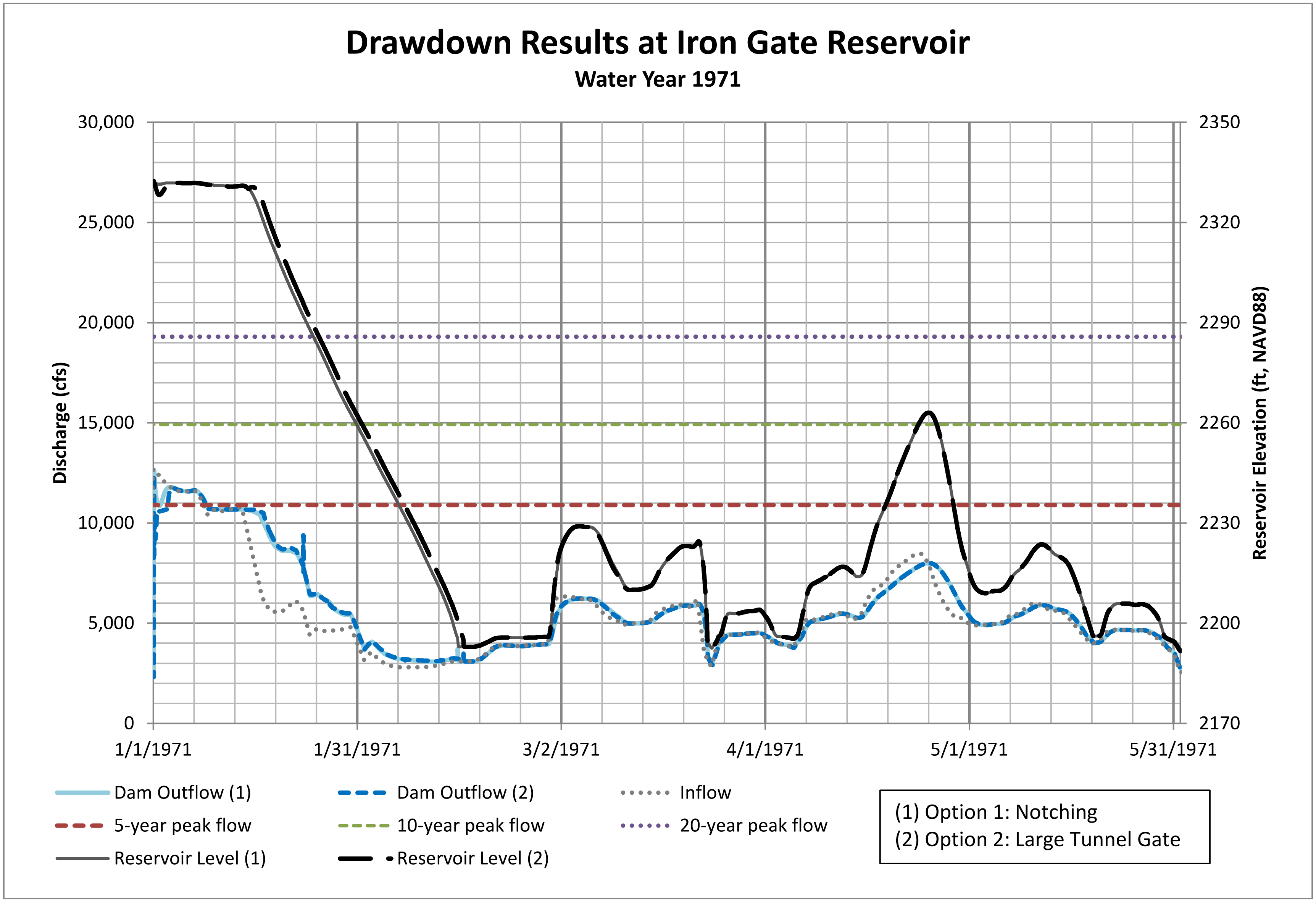



**Figure F4-11 Iron Gate Reservoir Drawdown, Water Year 1971**

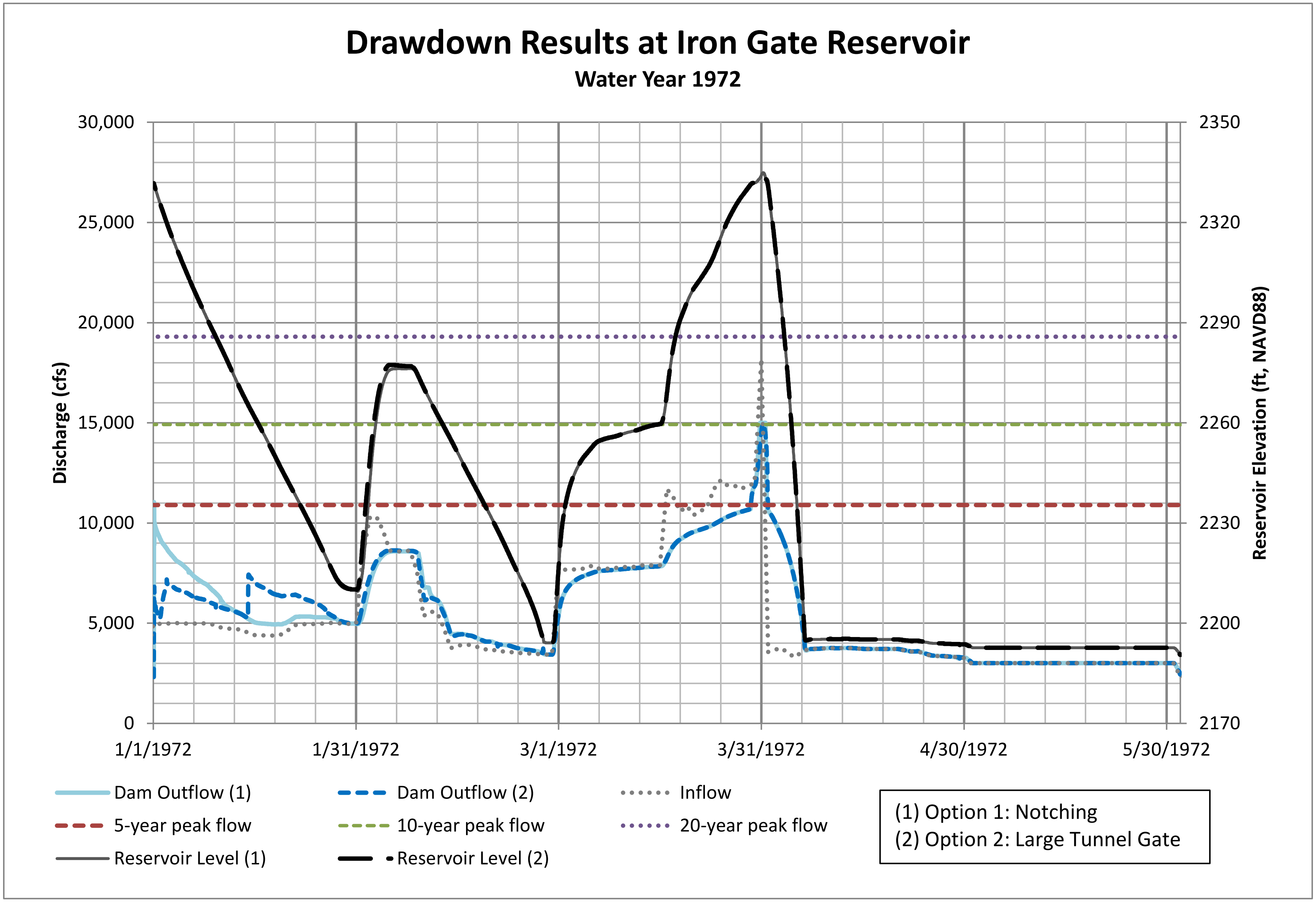



**Figure F4-12 Iron Gate Reservoir Drawdown, Water Year 1972**

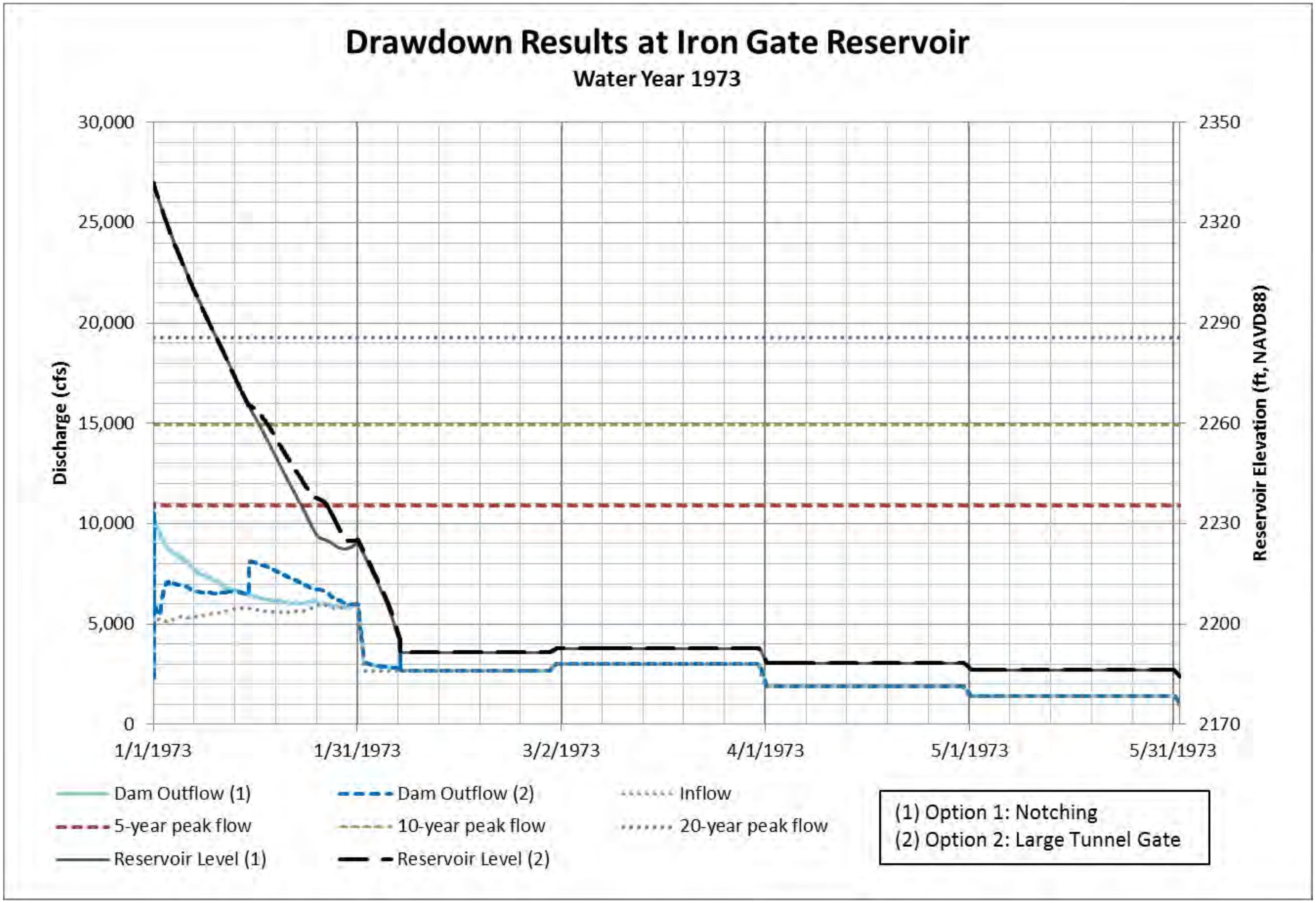



**Figure F4-13 Iron Gate Reservoir Drawdown, Water Year 1973**

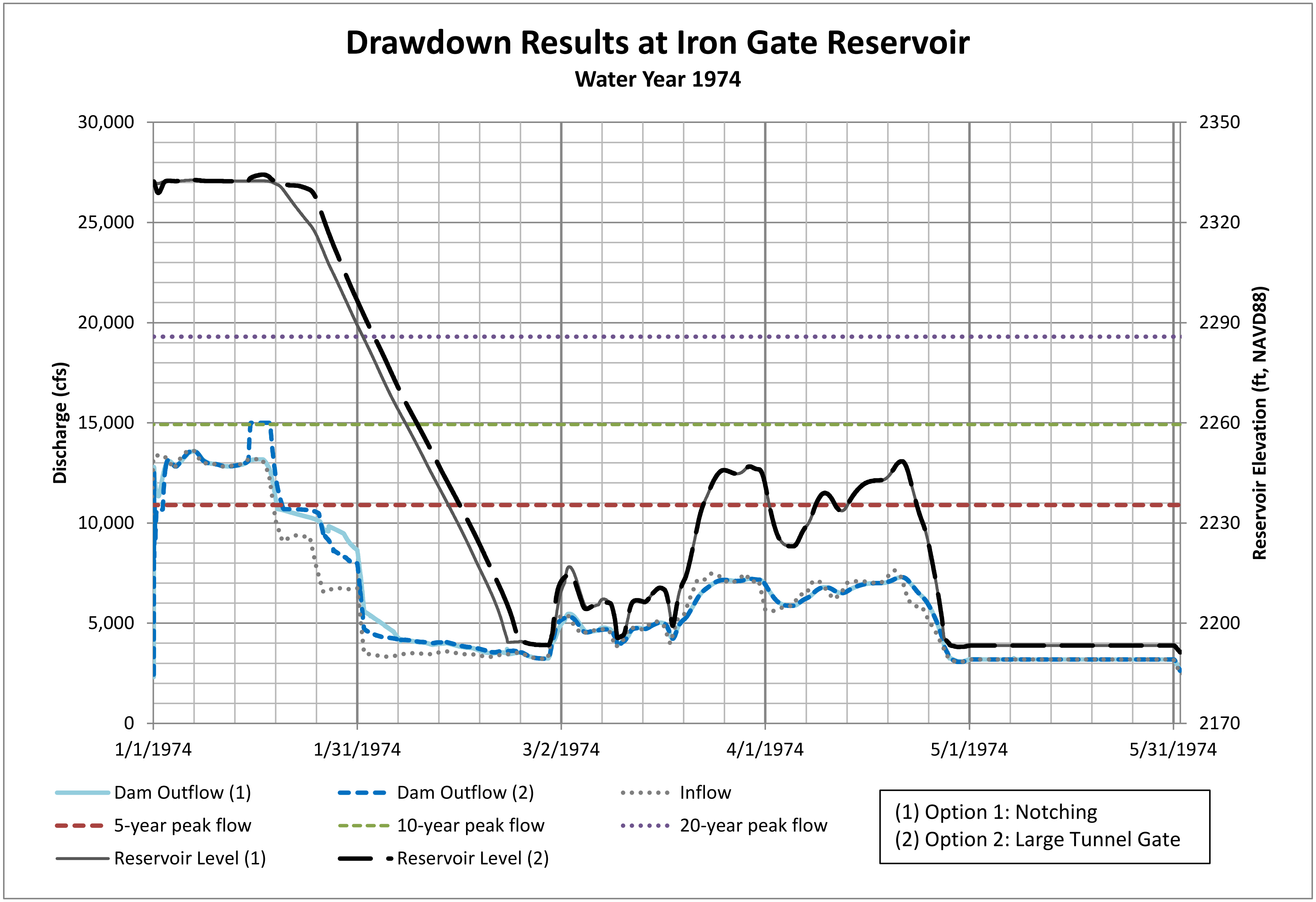



**Figure F4-14 Iron Gate Reservoir Drawdown, Water Year 1974**

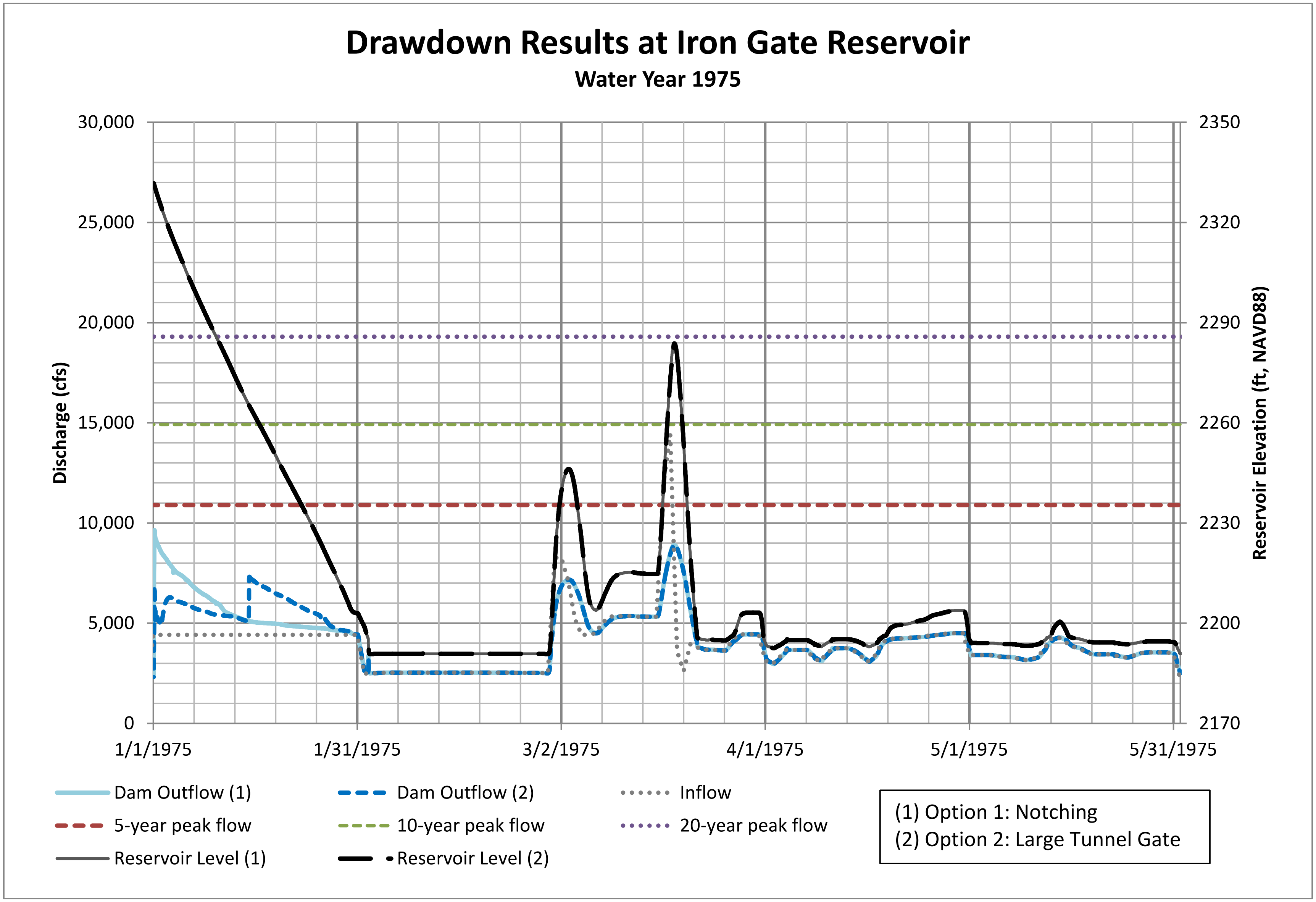



**Figure F4-15 Iron Gate Reservoir Drawdown, Water Year 1975**

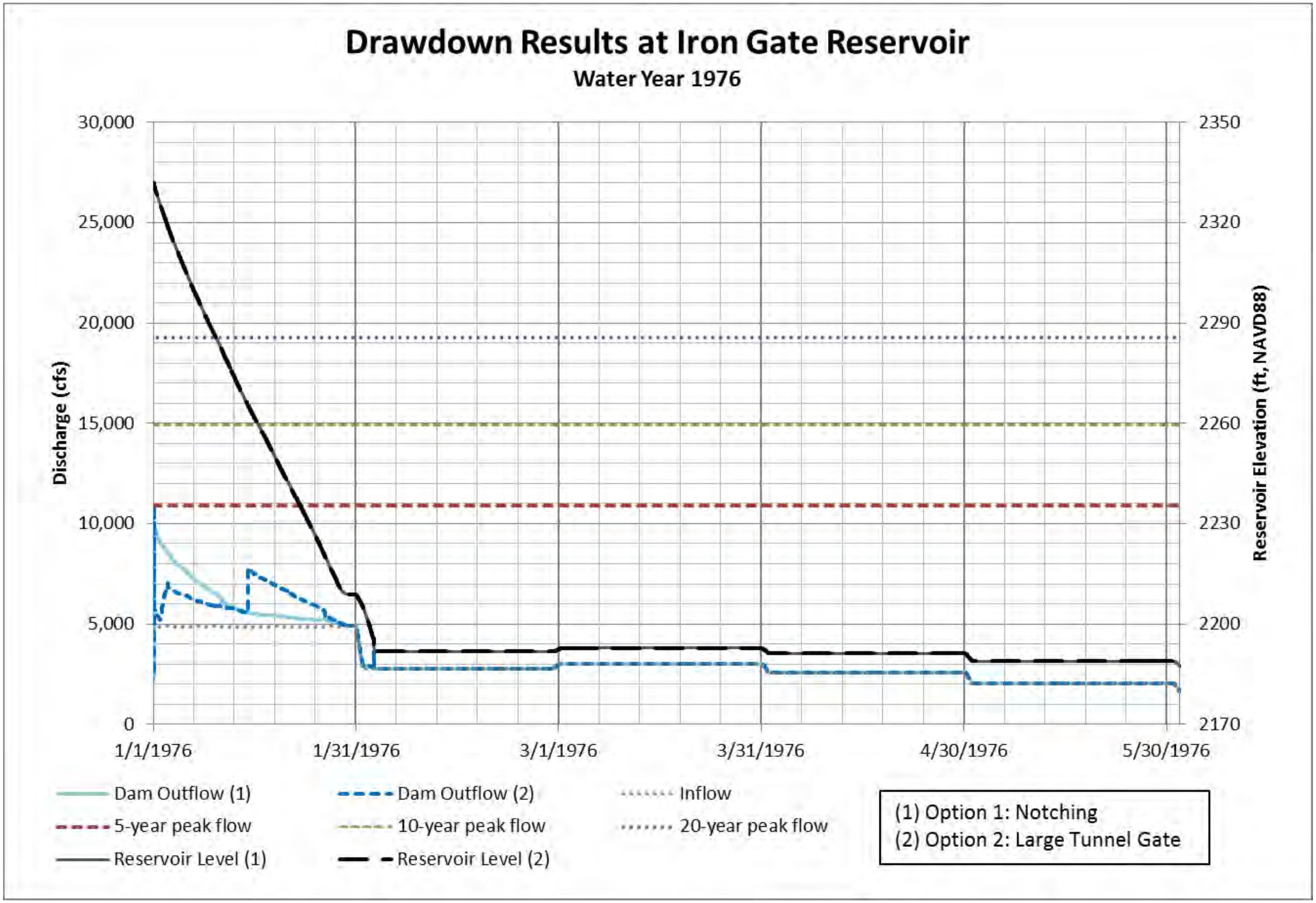



**Figure F4-16 Iron Gate Reservoir Drawdown, Water Year 1976**

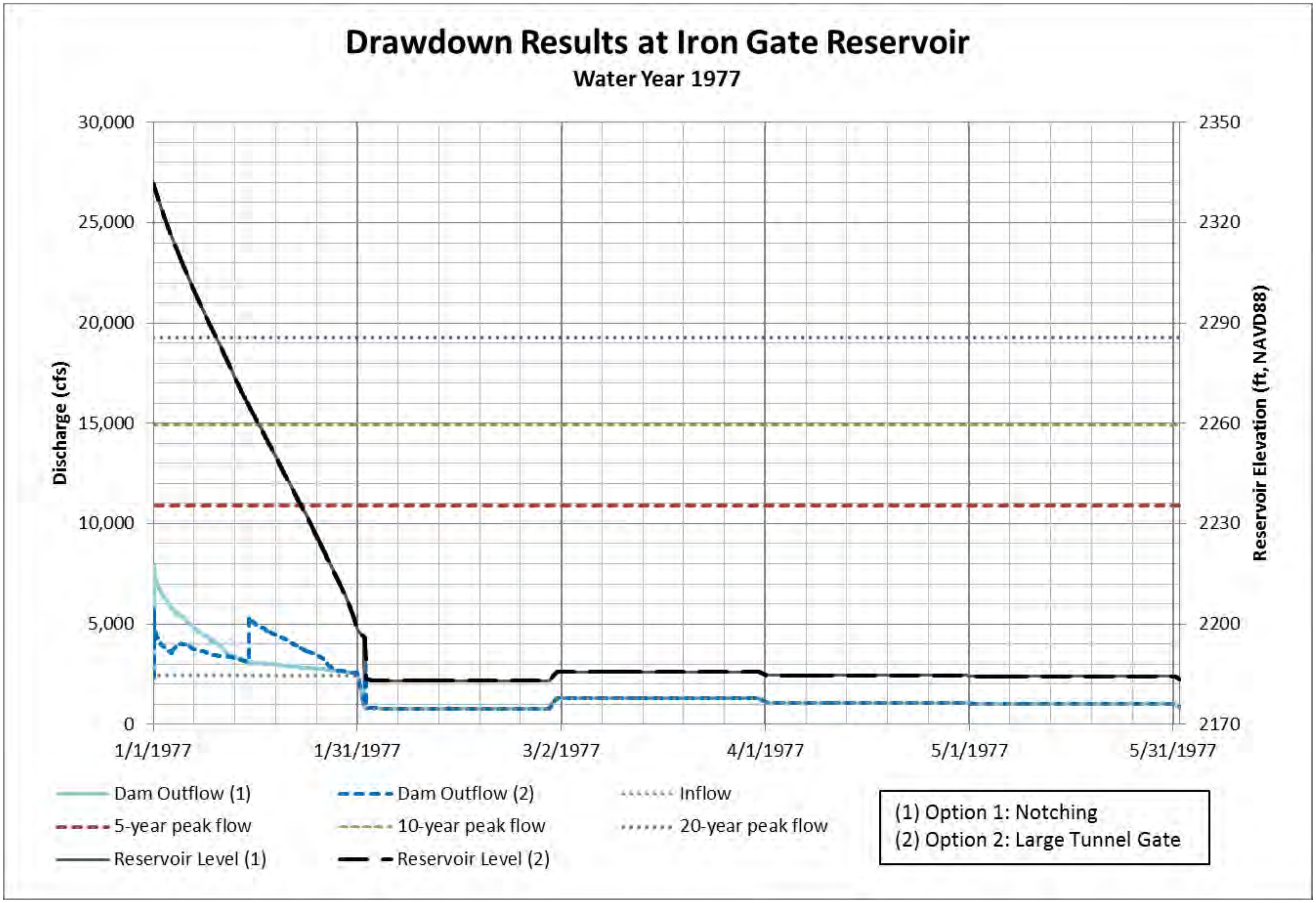



**Figure F4-17 Iron Gate Reservoir Drawdown, Water Year 1977**

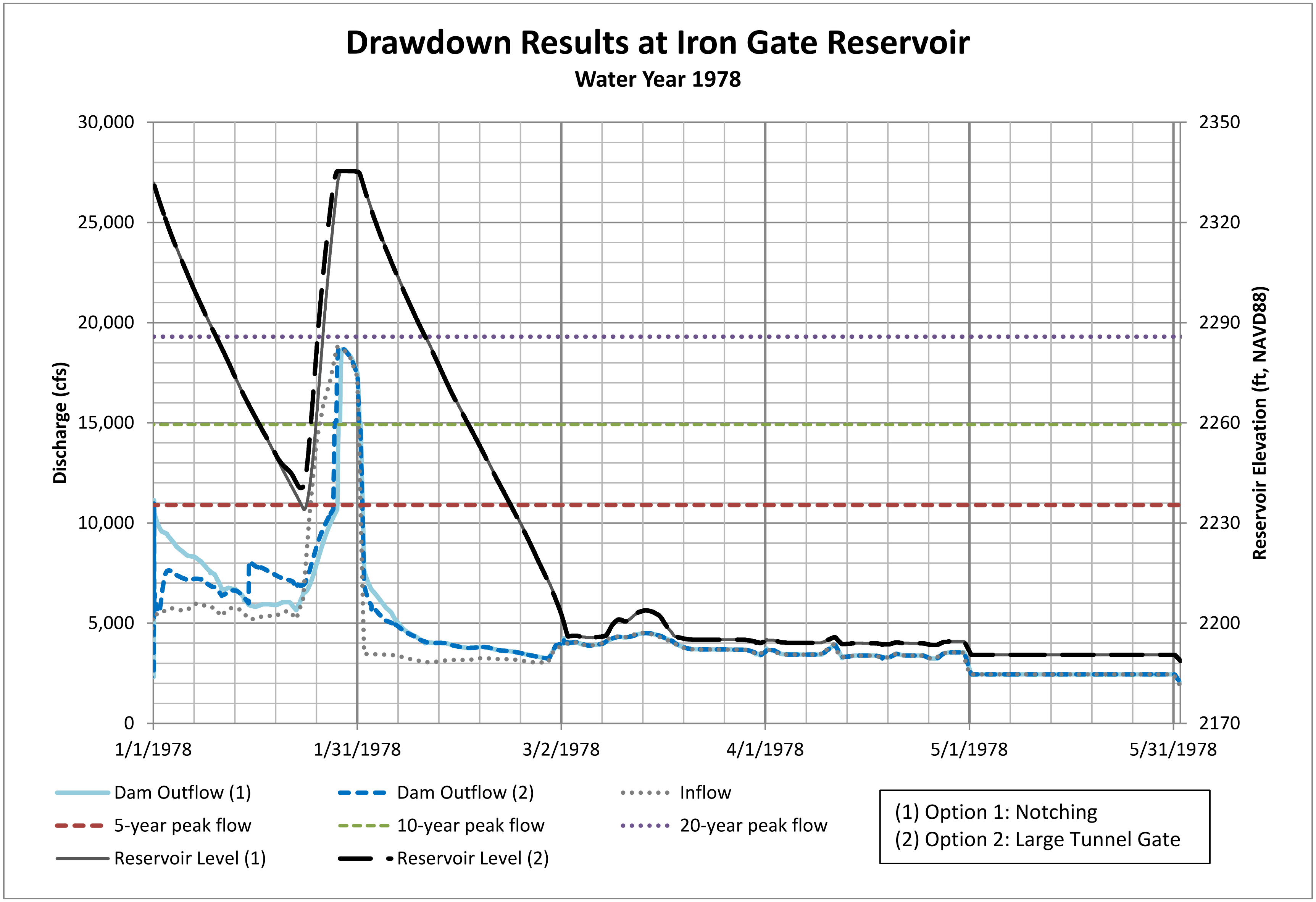



**Figure F4-18 Iron Gate Reservoir Drawdown, Water Year 1978**

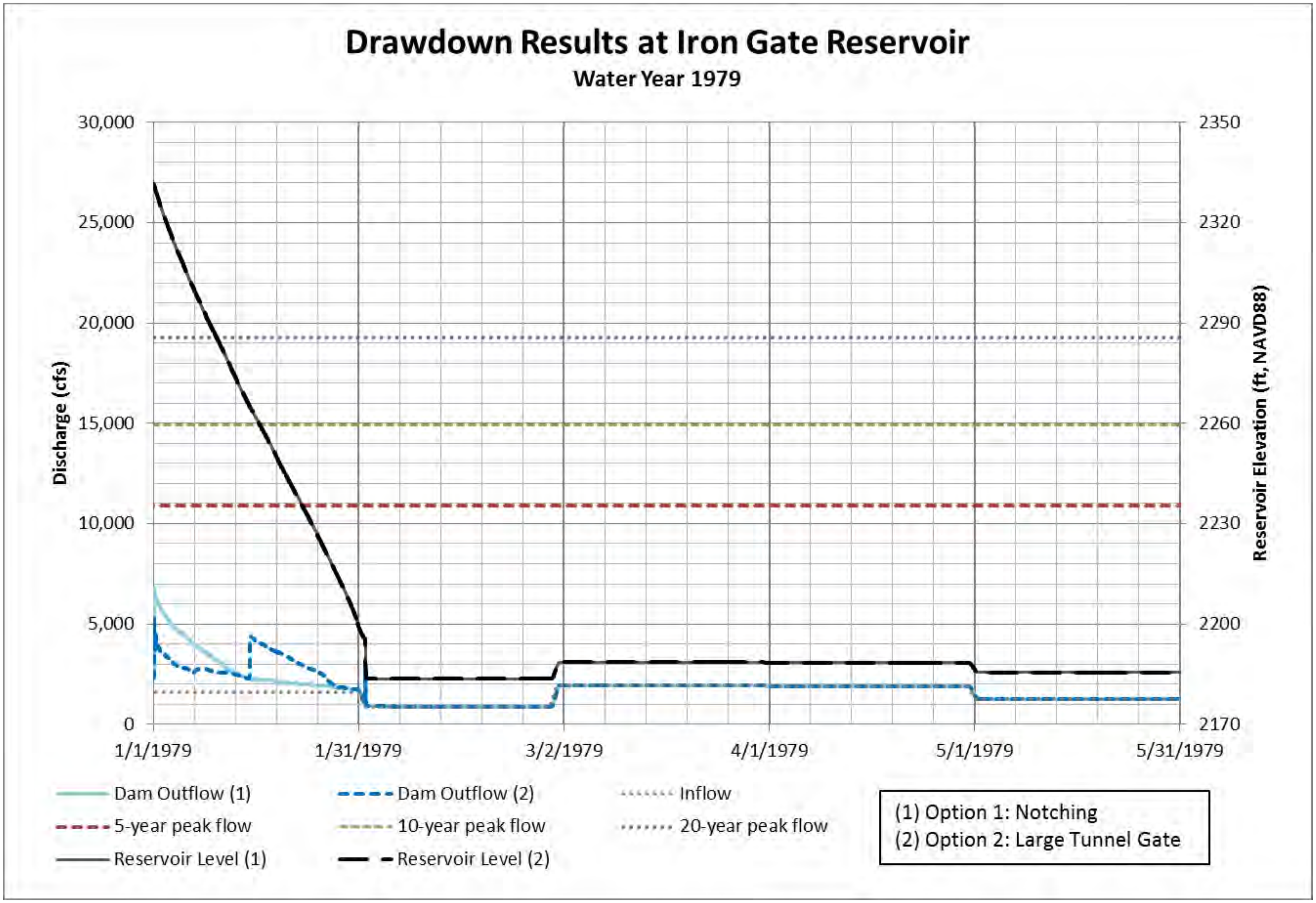



**Figure F4-19 Iron Gate Reservoir Drawdown, Water Year 1979**

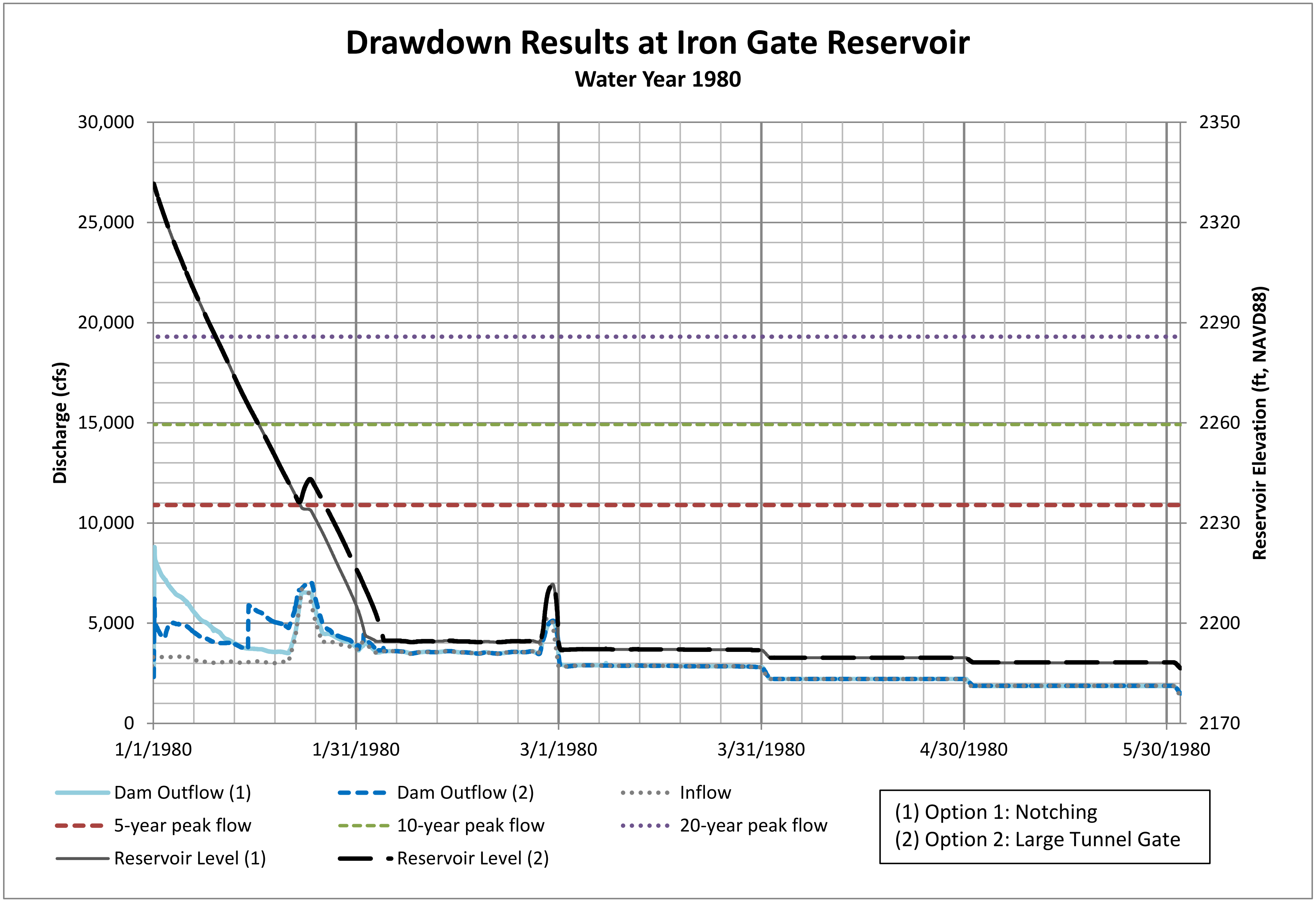



**Figure F4-20 Iron Gate Reservoir Drawdown, Water Year 1980**

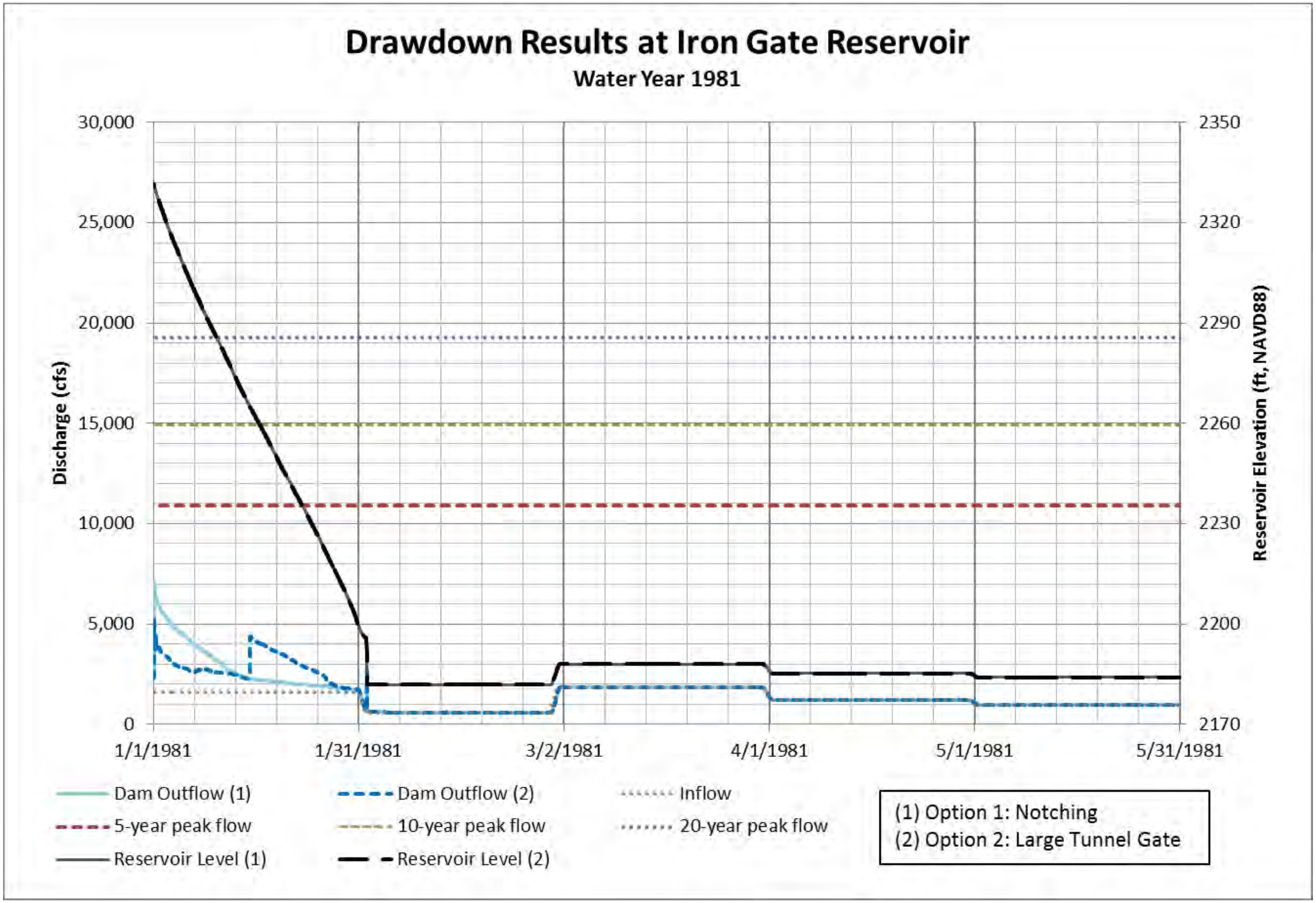



Figure F4-21 Iron Gate Reservoir Drawdown, Water Year 1981

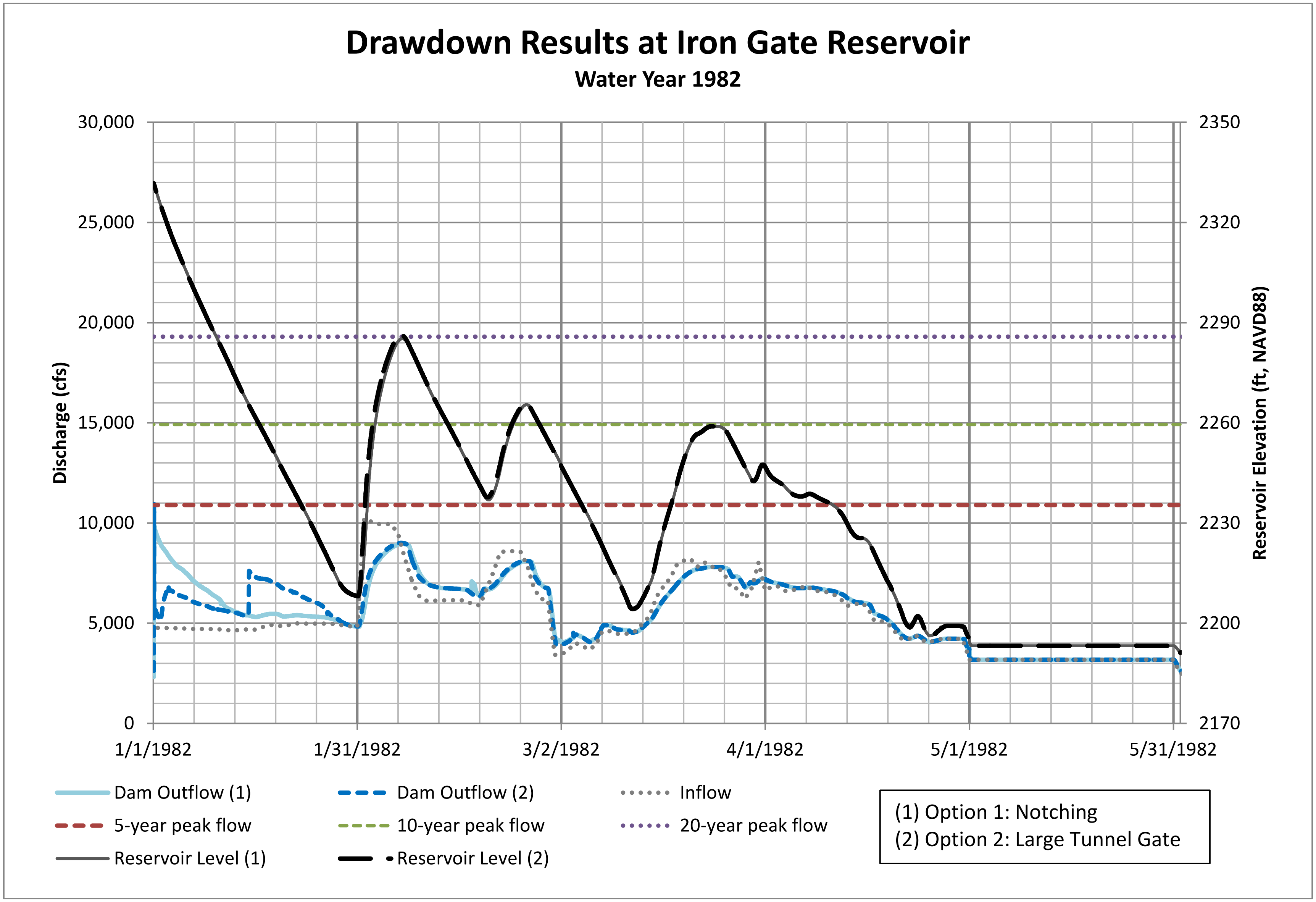



**Figure F4-22 Iron Gate Reservoir Drawdown, Water Year 1982**

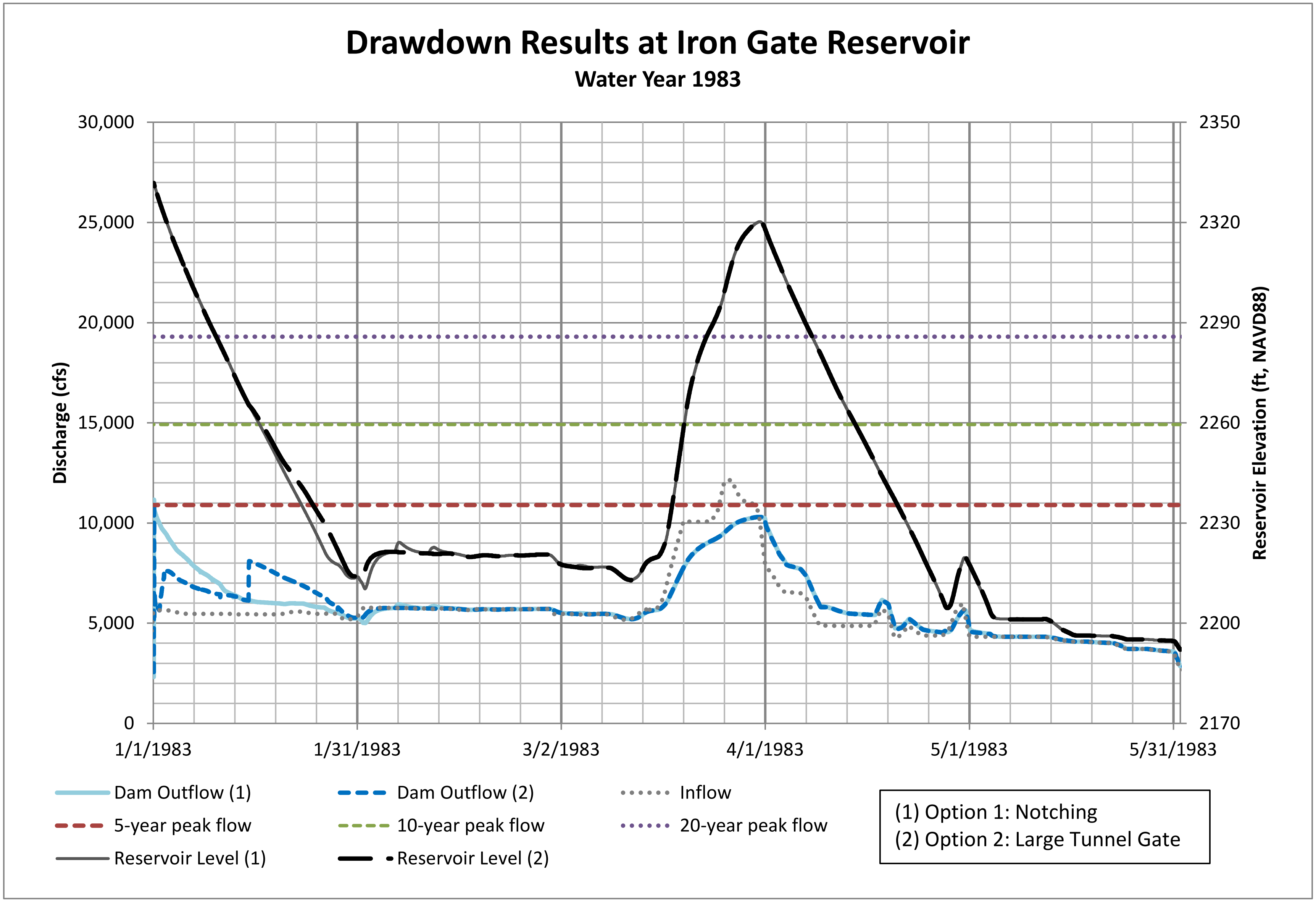



**Figure F4-23 Iron Gate Reservoir Drawdown, Water Year 1983**

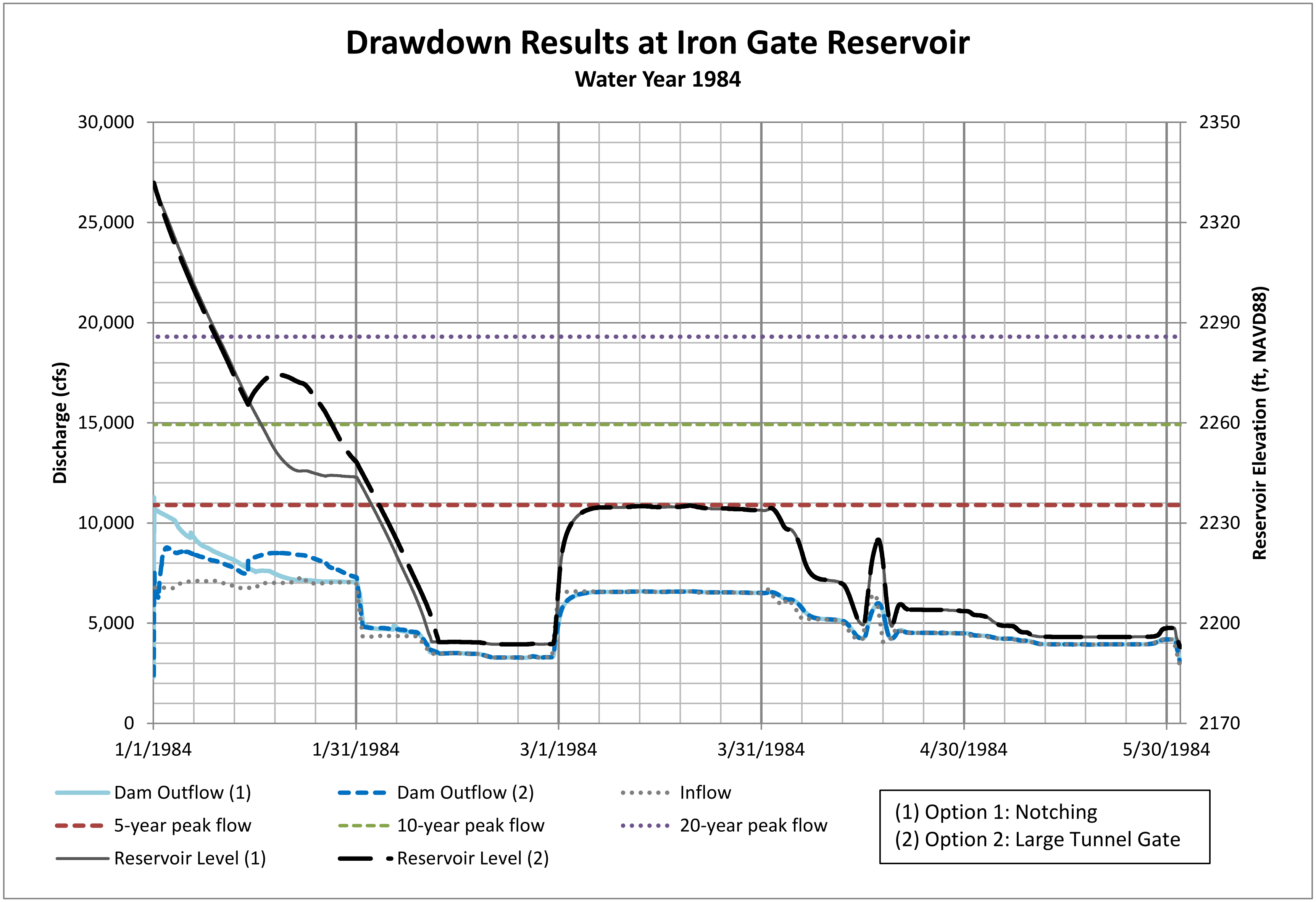



**Figure F4-24 Iron Gate Reservoir Drawdown, Water Year 1984**

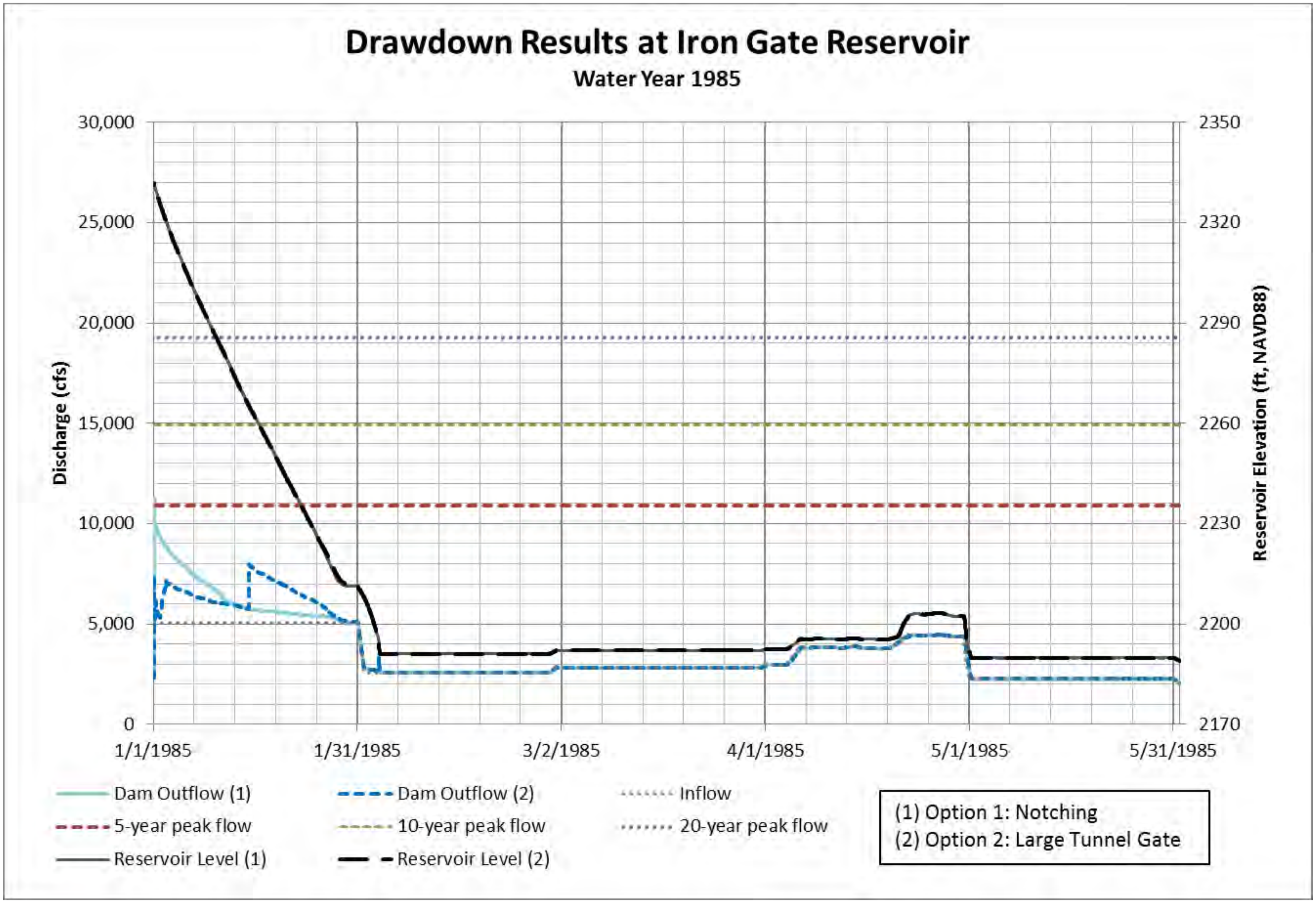



**Figure F4-25 Iron Gate Reservoir Drawdown, Water Year 1985**

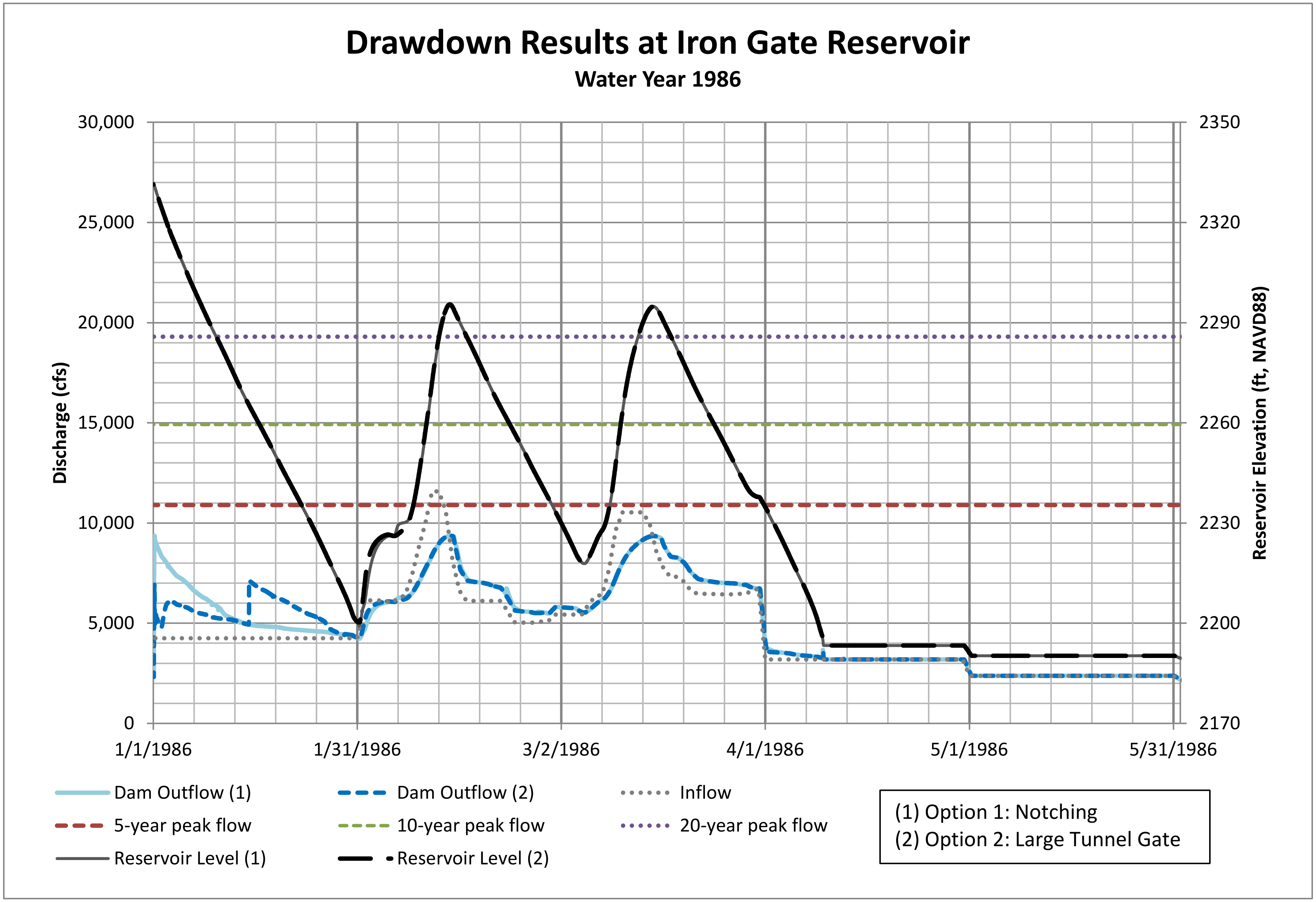



Figure F4-26 Iron Gate Reservoir Drawdown, Water Year 1986

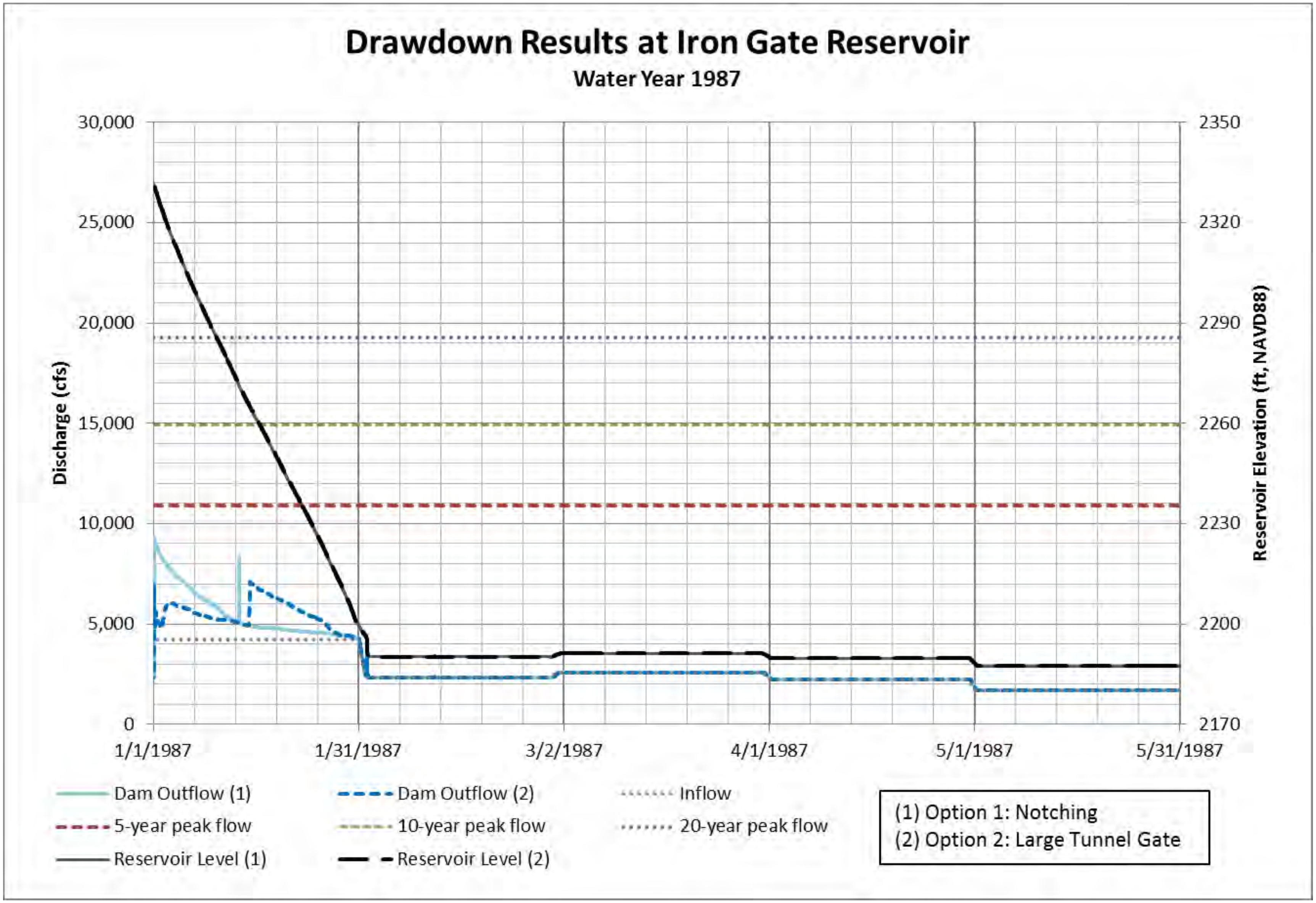



Figure F4-27 Iron Gate Reservoir Drawdown, Water Year 1987

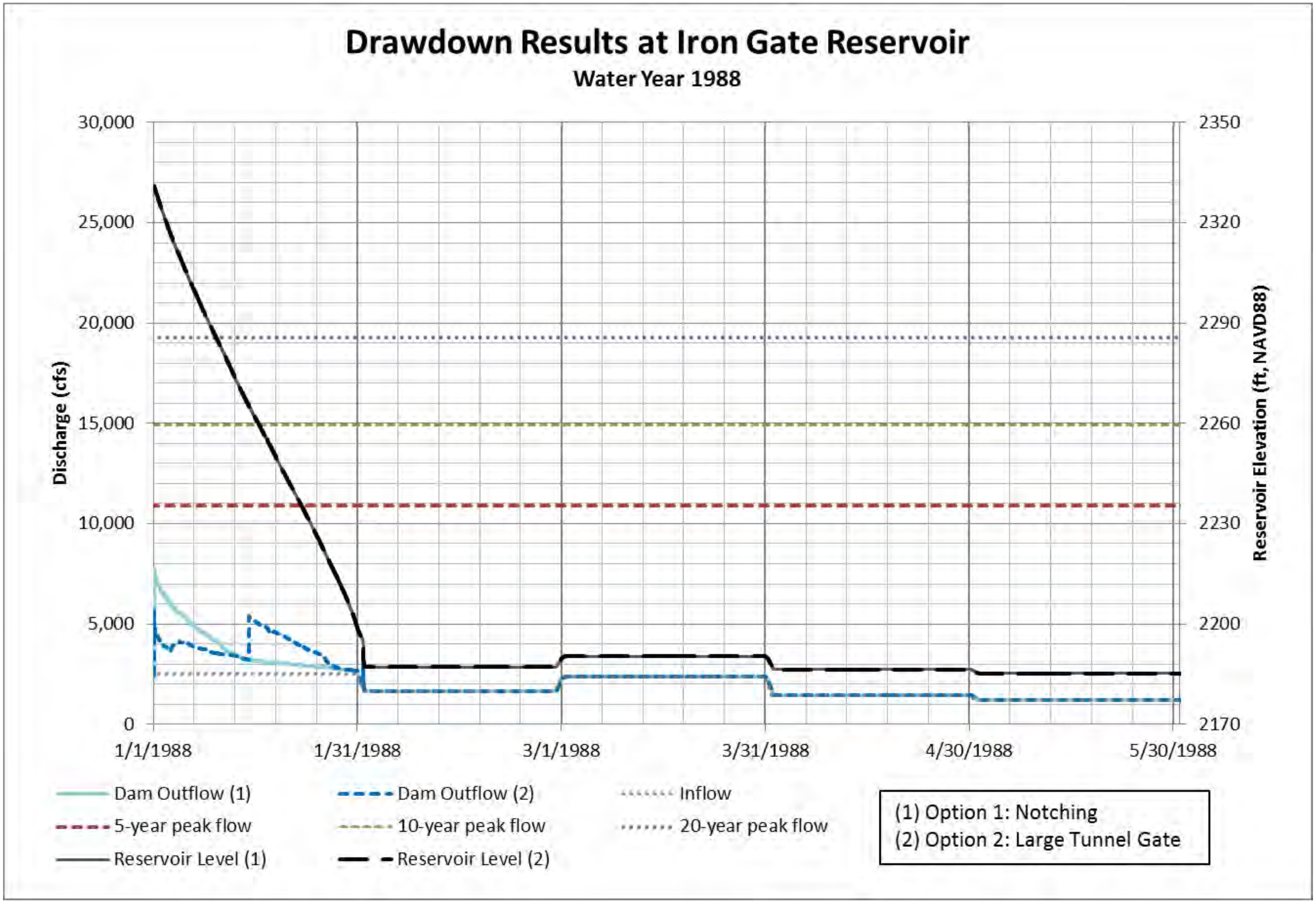



**Figure F4-28 Iron Gate Reservoir Drawdown, Water Year 1988**

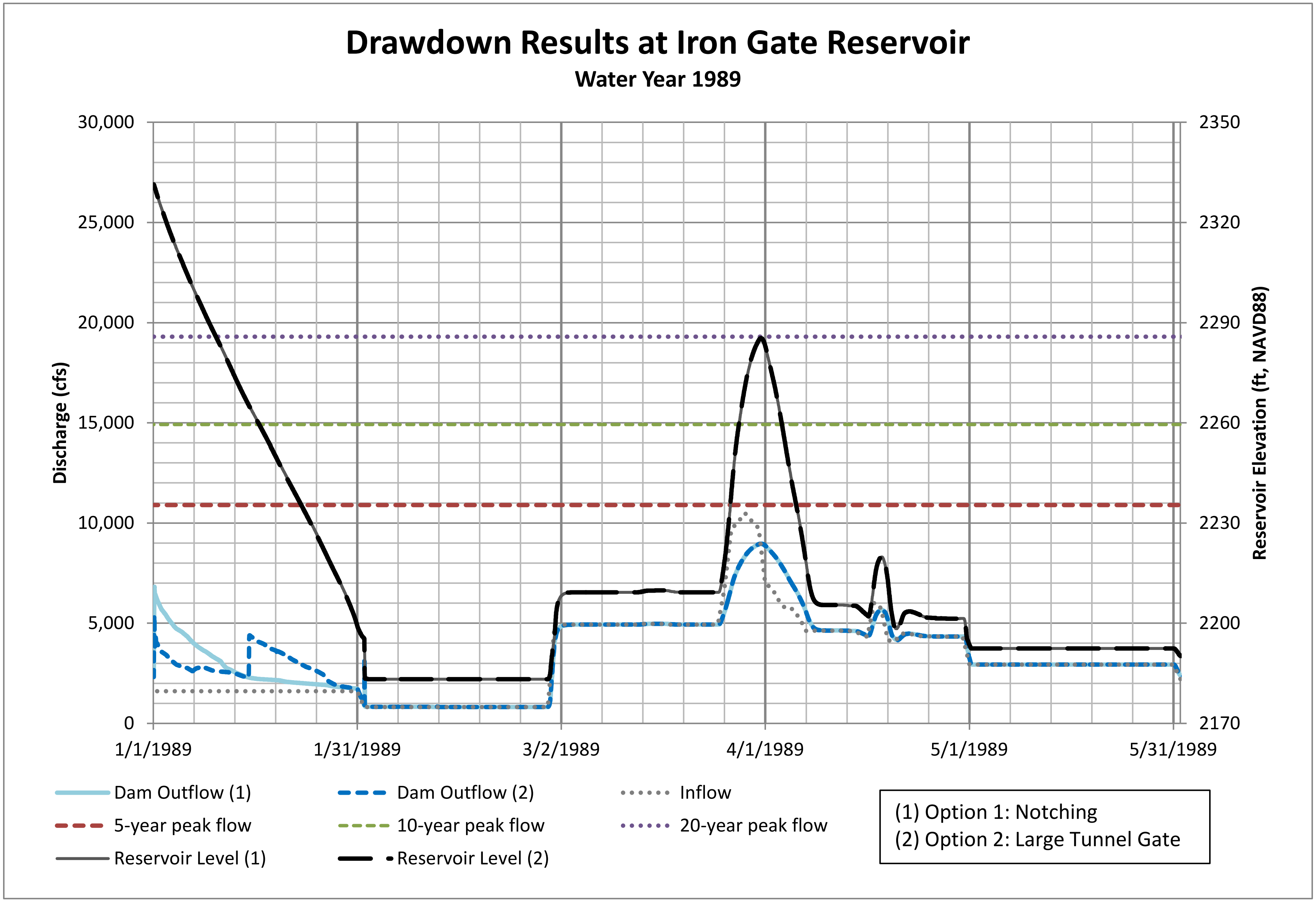



**Figure F4-29 Iron Gate Reservoir Drawdown, Water Year 1989**

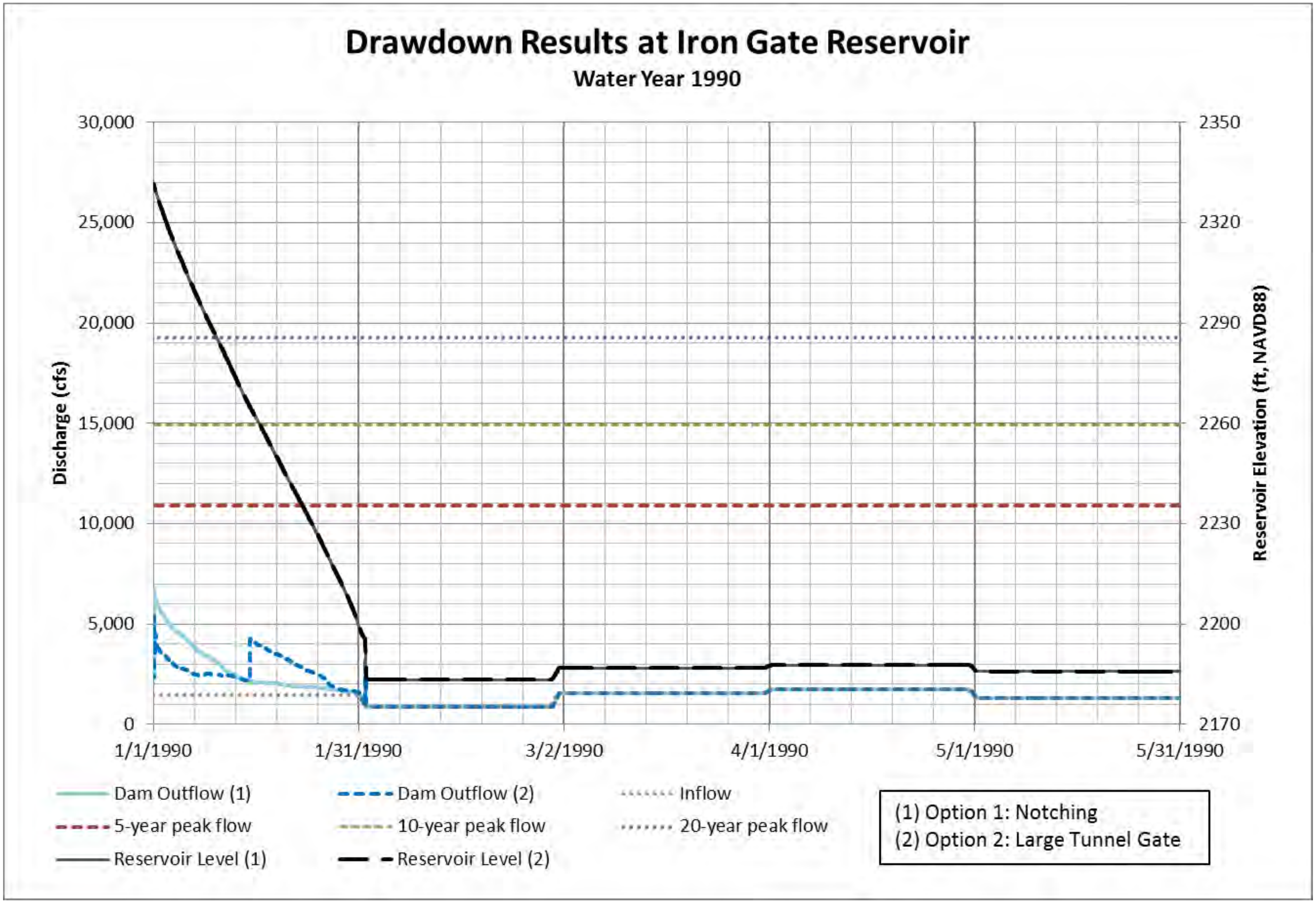



**Figure F4-30 Iron Gate Reservoir Drawdown, Water Year 1990**

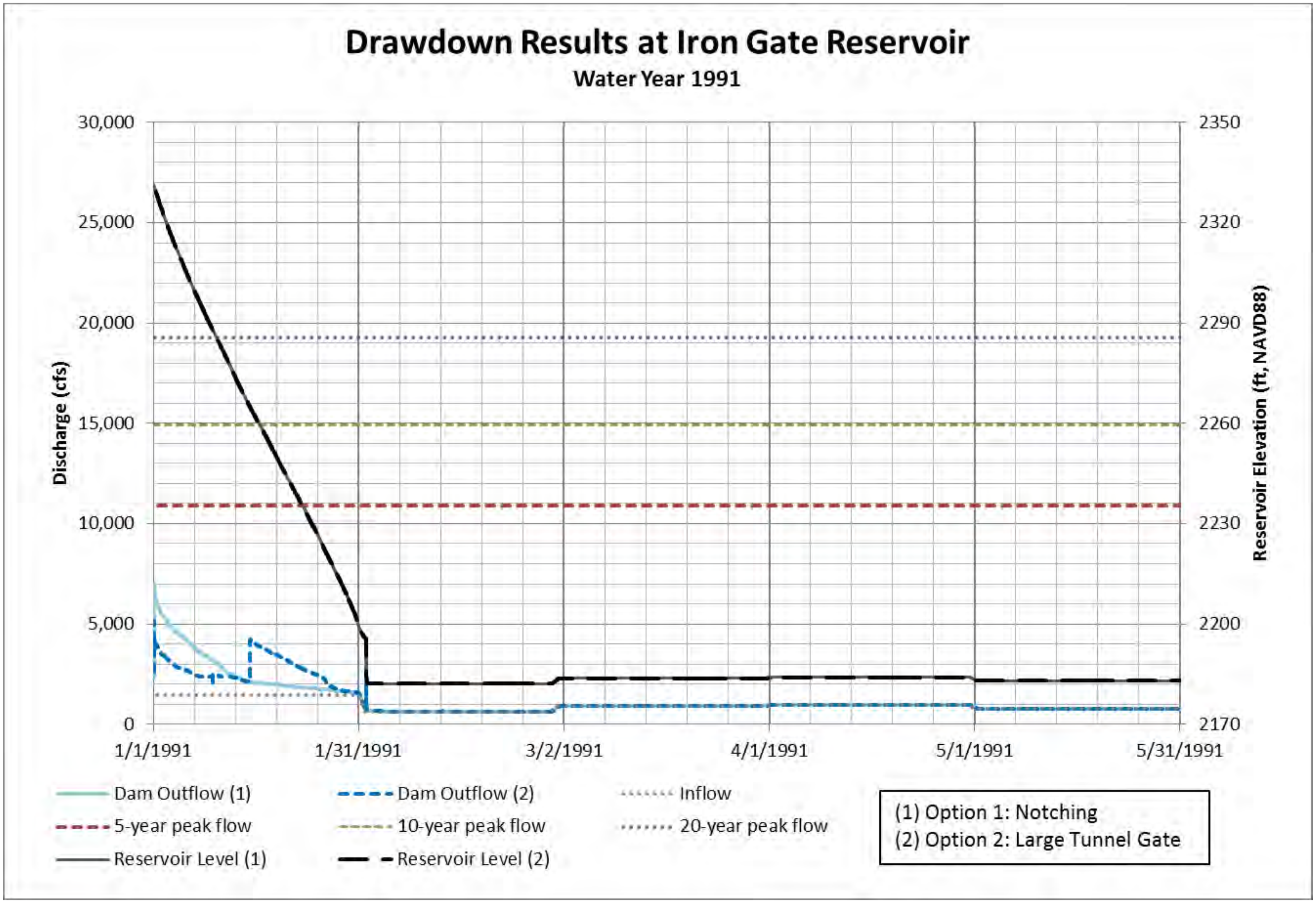



**Figure F4-31 Iron Gate Reservoir Drawdown, Water Year 1991**

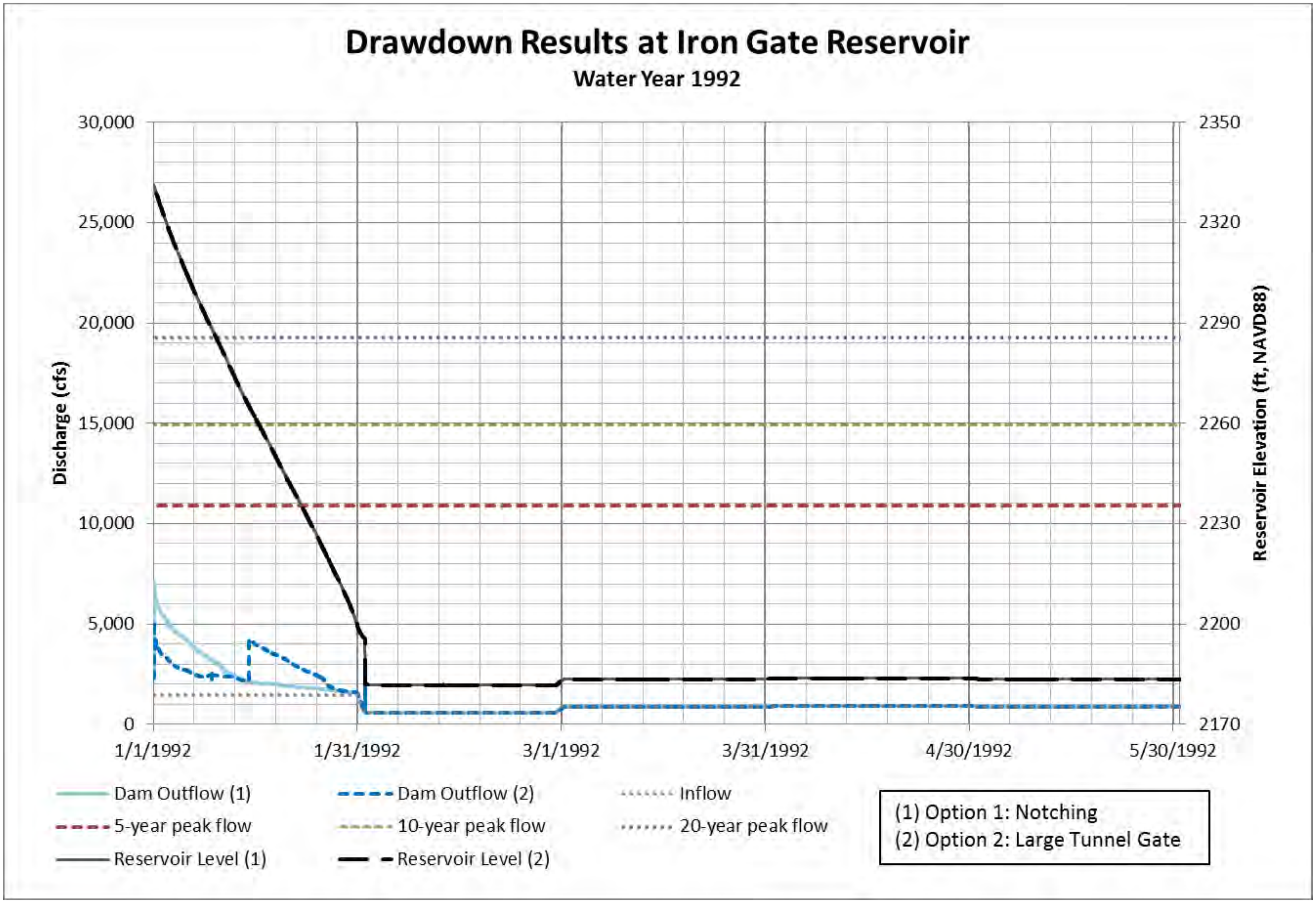



**Figure F4-32 Iron Gate Reservoir Drawdown, Water Year 1992**

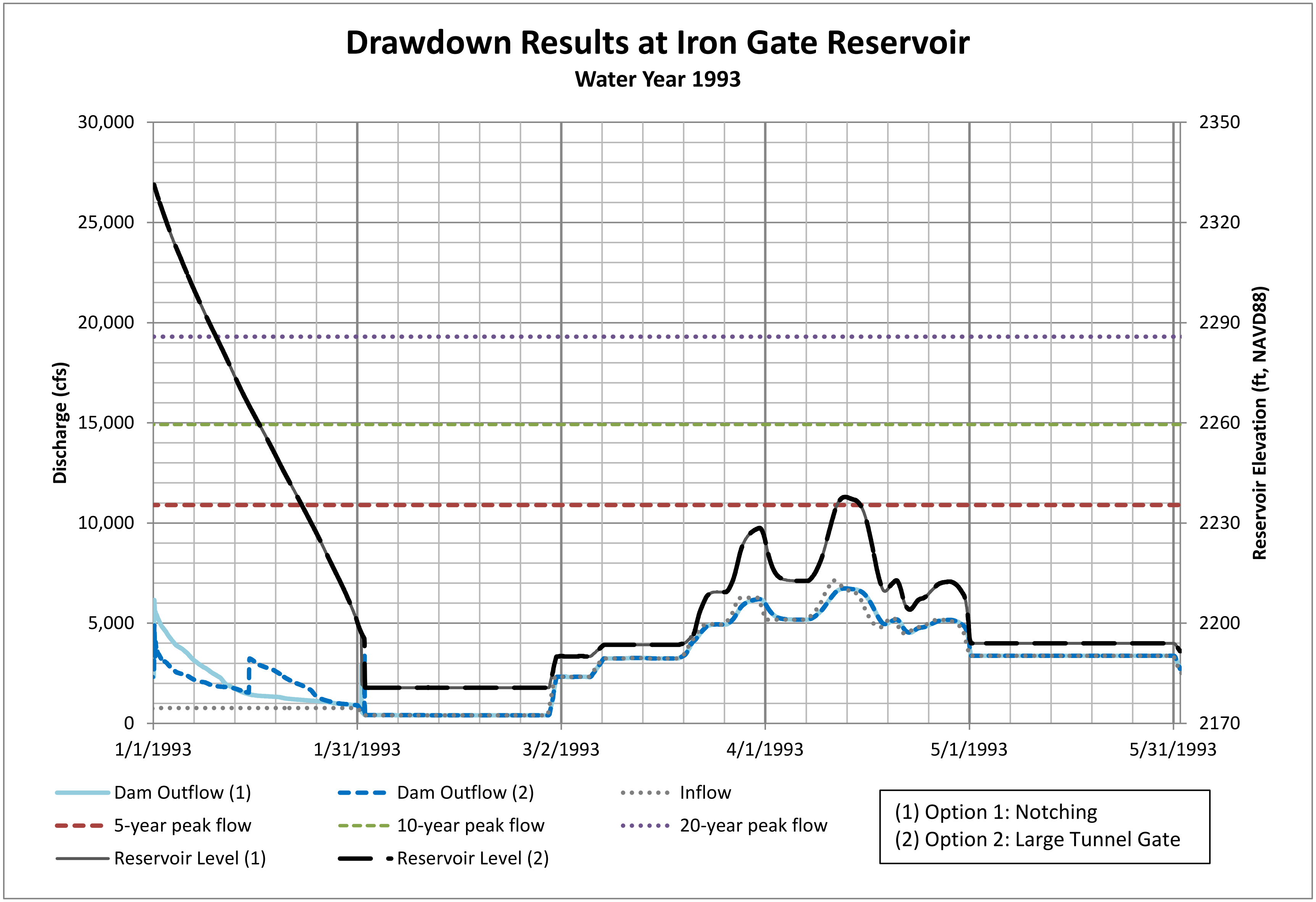



**Figure F4-33 Iron Gate Reservoir Drawdown, Water Year 1993**

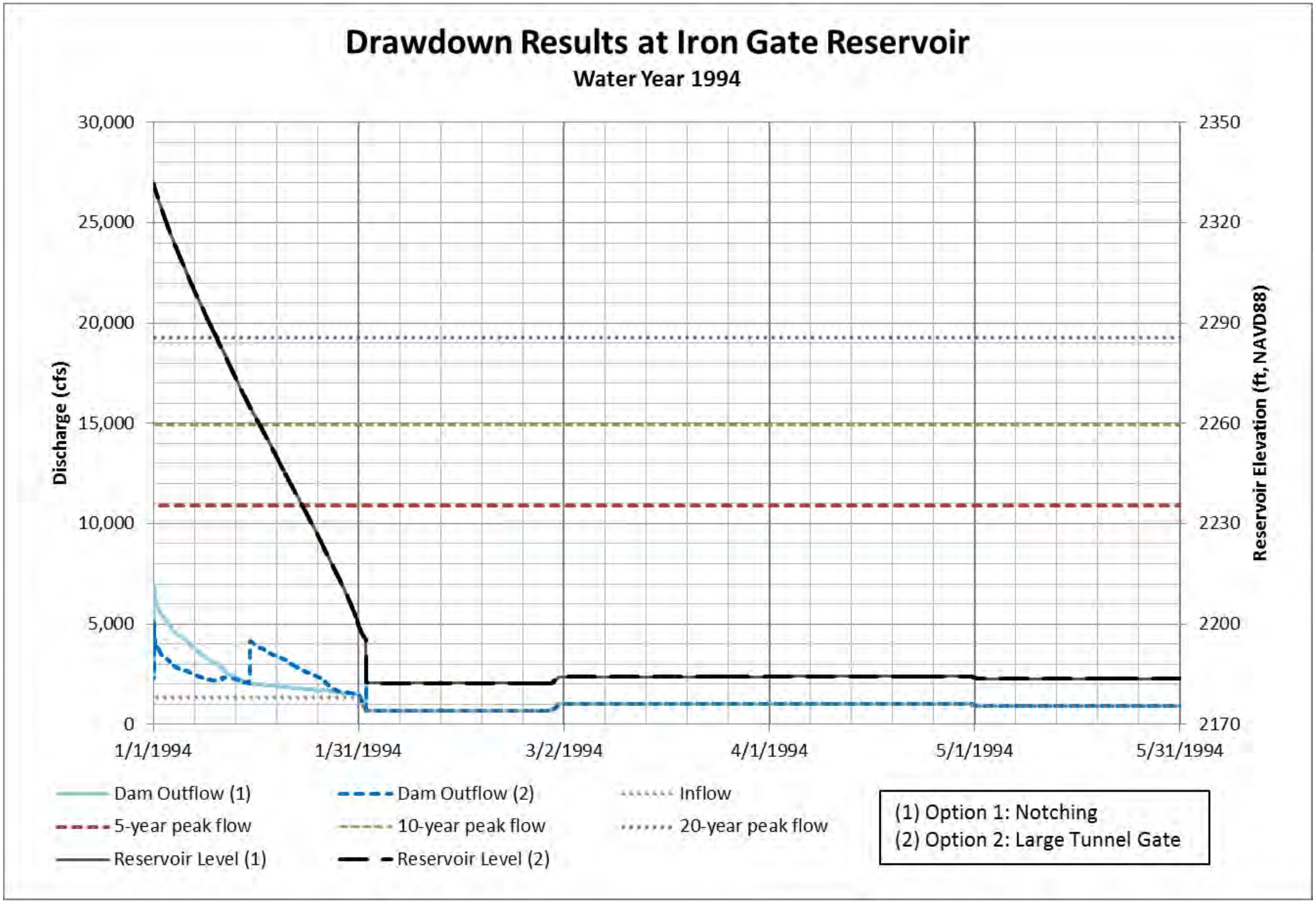



**Figure F4-34 Iron Gate Reservoir Drawdown, Water Year 1994**

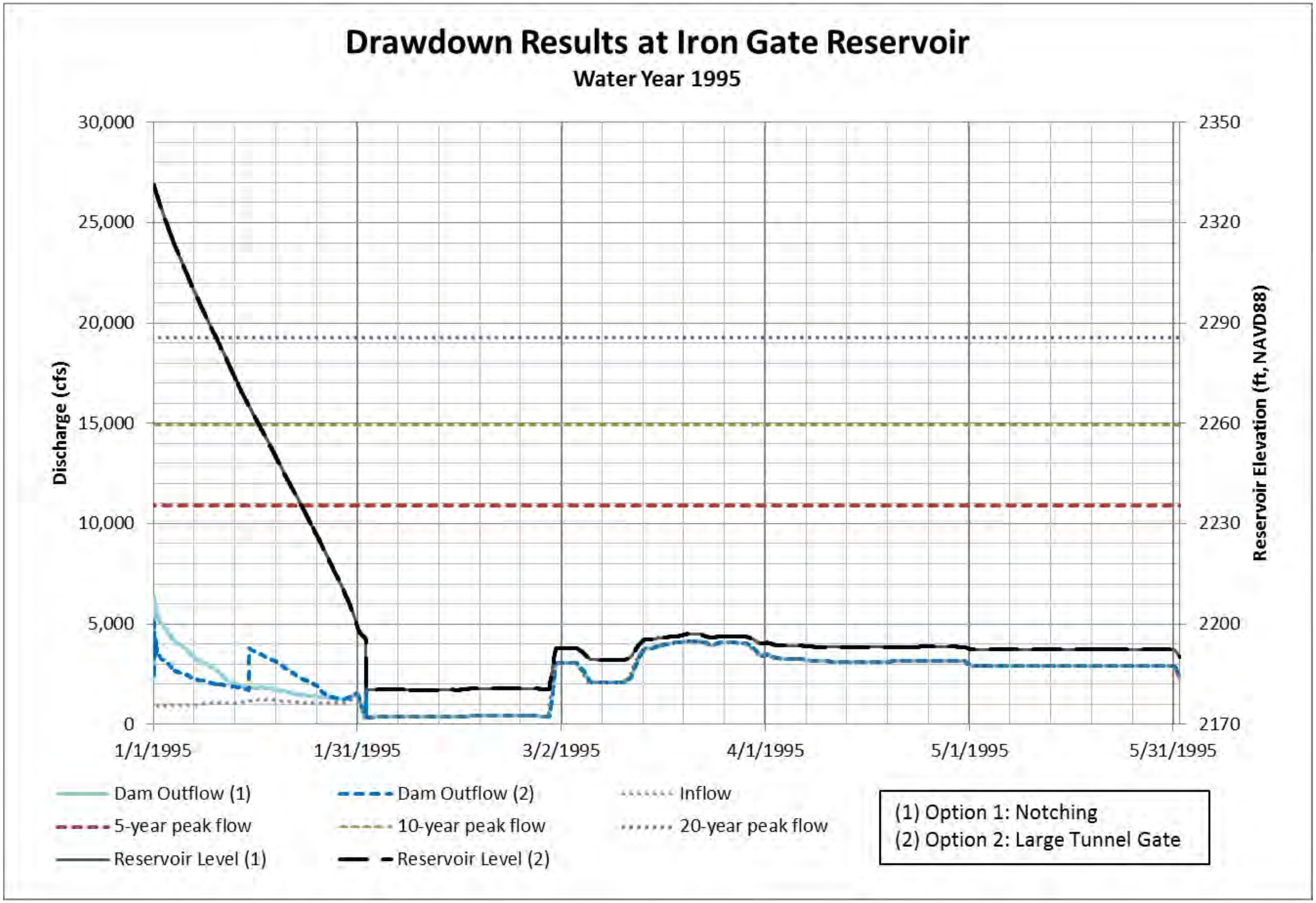



**Figure F4-35 Iron Gate Reservoir Drawdown, Water Year 1995**

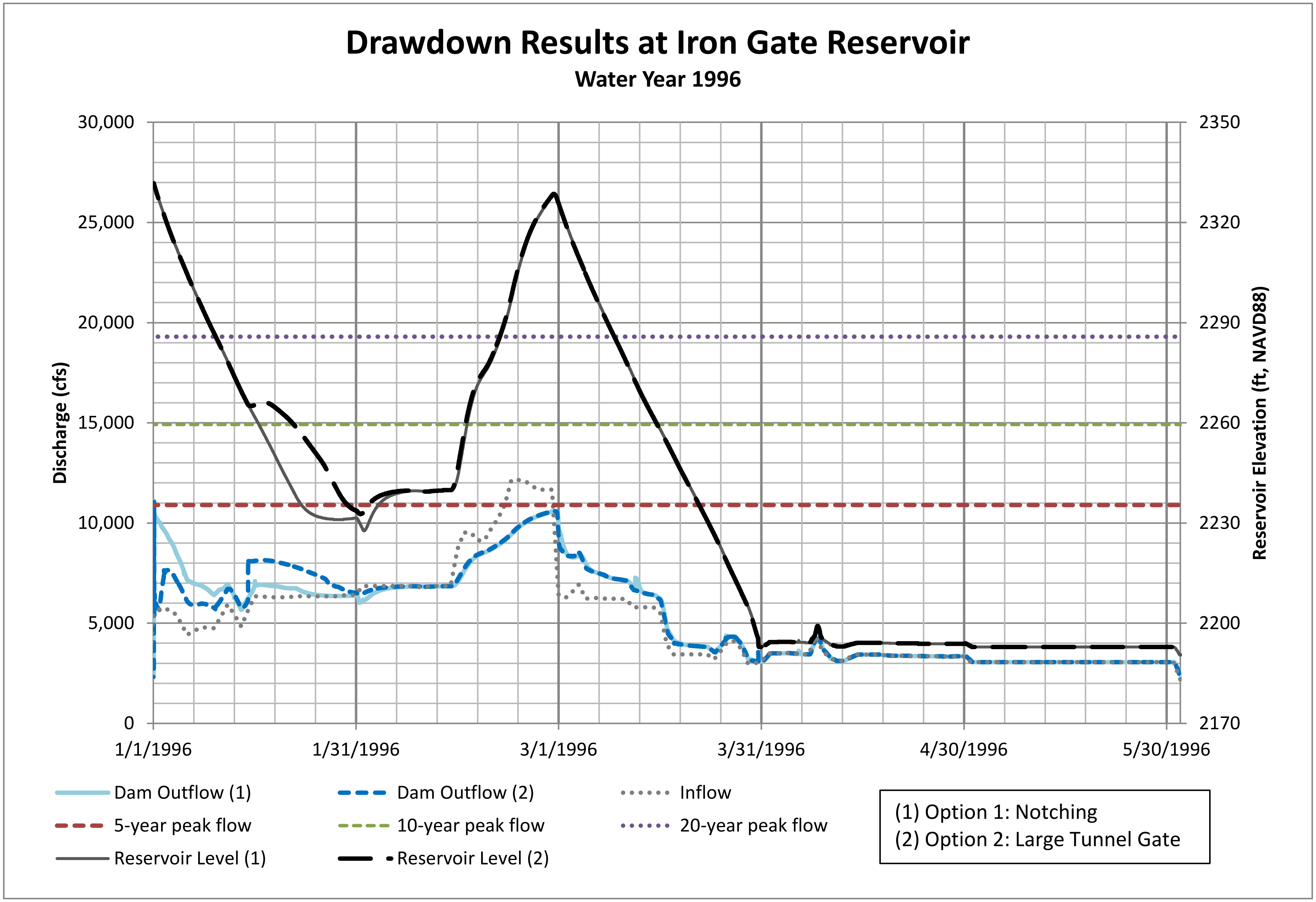



**Figure F4-36 Iron Gate Reservoir Drawdown, Water Year 1996**

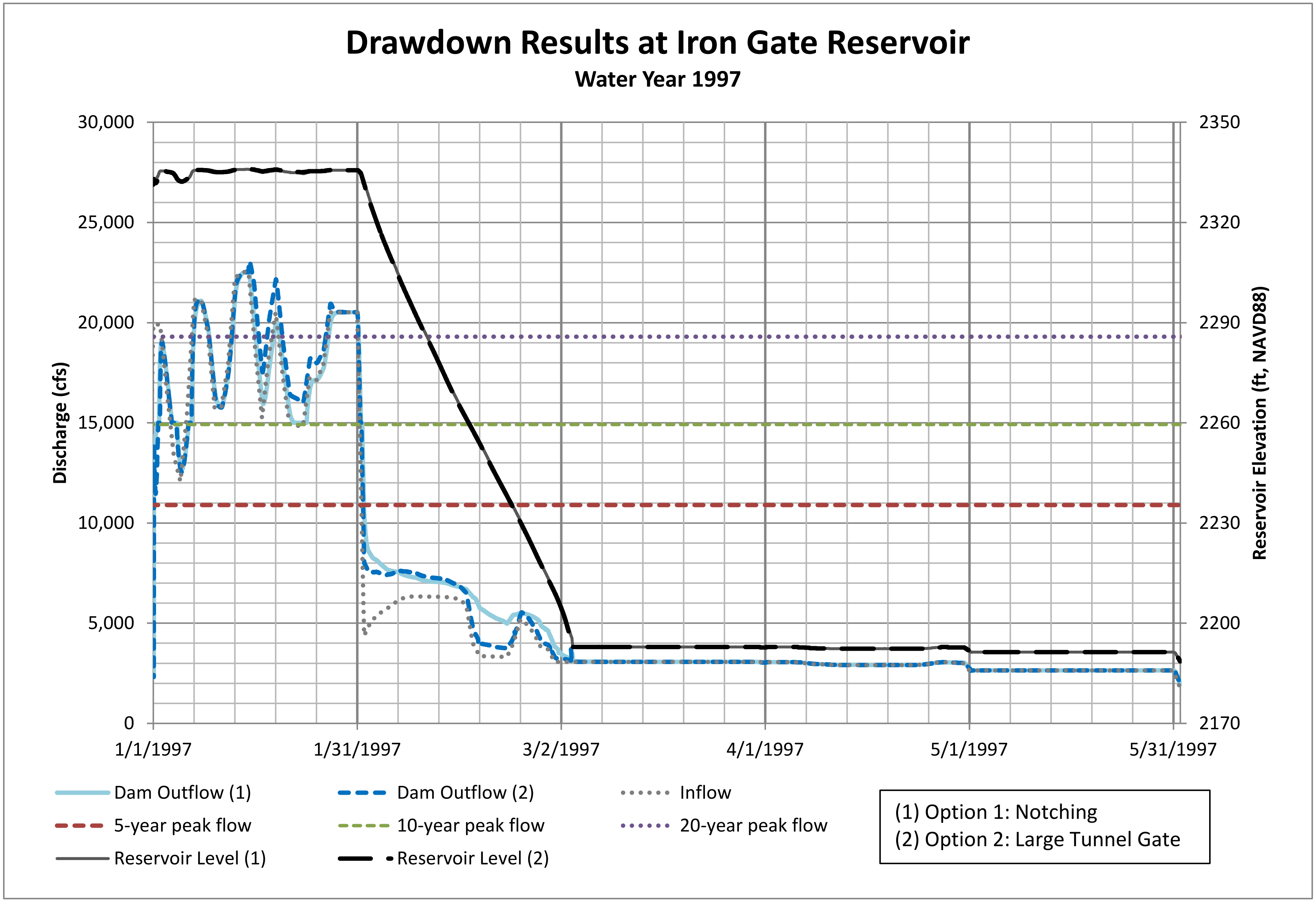



**Figure F4-37 Iron Gate Reservoir Drawdown, Water Year 1997**

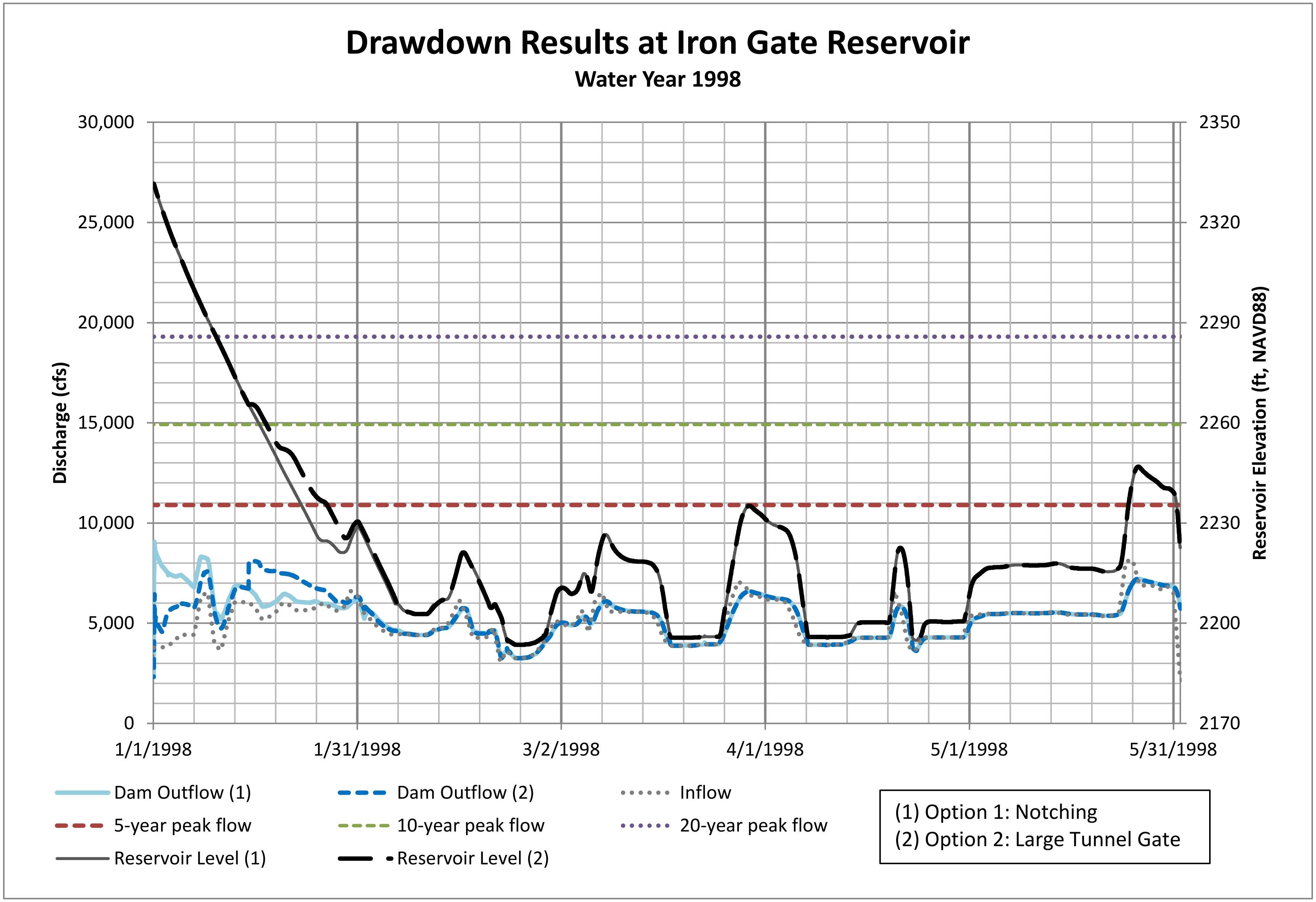



**Figure F4-38 Iron Gate Reservoir Drawdown, Water Year 1998**

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**Figure F4-39 Iron Gate Reservoir Drawdown, Water Year 1999**

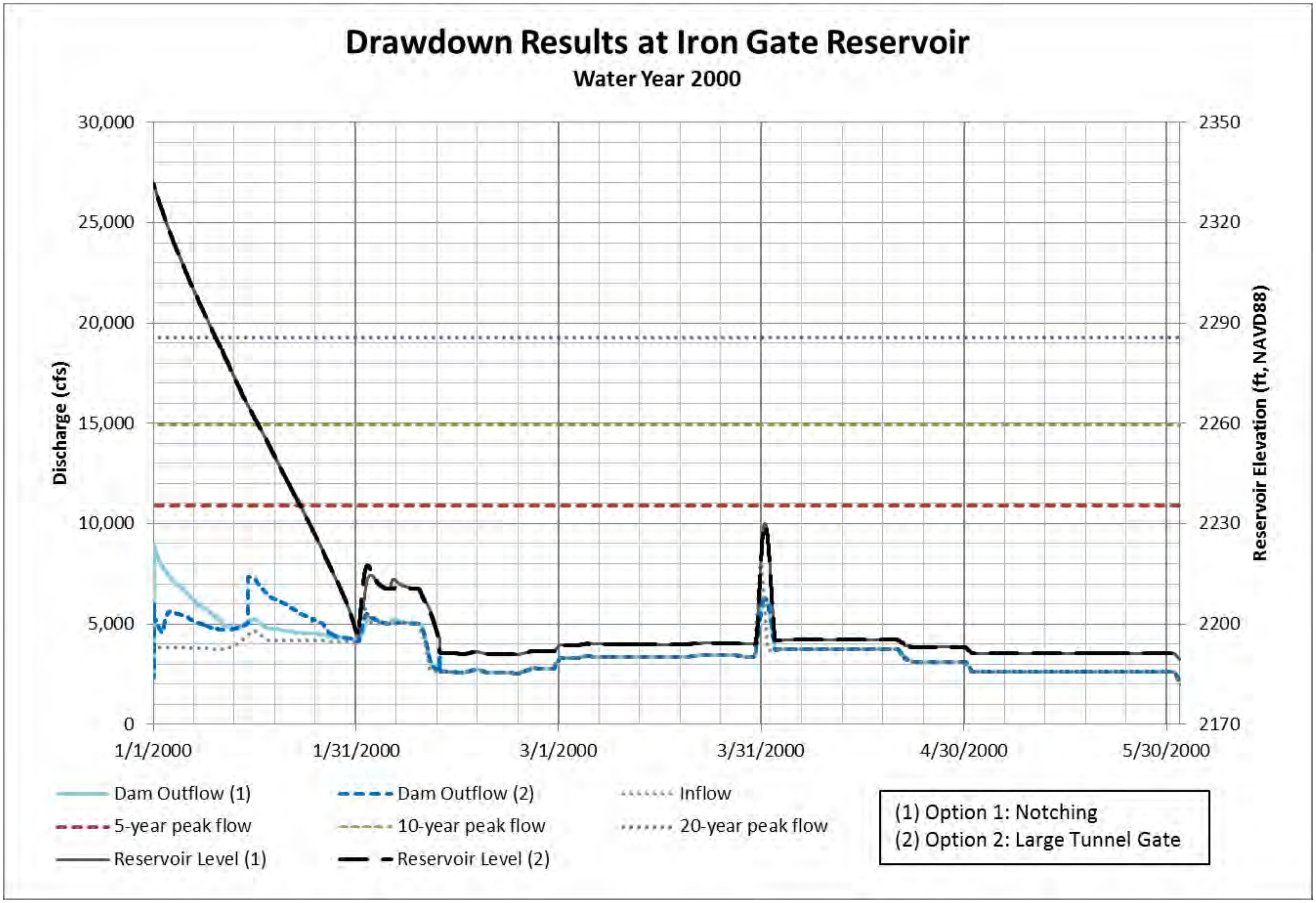



**Figure F4-40 Iron Gate Reservoir Drawdown, Water Year 2000**

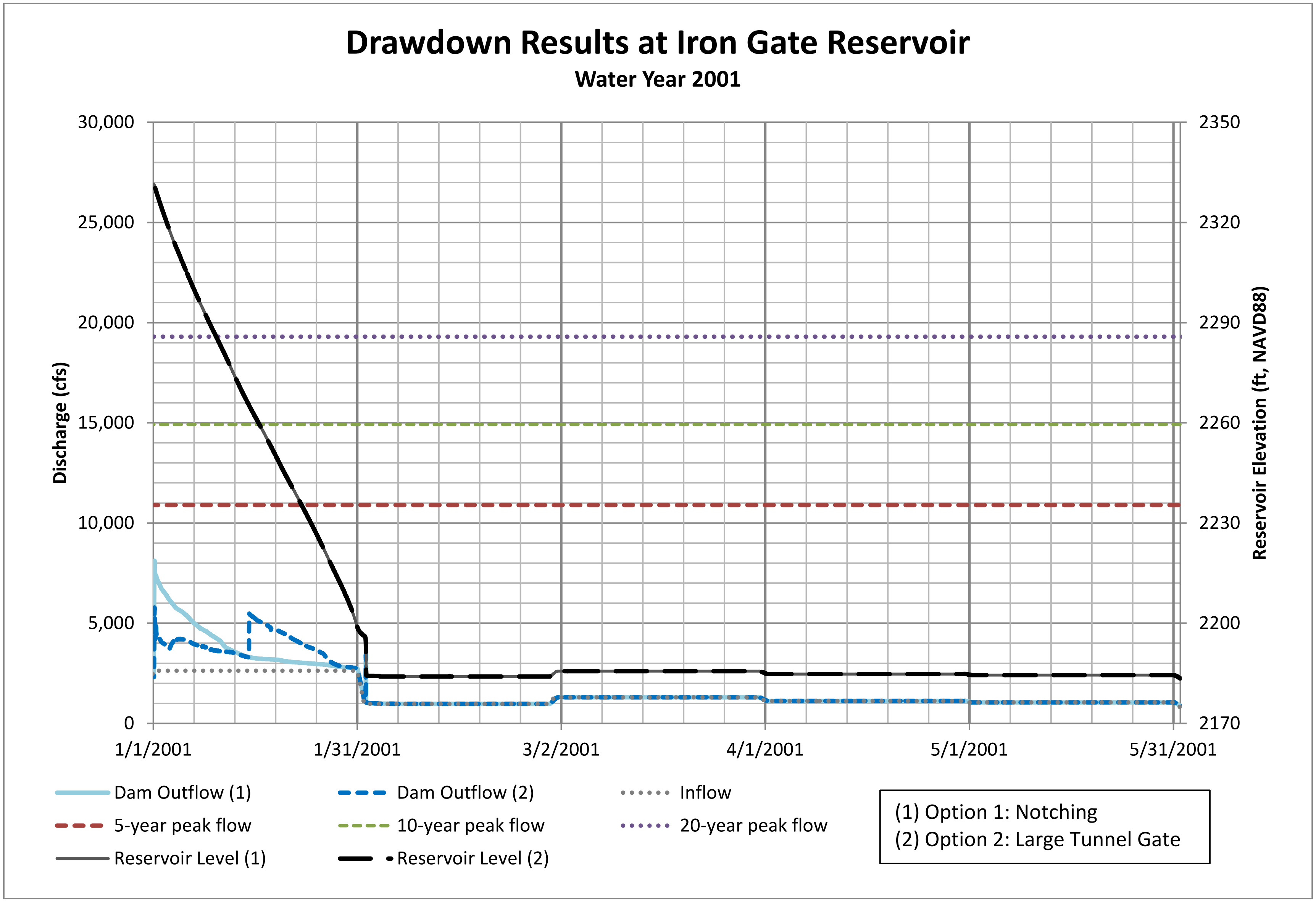



**Figure F4-41 Iron Gate Reservoir Drawdown, Water Year 2001**

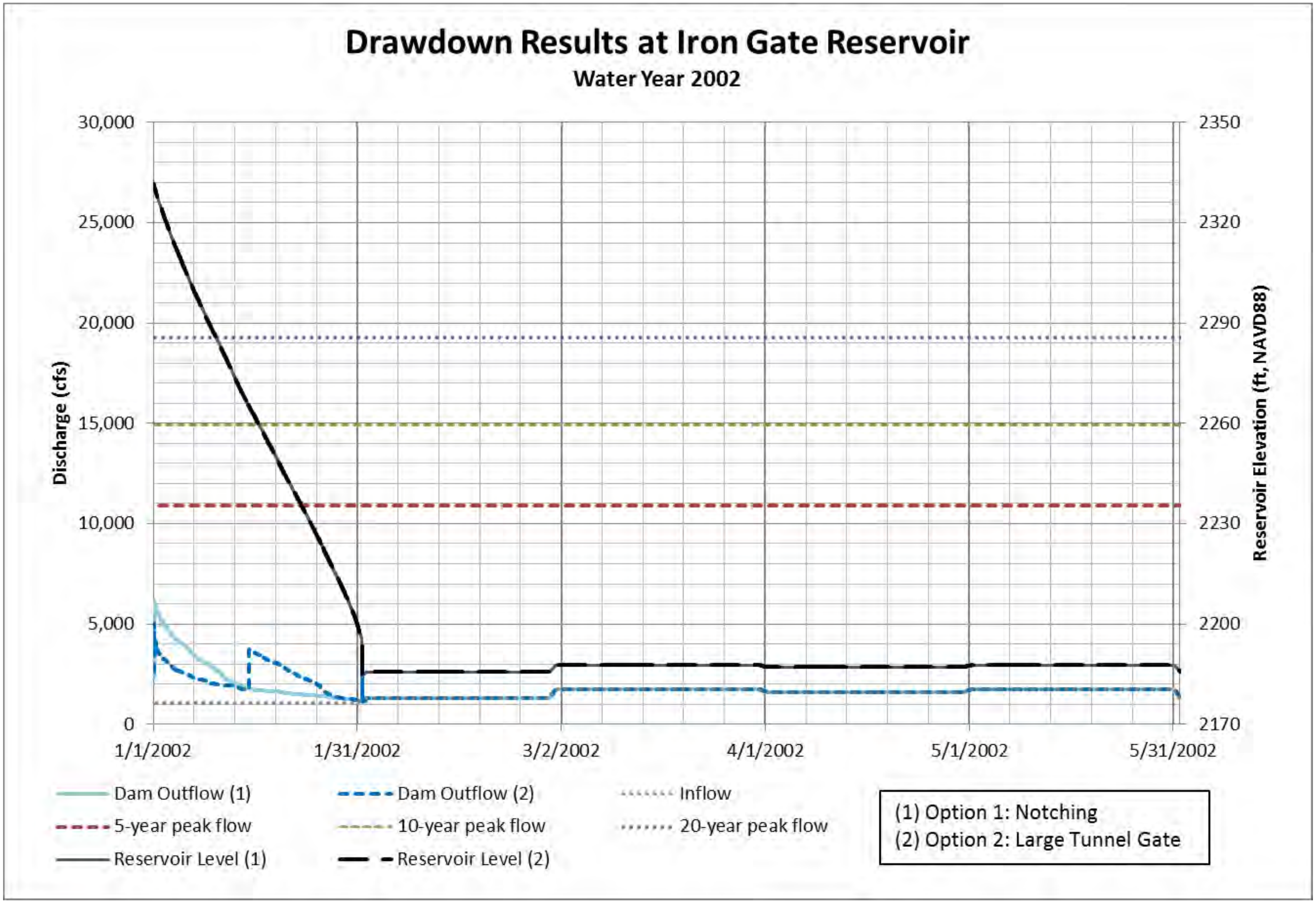



**Figure F4-42 Iron Gate Reservoir Drawdown, Water Year 2002**

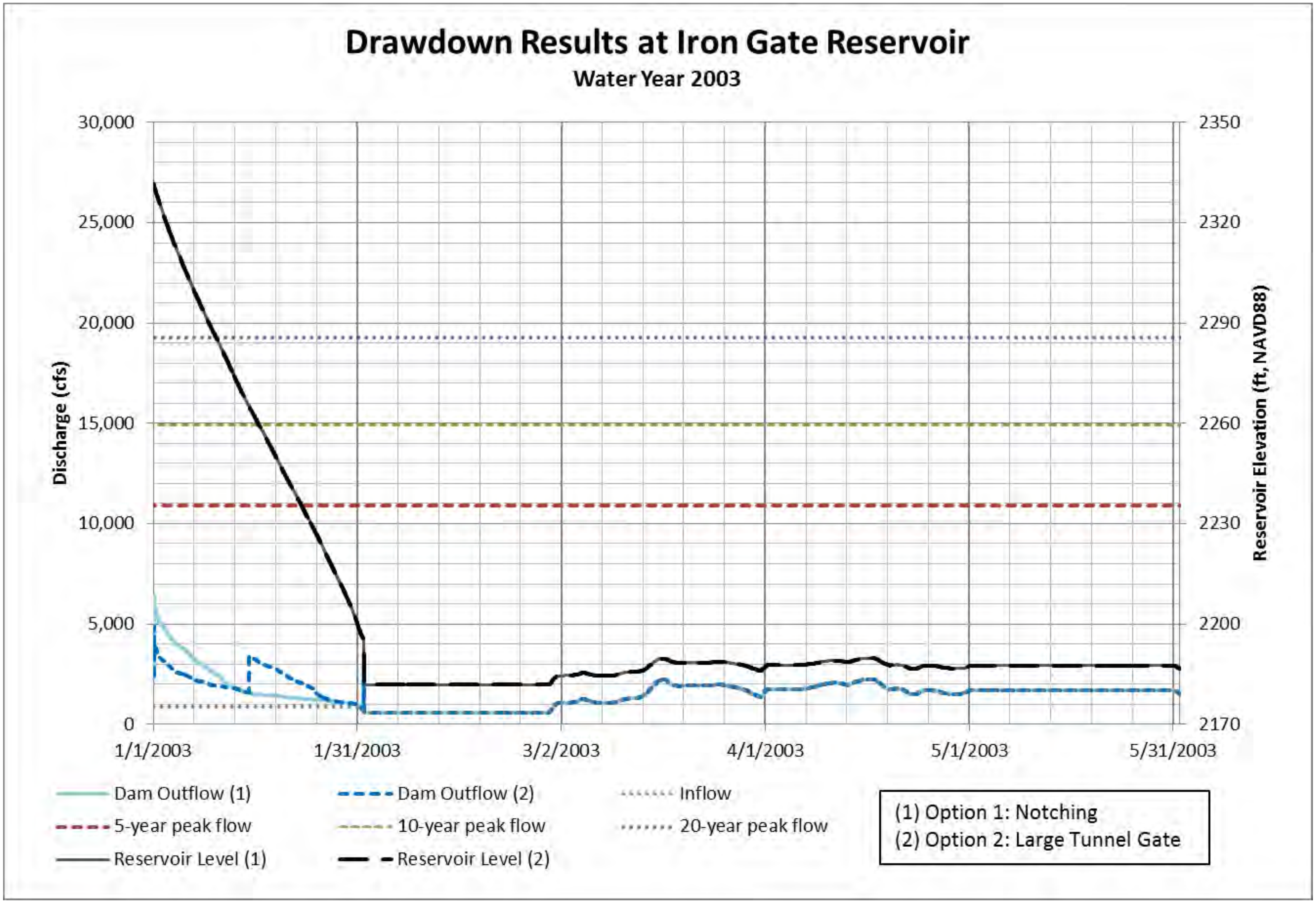



**Figure F4-43 Iron Gate Reservoir Drawdown, Water Year 2003**

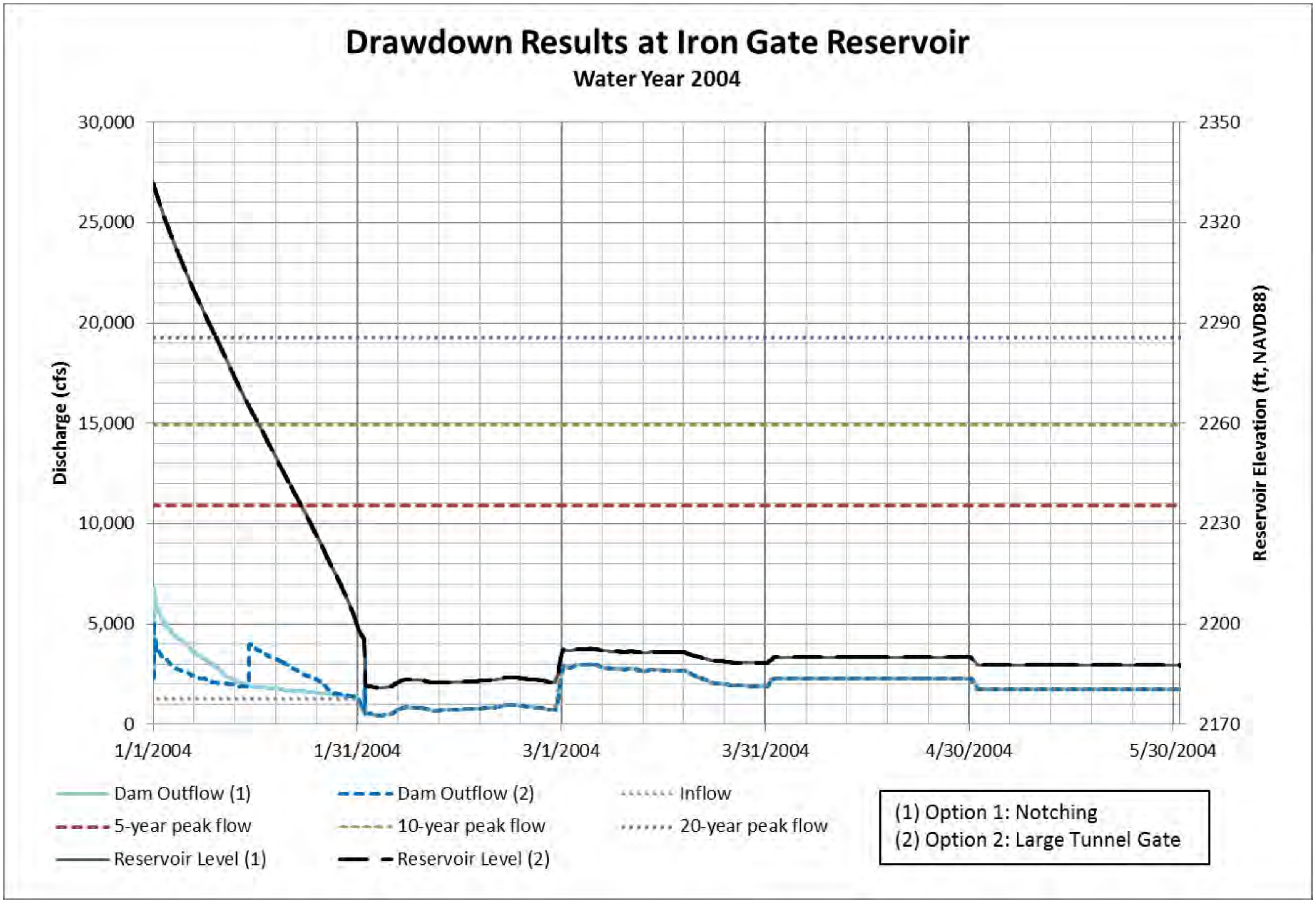



**Figure F4-44 Iron Gate Reservoir Drawdown, Water Year 2004**

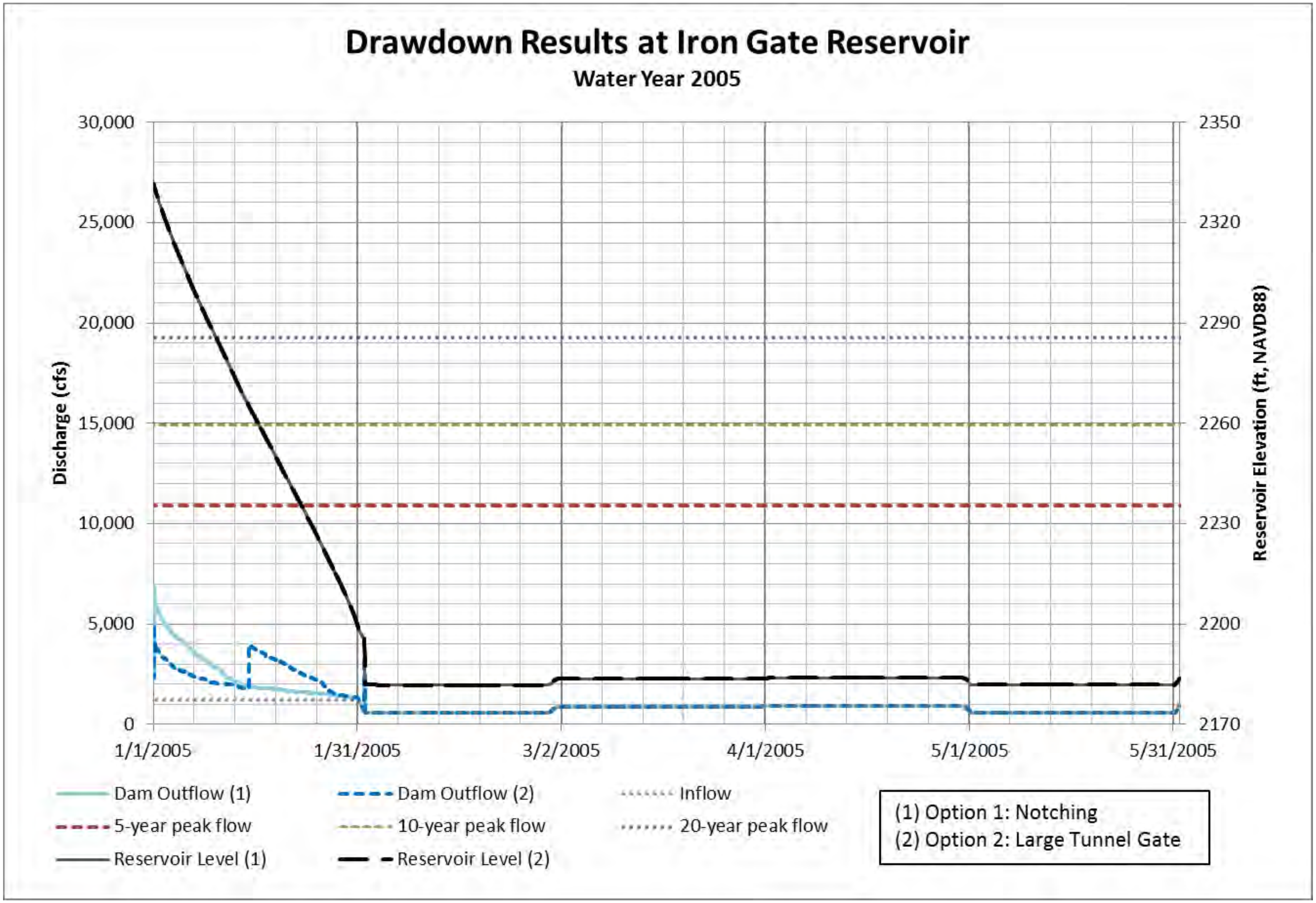



**Figure F4-45 Iron Gate Reservoir Drawdown, Water Year 2005**

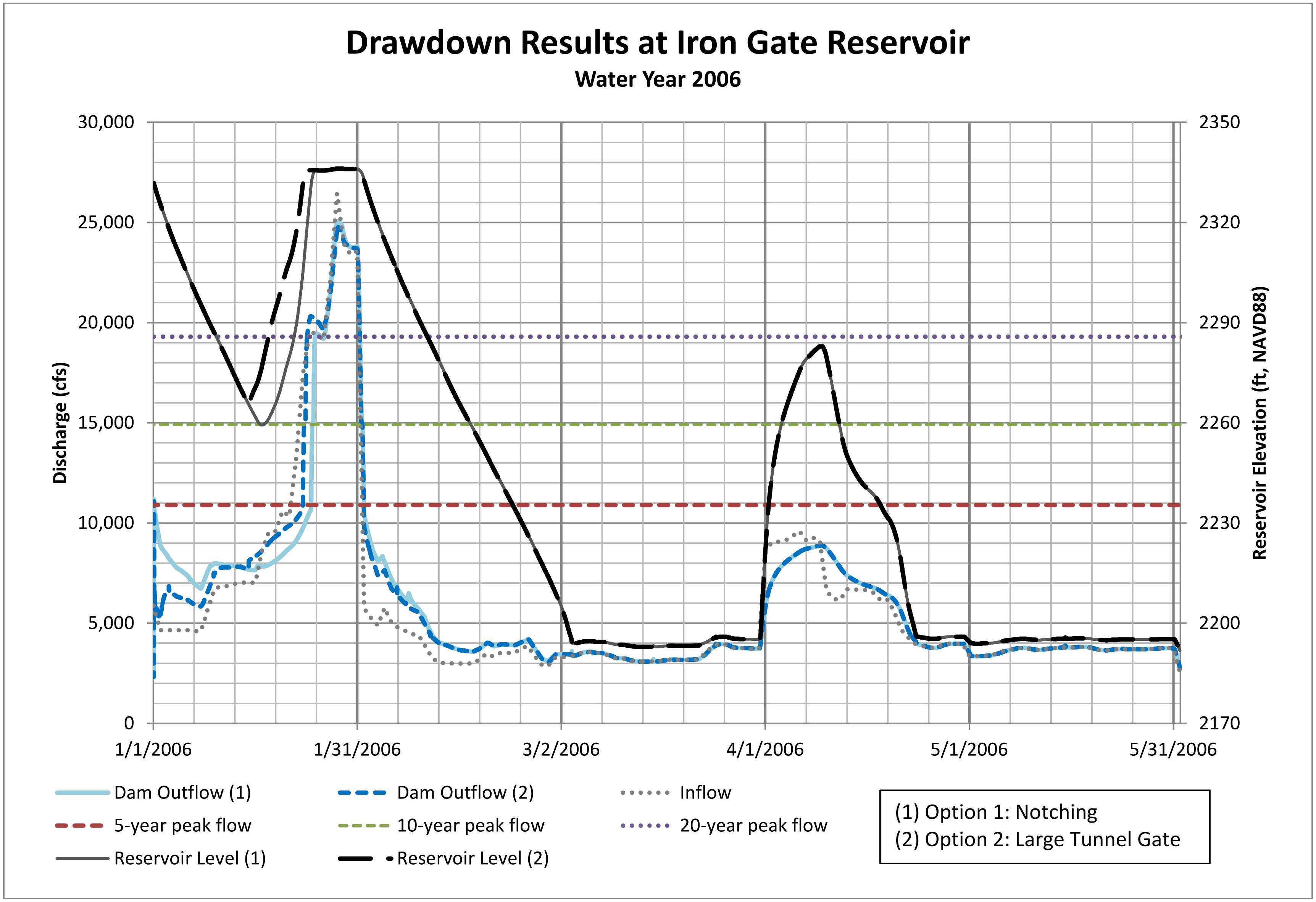



**Figure F4-46 Iron Gate Reservoir Drawdown, Water Year 2006**

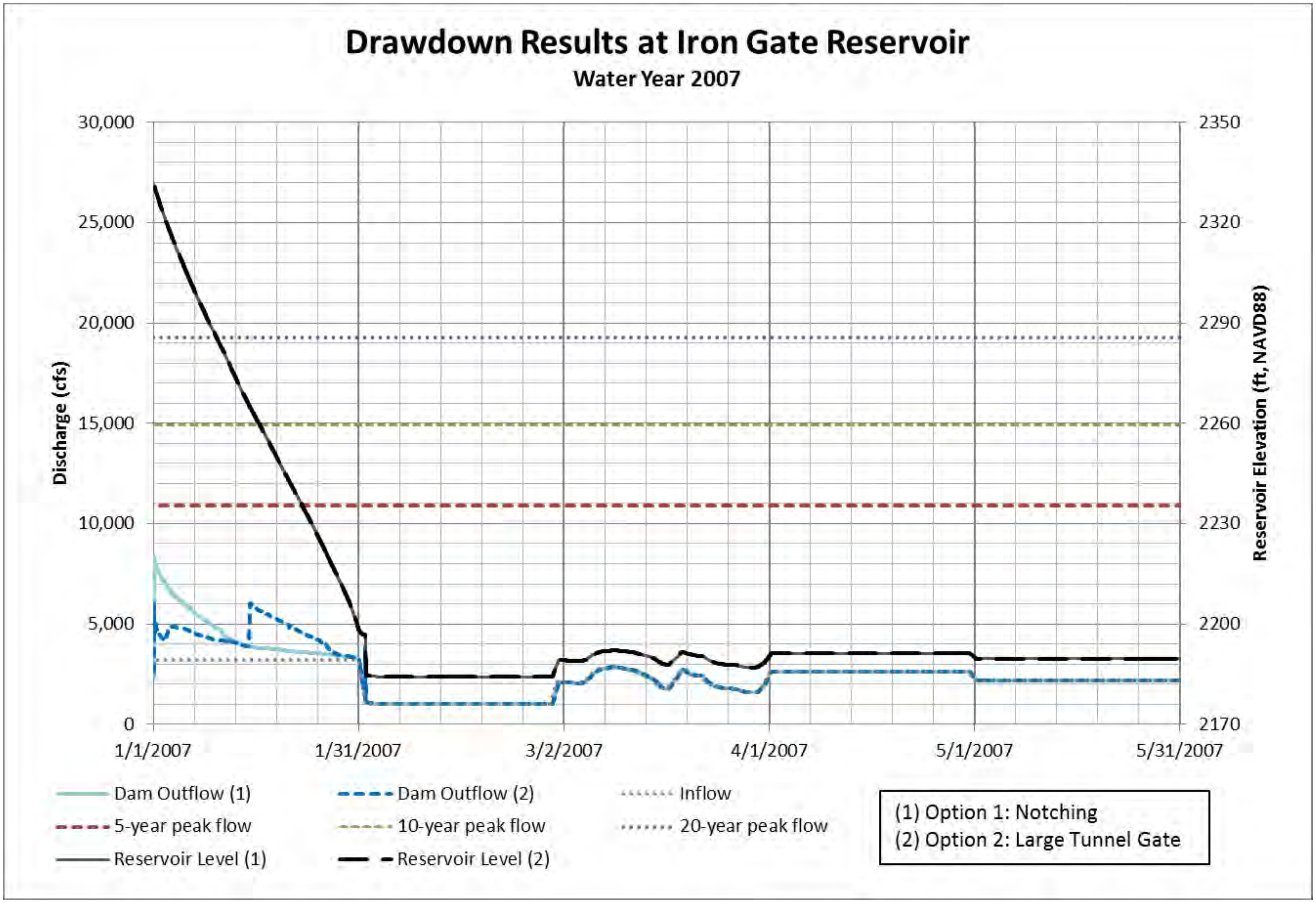



**Figure F4-47 Iron Gate Reservoir Drawdown, Water Year 2007**

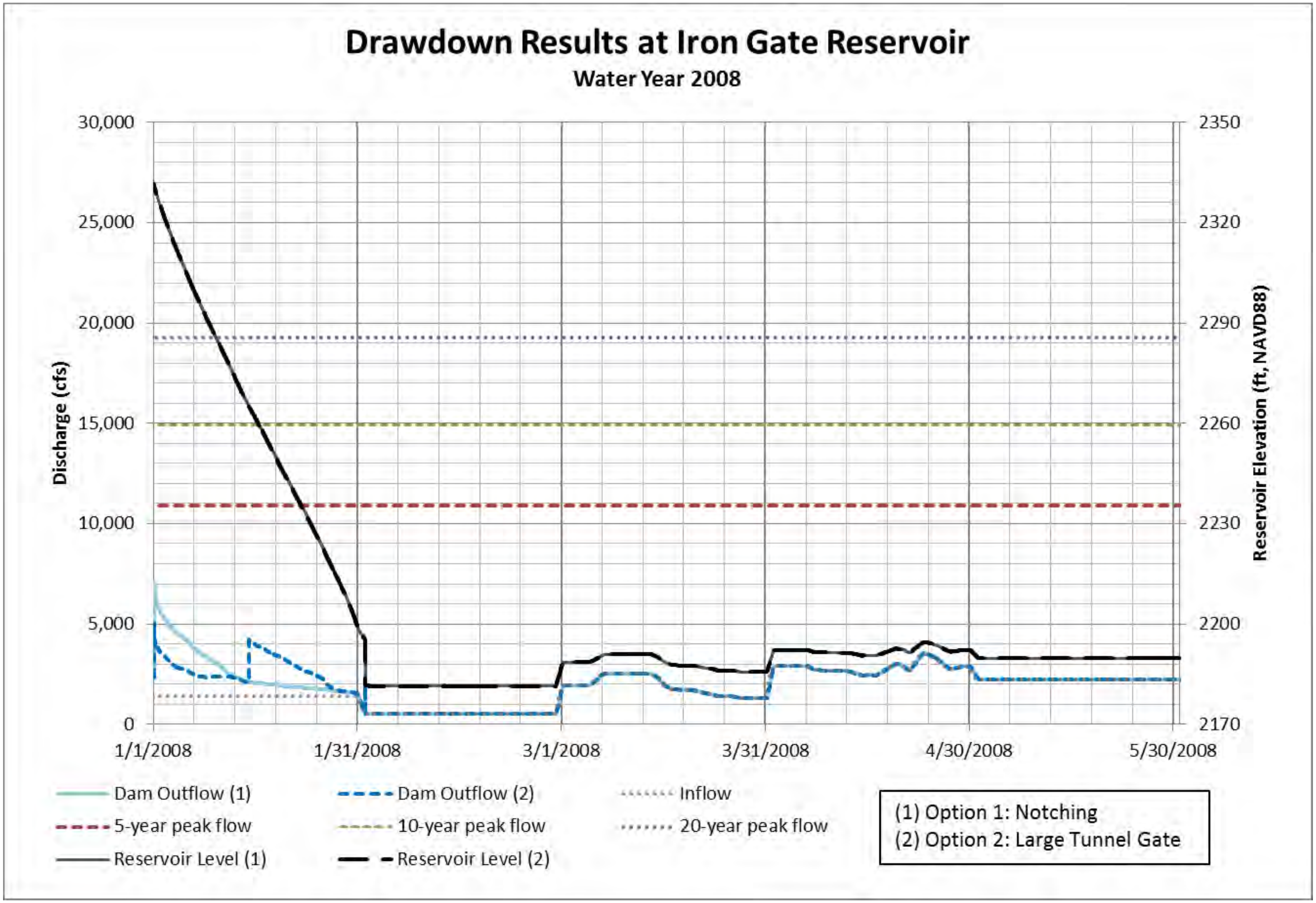



**Figure F4-48 Iron Gate Reservoir Drawdown, Water Year 2008**

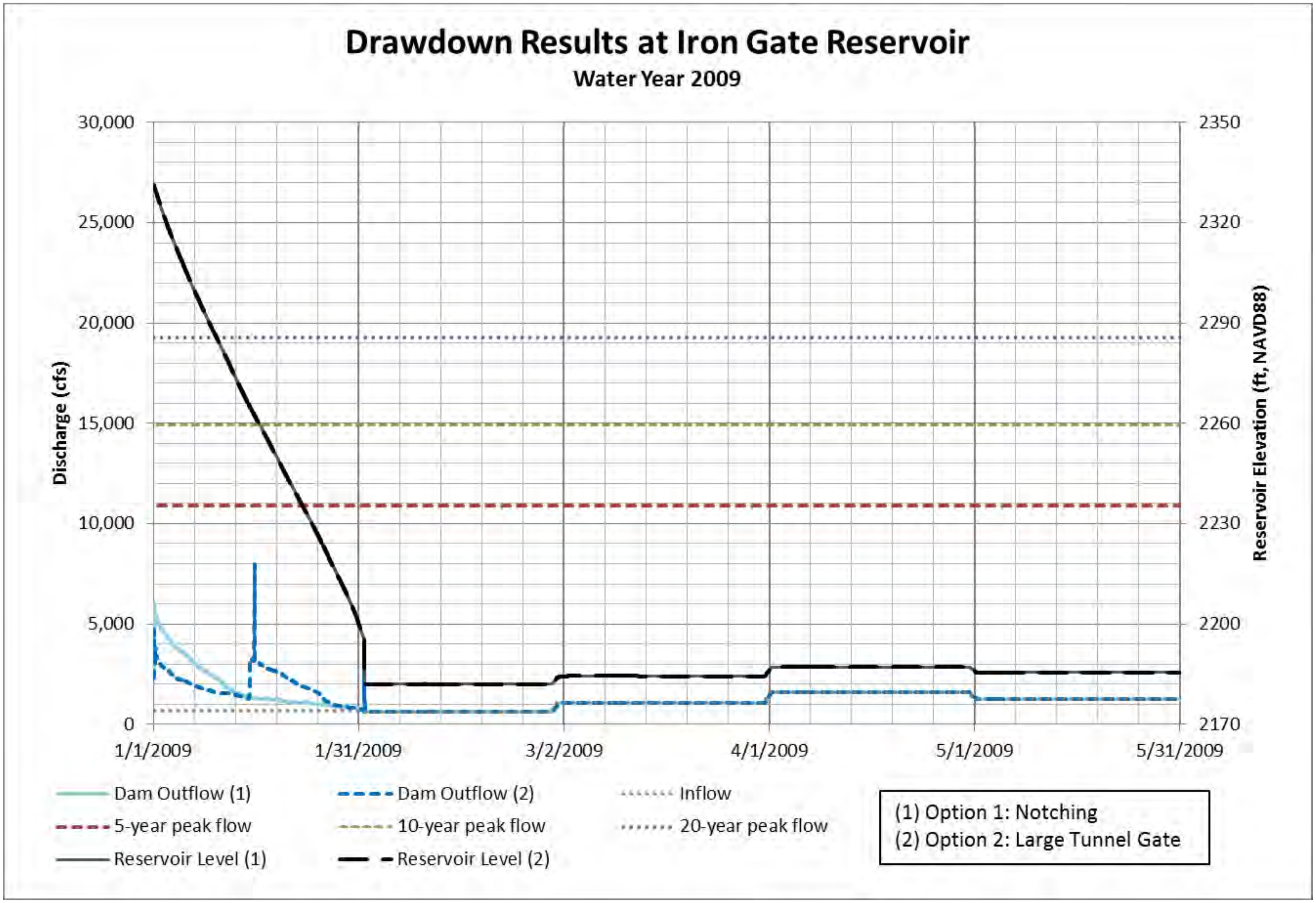
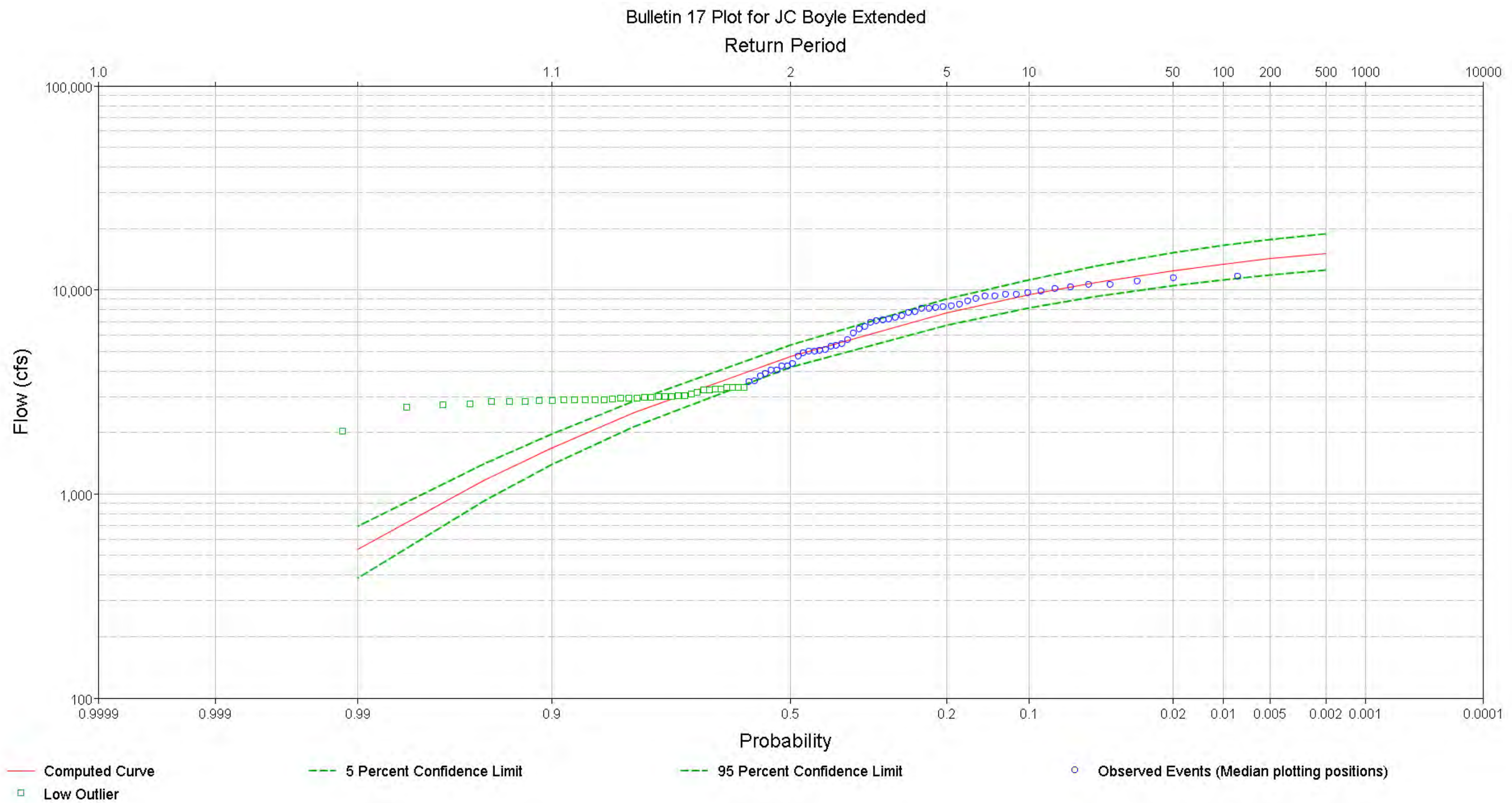



**Figure F4-49 Iron Gate Reservoir Drawdown, Water Year 2009**

# F5. Flood Frequency Analysis




## Figure F5-1 Flood Frequency Curve, J.C. Boyle

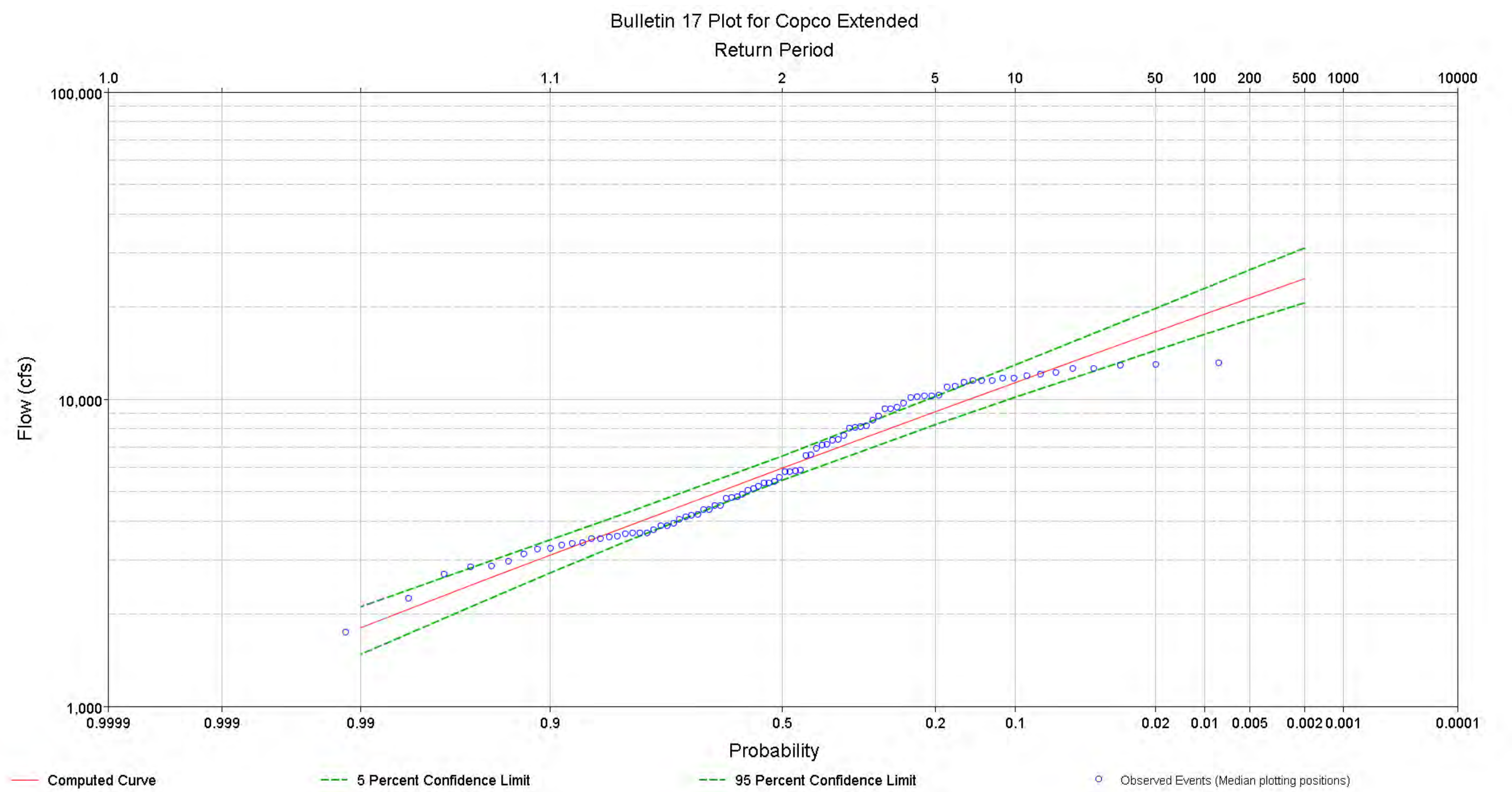
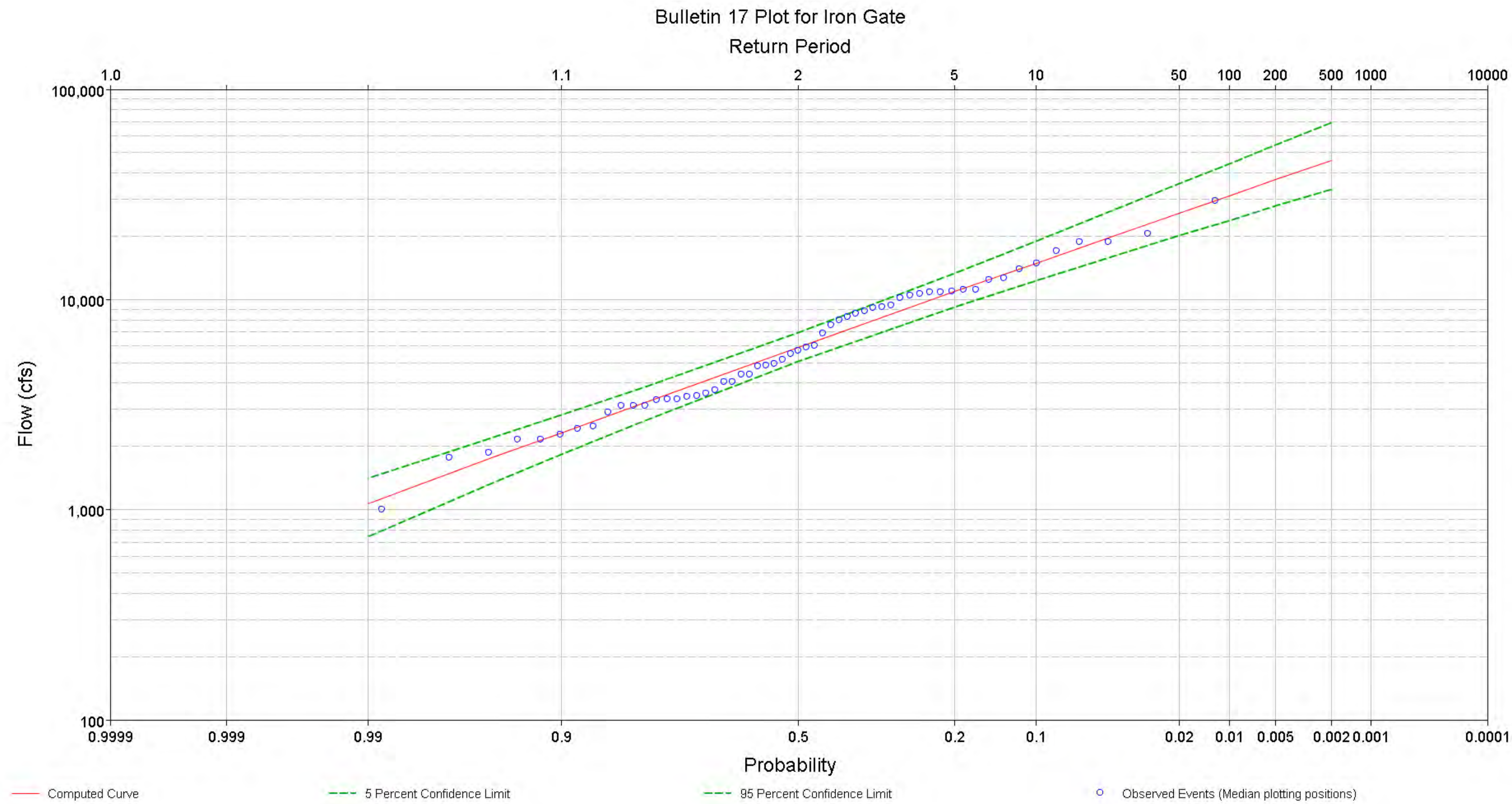



**Figure F5-2 Flood Frequency Curve, Copco 1**




## Figure F5-3 Flood Frequency Curve, Iron Gate

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# Appendix G Reservoir Restoration Plan

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# Klamath River Renewal Project

## California Environmental Quality Act (CEQA) and California and Oregon 401 Water Quality Certifications Technical Support Document
## Appendix G – Reservoir Area Management Plan

**Submitted to:** California State Water Resource Control Board and Oregon Department of Environmental Quality

**Submitted by:** Klamath River Renewal Corporation

**Date**: September 2017

**Prepared for:**

Klamath River Renewal Corporation
California State Water Resources Control Board
Oregon Department of Environmental Quality

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# Table of Contents

## Figures

## Tables

# 1. Introduction

The Klamath Hydroelectric Settlement Agreement (KHSA) signed in 2010 and updated in 2016 establishes the framework for decommission and removal of four dams (Iron Gate, Copco 1 and 2, and JC Boyle) on the Klamath River as shown on Figure 1-1. The dams would be removed under the direction of the Klamath River Renewal Corporation (KRRC) once an approved Transfer Application with PacifiCorp and the KRRC is agreed to by the Federal Energy Regulatory Commission (FERC) that would result in KRRC ownership of the hydroelectric license and facilities. As the dams are removed, vast reservoir areas will become exposed and require restoration and stabilization of bare sediment deposits for long-term water quality and ecological benefits, and restoration of natural river functions and processes.

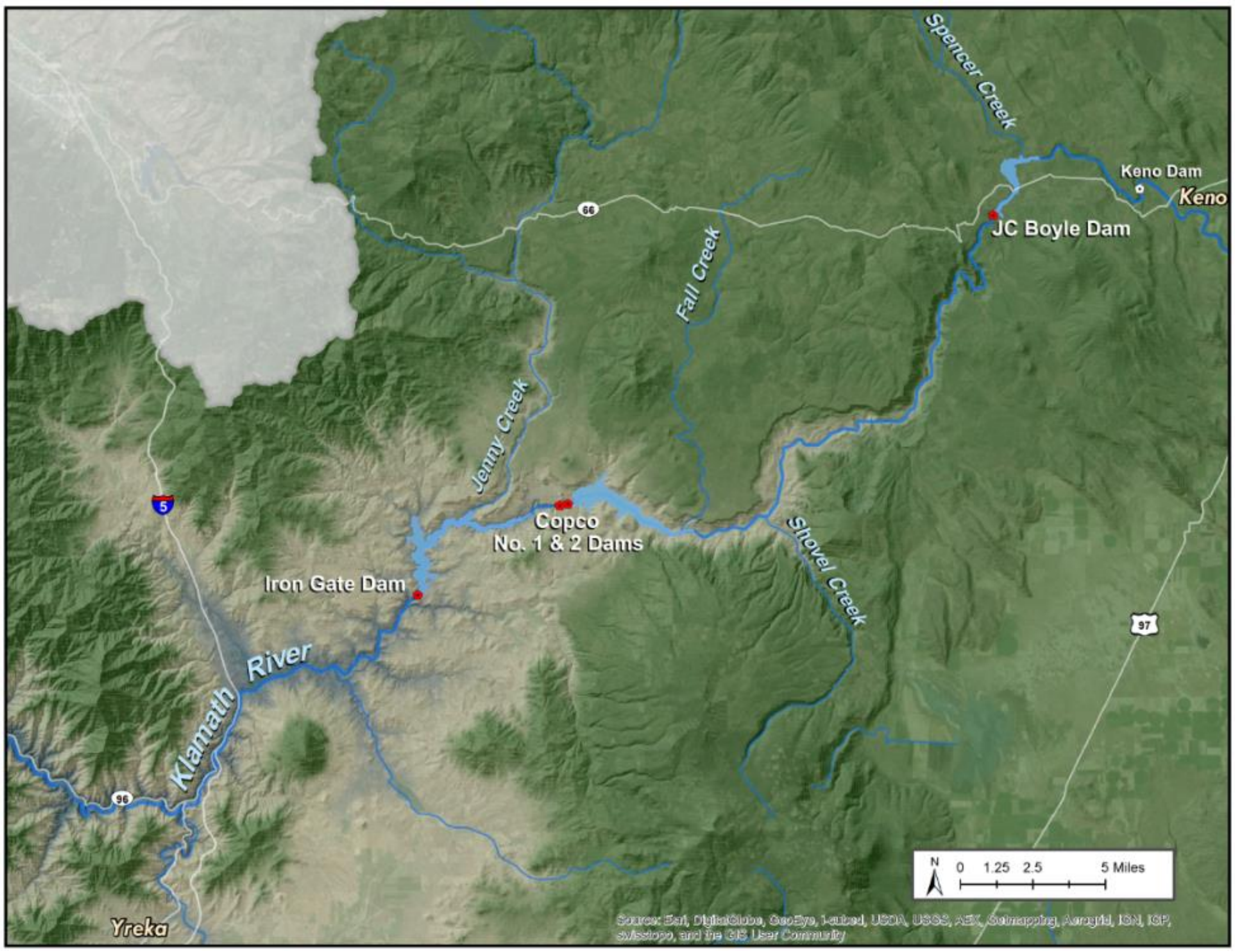



**Figure 1-1 Vicinity map showing locations of Klamath River dams**

## 1.1 Purpose

As part of the 2012 Environmental Impact Statement/Report (EIS/EIR) and 2013 Secretarial Determination of Record (SDOR), a Reservoir Area Management Plan (Reclamation, 2011a) was developed by the Bureau of Reclamation (Reclamation) with assistance from the National Marine Fisheries Services (NMFS), Bureau of Land Management (BLM) and the EIS/EIR project team. The document describes anticipated conditions in the reservoir areas after removal of the four dams based on hydraulic modeling, sediment characteristics, and reservoir drawdown scenarios. The plan provides goals and objectives developed with a multi-disciplinary team of professionals for the Reservoir Area Management Plan as summarized in Table 1-1.

**Table 1-1 Compiled goals, objectives and potential projects for managing the reservoir areas from the 2012 Reservoir Area Management Plan**

| 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. | Implement a weed management program. |
| Construction period: (0 to 1 year) | Natural erosion and transport of reservoir deposits and dispersal in the ocean. | Maximize erosion of reservoir deposits during drawdown. | Allow erosion of deposits during reservoir drawdown. Do not stabilize reservoir deposits. |
| Short-term: (1-5 years after dam removal) | Limit windblown dust and surface erosion from reservoirs. | Less than 25% of reservoir areas will be exposed to erosion. | Active planting of native grasses and other species. |
| | Establish native vegetation. | 75% of reservoir areas will have native vegetation cover. | Active planting of native grasses and other 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 or tree species per acre within riparian-bank areas. | Active planting of native shrub and tree species within riparian-bank areas. |
| Mid-term: (5 to 10 years) | Fish habitat within reservoir reaches similar to reaches found upstream or downstream. | Spawning and rearing habitat performing within 25% of similar up/down stream habitats. | Passive rehabilitation of riffles and pools. Natural resupply of gravel to reservoir reaches. |

| Period | Goal | Objective | Potential Project |
|---|---|---|---|
| Long-term: (10 to 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. |

*USBR 2011c*

The 2011 Reservoir Area Management Plan was developed primarily with the intent to minimize invasive vegetation and stabilize the sediments to reduce the likelihood of future sediment releases. Since the development of the plan, several dam removals and reservoir restoration projects have been completed that provide additional insight into the best methods for restoration success. Hence, an update to the plan is necessary to incorporate current restoration practices and techniques and improve the likelihood for restoration success. The primary purpose of updating the existing plan is threefold:

1. Update the goals and objectives to better match current stakeholder and regulatory requirements;
2. Add current knowledge base and lessons learned from other dam removal and restoration projects to the existing 2011 Reservoir Area Management Plan; and
3. Add details and information that were not fully developed in the 2011 Plan.

## 1.2 Review of Similar Dam Removal Restoration Plans

Dam removal and reservoir restoration has become more commonplace as a technique to restore fish passage and reinstate natural river functions and processes. As a result, several different approaches to river and reservoir area restoration have been implemented with varied results. Table 1-2 provides a summary of seven selected dams that were removed over the last eight years and the associated approaches to reservoir area restoration.

### Table 1-2 Select dam removals in the Western US over the last eight years

| Dam | State | Year Removed | Removal Strategy | Reservoir Restoration Approach |
|---|---|---|---|---|
| Glines Canyon | WA | 2014 | Phased | Minimize invasive exotic species, revegetate with native plants, restore floodplain ecosystem processes, and no in-channel restoration. Active planting % cover. |
| Elwha | WA | 2012 | Phased | Minimize invasive exotic species, revegetate with native plants, restore floodplain ecosystem processes, and no in-channel restoration. Active planting % cover. |
| Milltown | MT | 2009 | Sudden | Engineer river channel and habitat features, floodplain reconstruction, comprehensive revegetation plan and control of invasive species. |
| Condit | WA | 2011 | Sudden | Revegetate reservoir area, noxious weed control, regrade reservoir and disturbed areas, no in-channel restoration in mainstem, large wood placement in tributaries. Active planting % cover. |

| Dam | State | Year Removed | Removal Strategy | Reservoir Restoration Approach |
|---|---|---|---|---|
| Savage Rapids | OR | 2009 | Sudden | No active restoration or revegetation in reservoir area. |
| Gold Ray | OR | 2010 | Sudden | Vegetate disturbed areas with native plants, helicopter application of grass seed on reservoir area margins, and large wood structures in-channel. Active planting % cover. |
| San Clemente | CA | 2015 | Phased | Minimize invasive exotic species, revegetate with native plants, restore floodplain ecosystem processes, entire river channel reconstruction and relocation. |

Based on project monitoring reports and adaptive management documentation, several common threads have emerged from the various project restoration plans that can improve chances for successful reservoir restoration and revegetation:

- Control of invasive and noxious weeds is important to short-term and long-term success of vegetation. Activities to control weeds should start before dam removal.
- Revegetation of exposed reservoir areas with native plants is the preferred method to speed recovery, and larger plant sizes help reduce browse.
- An irrigation system or regular watering is critical for the first and second years of reservoir area revegetation, particularly for wetland vegetation.
- Maximize initial, natural erosion and evacuation of accumulated reservoir sediment and then enhance remaining sediment with active vegetation planting and construction of habitat features.

## 1.3 Updated Reservoir Area Management Goals and Objectives

The Klamath Restoration Work Group (KRWG), led by the KRRC Technical Representative, was developed with regulatory, tribal, and consulting professionals to provide expert knowledge and recommendations for updating the 2011 Reservoir Area Management Plan (Reclamation, 2011c). The KRWG held a workshop in August 2017 and one of the consensus recommendations was to update the goals and objectives based on current knowledge of restoration and experience from recent dam removal and restoration plans. Table 1-3 provides a summary of updated goals and objectives that guide this update to the Reservoir Area Management Plan.

### Table 1-3 Updated goals, objectives, and restoration activities for reservoir restoration

| Period | Goal | Objective | Restoration Activity |
|---|---|---|---|
| Pre-construction Period | Prepare native plant materials for revegetation. | Collect and propagate native plant seed and grow container plants. | Identify potential seed collection, seed propagation, pole harvest cutting areas, and container plant grow contractors. |
| | | | Perform surveys to identify and map seed collection and pole harvest areas. |
| | | | Prepare seed collection, seed propagation, container plant growing, and pole harvest contract documents. |
| | | | Award and monitor native plant and seed contracts. |
| | | | Develop revegetation contract documents. |
| | Reduce invasive exotic vegetation (IEV). | Reduce and minimize the local sources of IEV. | Gather existing IEV data and perform EIV surveys. |
| | | | Review potential herbicides and potential impact on fish and water quality. |
| | | Implement an IEV management program | Create management plan and review with stakeholders. |
| | | | Procure local contractor to perform IEV removal. |
| | | | Inspect and monitor IEV removal execution. |
| | Understand evolution of reservoir post-removal and response to restoration and reservoir management | Conduct studies to fill in data gaps from 2011 Reservoir Area Management Plan | Sample sediment and perform tests to investigate wetting and drying characteristics, plant nutrient availability, and natural revegetation. |
| | | | Perform revegetation pilot tests for native seed mixes. |
| | | | Identify reference physical and ecological conditions in tributaries. |

| Period | Goal | Objective | Restoration Activity |
|---|---|---|---|
| Dam removal period (0 to 1 year) | Allow natural erosion and transport of reservoir deposits and dispersal in the ocean. | Maximize erosion of reservoir deposits during drawdown | Allow erosion of reservoir deposits during drawdown. |
| | Stabilize remaining reservoir sediments | Initiate native plant revegetation | Prepare and amend sediment based on pilot test plot results. |
| | | | Install irrigation system. |
| | | | Hydroseed sediment by planting zones. |
| | | | Install pole cuttings, acorns, and container plants. |
| | Restore volitional fish passage in mainstem and tributaries. | Monitor and rectify any non-natural fish passage barriers | Conduct field monitoring of mainstem/tributaries, fix non-natural barriers. |
| | Minimize invasive exotic vegetation. | Implement and monitor IEV removal during revegetation | Include criteria for IEV removal during revegetation implementation. |
| | | | Bi-weekly inspections of revegetation areas to verify IEV compliance. |
| Short-term (1 to 5 years after removal) | Restore natural ecosystem processes. | Continue native plant revegetation, maintenance and monitoring | Monitor establishment and adaptively replace failed pole cuttings, acorns, and container plants. |
| | | | Maintain irrigation system. |
| | | | Re-seed poorly established areas. |
| | Minimize IEV | Continue IEV monitoring and removal. | Include criteria for IEV removal during establishment. |
| | | | Perform monthly inspections to verify IEV removal compliance. |
| | Restore volitional fish passage in mainstem and tributaries. | Monitor and rectify any non-natural fish passage barriers. | Conduct field monitoring of mainstem/tributaries, fix non-natural barriers. |
| Long-term (5 to 10 years) | Restore natural ecosystem processes. | Continue revegetation monitoring and adaptive management. | Monitor establishment and adaptively replace failed pole cuttings, acorns, and container plants. |
| | Minimize IEV. | Continue IEV monitoring and removal. | Perform quarterly site inspections and verify compliance. |
| | Restore volitional fish passage in mainstem and tributaries. | Continue monitoring for non-natural fish passage barriers. | Remove all non-natural fish passage barriers. |

# 2. Historical and Existing Conditions

J.C. Boyle, Copco No. 1, and Iron Gate reservoirs were well documented prior to construction of the dams. A topographic survey was conducted and numerous pictures of existing conditions prior to construction of each dam. Many pictures are also available that show construction of each dam. The following sections describe the physical and ecological conditions of each reservoir area prior to dam construction and the current reservoir conditions. Copco No. 2 reservoir area is small and is not further discussed in this updated plan as it will easily transition back to pre-dam conditions without active restoration.

## 2.1 J.C. Boyle

The J.C. Boyle Dam reach of the Klamath River is subdivided into two sections based on valley morphology and geomorphic features mapped prior to dam construction in 1958. The Canyon Reach extends from J.C. Boyle Dam to Highway 66 bridge (USGS river miles [RM] 225 to 226) and the Upstream Reach runs from the Highway 66 bridge to the upstream extent of the J.C. Boyle Reservoir (RM 226 to 228) (Figure 2-1).

### 2.1.1 Historical Conditions

In the Canyon Reach, the Klamath River was historically incised several tens to hundreds of feet into the surrounding volcanic bedrock to form a deep, narrow valley. The narrow valley contained limited space for sediment storage, and accordingly there are no mapped historical geomorphic features. The Klamath River was single threaded with significant exposures of bedrock on the river bed and banks that limited channel adjustment. There is little evidence of bedform development, and most in-channel sediment visible in photos is boulder or cobble size. Rapids that were likely bedrock-controlled are visible upstream of RM 225 and downstream of the Highway 66 bridge (Figure 2-3). In the 1,000 feet between RM 225 and the dam site downstream, an unnamed tributary enters from river left, and the historic valley widens and relief decreases (Figure 2-4). Ponderosa pines occupied upland hillsides adjacent to the river, but the bedrock banks of the riparian corridor were sparsely vegetated primarily with shrubs and grasses. There is little photographic evidence of large wood accumulations in the channel, which is consistent with low tree recruitment and the high velocities and lack of accommodation space that restricted sediment accumulation and created exposed bedrock in the reach.

In the Upstream Reach, the valley is wide with low relief as the river abruptly exits the steep, narrow bedrock canyon upstream of RM 228. Bedrock control is visible on river right approximately 1,000 feet upstream of RM 227 where the Klamath River abruptly turns south, but otherwise the historical channel was primarily alluvial. The valley geometry promoted sediment accumulation, and there were alluvial fans and terraces mapped on both sides of the Klamath River (Figure 2-1). The large alluvial fan and terrace on the west side of the river was likely formed by distributary deposition from several unnamed tributaries that would have migrated across the deposit surface. The primary tributary, Spencer Creek, enters the reservoir from the north 0.5 miles downstream of RM 228 and was associated with a mapped floodplain and alluvial fan. The Klamath River actively modified its channel as suggested by the floodplains and both vegetated and unvegetated bars, including a large semi-vegetated, mid-channel bar upstream of the Highway 66 bridge (Figure 2-3). High flows likely occupied the surfaces of the mapped deposits given their small heights above the historical river level. Ponderosa pine forest dominated upland areas in the Upstream Reach, but woody vegetation was sparse to non-existent in the areas of the mapped geomorphic features. These areas were cleared of trees for agricultural use and wood production. No large wood was visible in the active channel. Wetland conditions were likely supported in Spencer Creek, which had a multi-threaded character in its lower sections.

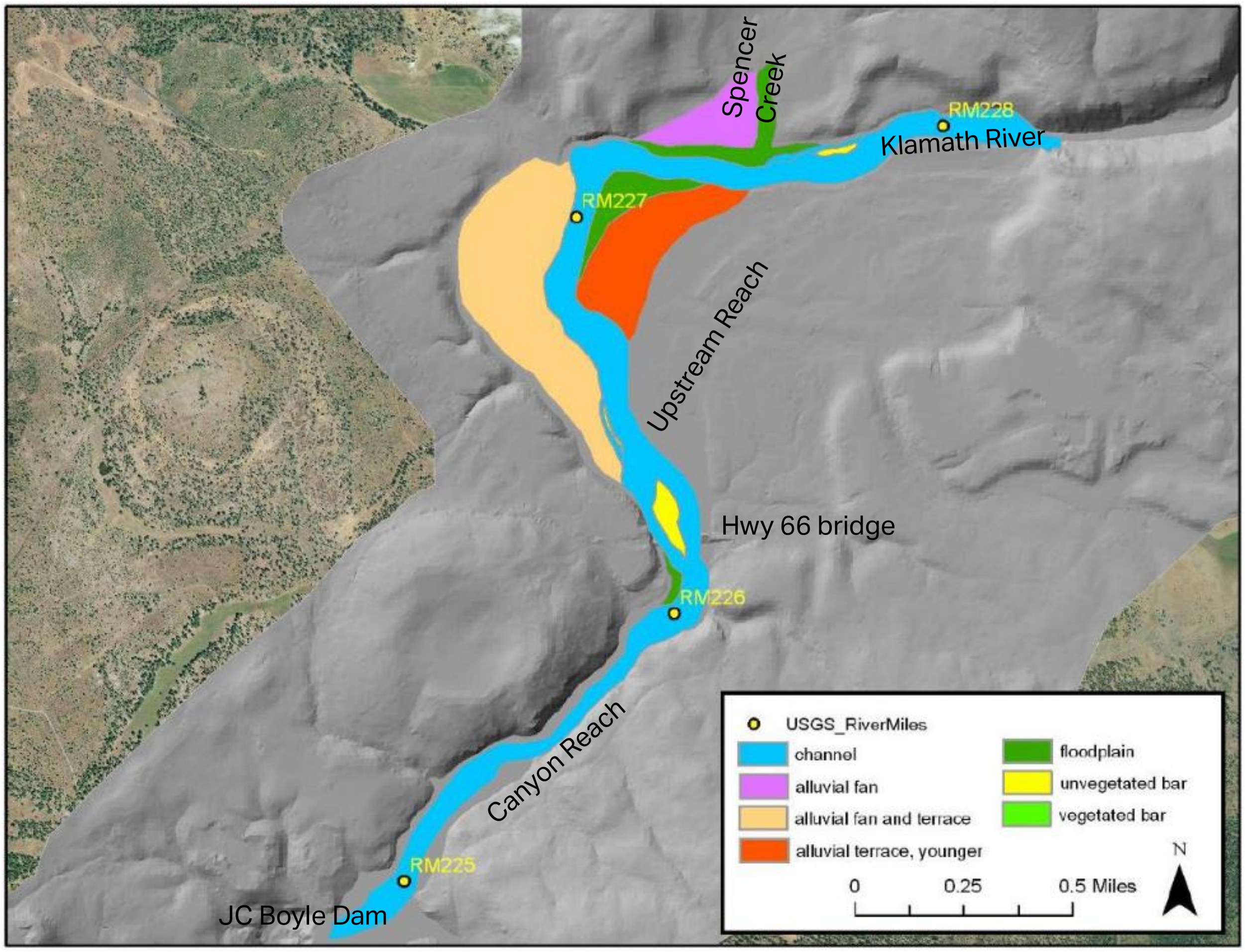
### 2.1.2 Current Conditions

Current conditions in the J.C. Boyle Reservoir vary considerably between the two reaches. The reservoir is narrow and linear in the Canyon Reach with water depths increasing from approximately 10 feet at the Highway 66 bridge to maximum values around 35 feet at the unnamed tributary junction 1,000 feet upstream from the dam. In the Upstream Reach, water depths are near zero for all but the historical channel location where depths are typically 10 to 15 feet with maximum values of 20 feet within the deep pool at the river right bedrock control.

J.C. Boyle Dam impounds an estimated 990,000 ± 300,000 cubic yards (CY) of fine-grained sediment, a large fraction of which is dead algae and other organic material (Reclamation, 2011c). Most of the sediment volume is stored in the Canyon Reach, where sediment thicknesses increase from 0 to 2 feet at the Highway 66 bridge to maximum values of 20 feet near the dam. The sediment in this reach is, on average, 50% silt, clay 40%, and 10% sand. The accumulated reservoir sediment deposit in the Upstream Reach is primarily confined to the historical channel where it is typically less than 4 feet thick except for a 1,000 feet section around RM 226.5 where thicknesses of 8 to 10 feet filled the local low topography. As expected, the Upstream Reach sediment is coarser than downstream and is approximately 55% sand, 25% silt, and 20% clay on average (Reclamation, 2011c). In the Upstream Reach, the reservoir sediments are underlain by a 0 to 2 feet thick layer of coarser Quaternary alluvial gravel and sand, which is in turn underlain by fine-grained, but resistant, weathered Tertiary volcanics (Reclamation, 2010). Intact organic fragments, such as roots, twigs, bark, wood, were only found at the pre-reservoir contact in a three of the cores (Reclamation, 2010).

The accumulated in-situ reservoir sediment in both reaches has high moisture contents over 100% with low cohesion, low strength, and high erodibility (Reclamation, 2011c). The measured friction angle for the reservoir sediments from a sediment core near the dam site is approximately 30 degrees. Reservoir sediment testing determined that, upon drying, the sediments undergo significant changes in their physical properties. When dry, erosion resistance increases by an order of magnitude and the erodibility decreases. In dried samples from the Upstream Reach, average decreases in sediment thickness of 60% and in volume of 66%, and considerable density increases, were measured.

Upland vegetation type and distribution around both reaches of the J.C. Boyle Reservoir is similar to pre-dam conditions and is dominated by ponderosa pine. Wetland conditions exist in the tributaries and the wide, shallow reservoir margins of the Upstream Reach that experience seasonal fluctuations in water level. Assorted native grasses were observed, primarily along the river right bank of the Upstream Reach reservoir (Reclamation, 2011c). Conifers were mapped along the full margin of the reservoir, with the highest concentrations along the west bank of the Upstream Reach. Rushes and reed canary grass were mapped primarily along the river left/east bank of the Upstream Reach. Willow species were largely absent except for a few places near Highway 66.




*USGS river miles and the Highway 66 bridge are noted for reference. Figure modified from USBR 2011c.*

**Figure 2-1 Bare earth LiDAR hillshade of J.C. Boyle Reservoir area with mapped pre-dam geomorphic features**

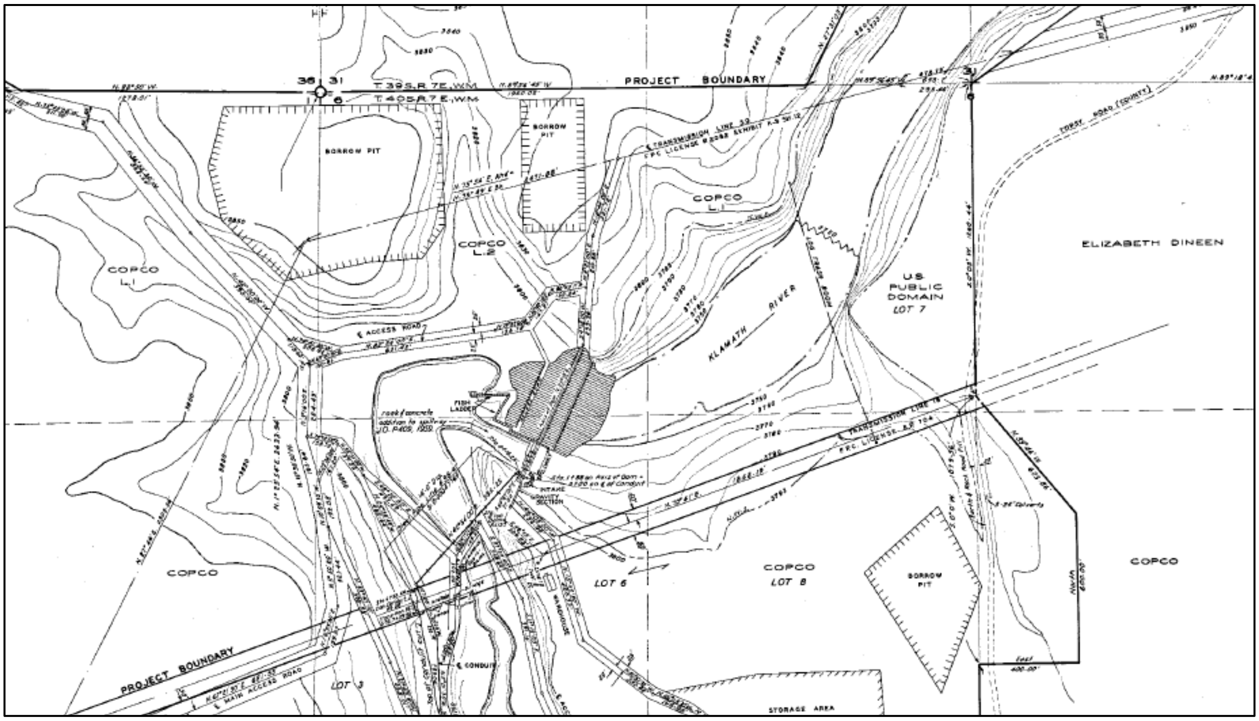



**Figure 2-2 Site plan view of J.C. Boyle Dam showing topographic contours prior to dam construction**


*Highway 66 bridge crosses the Klamath River in current location. Dam location is out of frame to the southwest.*

**Figure 2-3 Aerial photo of J.C. Boyle Reservoir area (1952) prior to dam construction**

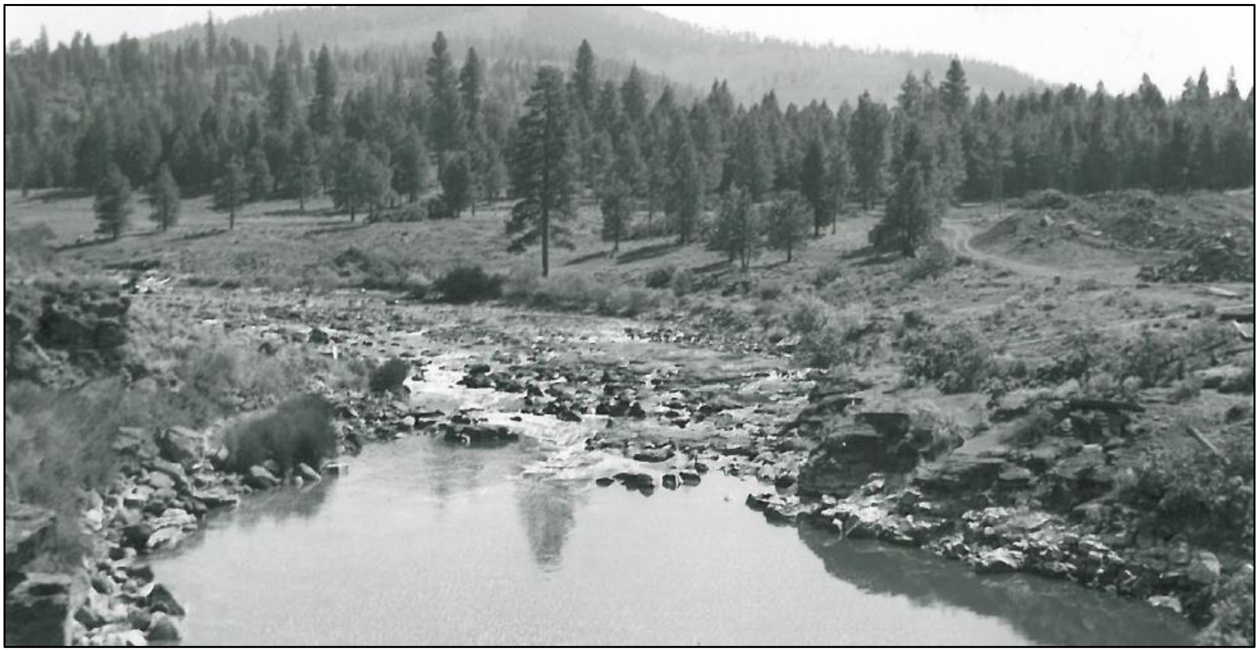


**Figure 2-4 View looking upstream at location where J.C. Boyle Dam was constructed in 1957 with view of historical vegetation and fluvial geomorphology**

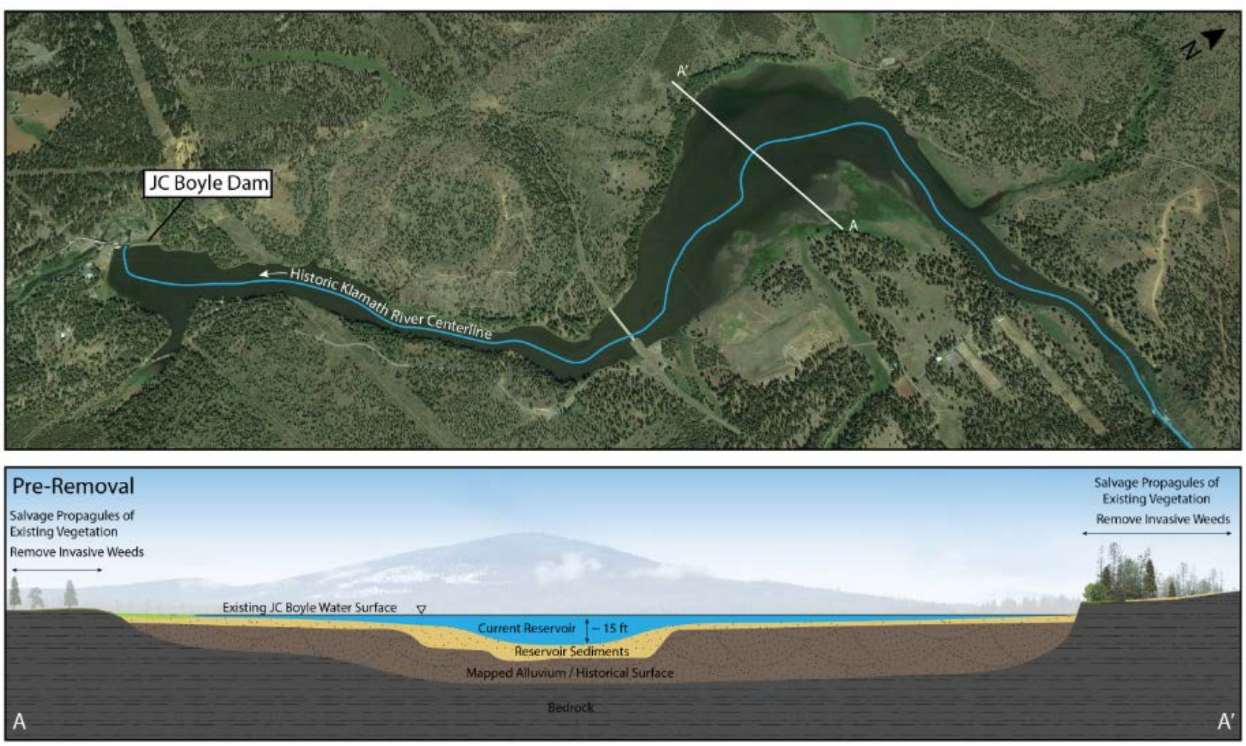
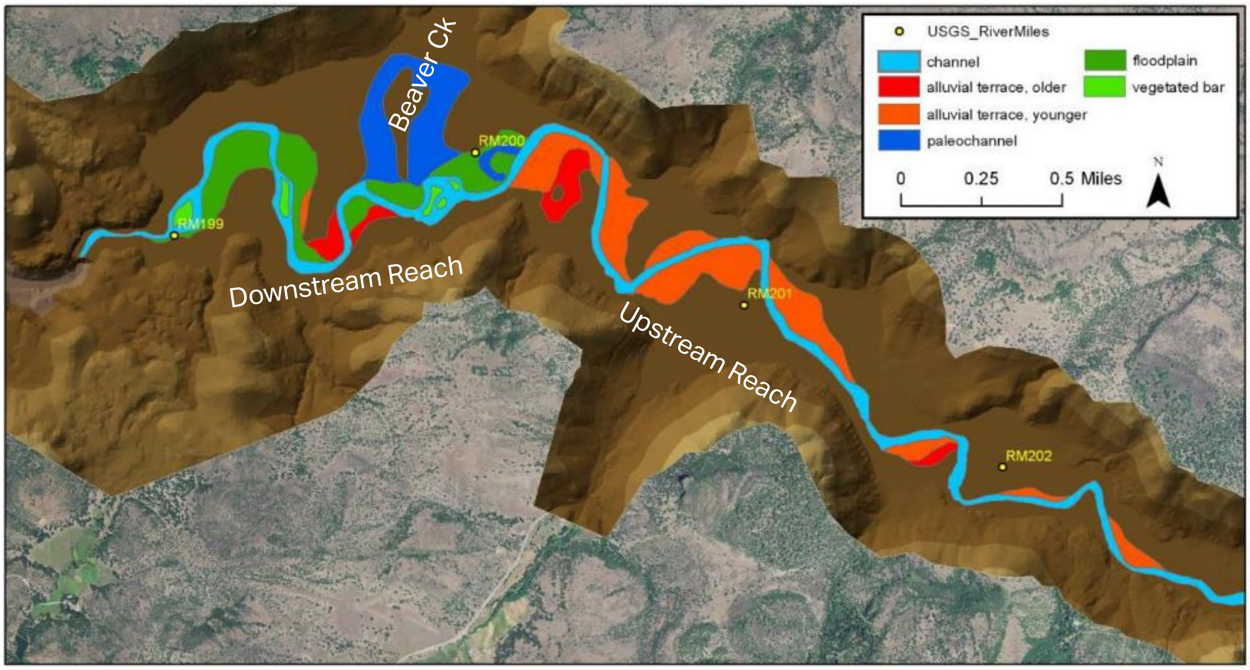



**Figure 2-5 Typical cross section at J.C. Boyle Reservoir Upstream Reach for current conditions**

## 2.2 Copco No. 1

The Copco No. 1 Reservoir is subdivided into two sections based on valley morphology and geomorphic features mapped prior to dam construction in 1918. The Downstream Reach extends from Copco No. 1 Dam to the upstream extent of the mapped historical floodplain near RM 200 upstream of Beaver Creek, and the Upstream Reach extends from RM 200 to the upstream extent of the reservoir at RM 203 (Figure 2-6).




*USGS river miles and approximate location of Beaver Creek are noted for reference. Figure modified from USBR 2011c.*

**Figure 2-6 Bare earth LiDAR hillshade of Copco Lake area with mapped pre-dam geomorphic features**

### 2.2.1 Historical Conditions

Historically, the Klamath River within the Copco No. 1 Downstream Reach was a sinuous, meandering and single-thread channel with mapped vegetated mid-channel bars and active floodplain. The historical channel occupied asymmetric valley cross-sections which were comprised of steep resistant banks on the outsides of bend and more gradual alluvium-draped slip-off slopes on the insides of the meanders (Figure 2-7). The historical valley bottom was relatively wide and flat compared to reaches of the Klamath River downstream of the dam (e.g., historical Iron Gate reservoir valley) and upstream of the reservoir. The wide and flat valley morphology was likely the result of aggradation caused by the damming of the ancestral Klamath River by Tertiary and Quaternary andesitic and basaltic lava and pyroclastic flows. The dam is built into these volcanic units, which continue to constrict the Klamath River and form the canyon walls downstream of Copco No. 1 Dam. The valley fill consists of material derived from Tertiary volcaniclastic rocks. This material, which composed the tall and steep outside banks of the large downstream meanders and is potentially tens of feet thick below the historical valley floor, is fine-grained but resistant to erosion and capable of supporting vertical slopes where it is exposed on the outsides of bends (Figure 2-8). The historical channel was actively inundating and modifying its floodplain as evidenced by the extensive mapped floodplain and the presence of a large cut-off meander loop (symbolized as "paleochannel" in Figure 2-6) of the mainstem Klamath River occupied by historical Beaver Creek at the time of dam construction. Swales, side channels, remnant meanders, and additional floodplain complexity are noted on the 1906 topographic map (Figure 2-7).

The Upstream Reach was a sinuous single thread channel that knocked about between its valley walls, rather than forming traditional loopy meander bends. The valley bottom was relatively flat as a result of the valley fill, but the valley bottom width (and likely the thickness of underlying material) decreased with distance upstream except at larger tributary junctions (Figure 2-6). Bedrock was exposed locally in the banks where the river interacted with the Tertiary volcanic valley fill (e.g., Figure 2-8) and valley walls of volcanic tuff. A series of alluvial terraces are mapped along the upstream reach and are visible in historical photos (Figure 2-8).

The valley bottom was inhabited by humans prior to dam construction and orchards and ranchlands covered much of the land surface with evidence of widespread land clearing. Oak, juniper, and pine groves are visible in photos (Figure 2-8) and marked on the survey maps (Figure 2-7). Riparian vegetation along the mainstem, tributaries, smaller side-channels, and floodplain swales consisted primarily of willows, tule, and brush. Upland vegetation was a mix of oak, pine, juniper, and fir. Prior to dam construction, it appears the valley bottom was cleared of larger trees (e.g., pine) for agricultural purposes.

### 2.2.2 Current Conditions

Current physical conditions in the Copco No. 1 Reservoir generally vary with distance upstream from the dam and additional cross-sectional variability is due to the historical meandering valley geometry. Reservoir width and maximum depths decrease with distance upstream from the dam with maximum depths located in the historical channel of 100 feet and 60 feet at the dam site and at RM 200, respectively. In the Downstream Reach, shallower depths are present on the dammed ancestral lake bed surfaces and terraces on the insides of meander bends. Upstream of RM 201, depths are relatively uniform and are 10 feet or less. Bedrock cliffs, some formed by post-dam erosion of volcaniclastic rocks, line portions of the reservoir.

Copco No. 1 Dam impounds an estimated 7.44 million ± 1.50 million CY of fine-grained sediment that contains a significant fraction of dead algae and other organic material (Reclamation, 2011c). Sediment thicknesses decrease longitudinally with distance upstream from the dam and decrease laterally with increasing elevation above the historical channel. Maximum deposit depths are 10 to 12 feet immediately upstream from the dam. Deposit thicknesses are 6 to 10 feet in the historical valley bottom (i.e. location of mapped geomorphic features) downstream of RM 201. In the Downstream Reach, the reservoir sediment is, on average 55% clay, 35% silt, and 10% sand (Reclamation, 2011c), and is underlain by fine-grained, but resistant, weathered Tertiary volcanics with varying concentrations of fluvial gravels and sand (Reclamation, 2010). In the Upstream Reach, the coarser reservoir sediment comprises approximately 30% clay, 45% silt, and 25% sand on average (Reclamation, 2011c) and is underlain by fine-grained, but resistant, weathered Tertiary volcanics with varying concentrations of fluvial sand and trace gravels (Reclamation, 2010). Intact organic fragments, such as roots, twigs, bark, wood, were only found at the pre-reservoir contact in a single core (Reclamation, 2010).

The in-situ reservoir sediment in both reaches has high moisture contents of nearly 300% with low cohesion, low strength, and high erodibility (Reclamation, 2011). The measured friction angle from a sediment core approximately 1 mile upstream from the dam is approximately 27 degrees. Reservoir sediment testing determined that, upon drying, the sediments undergo significant changes in their physical properties. When dry, erosion resistance increases by an order of magnitude and the erodibility decreases.

Upland vegetation type and distribution around both reaches of the Copco No. 1 Reservoir is similar to pre-dam conditions and is dominated by oak, juniper, and pine with higher concentrations on north aspects and in tributary valleys. Consistent coverage of native grasses, shrubs, and oaks is mapped along the entire margin of the reservoir, and invasive yellow-star thistle is common along the northern margin (Reclamation, 2011c). Conifers, willows, rushes, and reed canary grass are more sparsely distributed, but are mapped intermittently around the entire reservoir.

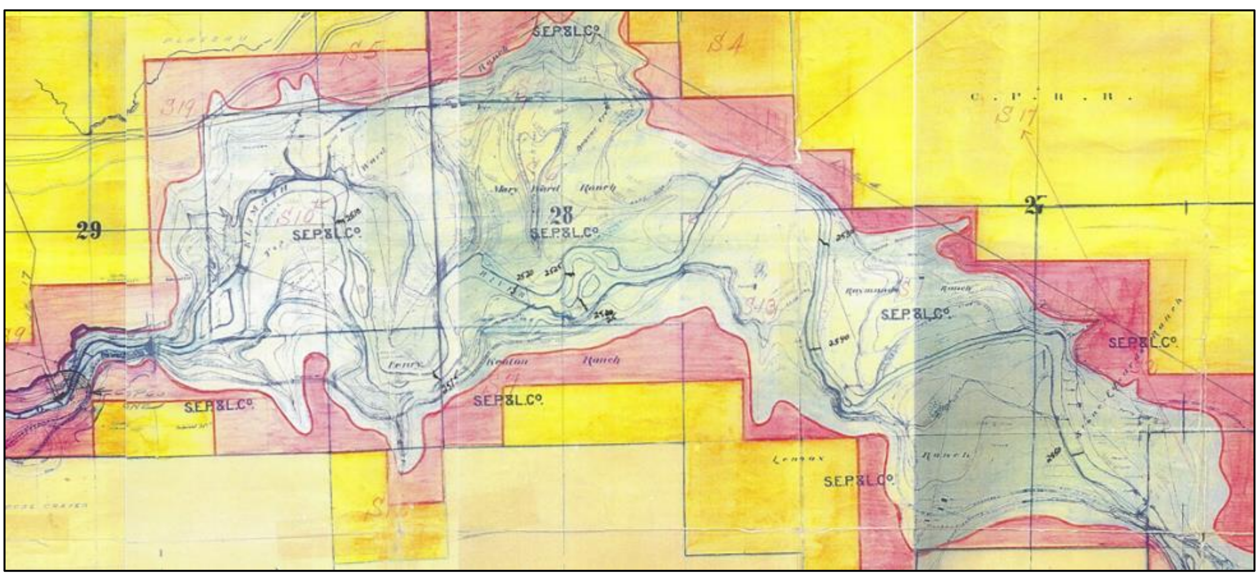
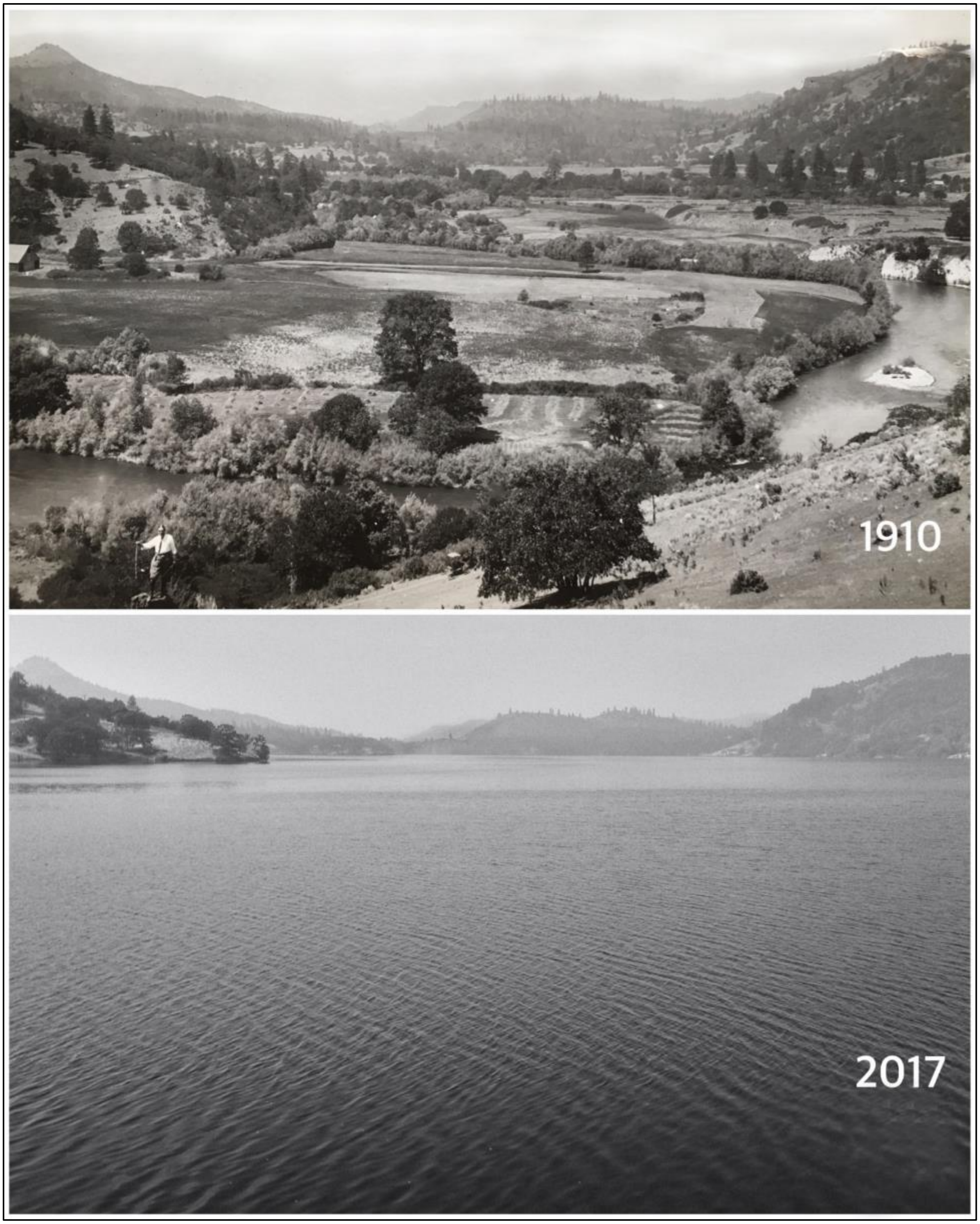
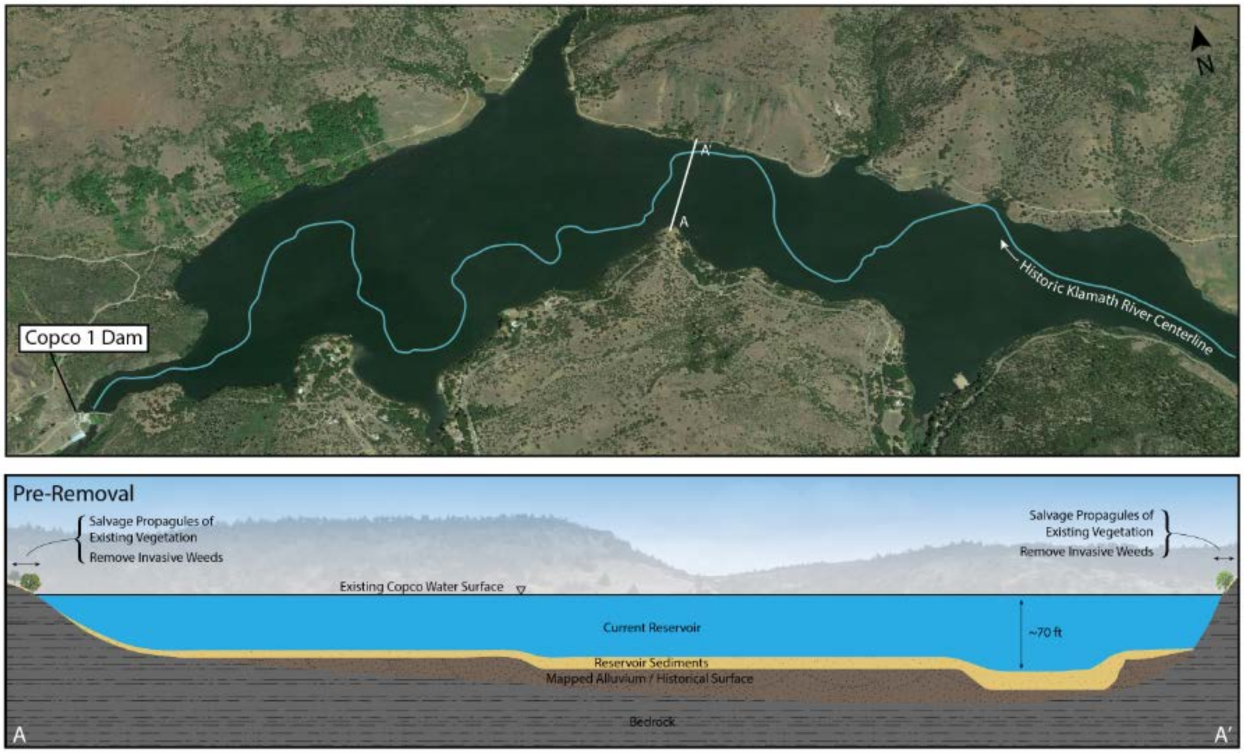



**Figure 2-7 Topographic survey and field notes from 1906 survey of Copco Lake area**




*1910 is prior to dam construction (top photo) showing existing vegetation and land use in the reservoir area. Bedrock/valley fill exposure in the right bank is marked. A sequence of two mapped alluvial terraces are located on river left in the center of the photograph and bottom photo shows current conditions in 2017*

**Figure 2-8 Historical photo of Copco Lake area, 1910 and 2017**




*Location is approximately the same perspective as 1910 historical picture shown in Figure 2-8*

**Figure 2-9 Typical cross section of Copco Lake for current conditions at Lennox-Ward ranch site**

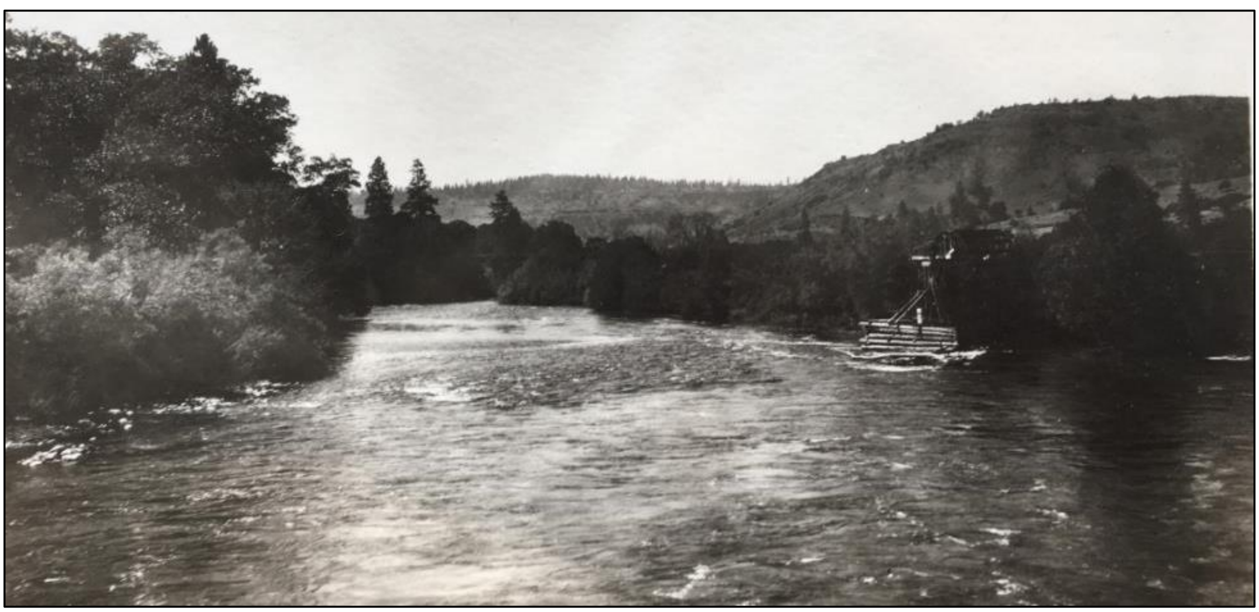
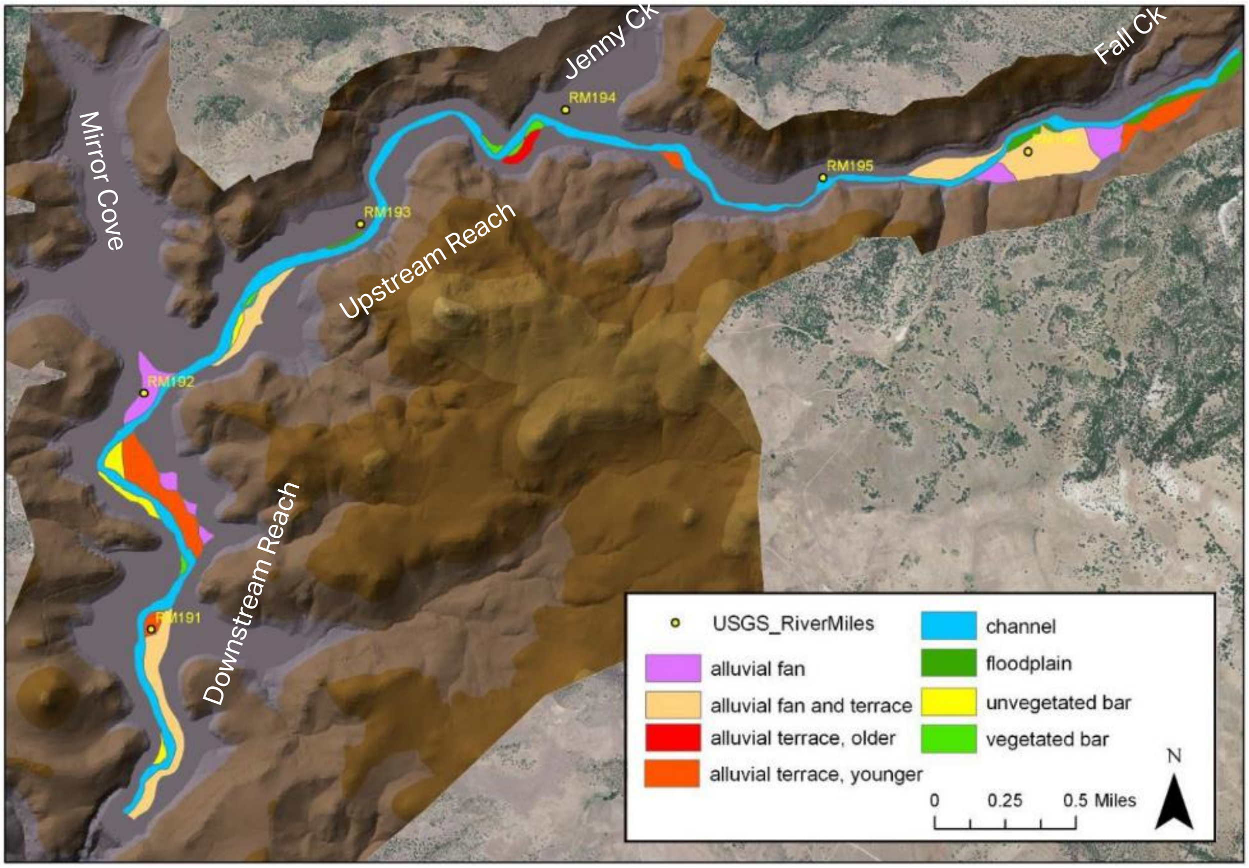


**Figure 2-10 1910 photo showing Copco Lake area and vegetation prior to inundation**

## 2.3 Iron Gate

Iron Gate Reservoir is subdivided into two sections based on the location of primary tributaries and geomorphic features mapped prior to dam construction in 1962. The Downstream Reach extends from Iron Gate Dam to upstream of the Camp Creek confluence/Mirror Cove arm of the reservoir near RM 192, and the Upstream Reach extends upstream from RM 192 to the upstream extent of the reservoir at RM 197 (Figure 2-11).




*USGS river miles and locations of Mirror Cove/Camp Creek, Jenny Creek, and Fall Creek are noted for reference. Figure modified from USBR 2011c.*

**Figure 2-11 Bare earth LiDAR hillshade of Iron Gate Reservoir area with mapped pre-dam geomorphic features**

### 2.3.1 Historical Conditions

Prior to dam construction, the Klamath River was a single thread channel with low to moderate sinuosity that occupied a deep, narrow, and symmetric valley incised into a complex set of intrusive rock, Tertiary volcaniclastic rocks, and younger basaltic and andesitic lava flows that outcrop in many of the ridges adjacent to the channel. Much of the channel bed was composed of coarse sediment that was sourced from adjacent hillslopes and bedrock exposures and formed rapids in the steep and swift reach. Physical conditions (e.g., cross-sectional valley geometry, channel dimensions and characteristics) in the Iron Gate reach were relatively uniform longitudinally, except locally at tributary junctions. Several larger tributaries contributed appreciable sediment to the mainstem and mapped geomorphic features were coincident with the confluences (Figure 2-11).

In the Downstream Reach, Camp Creek, which flows into the present-day Mirror Cove, likely contributed a considerable amount of sediment to the mainstem (Reclamation, 2010), and there was a large alluvial fan mapped at the historical confluence. Downstream of the Camp Creek confluence at RM 192, there was an increase in mapped alluvial terraces, fans, floodplain, and unvegetated bars along the mainstem channel. These geomorphic features were longitudinally extensive, but typically limited to 1 to 2 channel widths in lateral extent due to the confined nature of the valley. Rapids were visible in several locations coincident with mapped terraces. In the Upstream Reach, geomorphic features were largely absent from RM 192 to RM 195, with a notable exception at the confluence with Jenny Creek, which likely contributed a substantial amount of sediment (Reclamation, 2010), judging by its large contributing area and the volume of sediment it deposited in Iron Gate Reservoir. In the vicinity of RM 196 and downstream of the Fall Creek confluence, the valley bottom widened and there was a sequence of mapped alluvial fans and terraces.

Prior to dam construction, upland vegetation consisted of grasses with dominant tree species of oak and juniper. Tree concentrations were sparse on southern aspects and considerably thicker on northern aspects and in tributary valleys.  A narrow band of willows, tule, and other species lined the riparian zone.

### 2.3.2 Current Conditions

The Iron Gate Reservoir geometry is consistent with inundation of a relative uniform, deep, and narrow canyon, whereby reservoir width and water depth decrease monotonically with distance upstream from the dam, except at tributary valleys where the reservoir widens into coves. Iron Gate Reservoir is the deepest of the three reservoirs with maximum water depths of 150 feet near the dam. The reservoir maintains maximum water depths of over 100 feet to approximately RM 193.

Iron Gate Dam impounds an estimated 4.71 million ± 1.30 million CY of fine-grained sediment, which has the highest clay content and thinnest deposits of the three reservoirs and a considerable amount of dead algae and organic matter (Reclamation, 2011c). Sediment thicknesses are deepest in the historical channel than the historical floodplain and current reservoir margins and decrease with distance upstream from the dam with maximum values of 4 to 5 feet in the mile upstream of the dam. Mirror Cove has relatively uniform sediment thicknesses of 2 to 3 feet. The maximum sediment thicknesses of 5 to 6 feet are located at the Jenny Creek confluence and indicate the relative significance of the creek as a sediment source. Accumulated reservoir sediment is approximately 60% clay, 25% silt, and 15% sand in the Downstream Reach and approximately 35% clay, 45% silt, and 20% sand in the Upstream Reach (Reclamation, 2011c). Reservoir deposits are underlain by fine-grained weathered Tertiary volcaniclastic material with varying concentrations of gravel and sand (Reclamation, 2010). At the reservoir – pre-reservoir contact, six cores had a layer of decaying organic matter and intact organic fragments (e.g., vertical roots, grasses, twigs, bark) in the upper portion of the pre-reservoir material (Reclamation, 2010). In locations of some mapped geomorphic features, such as the Jenny Creek confluence and alluvial terraces in the Downstream Reach, layers of Quaternary alluvial gravel and sand are interbedded between the reservoir sediments and Tertiary volcanics (Reclamation, 2010).

The accumulated in-situ reservoir sediment has high moisture contents of nearly 200% in the Upstream Reach and nearly 300% in the Downstream Reach with low cohesion, low strength, and high erodibility (Reclamation, 2011c). The measured friction angle from a sediment core located at RM 192.5 is approximately 32 degrees. Reservoir sediment testing determined that, upon drying, the sediments undergo significant changes in their physical properties. When dry, erosion resistance increases by an order of magnitude and the erodibility decreases.

Upland vegetation is similar to historical conditions and consists of grass covered land with oaks and junipers. Vegetation is generally sparse around the reservoir margins. Higher concentrations of native grasses and shrubs are mapped around the full margin of the reservoir (see Appendix C, Reclamation, 2011c). Rushes and invasive yellow starthistle are more abundant on the banks of southern aspect slopes, whereas oak are preferentially on the banks of northern aspect slopes. Willows are primarily found on the margins of Mirror Cove and on the banks upstream of Fall Creek.

**Figure 2-12 Aerial photo of Iron Gate Dam location prior to construction in 1955**

**Figure 2-13 Photo of Iron Gate Dam during construction and showing reservoir area**

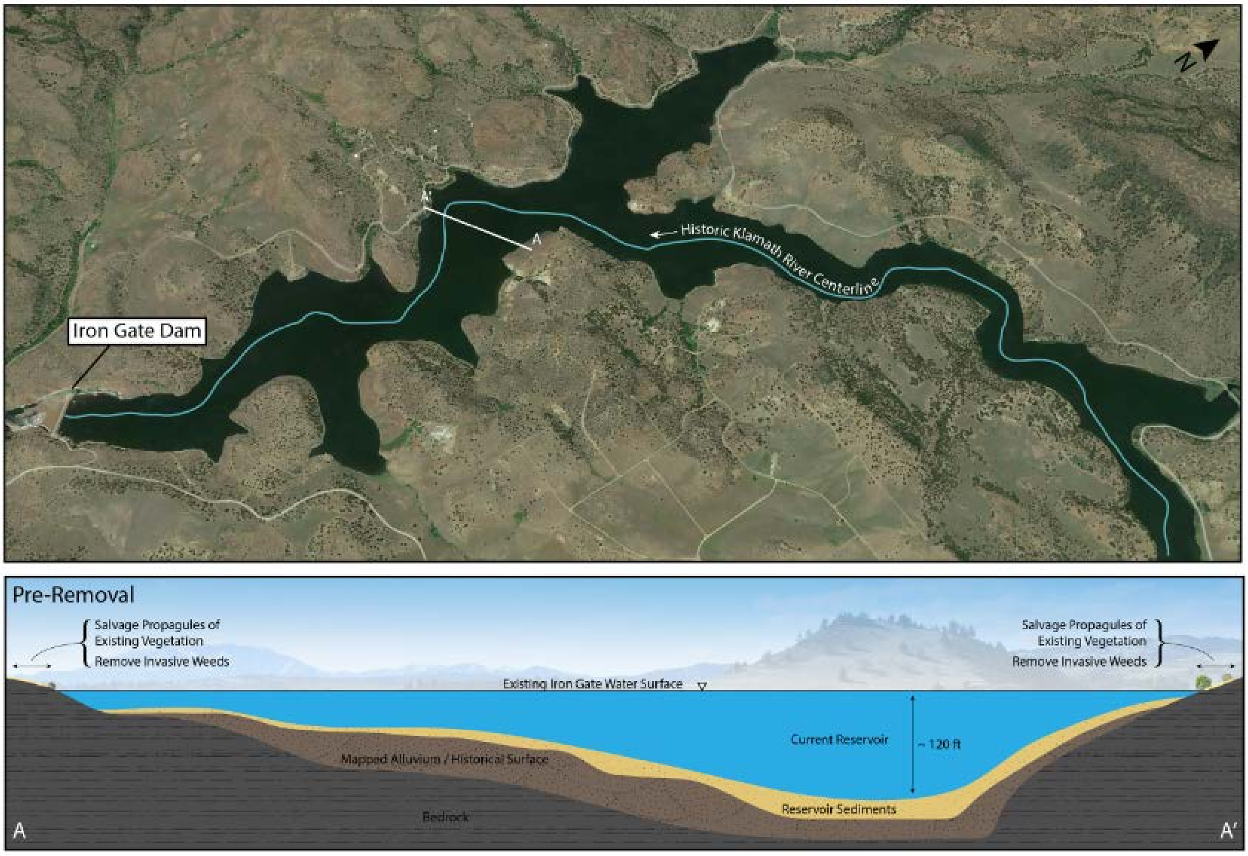



**Figure 2-14 Cross section of Iron Gate Reservoir for current conditions**

## 2.4 Data Gaps and Proposed Studies

There are several existing data gaps that need to be addressed to sufficiently inform the updated reservoir area management approach. These data gaps will be the focus of field testing and investigation in 2017/2018 as described below.

### 2.4.1 Reservoir Sediment Changes and Erosion Rates During Wetting-Drying Cycles

An evaluation of the physical characteristics of the sediments and potential erosion rates in the three reservoirs is important for predicting responses to dam removal and has been the focus of several previous studies (J.C. Headwaters, 2003; Shannon and Wilson, 2006, Reclamation, 2010; Strauss, 2010; Simon et al., 2010), which are summarized in Reclamation (2011c). The physical and behavioral properties analyzed include grain size, Atterberg limits, water content, cohesion, shear strength, erodibility, and changes associated with desiccation (drying). Important results include the high water content, low material strength, and high erodibility of the fresh, wet reservoir sediments and the significant increase in material strength and decrease in erodibility of the sediments once dried (Simon et al., 2010). Reservoir sediments from J.C. Boyle were observed to decrease in porosity and in thickness and volume by 60% and 66%, respectively, when air dried, and significant crack development occurred in concert with the decrease in volume (Reclamation, 2011c). These experiments informed predictions of the response of the accumulated reservoir sediments after drawdown. Specifically, the mechanically weak saturated sediments will erode rapidly during drawdown, but, upon drying in the summer after drawdown, the material will stabilize, the undisturbed reservoir surface elevations will be reduced, and cracks will form.

The response of the physical properties of the accumulated reservoir sediments to rewetting (e.g., as would occur in the Fall following removal) remains untested and, therefore, uncertain. Many soils and fine-grained sedimentary rocks can mechanically weaken and erode rapidly when subjected to wetting and drying cycles that might occur at channel margins or bare surfaces exposed to precipitation. The high clay content of the reservoir sediments and the combined reduction in porosity and increase in cracks and fractures have important implications for surface run-off and infiltration responses to precipitation, moisture availability for revegetation, deposit evolution by gully erosion, and associated river suspended sediment concentrations.

This data gap will be investigated by collecting grab samples from each reservoir and measuring the response of physical properties in a laboratory setting during several cycles of wetting and drying. Analytical methods are derived from Simon et al., (2010), who established a relationship between total shear strength, which is measured simply with a Torvane sampler, and critical shear stress and the erodibility coefficient. Several combinations of simulated rainfall intensity and duration, using realistic values from Klamath area weather stations, will be applied to the sediment samples. Crack development, changes in volume, and responses of shear strength are among the physical qualities that will be measured.

The experimental setup will allow for an estimation of relative erosion rates under the various rainfall scenarios. Similar experiments were completed on fine-grained reservoir sediments on sediments from the Elwha River prior to dam removal and included an examination of the erosional resistance provided by different sediment surface treatments (e.g., bare sediment/no treatment, mulch application, seeding) (Mussman et al., 2008). During the wetting cycles for this study, fine-grained sediment removed in suspension from each sample will be collected and measured to yield experimental erosion rates. The results of the erosion rates, in conjunction with measurements of shear strength, enable the estimate of secondary deposit erosion with the Revised Universal Soil Loss Equation (USDA-ARC, 2001).

### 2.4.2 Reference Conditions

Documentation and establishment of physical and ecological reference conditions is important for understanding potential responses to dam removal and developing target conditions and performance metrics for reservoir area restoration. Bathymetry of the reservoirs is over five years old and a detailed new surface is needed to provide accurate representation of current stored sediment volumes and surfaces. Reference conditions for the Klamath River have been identified from analog reaches near the current reservoirs and from historical imagery and photographs. A similar analysis needs to be completed for tributaries, which will factor significantly into the evolution of the river and adjacent riparian corridors and will be a focus of post-removal restoration.

Existing vegetation surveys were completed along the margins of each reservoir in 2009 and 2010 (Reclamation, 2011c), but these studies were relatively coarse and were conducted over a short period of time. Therefore, the surveys need to be updated and expanded to include reference areas to inform the salvage of existing vegetation, the removal of invasive weeds, and more accurately characterize achievable vegetative conditions for restoration.

New bathymetric and vegetation surveys will be done in 2017/18 to provide a more recent and thorough baseline for the restoration approach.

### 2.4.3 Reservoir Sediment Plant Nutrient Testing

A primary feature of the restoration plan is revegetation of the former reservoir. Successful revegetation is essential for stabilizing reservoir deposits, establishing critical habitat, and restoring natural ecosystem and geomorphic functions. A seedbank study of reservoir sediments was conducted in 2010 (Reclamation, 2011c) and showed viable wetland seed material in the reservoir deposits. However, additional analyses need to be completed to determine species composition and germination rate under drawdown conditions. Likewise, a better understanding of the reservoir sediment as a growth medium for upland and riparian plants needs to be evaluated.

Revegetation "grow tests" are proposed to identify the ideal seed mix for each drawdown area type (i.e., upland, floodplain, riparian, and wetland) in each unique reservoir setting, and experimental design will account specifically for different environmental parameters, such as reservoir sediment texture, treatment, aspect, and hydrology. Tests will minimize the potential for exotic plant invasions and assist in simplifying the grouping of drawdown area types to a meaningful number while maintaining plant diversity. Surface grab samples of reservoir sediments will be collected in tandem with the sediments for the wetting drying experiments. Some material will be field tested with the various seed mixtures near the reservoirs in locations with representative environmental conditions. Other material will be tested in a laboratory setting in the sediment subjected to the wetting and drying experiments to evaluate the effectiveness of secondary revegetation activities in the fall following dam removal.

The suitability of the reservoir sediments as a growth medium will be assessed with a plant nutrient availability analysis. Reservoir sediment samples will be tested by a soils lab to identify any chemical deficiencies or excesses that may inhibit plant growth. The goals are to assure optimal growth of seeded and planted vegetation and to determine the viability and potential cost of enhancing sediment for plant growth.

### 2.4.4 Revegetation Species

Optimization of revegetation activities is dependent on identifying the ideal revegetation species combination for each drawdown zone (i.e., upland, floodplain, riparian, and wetland) in each reservoir. A list of potential species for revegetation of different drawdown zones in the reservoirs has been previously compiled by USBR (Reclamation, 2011c). This list will need to be updated in response to the updated existing vegetation surveys and the results from wetting-drying experiments, plant nutrient availability analysis, and grow tests.

### 2.4.5 Availability of Revegetation Materials

Existing vegetation around the reservoirs can be used to complement reservoir revegetation efforts. Plant and vegetation inventories have been completed around the reservoirs in 2009 and 2010 as part of the EIS preparation (Reclamation, 2011c). An updated vegetation inventory needs to be carried out that also includes key tributaries, which have some of the highest concentrations of native vegetation in the project areas.

### 2.4.6 Acquisition of Existing Data

A considerable amount of data collection, analysis, and modeling has been completed for the Klamath dam removals to inform previous studies and predict impacts of the removals. An effective restoration plan needs to incorporate and build off these previous efforts, and access to existing data is critical. The Bureau of Reclamation has an extensive GIS database that was used to create exhibits in the various technical reports (e.g., Reclamation (2011b)). Useful GIS data include detailed historical topography, reservoir sediment thicknesses, geomorphic maps, morphodynamic modeling results and predicted erosion/deposition patterns, existing vegetation surveys, and revegetation zone maps. These data can be used to more accurately inform predictions of reservoir development, guide restoration design and management planning, and create effective exhibits.

### 2.4.7 Proposed Data Collection and Studies for 2017/2018

Table 2-1 summarizes the proposed activities and schedule for performing the necessary data collection efforts.

**Table 2-1 Schedule for proposed data collection activities to meet data gaps**

| Data Collection Activity | Data Gap Addressed | Schedule |
|---|---|---|
| Reservoir Sediment Collection | • Wetting-Drying Tests<br>• Grow Tests<br>• Plant Nutrient Availability | Fall 2017 |
| Laboratory wetting and drying experiments | • Wetting-Drying Tests<br>• Grow Tests | Fall 2017 |
| Bathymetric Survey | • Reference Conditions | Winter 2018 |
| Reservoir and Tributary Existing Vegetation Survey | • Reference Conditions<br>• Revegetation Species<br>• Availability of Revegetation Materials | Spring 2018 |
| Tributary Geomorphic Survey | • Reference Conditions | Fall 2017 |
| Acquire Reclamation GIS data | • Acquisition of Existing Data | Fall 2017 |

# 3. Dam Removal and Expected Reservoir Conditions

The J.C. Boyle, Copco No. 1, and Iron Gate reservoirs will be simultaneously drawn down, and the accumulated sediment will be allowed to naturally erode and evacuate from the reservoir areas, to the extent possible. The accumulated sediment is predominantly silt, clay, and organic material that is over 80% water and highly erodible. Both one-dimensional (1D) and two-dimensional (2D) sediment transport models were used to predict likely sediment transport and river conditions in the reservoirs after dam removal. It was estimated by Reclamation that approximately 50% of the stored sediment in the reservoirs will be eroded during drawdown for a median water year with a range of 41% to 65% for dry and wet years, respectively.

The Reservoir Area Management Plan (Reclamation, 2011c) summarizes the previous hydraulic modeling completed by Reclamation and responses of the reservoir areas to drawdown including: erosion of reservoir deposits, slumping of saturated sediment deposits toward the river channel due to limited shear strength and draining of water in the pore spaces of the deposits, and drying, consolidation, cracking and hardening of remaining deposits.

Each reservoir has distinct features and characteristics. For instance, Copco No. 1 has a large floodplain and meandering historical river planform while the historical channel in the lower reaches of J.C. Boyle Reservoir was confined to a narrow canyon. Table 3-1 summarizes historical water features in each of the reservoirs. Additional information and description of the likely response of the reservoir areas is discussed below for each reservoir.

**Table 3-1 Summary of mainstem river, side channel, and tributaries currently inundated in each reservoir**

| Location | Mainstem River Length (mi) | Side Channel Length (mi) | Tributary Length (mi) | Number of Tributaries |
|---|---|---|---|---|
| J.C. Boyle | 3.3 | - | 0.2 | 10 |
| Copco 1 | 6.9 | 1.2 | 1.5 | 18 |
| Iron Gate | 6.8 | - | 2.5 | 52 |

*USFWS 2009*

## 3.1 J.C. Boyle

The evolution of the J.C. Boyle Reservoir in response to dam removal is expected to be relatively minor and straightforward. The accumulated reservoir sediments are limited primarily to the historical channel and are thickest in the confined Canyon Reach. Lacking alternative flow pathways in the confined lower reach, the river will readily scour out the reservoir sediment down to the prominent bedrock in the historical river channel bed. Narrow, but potentially several feet thick, deposits may persist outside the channel banks. In the Upstream Reach, the channel is anticipated to preferentially erode its historical channel bed and leave the broad (approximately 1,000 feet wide) deposits on the channel margins relatively intact. These deposits are less than 2 feet thick and will reduce in height and volume by approximately 30-40% as the material dries and consolidates. There are few tributaries on these marginal deposits, so little subsequent evacuation is expected after initial drawdown. Given the low relief of the Upstream Reach, high flow events will periodically inundate and modify the remnant reservoir surfaces. It is uncertain if pre-dam bedforms, such as the large mid-channel bar, will be reestablished post-drawdown.

## 3.2 Copco No. 1

At Copco No. 1, the reservoir deposit layer is wide and the historical valley is more complex geomorphically; therefore, predictions of post-drawdown conditions are more uncertain. Sediment thicknesses vary with pre-existing valley geometry such that the lower elevation historical channel contains deeper deposits than higher elevation terraces and other historical surfaces. The pre-dam valley relief was high in the Downstream Reach with elevation differences in excess of 50 feet between the channel bed and the higher elevation low-gradient surface the channel was eroding into on the outsides of its meander bends. These steep outside banks and the material underlying the valley bottom are composed of erosionally-resistant fine-grained material. The Klamath River is not expected to incise appreciably into this material, but, rather, will reactivate its historical planform during drawdown and leave accumulated reservoir sediment on higher elevation floodplain and upland surfaces.

These spatial patterns of erosion were generally predicted by two-dimensional morphodynamic modeling of Copco Reservoir during drawdown (Reclamation, 2011c). Erosion in excess of 5 feet was concentrated within the sinuous historical channel and in the downstream limb of the cut-off meander bend, which will likely be re-occupied by Beaver Creek following drawdown. The model predicts nearly zero erosion outside of the historical channel. The model does not simulate fluvial bank erosion or bank failure, nor does it incorporate erosion from tributaries, springs, or concentrated surface runoff from hillslopes. Therefore, the extent of modeled erosion is a minimum prediction, and it is likely that more material will be naturally evacuated during drawdown.

Given the topographic variability and width of low-relief upland surfaces of the pre-dam valley bottom, reservoir deposits 2 to 6 feet thick and hundreds of feet in lateral extent may persist at elevations tens of feet above the mainstem active channel post-drawdown. Tributaries and springs may erode these deposits in some places, and remaining sediments will undergo the physical changes associated with drying. The volume reduction during consolidation may lower the surfaces up to 40% of the deposit thickness, and cracks are expected to form. These cracks may concentrate flow from surface runoff in the future and be foci of subsequent erosion of the deposit by rilling and gullying, and this behavior will be examined in more detail in reservoir sediment experiments (see Section 2.4.1). Pending the results of testing, stabilization of these features may be included as a restoration task.

## 3.3 Iron Gate

At Iron Gate, the Klamath River is anticipated to efficiently evacuate the majority of the reservoir sediment because the reservoir deposit layers are thin, the reservoir water depths are large, drawdown will be more rapid, and the historical channel occupied a narrow pre-dam valley with steep adjacent hillslopes (Reclamation, 2011c). Reservoir sediments do not exceed 5 feet in thickness except at the Jenny Creek delta, so uneroded sediment persisting after drawdown would be expected to reduce in thickness to around 3 feet. Given the relatively more rapid drawdown proposed at Iron Gate, reservoir deposit erosion from slumping should be more efficient (Reclamation, 2011c). There are several mapped low relief terraces, fans, and historical floodplains in the valley bottom on which larger areal extents of sediment may persist. The greatest uncertainties relate to the deposit erosion by tributaries, particularly the Camp-Scotch-Dutch Creek complex in Mirror Cove. The valley is wider in Mirror Cove relative to the size of the historical tributaries, and therefore a larger areal extent of sediment relative to the mainstem areas would be expected to remain after drawdown. These deposits are only 2 to 3 feet thick, however, and would consolidate upon drying.

# 4. Reservoir Area Revegetation

The 2011 Reservoir Area Management Plan (Reclamation, 2011c) focuses on control of invasive exotic plant species and revegetation of the reservoir areas with native grasses, shrubs and trees as the primary method for restoration. This approach is consistent with nearly all dam removal and reservoir restoration plans in the past 10 years wherein restoration efforts have emphasized revegetation of newly exposed floodplain areas with native plants while actively controlling invasive exotic vegetation. The following sections provide additional details and updates necessary to move forward with revegetation and establishment of the reservoir areas with local, native vegetation and strategies to control non-native species.

## 4.1 Revegetation Plant and Seed Sources

The reservoir areas will be actively revegetated during and after their drawdown and the subsequent removal of the dams. Although some degree of natural revegetation development will occur, especially in the bank and emergent wetland habitats, the revegetation approach will use a combination of seeding, acorn and pole-cutting installation, riparian tree plantings and transplants to accelerate the natural succession to stable native plant communities. The bed of the former reservoirs will be divided into revegetation planting zones in which different implementation techniques and plant species will be employed based on the hydrology, sediment texture, slope aspect and other characteristics. These areas will include upland, floodplain riparian, bank riparian, and wetland planting zones. Revegetation of each of these zones is described below. Rocky substrate and steep slope areas that may occur within the reservoir beds will not be actively revegetated. Native grasses, sedges, rushes and forbs will be hydroseeded in all revegetation zones, possibly with addition of a very small amount of sterile wheat to enhance the initial erosion protection function of the herbaceous vegetation. To effectively and rapidly revegetate the large reservoir beds upstream of the four dams will require large quantities of seed, on the order of 100,000 lbs. of PLS (pure live seed).

**Figure 4-1 Perennial bunchgrass - bluebunch wheatgrass is the keystone native species in the Upper Klamath Basin and its range extends into large parts of the Great Basin**

The most efficient method for acquiring seed for the revegetation will be early collection of native seed from the project area and vicinity, and subsequent large-scale seed propagation.

Several local nurseries, farming operations, and the USDA Forest Service - J Herbert Stone Nursery in Central Point, Oregon were contacted and may be engaged in the near future to propagate the native seed. Previously identified (Reclamation 2011a) and other keystone species suitable for the reservoir areas' hydroseeding are listed in Table 4-1. These species will constitute the backbone of the revegetation for the Project, however, other native species will be collected and included either as supplemental, to be used only in some planting zones based on suitable soil texture, slope aspect, local topography and hydrology as described below, or as backup species in case native seed collection of keystone species does not produce sufficient amounts of seed (Table 4-1). Oregon white oak (Quercus garryana) and California black oak (Quercus kelloggii) acorns will be collected in the fall before the drawdown, cold stratified through the winter and early spring, and installed in mid- to late spring during drawdown in the riparian zones and mesic parts of the upland zones if feasible. If access to planting areas is not possible, acorns will be temporarily grown in small treepot containers and maintained until the fall of the drawdown year when the oak seedlings will be planted along with freshly collected acorns. Since California black oak trees only produce acorns every other year and Oregon white oak crop is not reliable from year to year, this approach will ensure a good supply of oak saplings and acorns. Seeds of other native woody species will be collected and seeded based on availability (Table 4-3, Table 4-4, Table 4-5 below).

### Table 4-1 Hydroseed species Proposed for Collection and Propagation

| Common name | Scientific name | Life Form |
|---|---|---|
| common yarrow | *Achillea millefolium* var. *lanulosa* | perennial herb |
| Spanish lotus | *Acmispon americanus [Lotus purshianus]* | annual herb |
| spike bentgrass, spike redtop | *Agrostis exarata* | perennial grass |
| California brome | *Bromus carinatus* | perennial grass |
| slender beak (wheat) sedge | *Carex athrostachya* | perennial herb |
| slender beak (wheat) sedge | *Carex athrostachya* | perennial herb |
| Nebraska sedge | *Carex nebrascensis* | perennial herb |
| woolly sedge | *Carex pellita [lanuginosa]* | perennial herb |
| clustered field sedge | *Carex praegracilis* | perennial herb |
| clustered field sedge | *Carex praegracilis* | perennial herb |
| awlfruit sedge | *Carex stipata* | perennial herb |
| turkey mullein | *Croton [Eremocarpus] settiger* | annual herb |
| tufted hairgrass | *Deschampsia caespitosa* | perennial grass |
| annual hairgrass | *Deschampsia danthonioides* | annual grass |
| salt grass | *Distichlis spicata* | perennial grass |
| bluebunch wheatgrass | *Elymus [Pseudoregneria] spicatus* | perennial grass |
| squirreltail grass | *Elymus elymoides* | perennial grass |
| blue wildrye | *Elymus glaucus* | perennial grass |
| common rabbitbrush | *Ericameria [Chrysothamnus] nauseosa* var. *leiosperma* | semi-deciduous shrub |
| common woolly sunflower | *Eriophyllum lanatum* | perennial herb |
| small fescue | *Festuca [Vulpia] microstachys* | annual grass |

| Common name | Scientific name | Life Form |
|---|---|---|
| Idaho fescue | *Festuca idahoensis* | perennial grass |
| California barley | *Hordeum brachyantherum* ssp. californicum | perennial grass |
| meadow barley | *Hordeum brachyantherum* sspp. brachyantherum | perennial grass |
| toad rush | *Juncus bufonius* | perennial herb |
| sword-leaved rush | *Juncus ensifolius* | perennial herb |
| western rush | *Juncus occidentalis* | perennial herb |
| junegrass | *Koeleria macrantha* | perennial grass |
| Great Basin wildrye | *Leymus cinereus* | perennial grass |
| creeping (beardless) wildrye | *Leymus triticoides* | perennial grass |
| silvery lupine | *Lupinus argenteus* | perennial herb |
| chick lupine | *Lupinus microcarpus* | annual herb |
| mat muhly | *Muhlenbergia richardsonis* | perennial grass |
| pine (Sandberg) bluegrass | *Poa secunda* | perennial grass |
| Lemmon's needlegrass | *Stipa [Achnatherum] lemmonii* | perennial grass |
| western needlegrass | *Stipa [Achnatherum] occidentalis* var. *occidentalis* | perennial grass |
| tomcat clover | *Trifolium willdenovii* | annual herb |

*Shaded rows indicate keystone species.*

Live pole cuttings will be planted in the bank riparian and parts of floodplain riparian zones to expedite the revegetation progress of these habitats to natural succession. Dense, native riparian vegetation is essential for the health of the riverine ecosystem. Existing riparian areas along the Iron Gate, Copco and JC Boyle reservoir edges contain robust populations of willows and other native riparian species suitable for pole cuttings harvest or whole plant salvaging and transplantation. Some of these parent plants will be cut to the ground approximately one to two years before dam removal, to increase the number of new stems and suckers available to harvest, and to extend their survival time after drawdown. Temporary onsite nurseries or existing local nurseries in the Upper Klamath Basin and nearby vicinity will be engaged to harvest and store pole cuttings for the Project. Native species listed in Table 4-2 below will be harvested for pole cuttings,

**Figure 4-2 Sandbar willow is an important riparian bank shrub that provides shade over water surface, reducing temperatures. The background tree is Oregon ash**

maintained or container-grown until planting time, and installed in the riparian areas as soon as access is feasible.

### Table 4-2 Primary Pole Cutting Species to be Collected and Stored

| Common name | Scientific name | Lifeform |
|---|---|---|
| western serviceberry | *Amelanchier alnifolia* | small deciduous tree |
| smooth dogwood | *Cornus glabrata* | large deciduous shrub |
| red-osier dogwood | *Cornus sericea* | large deciduous shrub |
| black cottonwood | *Populus balsamifera ssp. trichocarpa* | large deciduous tree |
| fragrant (three-leaf) sumac | *Rhus aromatica [trilobata]* | deciduous shrub |
| California rose | *Rosa californica* | deciduous shrub |
| Pacific blackberry | *Rubus ursinus* | deciduous shrub, vine |
| narrowleaf willow | *Salix exigua* | large deciduous shrub |
| red willow | *Salix laevigata* | large deciduous tree |
| arroyo willow | *Salix lasiolepis* | small deciduous tree |
| shining willow | *Salix lucida* | small deciduous tree |
| common snowberry | *Symphoricarpos albus* | deciduous shrub |

*Shaded rows indicate keystone species.*

Bare root and container plants will supplement pole cuttings (live stakes) installation in some riparian areas. These could include keystone riparian species that are difficult to reproduce through division/cuttings such as Oregon ash (*Fraxinus latifolia*), white alder (*Alnus rhombifolia*), big leaf maple (*Acer macrophyllum*), chokecherry (*Prunus virginiana*), and creek clematis (*Clematis ligusticifolia*). Bare root and container plants will be contract grown for the project by local nurseries.

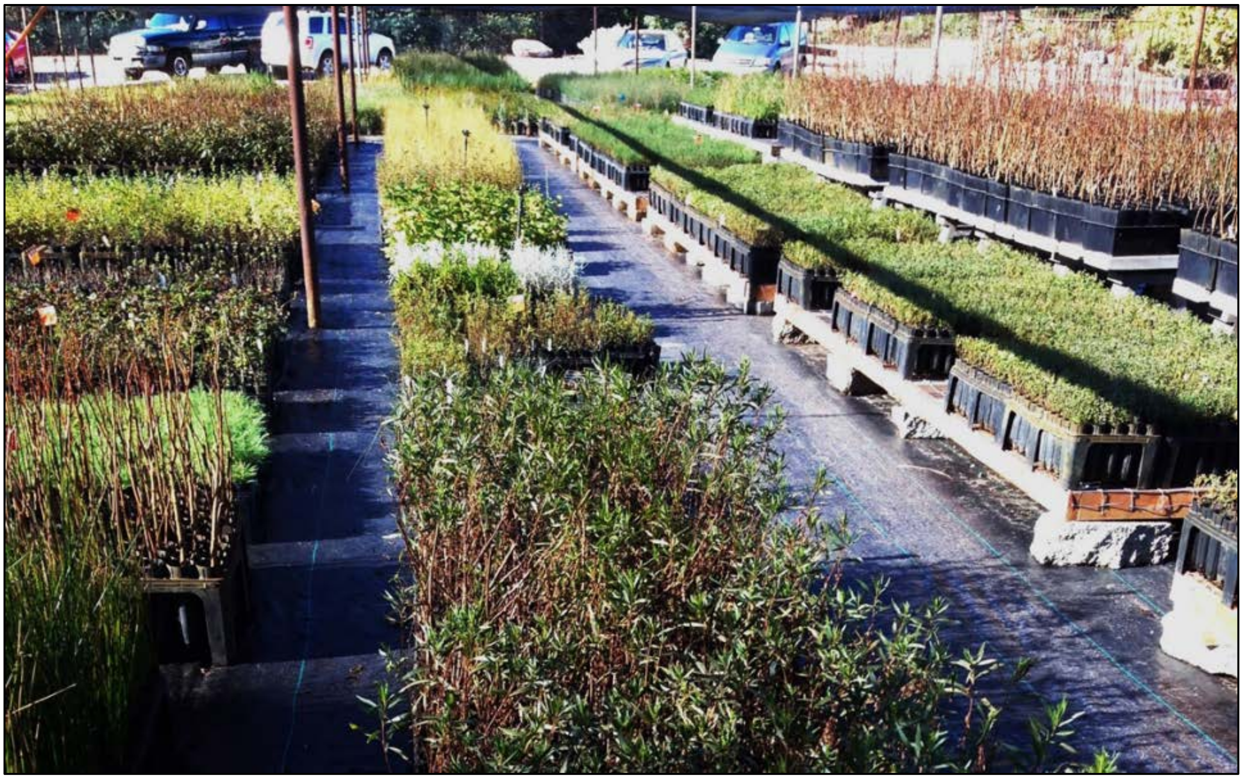


**Figure 4-3 A large nursery native plant production supported the restoration of a Carmel River reach after San Clemente Dam removal**

## 4.2 Revegetation Amendments

In typical erosion control and landscaping type hydroseeding, fertilizers are very often used to enhance the early growth and establishment of seeded, non-native vegetation such as sterile wheat, red clover, and alfalfa. However, in restoration projects, fertilizers are typically not included for several reasons:

1. Fertilizer promotes heavy, fast growth of non-native annual invasive exotics (weeds) that are typically already present in the soil and that then successfully compete with natives and shade them out
2. Native plants are not forming symbiotic relationships with soil mycorrhizal fungi because of the widespread nutrient availability of fertilizer in hydroseeding slurry. The mycorrhizal fungi would otherwise support native plants for a much longer duration than an initial fertilizer boost
3. Fertilizer negatively impacts any adjacent water bodies, promoting eutrophication and anoxic conditions

The KRRC will be performing extensive plant nutrient availability testing of existing sedimentary soils within the project area, and specifically along the riparian bank and riparian wetland zones adjacent to the river, and the seedings/plantings will rely on mycorrhizal inoculants to promote the growth of the native vegetation. At this point, fertilizers are not planned to be included either in the hydroseeding step or in the soil preparation phase of the revegetation process.

## 4.3 Planting Zones

The native plant species selected for the planting zones for the revegetation of the former reservoir areas are based on plants known to be native in the Project area, expected to establish readily, and anticipated to thrive within their planting zones. Small-scale test plot growing experiments will be conducted to determine the most effective species selection for each planting zone, seeding rate, timing, and other factors in order to meet the goals of the Project. Planting material collected on-site will be used as transplants or as nursery stock to propagate additional seed or plants in the required amounts. Local plant ecotypes are best adapted to thrive and coexist with other native species within the revegetation area and will likely have the highest establishment rate. Sourcing propagules from the Project site and its immediate vicinity will result in a plant community that is genetically adapted to the local environment and will strengthen the biodiversity in the larger ecosystem of Upper Klamath Valley.

### 4.3.1 Upland Zone

Upland areas will be delineated as areas suitable for revegetation that are above the post-removal 100-year flood water surface elevation of the Klamath River and all of its related tributaries and seeps, occurring within the project boundary.

**Figure 4-4 Grasses are an important component of the Upland Planting Zone. Their cover varies greatly with slope aspect.**

The first step in establishment of upland vegetation cover will be hydroseeding of all upland areas as the water recedes during reservoir drawdown using the upland planting zone seed mix. The typical hydroseeding mix will contain virgin wood fiber, seed, mycorrhizal inoculant, mulch and soil amendments as determined by soil testing laboratory. Areas not accessible by ground equipment because of rough terrain, steep slopes, and sediment instability will be seeded with a combination of barge and rotary/fixed-wing aircraft. Hydroseeding from a barge will be accomplished by placing a ground rig on one barge with another boat used to ferry materials from shore. A moveable pier or other engineered method of accessing the supply boat 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 will be too shallow and/or the current too swift to maneuver the barge effectively. The upland seed mix has been developed to ensure erosion control and provide initial weed suppression. The species included in the seed mix typically germinate early in the spring (March-April) and their germination will be sustained by their dispersal over the moist sediments during the drawdown that will be implemented at this time of the year. Several repeated seedings will be adaptively performed as necessary during the first two years after drawdown in order to increase native vegetation coverage in underperforming areas.

## Table 4-3 Upland Planting Zone Seed Mix

| Common name | Scientific name | Lifeform |
|---|---|---|
| common yarrow | *Achillea millefolium* var. *lanulosa* | perennial herb |
| California brome | *Bromus carinatus* | grass |
| buckbrush | *Ceanothus cuneatus* | evergreen shrub |
| deerbrush | *Ceanothus integerrimus* | semi-deciduous shrub |
| Douglas fir | *Pseudotsuga menziesii* var. *menziesii* | coniferous tree |
| birchleaf mountain mahogany | *Cercocarpus betuloides* | semi-deciduous shrub |
| turkey mullein | *Croton [Eremocarpus] settiger* | annual herb |
| bluebunch wheatgrass | *Elymus [Pseudoroegneria] spicatus* | perennial grass |
| squirreltail | *Elymus elymoides* | perennial grass |
| blue wildrye | *Elymus glaucus* | perennial grass |
| common rabbitbrush | *Ericameria [Chrysothamnus] nauseosa* var. *leiosperma* | semi-deciduous shrub |
| common woolly sunflower | *Eriophyllum lanatum* | perennial herb |
| small fescue | *Festuca [Vulpia] microstachys* | annual grass |
| Idaho fescue | *Festuca idahoensis* | perennial grass |
| red buckthorn | *Frangula [Rhamnus] rubra* | evergreen shrub |
| California barley | *Hordeum brachyantherum* ssp. *californicum* | perennial grass |
| junegrass | *Koeleria macrantha* | perennial grass |
| hot rock penstemon | *Penstemon deustus* | perennial herb |
| royal penstemon | *Penstemon speciosus* | perennial herb |
| varied leaf phacelia | *Phacelia heterophylla* var. *virgata* | perennial herb |
| ponderosa pine | *Pinus ponderosa* | coniferous tree |
| Sandberg bluegrass | *Poa secunda* | perennial grass |
| Klamath plum | *Prunus subcordata* | small deciduous tree |
| antelope brush | *Purshia tridentata* | Deciduous shrub |
| Oregon white oak | *Quercus garryana* | deciduous tree |
| California black oak | *Quercus kelloggii* | deciduous tree |
| fragrant (three-leaf) sumac | *Rhus aromatica [trilobata]* | shrub |
| plateau (desert) gooseberry | *Ribes velutinum* | deciduous shrub |
| western needlegrass | *Stipa [Achnatherum] occidentalis* | perennial grass |

*Shaded rows indicate keystone species.*

The revegetation seed mix listed above will be adjusted to include site specific species for each reservoir and applied to all topographically suitable areas, as well as stable slope areas (i.e., areas determined to be safe from further erosion and not in need of sediment removal) upon completion of all required earthwork. Repeated supplemental seeding will be applied in underperforming areas as necessary until good coverage is achieved.

California black oak and Oregon white oak acorns or seedlings will be planted in selected upland areas suitable for revegetation. They will be installed as soon as the weather begins to cool down and exposed sediments become accessible to the restoration contractor's personnel. It is anticipated that this could occur in October of the drawdown year. Fresh acorns could also be harvested and planted immediately at that time. Other tree saplings such as incense cedar, ponderosa pine or Douglas fir will be planted as appropriate based on environmental factors such as soil texture, slope aspect, local topography and hydrology as described below. Their seed should be harvested at least two years ahead so that well developed seedlings can be installed. Trees will be initially irrigated by the biodegradable donut-shape water bowl (Figure 4-5) made from recycled paper pulp (Cocoon). Water will be slowly delivered from the Cocoon filled with water through wicks placed near the root system of the trees. After the first season, trees should be self-sufficient and would be watered only supplementally with water trucks in case of extended drought or excessively hot weather. Proposed upland planting zone species are listed in (Table 4-3), and would be planted at an average density between 1 and 10 trees per acre.

### 4.3.2 Floodplain Riparian Zone

Floodplain riparian zones will be delineated as those areas suitable for revegetation that occur approximately between the 25-year (Q25) and 100-year (Q100) flood water surface elevations of the Klamath River and its related tributaries and seeps occurring within the project boundary, excluding all wetland areas. These zones will be additionally adjusted on a case by case basis and depending on after drawdown topography.

Floodplain riparian zones will be hydroseeded with a hydroseed mix that will consist of seeds of native grasses, forbs and shrubs that will be collected and propagated for several years before the revegetation. California black oak and Oregon white oak acorns or seedlings, willow and cottonwood pole cuttings, and bare root or containerized shrub and tree saplings will be planted in selected areas within this zone based on environmental factors such as soil texture, slope aspect and hydrology as described below. Acorns stay viable only for approximately 6 months and will be either planted shortly after their collection in October and November or cold stratified and planted early in the spring. Most plants could be started from seed in small containers and installed in the fall of the first or second year. Bigleaf maple, western serviceberry, chokecherry, blue elderberry, fragrant sumac, whitestem gooseberry, snowberry and incense cedar are other potential candidate shrub and tree species for this zone. They would be planted from small containers such as T4 (treepot 4"x 4"x 14") or T8 (treepot 8"x8"x18"). Additional, smaller planting zones may be introduced in the riparian floodplain zone based on the post-drawdown topographic complexity in order to encourage the formation

**Figure 4-5 Carboard basin (Cocoon) tree planting of incense cedar**

of typical floodplain environments such as oxbows, floodplain depressions, overflow channels, seasonal wetlands and others. The riparian floodplain zone species are listed in Table 4-4. The average tree planting density on the riparian floodplain would range from 10 to 25 trees per acre, at 4,400 to 1,600 sq. ft. per tree. Supplemental overhead irrigation of parts of the riparian floodplain zone will be provided in the form of temporary, surface mounted irrigation system that will draw water from the river.

### Table 4-4 Floodplain Riparian Zone Seed Mix

| Common name | Scientific name | Lifeform |
|---|---|---|
| bigleaf maple | *Acer macrophyllum* | large deciduous tree |
| Spanish lotus | *Acmispon americanus [Lotus purshianus]* | annual herb |
| spike bentgrass, spike redtop | *Agrostis exarata* | perennial grass |
| western serviceberry | *Amelanchier alnifolia* | small deciduous tree |
| mugwort | *Artemisia douglasiana* | perennial herb |
| Oregon grape | *Berberis aquifolium* | small evergreen shrub |
| California brome | *Bromus carinatus* | perennial grass |
| incense cedar | *Calocedrus decurrens* | large coniferous tree |
| bluebunch wheatgrass | *Elymus [Pseudoroegneria] spicatus* | perennial grass |
| squirreltail grass | *Elymus elymoides* | perennial grass |
| blue wildrye | *Elymus glaucus* | perennial grass |
| small fescue | *Festuca [Vulpia] microstachys* | annual grass |
| Idaho fescue | *Festuca idahoensis* | perennial grass |
| California barley | *Hordeum brachyantherum* sspp. *californicum* | perennial grass |
| junegrass | *Koeleria macrantha* | perennial grass |
| Great Basin wildrye | *Leymus cinereus* | perennial grass |
| creeping (beardless) wildrye | *Leymus triticoides* | perennial grass |
| silvery lupine | *Lupinus argenteus* | perennial herb |
| chick lupine | *Lupinus microcarpus* | annual herb |
| ponderosa pine | *Pinus ponderosa* | coniferous tree |
| pine (Sandberg) bluegrass | *Poa secunda* | perennial grass |
| black cottonwood | *Populus balsamifera ssp. trichocarpa* | large deciduous tree |
| chokecherry | *Prunus virginiana* var. *demissa* | small deciduous tree |
| Oregon white oak | *Quercus garryana* | large deciduous tree |
| California black oak | *Quercus kelloggii* | large deciduous tree |
| fragrant (three-leaf) sumac | *Rhus aromatica [trilobata]* | deciduous shrub |
| whitestem gooseberry | *Ribes inerme* | deciduous shrub |
| California rose | *Rosa californica* | deciduous shrub |
| Pacific blackberry | *Rubus ursinus* | deciduous shrub, vine |
| blue elderberry | *Sambucus nigra* ssp. *caerulea [mexicana]* | large deciduous shrub |
| Lemmon's needlegrass | *Stipa [Achnatherum] lemmonii* | perennial grass |
| western needlegrass | *Stipa [Achnatherum] occidentalis* | perennial grass |

| Common name | Scientific name | Lifeform |
|---|---|---|
| | var. *occidentalis* | |
| common snowberry | *Symphoricarpos albus* | deciduous shrub |
| creeping snowberry | *Symphoricarpos mollis* | deciduous shrub |
| tomcat clover | *Trifolium willdenovii* | annual herb |

*Shaded rows indicate keystone species.*

### 4.3.3 Bank Riparian Zone

While the bank riparian zone may not be the largest in area compared to other planting zones, it will be the most critical zone for rapid re-establishment of riparian habitat, short-term stability of the channel and banks, and for long-term establishment of an important transitional area between the riverine features and floodplain habitat areas. It will extend approximately from the 3-year (Q3) to the 25-year (Q25) flood water surface elevations (Q-lines) of the Klamath River and its tributaries, and seeps occurring within the project boundary, excluding wetland areas. Its quick establishment will promote and restart a number of important ecological processes and greatly contribute to the creation of quality fish habitat in the river. The zone will extend in a continuous corridor paralleling both banks of the Klamath River. The bank riparian zone native plant species will be selected based on their adaptations to the edaphic and climatic conditions of Upper Klamath Valley, their ability to survive fluctuating water tables, their preferred root depth to the water table, their flood inundation duration tolerance, and capability to resist exposure to high velocity flows. The riparian restoration planting palette will include both common and less common but ecologically desirable species. The existing riparian vegetation of the Project site and its vicinity were used as the basis for the riparian vegetation palette. Revegetation plants in this zone will consist of native grasses, forbs, perennial herbs, riparian trees and shrubs, and are listed below in Table

**Figure 4-6 Bank Riparian Zone on the Klamath River below Copco Dam. Sandbar willow at the water's edge, Oregon ash and black oak beyond**

4-5. Planting densities within the riparian-bank areas will be variable, but will be on average approximately 400 woody plants per acre, or one woody plant per 100 sq. ft.

A large factor in the correct placement of the bank riparian planting zone will be the modeled hydraulics and the anticipated topography of the banks. Key storm event water surface elevations will be used to determine the extent and boundaries of this planting zone. The 3, 5, 10, 25, 50 and 100-year storm water surface elevations will be modeled. The bank riparian zone species that will be re-introduced in this zone are listed in Table 4-5.

After reservoir drawdown, a re-assessment of areas selected for pole cuttings installation will be performed in the field. The best suitable areas for the planting of pole cuttings, and for the transplanting of reservoir rim riparian trees, will be identified along the banks of the Klamath River based on environmental factors such as soil texture, local topography, slope, aspect, and hydrology described in detail below. Live pole cuttings will be planted 10 feet on center in these areas along the river banks from approximately the OHWM to Q25 water surface elevations. Ideally, pole cuttings will be harvested from within the Klamath River watershed while the parent plants are dormant (late October through mid-February). The best time of year for planting the pole cuttings will be between February and March, however, with sufficient supplemental irrigation, or high ground water table, pole cuttings can be installed year-round.

Herbivore protection will be needed to increase the successful establishment of riparian-bank species. It may include screens, fencing, chemical deterrents, or overplanting. Herbivore protection is vital to successful establishment of planted cuttings and seedlings, since young plant cuttings and transplants will be highly susceptible to mortality from herbivory before root and shoot systems can sufficiently establish and are also often preferred browse material. The herbivores known from the Project area are elk, deer, beaver, and black-tailed jackrabbit (TR, 2004).

Although estimates of groundwater depths and fluctuations are not currently available, the water table is expected to be relatively shallow in proximity to the newly established river channel. Other areas may have terraces along the river channel that are higher than they once were because of reservoir sediment. It may not be possible in all cases to plant pole cuttings of riparian species with immediate connection to groundwater. Supplemental overhead irrigation of riparian vegetation will be provided in the form of temporary, surface mounted irrigation system that will draw water from the river.

## Table 4-5 Bank Riparian Zone Seed Mix

| Common name | Scientific name | Lifeform |
|---|---|---|
| bigleaf maple | *Acer macrophyllum* | large deciduous tree |
| spike bentgrass, spike redtop | *Agrostis exarata* | perennial grass |
| mugwort | *Artemisia douglasiana* | perennial herb |
| slender beak (wheat) sedge | *Carex athrostachya* | perennial herb |
| clustered field sedge | *Carex praegracilis* | perennial herb |
| smooth dogwood | *Cornus glabrata* | large deciduous shrub |
| red-osier dogwood | *Cornus sericea* | large deciduous shrub |
| tufted hairgrass | *Deschampsia caespitosa* | perennial grass |
| annual hairgrass | *Deschampsia danthonioides* | annual grass |
| blue wildrye | *Elymus glaucus* | perennial grass |
| small fescue | *Festuca [Vulpia] microstachys* | annual grass |
| Oregon ash | *Fraxinus latifolia* | medium deciduous tree |
| meadow barley | *Hordeum brachyantherum* sspp. *brachyantherum* | perennial grass |
| toad rush | *Juncus bufonius* | perennial herb |
| sword-leaved rush | *Juncus ensifolius* | perennial herb |
| western rush | *Juncus occidentalis* | perennial herb |
| creeping (beardless) wildrye | *Leymus triticoides* | perennial grass |
| field mint | *Mentha arvensis* | perennial herb |
| Lewis' mock orange | *Philadelphus lewisii* | deciduous shrub |
| black cottonwood | *Populus balsamifera ssp. trichocarpa* | large deciduous tree |
| California black oak | *Quercus kelloggii* | large deciduous tree |
| California rose | *Rosa californica* | deciduous shrub |
| Pacific blackberry | *Rubus ursinus* | deciduous shrub, vine |
| California dock | *Rumex californicus [salicifolius* var. *denticulatus]* | perennial herb |
| narrowleaf willow | *Salix exigua* | large deciduous shrub |
| red willow | *Salix laevigata* | large deciduous tree |
| arroyo willow | *Salix lasiolepis* | small deciduous tree |
| shining willow | *Salix lucida* | small deciduous tree |
| common snowberry | *Symphoricarpos albus* | deciduous shrub |
| California grape | *Vitis californica* | deciduous vine |

*Shaded rows indicate keystone species.*

### 4.3.4 Bank Wetland Zone

Bank wetland zones will be delineated as areas suitable for plant growth approximately between the base flow and 3-year flood event water surface elevations (Q3) of the Klamath River and all of its related tributaries, and seeps occurring within the Project boundary. These zones will be adjusted on a case by case basis and depending on local topography.

**Figure 4-7 Bank wetland area at J.C. Boyle Reservoir**

Many bank wetland areas within the reservoir basins after drawdown are expected to support existing and river imported wetland vegetation propagules more readily than the species seeded in the riparian seed mix. The seed bank germination study indicated a high degree of viability and variability of wetland species seed in the reservoir deposit (see USBR 2011b), even after many years or even decades under water. This suggests wetland areas may re-vegetate naturally and relatively quickly where hydrology is favorable, however, because of the critical importance of this zone for the health of the river and the anadromous fish, and the high risk of invasive exotic plant establishment in this zone, it will be revegetated by hydroseeding, pole cutting and ballast bucket installation. The anticipated native wetland species are listed in Table 4-6, and all of them are already present in the Project area. Wetland areas will be very susceptible to non-native exotic plant invasions. A number of wetland invasives already occur in the Project area and are listed in Table 4-7.

**Table 4-6 Native plant species anticipated to establish in Bank Wetland Zone**

| Common name | Scientific name | Lifeform |
|---|---|---|
| white alder | *Alnus rhombifolia* | deciduous tree |
| mugwort | *Artemisia douglasiana* | perennial herb |
| slender beak (wheat) sedge | *Carex athrostachya* | perennial herb |
| Nebraska sedge | *Carex nebrascensis* | perennial herb |
| woolly sedge | *Carex pellita [lanuginosa]* | perennial herb |
| awlfruit sedge | *Carex stipata* | perennial herb |
| common spikerush | *Eleocharis macrostachya [palustris]* | perennial herb |
| common horsetail | *Equisetum arvense* | fern-like herb |
| western goldenrod | *Euthamia occidentails* | perennial herb |
| Baltic rush | *Juncus balticus* | perennial herb |
| common rush | *Juncus effusus var. pacificus* | perennial herb |
| sword-leaved rush | *Juncus ensifolius* | perennial herb |
| western rush | *Juncus occidentalis* | perennial herb |
| iris-leaved rush | *Juncus xiphioides* | perennial herb |
| seep monkey flower | *Mimulus guttatus* var. *guttatus* | Annual herb |
| knotgrass | *Paspalum distichum* | perennial grass |

| Common name | Scientific name | Lifeform |
|---|---|---|
| reed canarygrass | *Phalaris arundinacea* | perennial grass |
| narrow-leaf willow | *Salix exigua* | deciduous shrub |
| arroyo willow | *Salix lasiolepis* | deciduous tree |
| shining willow | *Salix lucida ssp. lasiandra* | deciduous tree |
| rigid hedge nettle | *Stachys ajugoides var. rigida* | Perennial herb |
| stinging nettle | *Urtica dioica ssp. holosericea* | perennial herb |
| rough cockleburr | *Xanthium strumarium* | annual herb |

*Shaded rows indicate keystone species.*

### Table 4-7 Invasive exotic plant species present in the project area with a potential to establish in Bank Wetland Zone

| Common name | Scientific name | Cal IPC Invasiveness Rating | Oregon DA Noxious Weed Rating |
|---|---|---|---|
| colonial bentgrass | *Agrostis capilaris* | None | None |
| poison hemlock | *Conium maculatum* | Moderate | B |
| teasel | *Dipsacus fullonum* | Moderate | None |
| Barnyard grass | *Echinochloa crus-galli* | None | None |
| tall fescue | *Festuca arundinacea* | Moderate | None |
| field pepperweed | *Lepidium campestre* | None | None |
| perennial pepperweed | *Lepidium latifolium* | High | B, T |
| European pennyroyal | *Mentha pulegium* | Moderate | None |
| Kentucky bluegrass | *Poa pratensis* | Limited | None |
| common knotweed | *Polygonum aviculare [arenastrum]* | None | None |
| Himalayan blackberry | *Rubus armeniacus* | High | B |
| climbing nightshade | *Solanum dulcamara* | None | none |
| knotted hedge parsley | *Torillis nodosa* | None | none |
| water speedwell | *Veronica anagallis-aquatica* | None | none |

*Shaded rows indicate highly invasive exotic/noxious weed species.*

### 4.3.5 Emergent Wetland Zone

Emergent wetland zones will be delineated as areas of low water velocities that occur approximately between the base flow and 2-foot water depth in the Klamath River and all of its related seeps and tributaries occurring within the Project boundary. These zones will be adjusted on a case by case basis and depending on local topography.

Figure 4-8 Emergent Wetland Zone with hardstem bulrush below Iron Gate

Many emergent wetland areas within the reservoir basins after drawdown are expected to support existing and river imported wetland vegetation propagules more readily than the species seeded in the riparian seed mix. Emergent wetland areas may re-vegetate naturally and relatively quickly where hydrology is favorable, however, this may include the risk of invasive exotic plant colonization of the same habitats earlier and faster, and the substantial cost associated with their removal and replacement with native species.

Active revegetation of emergent wetland areas will be done by installing root divisions of emergent wetland species such as common cattail, hardstem bulrush, broad fruit burr-reed, sedges, rushes, spikerushes and others in ballast buckets (Figure 4-9) made of coir fabric, and weighed down with cobbles to prevent their floating away. It will also consist of relocation of existing emergent vegetation from the rim of the reservoirs to suitable newly formed emergent wetland habitats with slower moving water. This could happen immediately after drawdown, in the late spring, in the fall or in the spring of the next year. To prevent desiccation and die-off of the existing reservoir rim vegetation before relocation, small areas with emergent wetland vegetation could be bermed off with clayey soil and irrigated to maintain a pool of water or saturated soil until transplantation. The native wetland plant species proposed for the emergent wetland zone are listed in Table 4-8.

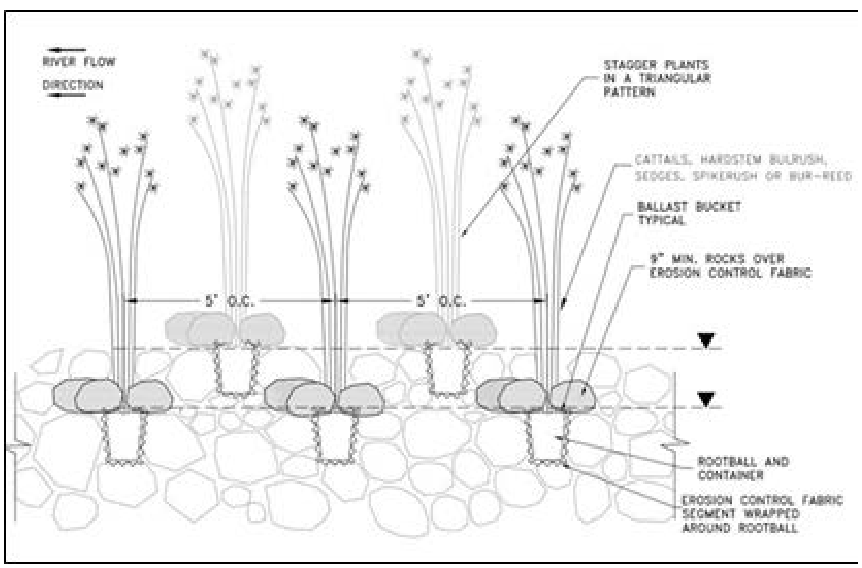



Figure 4-9 Emergent Wetland Zone with hardstem bulrush below Iron Gate

### Table 4-8 Native plant species proposed for the Emergent Wetland Zone

| Common name | Scientific name | Lifeform |
|---|---|---|
| devil's beggartick | *Bidens frondosa* | annual herb |
| water sedge | *Carex aquatilis* | perennial herb |
| Nebraska sedge | *Carex nebrascensis* | perennial herb |
| woolly sedge | *Carex pellita [languinosa]* | perennial herb |
| awlfruit sedge | *Carex stipata* | perennial herb |
| western water hemlock | *Cicuta douglasii* | perennial herb |
| needle spikerush | *Eleocharis acicularis* | perennial herb |
| common spikerush | *Eleocharis macrostachya [palustris]* | perennial herb |
| Baltic rush | *Juncus balticus* | perennial herb |
| iris-leaved rush | *Juncus xiphioides* | perennial herb |
| rice cutgrass | *Leersia oryzoides* | perennial grass |
| field mint | *Mentha arvensis* | perennial herb |
| watercress | *Nasturtium officinale* | perennial herb |
| water pepperweed | *Polygonum hydropiperoides* | perennial herb |
| hardstem bulrush | *Schoenoplectus [Scirpus] acutus* | perennial herb |
| broadfruit bur reed | *Sparganium eurycarpum* | perennial herb |
| common cattail | *Typha latifolia* | perennial herb |

*Shaded rows indicate keystone species.*

## 4.4 Environmental Factors

A number of environmental factors, in addition to flood event water surface elevations (Q-lines), will be considered in order to determine the most suitable location for each of the five planting zones (and their subsets) for each distinctive area of the project. Each factor is discussed separately in the sections below.

### 4.4.1 Soil Texture

The planting zone layout will be based on the sediment texture that will be mapped in the reservoir basins during pre-drawdown sediment testing. Coarse, sandy and gravelly soils will require a different plant composition of riparian species than fine, silty and clayey soils. Currently, there is only limited information on native plant species to predict with certainty how they will perform on sediments with different textures. However, some general conclusions can be drawn based on available information. On fine substrates, native annual grasses and forbs with shallow root systems tend to be the first pioneers in primary succession (Grubb, 1986). Coarse soils are favored by native perennial grasses (bunch grasses) that grow deep root systems that allow them to persist for years. Large trees and shrubs tend to pioneer newly-formed, coarse-textured substrates (Grubb, 1986). On fine sediments, native annual grasses may provide a short-term solution to invasion by exotic annual grasses, but a long-term solution requires the establishment of woody species. On coarse sediments, trees and shrubs will establish readily. However, riparian deciduous species, such as red alder, willows and cottonwood, will not perform well on deep layers of coarse sediments perched above the water table. These riparian trees are true phraetophytes and require permanent constant contact with the ground water table. Planting trees and shrubs in at least some key areas on coarse sediment terraces of each reservoir during dam removal while the water table is still high may improve plant performance and persistence (Auble et al., 2007) since many riparian trees can grow their roots at a rate that maintains pace with normal recession of the ground water table in riparian areas after the peak of the spring snowmelt.

### 4.4.2 Slope/Aspect

The restoration planting zone layout plan will consider slope and aspect in determining appropriate locations for each planting zone. West and south facing slopes receive more solar radiation, have higher evapotranspiration, and will be hotter and drier than north and east facing slopes. South and west facing slopes are more appropriate for juniper woodland or three-leaf sumac scrub habitats while north and east facing slopes will better support ponderosa pine and Douglas fir woodlands. Similarly, areas at the bottom of the valley slopes will be cooler and more mesic than areas higher up or on steeper slopes. Species such as big-leaf maple, California black oak and Oregon ash will be more successful in more mesic and moisture preserving environments while juniper woodland will be more appropriate on steeper, xeric slopes. A GIS analysis of solar radiation using aspect, season, day length, and slope will be conducted during detailed design to assess the amount of the sun's energy received in the former reservoir areas at certain times of the year. Areas with lower solar radiation will support species that prefer wetter, cooler environments (e.g., riparian and mesic communities) while areas of higher solar radiation will be more appropriate for species that are more tolerant of hot, dry xeric conditions with high evapotranspiration rates. Additionally, areas with a lower amount of solar radiation are expected to require less irrigation during plant establishment than comparable planting areas with more solar radiation. The amount of solar radiation, aspect and slope will be used to determine the most suitable planting zone for each area of the Project.

### 4.4.3 Other Factors

Information on sediment depth, plant nutrient availability, groundwater depth, irrigation water availability, local hydrology and microclimate, if available, will provide additional data that will support the planting zone layout process.

## 4.5 Revegetation Process

The revegetation process will be divided into six distinct periods: pre-dam removal (one to two years before drawdown commences), during reservoir drawdown (spring of drawdown year), first year revegetation (summer-fall of drawdown year), second year revegetation, plant establishment (first year after completion of revegetation), and long-term maintenance and monitoring (second through fifth years after completion of revegetation. The revegetation periods are described below in detail.

**Figure 4-10 Tree cover in existing upland areas around the reservoirs varies considerably in response to slope aspect. Grasslands dominate on south-facing slopes. Woodlands and scrub dominate on north-facing slopes**

### 4.5.1 Pre-dam Removal (1-2 years pre-drawdown)

In the years before drawdown, revegetation activities will primarily focus on invasive exotic species control, collection of native plant seed, and propagation of native plants and native plant seed in preparation for revegetation activities. Additional activities may consist of native and invasive exotic vegetation surveys, identification of restoration reference sites, test plot experiments to ascertain the best prescriptions for successful establishment of desired species, contingency plans preparation, and agency coordination.

The control of invasive exotic plants will be one of the most important goals of the project. Invasive, exotic species are not only a major threat to biodiversity (Wilcove et al., 1998) but can also inhibit the native plant succession (Urgenson et al., 2009). Invasive exotic species may also change successional trajectories by altering soil chemistry or modifying disturbance regimes (D'Antonio and Vitousek, 1992). The removal of the dams will create large areas devoid of vegetation, providing opportunities for exotic invasive plant species that are already present (Table 4-9) to colonize the open areas and attain dominance. Riparian zones are particularly susceptible to invasion by exotic plants (Hood and Naiman, 2000). The former reservoir edge and upland areas that contain many invasive species may serve as seed sources of exotic species for invasion into the vulnerable open areas after the drawdown. Active control of exotic invasive species in the project areas around the reservoir will begin several years before drawdown and will continue until the project completion. Control may consist of manual weed eradication, solarization, covering of ground areas with black visqueen, mechanical eradication by tilling in larger areas, and application of safe herbicides by wicking or brushing as a last resort. Active revegetation and weed control will accelerate succession and will help reduce the amount of open space available for exotic species establishment.

### Table 4-9 Invasive exotic plant species present in the project area with a potential to re-establish

| Common name | Scientific name | Cal IPC Invasiveness Rating | Oregon DA Noxious Weed Rating |
|---|---|---|---|
| Russian knapweed | *Acroptilon repens* | Moderate | B |
| cheatgrass | *Bromus tectorum* | High | none |
| diffuse knapweed | *Centaurea diffusa* | Moderate | B |
| yellow star thistle | *Centaurea solstitialis* | High | T |
| Canada thistle | *Cirsium arvense* | Moderate | B |
| bull thistle | *Cirsium vulgare* | Moderate | B |
| poison hemlock | *Conium maculatum* | Moderate | B |
| Scotch broom | *Cytisus scoparius* | High | B |
| teasel | *Dipsacus fullonum* | Moderate | none |
| medusahead | *Elymus [Taeniatherum] caput-medusae* | High | B |
| tall fescue | *Festuca arundinacea* | Moderate | none |
| St. John's wort, Klamath weed | *Hypericum perforatum* | Moderate | B |
| dyer's woad | *Isatis tinctoria* | Moderate | B |
| hoary cress | *Lepidium [Cardaria] draba* | Moderate | none |
| perennial pepperweed | *Lepidium latifolium* | High | B, T |
| Dalmatian toadflax | *Linaria dalmatica* | Moderate | B |
| European pennyroyal | *Mentha pulegium* | Moderate | none |
| Scotch thistle | *Onopordum acanthium* | High | B |
| Himalayan blackberry | *Rubus armeniacus* | High | B |
| Mediterranean sage | *Salvia aethiopis* | Limited | B |
| puncture vine | *Tribulus terrestris* | Limited | B |
| spiny clotbur | *Xanthium spinosum* | None | B |

*Shaded rows indicate highly invasive exotic/noxious weed species.*

Native plant seed collection will be implemented in a way that will not cause significant detriment to the existing plant populations. For some species, the existing populations may be insufficient for harvest and/or nursery production to the level required for the revegetation. In these cases, off-site sources will be used to collect supplemental propagation materials as needed and permitted. Collection of locally ecotypic seed subsequently grown by local commercial growers to produce larger amounts of seed or plant material will require advanced planning and will be implemented during the pre-dam removal period. Time, budget or availability constraints may make it necessary to acquire seed and plant materials from commercial seed companies or nurseries. 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 will be conducted as part of pre-project test plot revegetation experiments, regardless of source. Seed pre-treatment may include scarification, stratification, imbibition, and others.

### 4.5.2 Reservoir Drawdown (January-March, year of drawdown)

Native grass seed mixes appropriate for each vegetation zone will be hydroseeded on the entirety of the exposed reservoir basin during or immediately after drawdown. The topography, size, and distance from existing roads at J.C. Boyle Reservoir make this area well suited for ground-applied hydroseed. For Copco and Iron Gate Reservoirs, use of existing, and installation of temporary roads will allow areas with relatively low slopes (<5:1) to be seeded with ground equipment. Hydroseed mixes will be applied as the reservoir water level drops and before the exposed sediments dry up, in order to facilitate expedited seed germination through retained residual soil moisture and before crust formation on the surface. Experienced hydroseeders using the correct hose extensions, connections and thinner seeding mixes can reach up to 900 feet, especially when the hydroseeded area is downhill from the pump equipment. If there are large areas not accessible by ground equipment, they will be hydroseeded either from barges or aerially. Acorns, tree and shrub seedlings and some pole cuttings will be also installed early depending on feasibility and other factors such as weather, plant availability, and access.

### 4.5.3 Post-drawdown First Year Revegetation

Post-reservoir drawdown (e.g. summer through fall), the establishment of riparian habitat will be greatly accelerated by installation of pole cuttings, bare root and containerized tree saplings as well as transplantation of salvaged plants in the riparian and wetland zones. Woody riparian species are essential in riparian areas that in turn are critically important for shaded aquatic riverine fish habitat and for stabilization of the river banks. Planting pole cuttings and transplanting riparian species in the early summer of the first year of revegetation, shortly after drawdown, will allow for the harvesting and salvaging of existing live riparian vegetation that will be slowly drying up at the former rim of the reservoir. The existing reservoir rim riparian vegetation that would inevitably die because of ground water table recession with the drawdown will be an inexpensive source of locally ecotypic riparian species. Approximately 5-10% of the reservoir banks is vegetated with suitable riparian vegetation that could be relocated.

The exposed sediment may pose difficulties supporting native vegetation as it will not immediately possess typical topsoil characteristics. Supplemental fall hydroseeding and soil treatments such as ripping, tilling, amendment incorporation, and compost application may be necessary to augment areas where establishment from the spring hydroseeding was unsuccessful, or where exposed soil exhibits a high erosion potential

Areas predicted to support wetland species will be included in the grass-seeded/pole cutting planted areas. 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

(Reclamation, 2011c). 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.

### 4.5.4 Post-removal Second Year Revegetation

During the second year of revegetation, additional re-seeding of areas that failed to establish will be performed, additional pole cuttings will be collected and installed, containerized and bare-root plants will be acquired and planted, and previously seeded and planted areas maintained primarily by diligent weed removal and irrigation system upkeep. Bare soil patches larger than 10 feet x 10 feet or that are otherwise significant in size or problematic will be reseeded with native riparian grass and forb seed mixes. Primary importance will be placed on weed control and prevention of weeds achieving maturity. Repeated hydroseeding and soil treatments such as ripping, tilling, amendment incorporation, and compost application to augment areas where establishment from the first year hydroseeding was unsuccessful may be necessary during the second revegetation year. In cases where mulch has moved/degraded or otherwise exposed bare soil, supplemental hydroseeding will be used again to help prevent excessive erosion. In other cases where establishment has failed yet the mulch remains intact, new seed material applications may need to be incorporated in the soil in order to re-establish seed/soil contact sufficient for germination. This can be done with ground equipment or in small areas by hand with labor crews, depending on the size of the area, and accessibility.

### 4.5.5 Plant Establishment Period

The plant establishment period will be the most critical period in the entire revegetation process. The quality of plant establishment will determine whether the Project area will be taken over by invasive exotics or by native plants. The most important activities during plant establishment will be weed control, irrigation system maintenance, and herbivore control. A Weed Control Plan will be developed by the restoration contractor and diligently complied with. The key objective of the plan will be to limit invasive exotic vegetation cover to levels no greater than reference sites on nearby properties. Weed monitoring and the implementation of timely control measures will be used to control invasive weeds (e.g., Himalayan blackberry, yellow star thistle, Russian knapweed, and others listed above in Table 4-9) if they are interfering with the establishment of the desired permanent native vegetative cover.

The accepted approach for the control of invasive exotic plants it the Integrated Pest Management (IPM) strategy. The focus of the strategy is to implement a combination of management techniques that are selected to minimize the extent of environmental degradation and reduce the impact of chemical inputs on humans and non-target organisms. IPM is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established state guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment.

Integrated Pest Management will consist of the following key elements:

- Prevent invasive exotic weeds from establishing through use of weed-free plant materials and straw. Experienced seed production companies will be employed and will provide seed analysis for each collected and propagated species indicating seed purity, weed and hard seed amounts. Any containerized plants or transplants will be inspected for presence of invasive weeds. Only certified weed free straw will be allowed.
- Regular monitoring to facilitate early detection of emerging invasive exotic weeds. Monitoring will consist of bi-weekly surveys of the areas and tagging or immediate removal of invasive weeds during the establishment period (Year One), and less frequent surveys (monthly) in later years.
- Utilize appropriate and cost-effective strategies to reduce or eliminate weed populations. Typical methods include cultural, biological, mechanical, and chemical control methods.
- Chemical herbicides will be used when they offer the most effective methods for control and eradication of noxious weeds. Herbicides would be applied by a certified applicator and in accordance with all applicable laws and regulations.
- Establish a program of monitoring and observation to determine the effectiveness of the applied weed control methods.

The following best management practices will be applied to control the emergence and limit the spread of invasive exotic weeds:

- Planning and scheduling - Coordinate weed management with all aspects of the revegetation and dam removal management activities to prevent introduction of any new weed species into the Project area and limit existing weed species to no greater occurrence than currently present on nearby reference sites. Weed populations maps that were created in 2003 by PacifiCorp consultants will be updated, and weed areas close to revegetation areas, construction areas, and access roads will be treated before work begins to reduce the risk of spreading the weeds.
- Training – Require or encourage weed awareness and prevention efforts among staff and contractors through contract requirements of incentives. Distribute Weed Control Guidelines that will be prepared by the restoration contractor based on the construction specifications requirements.
- Cleaning machinery – Control the spread of weeds to newly exposed ground through cleaning of construction equipment.
- Expedite revegetation with native plants.
- Implement appropriate weed control methods – Methods available for weed control depend upon the severity of the infestation and the lifecycle stage at which the weed is observed. Mechanical and chemical methods are available to control many weeds, although caution must be exercised that mechanical control methods do not contribute to the spread of invasive exotics. Chemical control will adhere to label requirements. Herbicides must be on regulatory agencies approved chemical list.
- Assign weed severity priority – As weeds are identified in either the deconstruction areas or in the newly established planting areas, they will be classified according to the Cal IPC and Oregon Department of Agriculture. Weed control will be prioritized based on classification and potential to interfere with revegetation efforts.

- Monitor to identify and eradicate any invasive exotic species impeding achievement of the revegetation objectives – The Weed Control Plan will require strict adherence to the monitoring schedule and regularly planned weed removal activities.
- Evaluate effectiveness – A continual process of active management ensures the success of the weed control program.
- Revisit and reestablish goals or methods to achieve the objective – Methods will need to be adjusted in the event that either the Weed Control Plan and Guidelines prove inadequate to limit the spread of the weeds present to the baseline condition, or new species are introduced requiring the development of a new weed control strategy and plan. This adaptive approach to weed management is illustrated below in Section 6 that further discusses adaptive management and monitoring of the sites.

#### 4.5.6 Long-term Maintenance

The long-term maintenance period will consist of activities to keep revegetation efforts on track to achieve the monitored phase performance criteria. It will consist of re-seeding/re-planting of native vegetation (as necessary), invasive plant management, herbivore control, irrigation maintenance and other activities as situations arise (e.g. implementation of erosion repairs). Specific activities will be based on the monitoring results and activity thresholds. For purposes of monitoring the revegetation plan success and achieving natural conditions, performance criteria will be agreed to with the regulatory agencies for upland, riparian floodplain, riparian bank, and wetland zones, as well as for invasive exotic plant management. The general monitoring approach will be to observe the vegetation re-establishment trend, compare it to conditions expected for early-successional habitats, and take corrective action when necessary to steer the development trend. Plant species and cover, density of woody riparian vegetation, acres of wetlands, and noxious weed levels will be monitored. Monitoring will occur for 5 years or until the performance criteria have been met.

# 5. Reservoir Area Restoration

The 2011 Reservoir Area Management Plan (Reclamation, 2011c) was developed primarily with a focus to stabilize the remaining sediment in the reservoir areas after drawdown to minimize the potential for future large-scale sediment releases in the Klamath River. The 2017 Klamath restoration working group recommended that additional actions be taken in the reservoir areas to develop habitat features that maximize fisheries and wildlife habitat while at the same time further stabilizing and revegetating the reservoir areas. Based on the desire to maximize habitat recovery opportunities with active restoration, the reservoir revegetation time periods are summarized below with the addition of some level of habitat feature construction in the second dry season after drawdown or the post-removal period:

1. Pre-dam removal (1-2 years pre-drawdown) activities include: pre-treatment of noxious exotic vegetation species, collection of seeds and grow-out of trees and shrubs by local nurseries.
2. Reservoir drawdown (January to March, year of drawdown) activities include: reservoir drawdown with natural erosion and evacuation of reservoir sediment deposits, initial stabilization of sediments and exposed areas with hydroseeding.
3. Post-drawdown first summer/fall (dry season immediately after drawdown) activities include: additional seeding application of exposed areas and remaining reservoir deposits with grasses and ground cover, manual removal/treatment of invasive exotic vegetation, and installation of riparian trees and shrubs.
4. Post-removal (year after dam removal is complete) activities include: maintain vegetation, continue to remove and treat invasive exotic vegetation, install habitat features.
5. Establishment period (years 2 through 5 post-dam removal) activities include: continued monitoring and maintenance of vegetation, removal of invasive exotic vegetation, fish passage monitoring, and enhancement of habitat features as needed.

## 5.1 Restoration Techniques

A collection of restoration techniques has been developed to meet project goals and objectives that can be implemented as applicable in each reservoir. Development of the restoration techniques considered historical documentation of the reservoir areas prior to dam construction and reservoir area inundation, past performance of similar dam removal and restoration projects, and current restoration practices to develop a comprehensive suite of techniques useful for the reservoir areas as described below. Applicable use of the individual techniques discussed below are summarized in Section 5.2 for each reservoir area.

### 5.1.1 Tributary Connectivity

As reservoir water surfaces are lowered during drawdown and beyond, tributaries will be further exposed creating longer reaches of free-flowing water conditions. The newly exposed tributaries will flow over depositional areas of fine sediment that will likely be transported downstream, however, some larger sediment and debris may create fish passage barriers or un-natural discontinuities in the longitudinal profile. To rectify this, it is anticipated that light equipment and manual labor will be able to move materials and enhance access and longitudinal connectivity of the tributaries with the mainstem Klamath River. In addition, large wood (LW) may be added to tributaries to promote habitat complexity as further described below.

Another aspect of tributary connectivity is fish passage.  Many of the tributaries have road crossing at the current reservoir water surface with culverts and stream crossings that do not meet fish passage standards.  In addition, there are likely historical tributary crossings that area currently within the reservoir inundation zone and will likely create fish passage barriers. Therefore, an inventory of fish passage barriers in the tributaries will be determined after reservoir drawdown and as many of these will be rectified as funding allows.

### 5.1.2 Wetlands, Floodplain and Off-Channel Habitat Features

Incorporating floodplain features into newly exposed floodplains is a restoration strategy that promotes ecosystem diversity and natural processes. Based on historical pictures, it appears that three main types of floodplain features could be supported on the newly exposed floodplain areas: wetlands, floodplain swales, and side channels.

Wetlands are depressional or low-lying features with standing water or saturated soils for a portion of the growing season sufficient to support wetland vegetation such as willows, sedges and rushes. Wetlands provide a wide range of ecological functions such as water quality improvement, flood attenuation, and habitat for both terrestrial and aquatic organisms. Including wetlands in restoration will help address several limiting factors including water quality and lack of habitat diversity for wildlife. Wetland restoration strategies for the reservoir areas include preservation of existing wetlands, hydrologic connection of off-channel wetlands with the river, or creation of new wetlands at lower elevations corresponding to the post-dam removal surfaces and hydrologic regime as illustrated in Figure 5-1.

Floodplain swales are small depressional areas incorporated into the floodplain that provide microsites where floodplain vegetation can establish at slightly lower elevations (closer to the water table) than adjacent floodplain surfaces. Floodplain swales also provide storage for flood water and sediment at variable flows, in addition to broadening the range of ecological niches available on the floodplain surface to support different life stages (and behaviors) of plant, bird, amphibian, and many other terrestrial wildlife species. To maximize diversity, floodplain swales vary in size and depth, but do not extend below the anticipated baseflow elevation.

Side channel restoration is a strategy to improve instream habitat diversity. Side channels provide off-channel habitat for juvenile rearing and high flow refugia for other aquatic species. Like floodplains, side channels exchange water, sediment and nutrients between the main channel and off-channel areas thus supporting diverse vegetation communities. Side channel restoration strategies include modifying inlet and outlet hydraulics, improving hydraulic complexity with wood structures or realignment, and delivery of water to higher floodplain surfaces.

**Figure 5-1 Example of existing floodplain features upstream of Copco No. 1 reservoir (i.e. wetland area)**

### 5.1.3 Floodplain Roughness

Floodplain roughness is a technique applied to newly exposed areas where frequent interaction with the river channel is anticipated. Floodplain roughness helps address the initial geomorphic limiting factor on the newly exposed areas - lack of established, stable vegetation. Floodplain roughness also reduces browse pressure by making access more difficult, particularly for geese which require unobstructed runways for landing and takeoff. Installation of roughness features creates complexity and microsites on new floodplain surfaces to trap and protect seed and other plant propagules, and to provide resistance to erosion by reducing velocities and limiting rill formation. Floodplain roughness is created using equipment to roughen the floodplain surface with microtopography and partially bury brush, limbs, and wood in the soil. Microtopography creates variation in the constructed floodplain surface ranging from 0.5 feet above to 0.5 feet below the design floodplain surface. Brush and wood increases soil moisture retention, creates protective microsites for establishing seed and plants, and promotes soil development by introducing organic material as illustrated in Figure 5-2.

### 5.1.4 Bank Stability and Channel Fringe Complexity

Lack of initial roughness along channel margins results in higher than normal near-bank velocity and shear stress. This increase in active channel margin energy negatively affects aquatic species by requiring increased energy for migration and holding while also transporting desired gravels and depositional features downstream. Velocity shadows created by bankline complexity (i.e. vegetation, rootwads, etc.) and large wood create zones of complex hydraulic interactions that provide resting zones, feeding seams, cover and velocity refugia during high flow. Reaches that would benefit from these treatments are typically single thread, like the Klamath River, where the channel is laterally confined. In addition, bank roughness can improve bank stability and reduce un-natural erosion that degrades water quality. Channel fringe complexity is best improved through the strategic addition of LW as described in the following section and establishment of riparian vegetation.

**Figure 5-2 Example of restored floodplain area six months after construction showing new vegetation and wood roughness elements that provide habitat complexity and immediate, large scale roughness**

### 5.1.5 Large Wood Habitat Features

Large wood is a naturally occurring element in the Klamath Basin that hydraulically influences the movement of debris and sediment, causing local scour and deposition as well as hydraulic energy dissipation. LW obstructions lead to flow mechanics that result in a fining of stream substrate particles. Suspended sediment particles can drop out of the water column due to flow deceleration caused by LW skin roughness, form drag and turbulent energy dissipation around LW obstructions, hydraulic jumps over LW steps, and a general decline in water surface slope and energy gradient due to physical blockage of flow and backwater effects caused by LW obstructions (Buffington, 1995). LW can be used to disperse flow energy (Buffington and Montgomery, 1999), stabilize channel banks and bed forms (Bilby, 1984), increase aquatic habitat (Bryant and Sedell, 1995), narrow a stream and reduce the width to depth ratio (Sedell and Froggatt, 1984), cause localized deposition, form pools (Bilby and Ward, 1989), and route flood water. Although historical photos do not show LW as a predominant geomorphic feature, it can be used to improve habitat and promote reservoir area conditions that restore natural ecosystem processes and protect vegetation during the initial years of establishment.

#### 5.1.5.1 Ground-Based Equipment Placement

Use of track hoes (Figure 5-3) and industrial log moving equipment are typical methods for moving and placing wood to build LW habitat structures along river and floodplain areas. It is anticipated that these standard methods will be utilized for construction in specific areas of the reservoirs based on accessibility and amount of residual reservoir sediment remaining. In culturally sensitive areas, ground-based equipment will not be used to install LW.

**Figure 5-3 Example of LW structure being built for habitat benefits using ground-based equipment**

#### 5.1.5.2 Helicopter Placement

For access to difficult sites or culturally sensitive areas, and to minimize overall site impacts, LW can be efficiently placed using a helicopter. A standard twin rotor helicopter (Figure 5-4) can lift loads in excess of 10,000 lbs. that is roughly equivalent to log lengths over 80 feet with diameters of 24 inches or greater that are ideal for floodplain and tributary stream habitat forming features. Use of a helicopter also enables better preservation of limbs and rootwads with the LW that can help increase the amount of habitat created and the long-term stability of the wood.

**Figure 5-4 Example of LW being transported and placed with a twin rotor helicopter**

## 5.2 Proposed Restoration at J.C. Boyle, Copco No. 1 and Iron Gate Reservoirs

Restoration recommendations considered historical context of the reservoir areas prior to dam construction, past performance of similar dam removal and restoration projects, and current restoration practices to determine techniques suitable for improving habitat conditions in the reservoir areas. Figure 5-5, Figure 5-6 and Figure 5-7 provide overview maps of the reservoir areas with proposed restoration locations and habitat features. These restoration efforts are intended to work in concert with the revegetation efforts in the reservoir area to maximize the potential long-term habitat benefits.

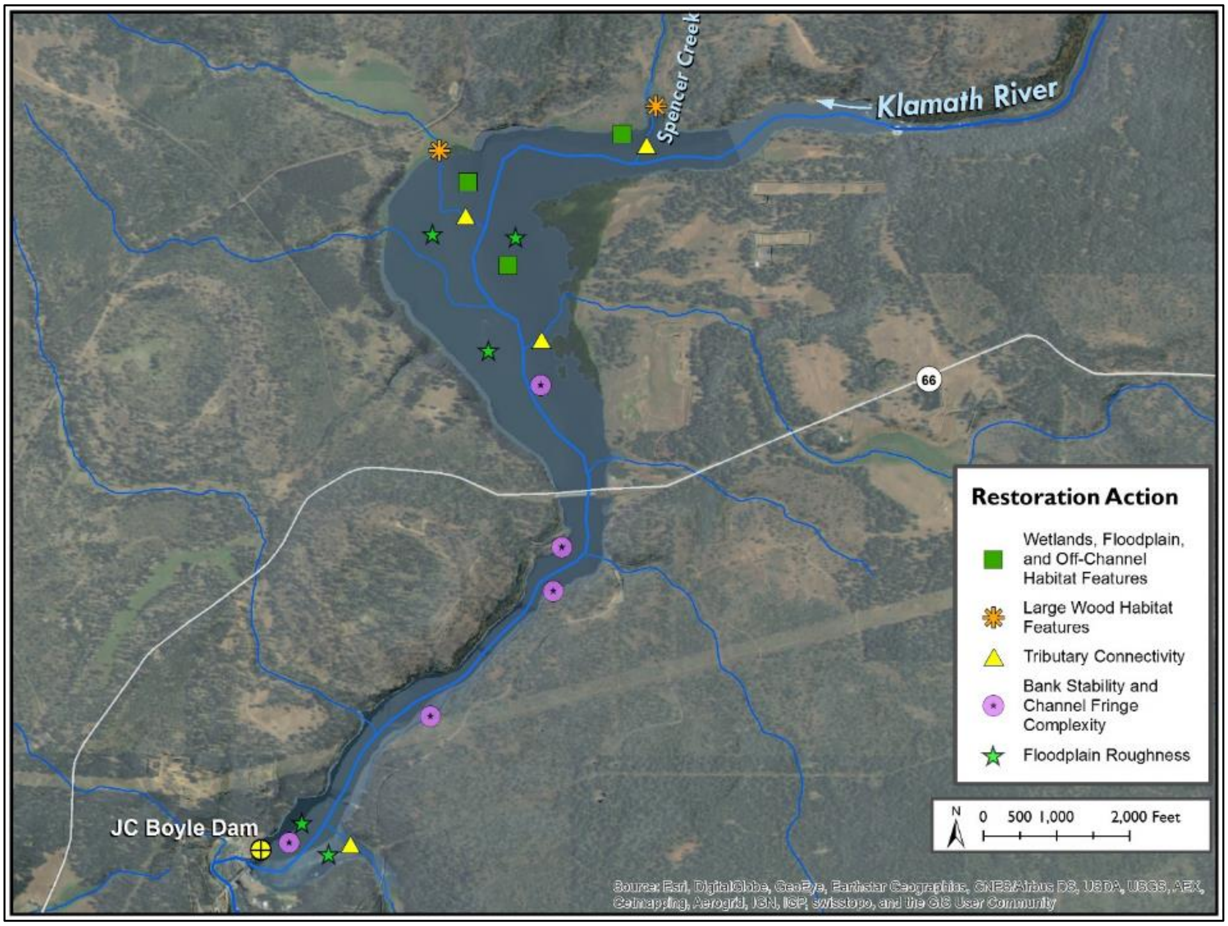



**Figure 5-5 Map of historical Klamath River centerline, tributaries, and locations of potential restoration actions in JC Boyle Reservoir. Pre-dam topography is included for context**

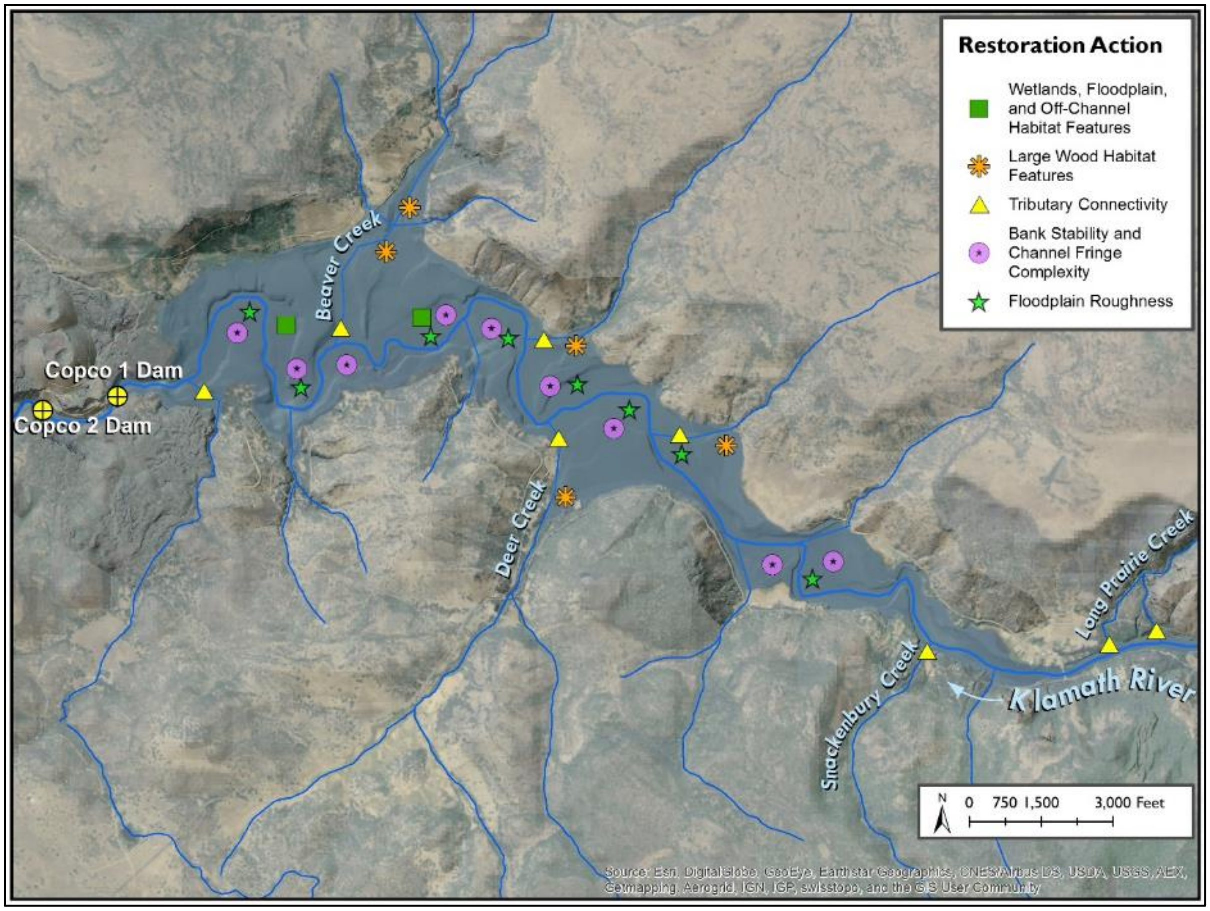



**Figure 5-6 Map of historical Klamath River centerline, tributaries, and locations of potential restoration actions in Copco No. 1 Reservoir. Pre-dam topography is included for context**

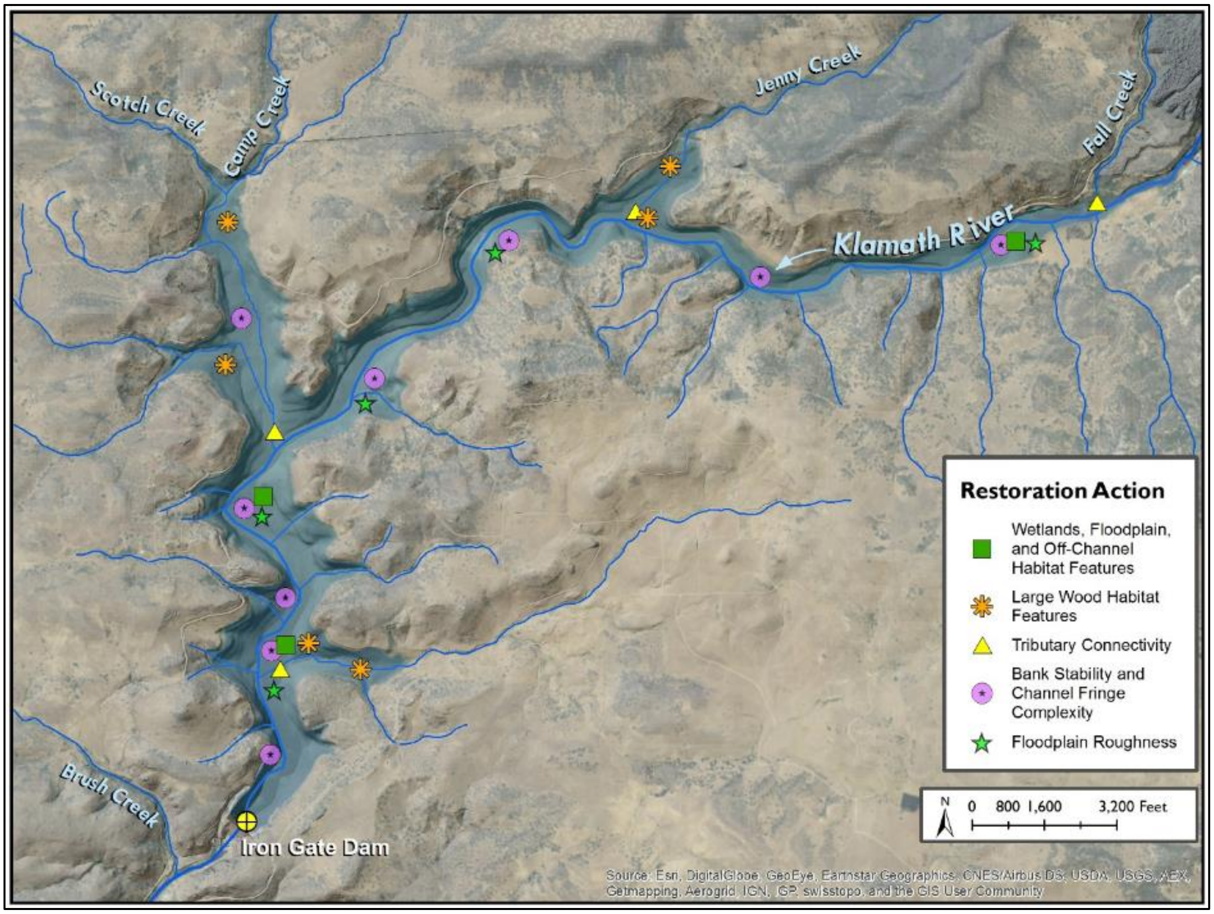



**Figure 5-7 Map of historical Klamath River centerline, tributaries, and locations of potential restoration actions in Iron Gate Reservoir. Pre-dam topography is included for context**

# 6. Monitoring and Adaptive Management

Dam removal is a rapidly evolving science and the study of dam removal effectiveness on river processes is expanding with each new dam removal. Several dam removal monitoring and adaptive management plans were reviewed from recent dam removal and reservoir restoration projects as summarized in (Table 6-1). These plans utilized a range of protocols and various levels of effort to track and document revegetation and restoration efforts.

### Table 6-1 Summary of dam removal monitoring and adaptive management plans

| Dam Removal | Description |
|---|---|
| Elwha & Glines Canyon Dams on the Elwha River, Washington | The Elwha and Glines Canyon dams were removed in 2012 and 2014, respectively. Monitoring was proposed for six years post removal. The monitoring strategy consisted of physical processes and vegetation (Chenowith et al., 2011). |
| Savage Rapids Dam on the Rogue River, Oregon | Savage Rapids Dam was removed in 2009. Monitoring was proposed for two years post removal. The proposed effectiveness monitoring strategy consisted of three protocols: biological, physical, hydrological measurements (Bountry et al., 2013). |
| Gold Ray Dam on the Rogue River, Oregon | Gold Ray Dam was removed in 2010. Monitoring was proposed for four years but stopped after two years due to funding cuts. The proposed effectiveness monitoring strategy consisted of multiple protocols including biological, physical processes, vegetation and habitat. |
| Condit Dam on the White Salmon River, Washington | Condit Dam was removed in 2011. An Environmental Monitoring Plan proposed two years post removal consisting of water quality, sediment transport, slope stability, and vegetation monitoring (Wilcox et al., 2014). |
| Milltown Dam on the Clark Fork River, Montana | Milltown Dam was removed in 2009. Monitoring was planned for 15 years and consisted of physical processes and changes to the channel/floodplain, vegetation, water quality, and habitat (Evans, 2014). |
| San Clemente Dam on the Carmel River, California | San Clemente Dam was removed in 2015. A monitoring plan comprised of multiple years of monitoring protocols focused on channel geomorphology, structure stability and persistence, and vegetation establishment (AECOM personal communications, 2017). |

## 6.1 Monitoring Metrics and Protocols for Reservoir Areas

Monitoring associated with the restoration aspects of the project is designed to measure progress toward achieving the project goals, inform potential adaptive management and maintenance needs, and provide feedback into river and reservoir area conditions to determine if the sites are trending towards or away from achieving project goals. Based on the project goals and compliance with stated objectives, physical parameters are appropriate monitoring parameters using standard field techniques that will produce data compatible with standard protocols derived from previously developed dam removal monitoring and adaptive management plans.

After drawdown of the reservoirs and removal of the dams, the following actions are proposed to establish “baseline” or “initial conditions”. The initial conditions reference data will be used for monitoring and adaptive management related to reservoir restoration:

1. Permanent ground photo points will be established throughout the reservoir areas that enable sufficient vantage points of critical areas within the reservoirs. Photos will be taken to provide initial conditions for monitoring data to develop informed maintenance/corrective actions. Each photo ground point will be monumented with 5/8" rebar and aluminum cap for long-term stability and documented with a northing, easting, and elevation using a survey-grade GPS.
2. High resolution vertical aerial photos, sub-meter accuracy, will be completed for the reservoir areas.
3. LiDAR will be collected for the reservoir areas after sediment evacuation and initial ground cover stabilization and used to create initial conditions surface models.

Baseline data will provide a clear starting point for initial conditions in the project area to help evaluate reservoir area restoration trends and trajectories. Project goals are described below along with desired future conditions for each goal that can be monitored. The monitoring plan is proposed for five years.

### 6.1.1 Reservoir Sediment Stabilization

During an average water year, it is expected that approximately 50% of the reservoir sediments will remain in the reservoir area on the floodplain and surrounding slopes after drawdown. To reduce potential water quality degradation from un-natural, episodic fine sediment releases, the remaining sediments will be vegetated and stabilized. In addition, habitat features will be constructed to help further improve sediment stability as described previously in this plan. To ensure the project meets the goals and objectives, monitoring of sediment stability will be performed. Since the reservoir areas are large and cover over 10 linear miles, monitoring will be done by visual inspection (aerial and ground photos) and LiDAR as summarized in Table 6-2.

**Table 6-2 Summary of reservoir sediment stability monitoring metrics**

| Project Goal | Monitoring Technique | Monitoring Metrics | Frequency |
|---|---|---|---|
| Stabilize remaining reservoir sediments | Visual inspection with photo points and physical measurements | Areal extent and limits of erosion | Yearly |
| Stabilize remaining reservoir sediments | LiDAR flight of reservoir areas | Surface model volume change | Yearly |
| Minimize invasive exotic vegetation and establish native vegetation cover | Visual inspection, aerial photos and ground based photo points | Area of invasive vegetation | 2 times per year |
| | | Area of native vegetation cover | 2 times per year |

### 6.1.2 Volitional Fish Passage Restoration

A goal of dam removal is to restore longitudinal river connectivity and natural river form and function that results in volitional fish passage. Experience from past dam removals show that potential fish passage barriers could exist beneath the reservoir water surface, that are not known now due to inundation caused by the dams. For example, there are often temporary structures built upstream of dams to control and bypass water during dam construction and these structures often remain after dam construction and can create fish passage barriers once reservoirs are reverted back to free-flowing systems. To address this uncertainty, a visual inspection and monitoring protocol can be enacted as summarized in Table 6-3.

**Table 6-3 Summary of volitional fish passage monitoring metrics**

| Project Objective | Monitoring Technique | Monitoring Metrics | Frequency |
|---|---|---|---|
| Restore fish passage to natural conditions | Visual inspection with ground photo points and physical measurements | Required fish jump height | After wet season, yearly |
| Restore fish passage to natural conditions | Visual inspection with ground photo points and physical measurements | Un-natural or man-made obstructions | After wet season, yearly |

### 6.1.3 Invasive Exotic Vegetation Control and Native Vegetation Restoration

In order to determine the success of the revegetation plan and to restore ecological functions and natural conditions in the Project area, performance criteria will be established for upland, riparian, and wetland zones, as well as for management of invasive exotic vegetation. The general approach to monitoring will be to record the vegetation re-establishment progress, compare it to references site conditions expected for early-successional habitats and established performance criteria, and take corrective action if and when necessary to guide further ecological succession on a trajectory to compliance with performance criteria, and to a fully functioning ecosystem.

Invasive exotic vegetation in all planting zones will be monitored for five consecutive years. Monitoring will be performed twice each year, early and late in the growing season (April-May and July-August) every year, starting the first year (Year One) after initial planting. Five consecutive years' documentation confirming that at the end of each year the target performance criteria for invasive exotic vegetation cover have been achieved, and that at Year Five after completion of revegetation, the occurrence of invasive exotic vegetation in all planting zones is not greater than the exotic invasive vegetation occurrence on nearby reference areas.

High resolution aerial photography with sub-meter accuracy taken each of the five monitoring years after the completion of revegetation work will be used to map the coverage of newly established vegetation in the project area footprint. Cover for herbaceous and woody species will be estimated with standard aerial photo interpretation methods and will be verified with ground surveys and photo stations. This information will be used to assess vegetation establishment trends. Monitoring will be conducted concurrently for upland, riparian, and wetland areas and coordinated with noxious weed monitoring to maximize efficiency. Fixed on-the-ground photo point stations will be established to photo-document upland and riparian revegetation and wetland establishment in the revegetation areas. Wetland area photographs used to document surface hydrology and vegetation structure will facilitate comparisons between monitoring events. Photographs will be taken during each monitoring visit and recorded by a pre-assigned photo-station number.

#### 6.1.3.1 Upland Planting Zones

Upland planting zones will be monitored for five consecutive years. Monitoring will be performed monthly during the growing season (March – September) of the first two years and late in the growing season (July-August) every year after that, starting the third year (Year Three) after initial planting. Targeted herbaceous cover (not including invasive exotics) of all upland areas will be as required by the performance criteria. At the conclusion of each of the five years of the monitoring period bare patches that are significant in size or problematic will be reseeded with native grass and forb seed mixes.

Biological monitor will provide documentation that for five consecutive years after the initial planting a minimum average of a number of woody shrubs and trees per acre that are vigorous, healthy, well-distributed, and of a minimum number of different native species are established in suitable areas as required by the revegetation performance criteria. Monitoring shall be performed each year in late summer from mid-July through mid-September. If at Year Five this success criterion has not been met, additional shrubs and trees will be planted and documentation of compliance with this success criterion will be repeated in Year Eight.

#### 6.1.3.2 Floodplain and Bank Riparian Planting Zones

Riparian planting zones will be monitored for five consecutive years. Monitoring will be performed late in the growing season (July-August) every year, starting the first year (Year One) after initial planting. Targeted herbaceous cover (not including invasive exotics) of all riparian areas will be as required by the performance criteria. At the conclusion of each of the five years of the monitoring period bare patches larger than 10 feet x 10 feet or that are otherwise significant in size or problematic will be reseeded with native riparian grass and forb seed mixes.

Biological monitor will provide documentation that for five consecutive years after the initial planting a minimum average of a number of riparian woody shrubs and trees per acre that are vigorous, healthy, well-distributed, and of a minimum number of different native species are established in suitable areas as required by the revegetation performance criteria. Monitoring shall be performed each year in late summer from mid-July through mid-September. If at Year Five this success criterion has not been met, additional riparian shrubs and trees will be planted and documentation of compliance with this success criterion will be repeated in Year Eight.

Willow live stakes shall be replanted as necessary to achieve the performance criteria required vegetative cover of riparian banks within all bank riparian planting zones each of the five consecutive years of monitoring.

#### 6.1.3.3 Wetland Planting Zones

The performance criteria required number of acres of jurisdictional wetlands will exist within the footprint of the project area by Year Five after last dam removal. Wetland conditions in bank and emergent wetland zones will be determined based on wetland hydrology, and hydrophytic plant indicators but may exclude hydric soil indicators in areas where recently deposited soil or sediment did not have sufficient time to develop them. If after Year Five the required acreage of wetlands is not established, wetland habitat alternatives will be implemented by Year Six and monitored as required.

#### 6.1.3.4 Invasive Exotic Vegetation in All Planting Zones:

Invasive exotic vegetation in all planting zones will be monitored for five consecutive years. Monitoring will be performed twice a year, early and late in the growing season (April-May and July-August) every year, starting the first year (Year One) after initial planting. Five consecutive years' documentation confirming that at the end of each year the target performance criteria for invasive exotic vegetation cover have been achieved, and that at Year Five after completion of revegetation, the occurrence of invasive exotic vegetation in all planting zones is not greater than the exotic invasive vegetation occurrence on nearby reference areas.

### 6.1.4 Natural Ecosystem Processes Restoration

Long-term restoration of the reservoir areas aims to restore a naturally functioning ecosystem that is sustainable without human intervention on a regular basis.  This long-term goal is achieved primarily through establishment of vegetation throughout the reservoir areas and especially along the river and tributaries.  A healthy and vibrant riparian corridor helps improve water quality, reduces thermal load (i.e. shade), stabilizes banks and sediment, slows and filters water, provides fish and wildlife habitat, and provides needed organic matter.  Monitoring for assessing this goal is simply looking at the other monitoring metrics and determining if the reservoir area is trending towards a restored natural ecosystem. If the trend is not towards a restored ecosystem then corrective actions will be determined by the project team to improve the trend.

## 6.2 Framework for Adaptive Management Actions Based on Monitoring

Restoration of natural rivers is an evolving science and requires building in mechanisms to deal with uncertainty. Adaptive management is a comprehensive approach to natural resource management activities where feedback between observation and corrective action is emphasized to address uncertainty, as illustrated in the CDFW adaptive management diagram in Figure 6-1. Through this structured effort, a decision-making framework allows the project monitoring metrics to be interpreted and to take corrective actions as necessary. Likewise, monitoring provides the data necessary for tracking ecosystem health, for evaluating progress towards restoration goals and objectives (i.e., performance measures), and for evaluating and updating problem statements, goals and objectives, conceptual models, and restoration actions. Table 6-4 summarizes a simple framework for making decisions and actions based on monitoring of project metrics.

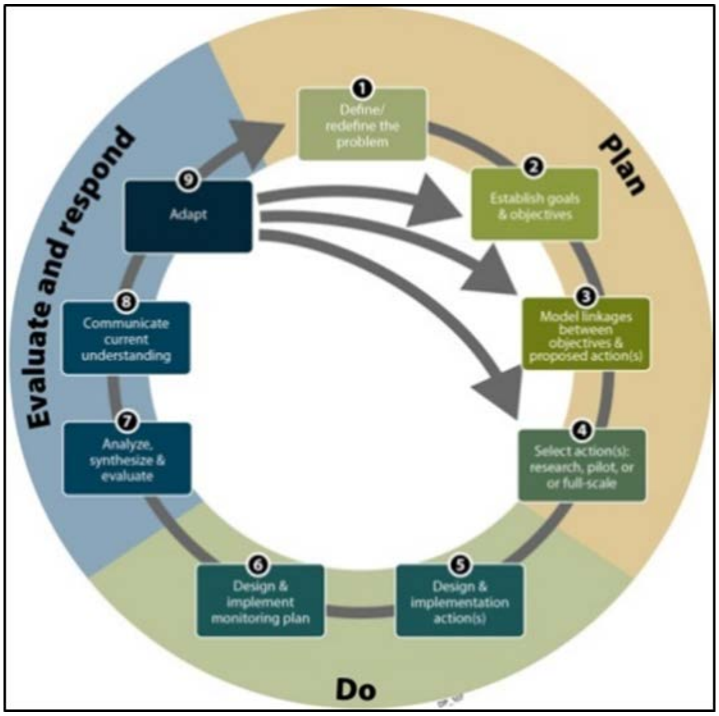



Figure 6-1 CDFW adaptive management diagram

Table 6-4 Monitoring decision making framework

| Conclusion Categories | Decisions and Actions |
|---|---|
| **Conclusion 1 -** Project is meeting objectives based on values of monitoring metric and criteria. | • Evaluate the monitoring program (continue, reduce, or eliminate some metrics) |
| **Conclusion 2 -** Project is trending towards objectives based on values of monitoring metric and criteria. | • Evaluate the monitoring program (continue, reduce, eliminate some metrics)<br>• Confer with project team to evaluate whether rates of progress toward objectives are appropriate |
| **Conclusion 3 -** Project is not meeting (or trending away from) objectives based on monitoring values of performance criteria. | • Evaluate causes<br>• Confer with project team to assess the monitoring program to determine if appropriate data area being collected to assess and evaluate causes<br>• Evaluate whether performance criteria metrics are appropriate<br>• Develop a plan to address problems<br>• Implement the plan and monitor results |

The monitoring plan will include key monitoring attributes that will provide a feedback loop of the trends and trajectory of the restoration efforts used to determine maintenance needs for the project. The project team will notify the regulatory agencies if monitoring demonstrates values outside of outlined thresholds as described in Table 6-5 below. If a monitoring metric is a "Pass", then there is no action required. If, however, the monitoring metric is a "Fail", then the project team will make an evaluation of the failure and a determination of potential maintenance and/or corrective actions dependent upon the severity and type of failure.

### Table 6-5 Monitoring data trends, conclusions and responses for selected metrics

| Metric | Thresholds | Decision Pathway | Corrective Action | Monitoring Technique |
|---|---|---|---|---|
| Longitudinal Stream Continuity | • No unnatural structures | • No unnatural structures (Pass)<br>• Man-made or unnatural structure observed (Fail) | • Remove historical structure if it is problematic | **Visual Inspection** by Photo Points<br>**Physical Survey** may be warranted if metric is found to be outside of threshold. |
| Fish Passage | • No unnatural barriers exceeding 6 inches<br>• No unnatural channel headcut exceeding 6 inches | • No jump height barriers exceeding 6" (Pass)<br>• Barriers/headcut present (Fail) | • Remove or rectify barrier<br>• Restore and stabilize streambed through headcut | **Visual Inspection** by Photo Points<br>**Physical Survey** may be warranted if metric is found to be outside of threshold. |
| Sediment Stability | • No significant sediment erosion or outside normal bank erosion | • No erosion threatening structures (Pass)<br>• Bank erosion threatening structures (Fail) | • Perform stabilization actions to limit/reduce extent of erosion<br>• Perform survey to evaluate trends in instability | **Visual Inspection** by Photo Points**<br>**Physical Survey** may be warranted if metric is found to be outside of threshold. |
| Vegetation coverage | • % cover invasive exotic vegetation<br>• % cover native vegetation | | | **Visual Inspection** by Photo Points<br>**Physical Survey** may be warranted if metric is found to be outside of threshold. |

## 6.3 Data Storage and Reporting

### 6.3.1 Data Storage

Monitoring data will be stored and maintained by KRRC and Klamath Basin Monitoring Program (KBMP), or their designated representative. Data will be maintained in standard database(s), and will be made available to entities as requested and available on the KBMP website (kbmp.net). Data tables and observation forms will be normalized to avoid redundant data and to ensure consistent data formats among sampling events.

### 6.3.2 Data Analysis and Reporting

After each monitoring event, survey data will be analyzed.  A brief site action memorandum will be prepared and provided to KBMP that includes:

- Overview of site conditions,
- Monitoring metric conclusions based on metrics target thresholds, and
- Any maintenance or corrective actions recommended.
- At the end of each monitoring season, an annual memorandum will be prepared that includes:
- Summary of or each monitoring event site action memorandum,
- Monitoring metric conclusions based on metrics target thresholds observed over the season as a whole, and
- Any recommended maintenance or corrective actions.

These annual memos will be made available at the end of each calendar year. If significant issues or concerns are identified, the project team will recommend future actions with sufficient time for planning and permitting prior to the "in water" work window. Lastly, a final monitoring report will be generated to summarize monitoring data collected and adaptive management actions taken over the five years of monitoring including:

- Metrics for which data were collected; including any adjustments made to monitoring program,
- Summary of all monitoring data collected using tables and figures to depict observed trends over three years of monitoring,
- Individual Monitoring Metric Conclusions based of target thresholds observed over three years,
- Narrative discussions to explain results in the context of projects goals, success criteria, and performance standards, and
- Final recommended maintenance and corrective actions.

# 7. References

Auble, G.T., Shafroth, P.B., Scott, M.L. and Roelle, J.E., 2007. Early vegetation development on an exposed reservoir: implications for dam removal. Environmental management, 39(6), pp.806-818.

Bilby, R.E., 1984. Removal of woody debris may affect stream channel stability. Journal of Forestry, 82(10), pp.609-613.

Bilby, R.E. and Ward, J.W., 1989. Changes in characteristics and function of woody debris with increasing size of streams in western Washington. Transactions of the American Fisheries Society, 118(4), pp.368-378.

Bountry, J.A., Lai, Y.G. and Randle, T.J., 2013. Sediment impacts from the savage rapids dam removal, Rogue River, Oregon. Reviews in Engineering Geology, 21, pp.93-104.

Bryant, M.D. and Sedell, J.R., 1995. Riparian forests, wood in the water, and fish habitat complexity. In Condition of the world's aquatic habitats. Proceedings of the World Fisheries Congress, Theme (Vol. 1, pp. 202-224).

Buffington, J.M., 1995. Effects of hydraulic roughness and sediment supply on surface textures of gravel-bedded rivers (Master's thesis, University of Washington).

Buffington, J.M. and Montgomery, D.R., 1999. Effects of hydraulic roughness on surface textures of gravel-bed rivers. Water Resources Research, 35(11), pp.3507-3521.

Chenoweth, J., Acker S.A. and McHenry M.L., 2011. Revegetation and Restoration Plan for Lake Mills and Lake Aldwell. Olympic National Park and the Lower Elwha Klallam Tribe. Port Angeles, WA.

Clewell, A., Rieger, J. and Munro, J., 2005. Guidelines for developing and managing ecological restoration projects, Society for Ecological Restoration International. Tucson, AZ.

D'Antonio, C.M. and Vitousek, P.M., 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual review of ecology and systematics, 23(1), pp.63-87.

Grubb, P.J., 1986. The ecology of establishment. in Ecology and Design in Landscape. Ed. A.D. Bradshaw, D.A. Goode and E. Thorpe, pp. 83-98. Oxford: Blackwell.

Hood, W.G. and Naiman, R.J., 2000. Vulnerability of riparian zones to invasion by exotic vascular plants. Plant ecology, 148(1), pp.105-114.

JC Headwaters, Inc., 2003. Bathymetry and sediment classification of the Klamath Hydropower Project impoundments. Prepared for Pacificorp by JC Headwaters, Inc.

Mussman, E.K., Zabowski, D. and Acker, S.A., 2008. Predicting secondary reservoir sediment erosion and stabilization following dam removal. Northwest Science, 82, pp.236-245.

Sedell, J.R. and Froggatt, J.L., 1984. Importance of streamside forests to large rivers: the isolation of the Willamette River, Oregon, USA, from its floodplain by snagging and streamside forest removal. Verh. Internat. Verein. Limnol, 22, pp.1828-1834.

Shannon and Wilson, Inc., 2006. Upland contaminant source study. Submitted to California State Coastal Conservancy.

Simon, A., Thomas, R.E. and Bell, R.B., 2010. Erodibility characteristics of bottom deposits from three Klamath River reservoirs, California and Oregon. USDA-ARS National Sedimention Laboratory, Oxofrd, MS.

Strauss, T., 2010. Results of geotechnical laboratory studies of reservoir sediment – Klamath dam removal study, California and Oregon, US Bureau of Reclamation, Technical Service Center Memorandum dated July 20, 2010.

Terrestrial Resources (TR), 2004. Final technical report, PacifiCorp, Portland, Oregon.

Urgenson, L.S., Reichard, S.H. and Halpern, C.B., 2009. Community and ecosystem consequences of giant knotweed (Polygonum sachalinense) invasion into riparian forests of western Washington, USA. Biological Conservation, 142(7), pp.1536-1541.

US Army Corps of Engineers, 1987. Wetlands Delineation Manual; U.S. Army Corps of Engineers, Engineer Research and Development Center.

US Bureau of Reclamation, 2010. Klamath River Sediment Sampling Program Phase 1 - Geologic investigations Volume 1 of 2. Mid-Pacific Region, MP-230, US Bureau of Reclamation.

US Bureau of Reclamation, 2011a. Detailed plan for dam removal – Klamath River dams. Klamath Hydroelectric Project FERC License No. 2082 Oregon – California. Prepared for Mid-Pacific Region, US Bureau of Reclamation, Technical Service Center, Denver, CO.

US Bureau of Reclamation, 2011b. Hydrology, hydraulics and sediment transport studies for the Secretary's determination on Klamath River dam removal and basin restoration, Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, US Bureau of Reclamation, Technical Service Center, Denver, CO.

US Bureau of Reclamation, 2011c. Reservoir area management plan for the Secretary's determination on Klamath River dam removal and basin restoration, Technical Report No. SRH-2011-19. Prepared for Mid-Pacific Region, US Bureau of Reclamation, Technical Service Center, Denver, CO.

US Department of Agriculture – Agriculture Research Service (USDA-ARS), 2001. Revised Universal Soil Loss Equation, US Department of Agriculture - Agriculture Research Service (USDA-ARS) Handbook No. 703, Version 1.06b [online].

Walker, L.R. and Del Moral, R., 2003. Primary succession and ecosystem rehabilitation. Cambridge University Press, New York.

Whisenant, S.G. 1999. Repairing Damaged Wildlands: A Process-Oriented, Landscape-Scale Approach. Cambridge University Press, New York.

Wilcove, D.S., Rothstein, D., Dubow, J., Phillips, A. and Losos, E., 1998. Quantifying threats to imperiled species in the United States. BioScience, 48(8), pp.607-615.

Wilcox, A.C., O'Connor, J.E. and Major, J.J., 2014. Rapid reservoir erosion, hyperconcentrated flow, and downstream deposition triggered by breaching of 38 m tall Condit Dam, White Salmon River, Washington. Journal of Geophysical Research: Earth Surface, 119(6), pp.1376-1394.

# Appendix H  Aquatic Resources Measures

AECOM

# Klamath River Renewal Project

**California Environmental Quality Act (CEQA) and California and Oregon 401 Water Quality Certifications Technical Support Document**
**Appendix H – Aquatic Resources Measures**

**Submitted to:** California State Water Resource Control Board and Oregon Department of Environmental Quality

**Submitted by:** Klamath River Renewal Corporation

**Date**: September 2017

**Prepared for:**

Klamath River Renewal Corporation
California State Water Resources Control Board
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# Table of Contents

## Tables

# Executive Summary

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

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

The proposed AR measures include:

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

**AR-2 Outmigrating Juveniles -** To offset reservoir drawdown effects on outmigrating juvenile anadromous salmonids and Pacific lamprey, a sampling, salvage, and relocation effort will be completed to relocate juvenile salmonids, particularly yearling coho salmon, from the Klamath River between Iron Gate Dam and the Trinity River confluence during the fall prior to reservoir drawdown. An adaptive management plan will also be developed to assess and restore tributary-mainstem connectivity in the Hydroelectric Reach and the 8-mile reach from Iron Gate Dam downstream to Cottonwood Creek. The second component of the monitoring and adaptive management plan will include monitoring water quality conditions at 13 key tributary confluences. Juvenile salmonids will be salvaged and relocated to cool water tributaries and off-channel ponds when tributary confluence water temperature exceeds 22°C (7-day average of the daily maximum values) and Klamath River suspended sediment concentration exceeds 665 mg/L. A one-day salvage effort for juvenile fish will be conducted at each tributary confluence area by a 4-person crew and 2 transport trucks.

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

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

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

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

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

# 1. Introduction

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

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

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

# 2. Dam Removal Benefits and Effects

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

## 2.1 Benefits of Recent Dam Removals in the Pacific Northwest

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

### 2.1.1 Fish Access to Historical Habitat

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

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

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

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

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

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

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

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

## 2.2 Anticipated Lower Klamath Project Benefits and Effects

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

Interior, U.S. Department of Commerce and National Marine Fisheries Service [NOAA Fisheries] 2013).

### 2.2.1 Access to Historical Habitat

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

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

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

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

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

*NOAA Fisheries 2013*

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

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

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

*1 FERC 2007*

*2 Fortune et al. 1966*

*3 Chapman 1981*

*4 CDFG 1965*

*5 Coots 1977*

*6 FERC 1963*

### 2.2.1.1 Chinook Salmon

Dam decommissioning will benefit fall Chinook salmon by restoring access to over 300 miles of historical habitat (Table 2-4) in the Klamath Basin upstream from Iron Gate Dam (improving water quality, increasing flow variability downstream from Iron Gate Dam, and reducing disease. Over time, Chinook salmon returns upstream of Keno Dam could be substantial, although fish passage at Keno Dam and habitat quality improvements in the Upper Klamath Basin will be necessary to realize recovery potential.

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

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

*Source: Cunanan 2009*

#### 2.2.1.2 Coho Salmon

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

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

#### 2.2.1.3 Steelhead

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

#### 2.2.1.4 Lamprey

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

### 2.2.2 Water Quality and Water Temperature

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

Elimination of the thermal lag caused by the existing reservoirs, will result in water temperatures more in sync with historical fish migration and spawning periods for the Klamath River, warming earlier in the spring, and cooling earlier in the fall compared to existing conditions (Hamilton et al. 2011). Warmer springtime temperatures would result in fry emerging earlier (Sykes et al. 2009), encountering favorable temperatures for growth sooner than under existing conditions, which could support higher growth rates and encourage earlier emigration downstream, thereby reducing stress and disease (Bartholow et al. 2005; FERC 2007). In addition, fall Chinook salmon spawning in the mainstem during fall would no longer be delayed (reducing pre-spawn mortality), and adult migration would occur in more favorable water temperatures than under existing conditions. For example, groundwater inputs in the J.C. Boyle Bypass Reach are anticipated to account for 30 to 40 percent of the total summer flow following dam removal. Groundwater inputs will have a positive effect on water temperature, benefiting both anadromous and resident fish and other aquatic organisms in the Klamath River.

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

### 2.2.3 Hydrograph

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

### 2.2.4 Disease

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

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

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

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

*Source: USFWS 2016*

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

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

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

Dam removal will also broaden the distribution of adult pre-spawn fall Chinook salmon, reducing crowding and the concentration of disease pathogens that currently occurs in the reach between Iron Gate Dam and the Shasta River (USFWS 2016). Lastly, a broader spawning distribution will also influence the distribution of post-spawn adult carcasses that contribute the bulk of the myxospores that enable the *C. shasta* life cycle within the infectious zone. Distributing adult carcasses over a longer reach of the Klamath River corridor will reduce myxospore densities likely leading to lower juvenile salmonid infection rates in the winter and spring rearing period (USFWS 2016).

### 2.2.5 Nuisance Algae

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

### 2.2.6 Sediment and Debris Transport

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

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

## 2.3 Klamath River Species-specific Benefits

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

## 2.4 Anticipated Klamath River Dam Decommissioning Short-term Effects

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

### 2.4.1 Suspended Sediment Effects

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

### 2.4.2 Bedload Effects

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

### 2.4.3 Dissolved Oxygen Effects

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

### 2.4.4 Effects Analysis

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

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

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

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

*Source: USBR and CDFG 2012*

# 3. AR-1 Mainstem Spawning

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

## 3.1 Proposed Updated AR-1

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

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

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

### 3.1.1 Action 1: Tributary-Mainstem Connectivity

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

#### 3.1.1.1 Tributary-Mainstem Connectivity Monitoring

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

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

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

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

#### 3.1.1.2 Tributary Connectivity Maintenance

Tributary obstructions that limit fish passage will be remedied through appropriate manual or mechanical means. Example removal methods may include removing sediment using hand tools or hydraulic equipment. Removed material will be placed in the mainstem Klamath River downstream of the tributary confluence or on the adjacent floodplain.

### 3.1.2 Action 2: Spawning Habitat Evaluation

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

#### 3.1.2.1 Spawning Habitat Target Metrics

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

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

| Metric | Fall Chinook Salmon | Winter Steelhead |
|---|---|---|
| Anticipated redd loss due to project effects | 2,100 | 179[1] |
| Surface area per spawning redd ($yd^2$) | 21 | 26 |
| Spawning habitat area to address redd loss ($yd^2$) | 44,100 | 4,700 |
| Pacific Lamprey | Significant | Yes |
| Lost River & Shortnose Suckers | Significant | Yes |
| Green Sturgeon | Significant | Yes |
| Freshwater Mussels | Significant | Yes |

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

#### 3.1.2.2 Spawning Habitat Monitoring

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

Tributary streams will be walked from their mouths to the first natural fish passage barrier to estimate amount of available spawning habitat following reservoir drawdown (Table 3-2). The area of available spawning habitat will be estimated from the mouth to the first natural barrier.

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

| Tributary | Tributary Confluence | Tributary Length |
|---|---|---|

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

#### 3.1.2.3 Response to Spawning Habitat Availability

KRCC will prepare a report summarizing the spawning habitat surveys and outline actions to augment spawning habitat if the existing spawning habitat amounts to less than the 44,100 $yd^2$ of mainstem and 4,700 $yd^2$ of tributary spawning habitat targets in the Hydroelectric Reach. KRRC will consult with ATWG for input on potential spawning gravel augmentation locations. Currently, if existing spawning habitat does not meet targets, spawning gravel augmentation will be completed in the mainstem Klamath River between Shovel Creek (RM 209.0) and the upstream extent of Copco Reservoir (RM 208.0). Tributary spawning gravel augmentation will be completed in Jenny Creek, Shovel Creek, Fall Creek, and/or Spencer Creek. Spawning gravel augmentation will be prioritized based on anticipated spawning habitat benefits. Mainstem gravel would be added at a rate of 7.0 cy (21 $yd^2$ x 1 ft depth) per compensatory mainstem redd and 8.6 cy (26 $yd^2$ x 1 ft depth) per compensatory tributary redd. Augmented gravel is anticipated to be redistributed with subsequent high flows, broadening potential spawning habitat over larger areas of the treated mainstem and tributary reaches.

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

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

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

### 3.2.1 AR-1 Affected Species

Species identified in AR-1 include:

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

### 3.2.2 Anticipated Dam Decommissioning Effects on AR-1 Species

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

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

| Species | Life Stage | Likely Effects | Worst Effects |
|---|---|---|---|
| Coho Salmon | Adult Spawning | Loss of 13 redds (0.7-26%)1 | Loss of 13 redds (0.7-26%)1 |
| Chinook Salmon - Fall | Adult Spawning | Loss of 2,100 redds (8%)1 | Loss of 2,100 redds (8%)1 |
| Steelhead - Summer | Migrating Adults | No anticipated mortality | Loss of 0-130 adults (0-9%)1 |
| Steelhead - Winter | Migrating Adults | Loss of up to 1,008 adults (14%)1 | Loss of up to 1,988 adults (28%)1 |
| Pacific Lamprey | Adult Migration and Spawning | High mortality (36%)2 | High mortality (71%)2 |

*Source: USBR and CDFG 2012*

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

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

#### 3.2.2.1 Coho Salmon

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

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

#### 3.2.2.2 Chinook Salmon – Fall Run

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

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

#### 3.2.2.3 Steelhead – Summer and Winter

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

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

#### 3.2.2.4 Pacific Lamprey

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

### 3.2.3 2012 EIS/R AR-1 Actions

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

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

### 3.2.4 KRRC Review of AR-1 for Feasibility and Appropriateness

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

- Feasibility of a weir and trap system during high flows and winter conditions.
- High anticipated mortality associated with trapping, handling, hauling, and releasing adult spawning condition fall Chinook salmon and coho salmon.
- Impacts to wild fish populations inhabiting streams used to relocate captured fish.
- Adult coho salmon location at time of the reservoir drawdowns.
- Chinook salmon with a high hatchery influence would be most affected by the reservoir drawdowns.
- 2012 EIS/R baseline population estimates and effects uncertainty.

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

#### 3.2.4.1 Weir and Trap System Feasibility

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

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

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

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

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

*Source: CDFW 2016*

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

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

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

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

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

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

#### 3.2.4.3 Impacts to Wild Fish Populations Inhabiting Relocation Streams

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

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

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

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

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

#### 3.2.4.4 Adult Coho Salmon Location at Time of the Reservoir Drawdowns

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

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

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

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

##### Steelhead Population Update

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

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

### Pacific Lamprey Population Update

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

### Project Effects Uncertainty

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

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

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

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

## 3.3 AR-1 Summary

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

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

# 4. AR-2 Juvenile Outmigration

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

## 4.1 Proposed Updated AR-2

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

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

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

### 4.1.1 Action 1: Mainstem Salvage of Overwintering Juvenile Salmonids

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

#### 4.1.1.1 Reconnaissance

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

#### 4.1.1.2 Overwintering Juvenile Salmonids Salvage and Relocation

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

### 4.1.2 Action 2: Tributary-Mainstem Connectivity Monitoring

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

#### 4.1.2.1 Tributary-Mainstem Connectivity Monitoring

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

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

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

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

#### 4.1.2.2 Tributary Connectivity Maintenance

Unnatural tributary obstructions that limit volitional fish passage will be remedied through appropriate manual or mechanical means. Example removal methods may include removing sediment using hand tools or hydraulic equipment. Removed material will be placed in the mainstem Klamath River downstream of the tributary confluence or on the adjacent floodplain.

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

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

#### 4.1.3.1 Tributary and Mainstem Water Monitoring and Juvenile Fish Salvage

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

Water temperatures in tributary streams will be monitored beginning March 1 of the drawdown year. Based on previous studies and analysis on the effects of water temperature and suspended sediment on juvenile fish, a tributary water temperature trigger of 22°C (7-day average of the daily maximum values) and Klamath River suspended sediment concentration trigger of 665 mg/L (7-day sustained daily maximum) will be established. Exceeding both water quality thresholds would necessitate capturing fish from confluence areas, loading them to aerated transport trucks, and relocating them to cool water tributaries including, but not limited to, Beaver Creek (RM 163.3), Cade Creek (RM 110.9), Elk Creek (RM 107.2), Tom Martin Creek (RM 144.6), and Sandy Bar Creek (RM 77.8) as well as constructed off-channel ponds located on Seiad Creek (RM 131.9), West Grider Creek (RM 131.8), Camp Creek (RM 57.4), and Stanshaw Creek (RM 77.1). A one-day salvage effort for juvenile fish will be conducted at each tributary confluence area by a 4-person crew and 2 transport trucks.

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

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

### 4.2.1 AR-2 Affected Species

Species identified in AR-2 include:

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

- Steelhead (*O. mykiss*) – Klamath Mountains Province distinct population segment (DPS) – Summer Run: California Species of Special Concern; Tribal Trust Species
- Steelhead (*O. mykiss*) – Klamath Mountains Province DPS – Winter Run: Tribal Trust Species
- Pacific lamprey (*Entosphenus tridentatus)*: California Species of Special Concern; Tribal Trust Species

### 4.2.2 Anticipated Dam Decommissioning Effects on AR-2 Species

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

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

| Species | Life Stage | Likely Effects | Worst Effects |
|---|---|---|---|
| Coho Salmon | Outmigrating Smolts | Loss of 2,668 (3%) | Loss of 6,536 (8%) |
| Chinook Salmon - Fall | Type III Smolts | Loss of 0-189 (<0.02%) | Loss of 0-669 (<0.07%) |
| Steelhead | Age-1+ Rearing1 | Loss of up to 8,200 (14%) | Loss of up to 11,207 (19%) |
| | Age-2+ Rearing | Loss of up to 6,893 (13%) | Loss of up to 9,412 (18%) |
| Pacific Lamprey | Ammocoetes | High mortality (52%)2 | High mortality (71%)2 |

*Source: USBR and CDFG 2012*

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

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

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

#### 4.2.2.1 Coho Salmon

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

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

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

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

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

#### 4.2.2.2 Chinook Salmon – Fall Run

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

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

#### 4.2.2.3 Steelhead – Summer and Winter

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

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

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

#### 4.2.2.4 Pacific Lamprey

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

### 4.2.3 2012 EIS/R AR-2 Actions

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

### 4.2.4 KRRC Review of AR-2 for Feasibility and Appropriateness

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

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

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

#### 4.2.4.1 Trapping Feasibility and Efficiency

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

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

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

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

#### 4.2.4.3 Potential Imprinting and Straying Issues

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

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

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

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

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

### Coho Salmon Smolt Population Estimates and Outmigration Timing

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

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

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

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

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

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

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

### Pacific Lamprey Population Update

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

### Project Effects Uncertainty

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

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

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

## 4.3 AR-2 Summary

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

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

# 5. AR-3 Fall Pulse Flows

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

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

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

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

### 5.1.1 AR-3 Affected Species

Species identified in AR-3 include:

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

### 5.1.2 Anticipated Dam Decommissioning Effects on AR-3 Species

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

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

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

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

*Source: USBR and CDFG 2012*

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

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

#### 5.1.2.1 Coho Salmon

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

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

#### 5.1.2.2 Chinook Salmon – Fall Run

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

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

#### 5.1.2.3 Steelhead – Summer and Winter

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

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

#### 5.1.2.4 Green Sturgeon

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

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

### 5.1.3 2012 EIS/R AR-3 Actions

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

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

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

### 5.1.4 KRRC Review of AR-3 for Feasibility and Appropriateness

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

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

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

#### 5.1.4.1 Uncertainty of Water Availability Prior to Reservoir Drawdown

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

#### 5.1.4.2 Tributary Flows Influencing Tributary Spawning

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

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

#### 5.1.4.3 Water Needs During Reservoir Drawdown

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

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

#### 5.1.4.4 Adult Coho Salmon Locations at Time of Reservoir Drawdown

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

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

#### 5.1.4.5 Green Sturgeon Outmigration Timing

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

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

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

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

#### 5.1.4.7 Project Effects Uncertainty

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

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

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

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

## 5.2 AR-3 Summary

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

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

# 6. AR-4 Iron Gate Hatchery Management

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

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

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

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

### 6.1.1 AR-4 Affected Species

Species identified in AR-4 include:

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

### 6.1.2 Anticipated Dam Decommissioning Effects on AR-4 Species

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

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

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

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

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

### 6.1.3 2012 EIS/R AR-4 Actions

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

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

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

### 6.1.4 KRRC Review of AR-4 for Feasibility and Appropriateness

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

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

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

#### 6.1.4.1 Iron Gate Hatchery Water Supply Uncertainty

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

#### 6.1.4.2 Potential Mortality Associated with Hauling and Releasing Juvenile Salmonids

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

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

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

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

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

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

## 6.2 AR-4 Summary

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

# 7. AR-5 Pacific Lamprey Ammocoetes

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

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

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

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

### 7.1.1 AR-5 Affected Species

Species identified in AR-5 include:

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

### 7.1.2 Anticipated Dam Decommissioning Effects on AR-5 Species

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

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

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

*Source: USBR and CDFG 2012*

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

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

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

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

### 7.1.3 2012 EIS/R AR-5 Actions

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

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

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

### 7.1.4 KRRC Review of AR-5 for Feasibility and Appropriateness

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

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

- Effects to the Pacific lamprey metapopulation.

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

#### 7.1.4.1 Pacific Lamprey Ammocoetes Absence from Salvage Reach

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

#### 7.1.4.2 Effects of Relocated Pacific Lamprey Ammocoetes on Endemic Lamprey Ammocoetes

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

#### 7.1.4.3 Pacific Lamprey Metapopulation

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

## 7.2 AR-5 Summary

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

# 8. AR-6 Suckers

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

## 8.1 Proposed Updated AR-6

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

- **Action 1**: Lost River and shortnose suckers will be sampled in the Klamath River and in Hydroelectric Reach reservoirs in 2017 and 2018. Reservoir sampling will be completed in fall of 2017 and fall of 2018, river sampling will be completed in spring of 2018. The purpose of sampling is to document the abundance and genetics of Lost River and shortnose suckers in the Hydroelectric Reach. Captured fish will be marked with a passive integrated transponder (PIT) tag, fin clipped for genetic material, measured, and released. Recaptured fish will be used to estimate the sucker population abundance. Fin clips will be used to determine the genetics of the sampled fish. USFWS is currently developing genetic markers for Lost River and shortnose suckers.
- **Action 2**: Adult Lost River and shortnose suckers in reservoirs downstream from Keno Dam would be captured and relocated to isolated water bodies in the Klamath Basin. The proposed relocation of rescued suckers to isolated waterbodies is to ensure hybridized suckers do not mix with sucker populations designated as recovery populations in Upper Klamath Lake. An estimated 21 days will be required for sampling, and 14 days will be required for salvage and release efforts. We anticipate salvaging and translocating 100 Lost River and 100 shortnose suckers from each of the three Klamath River reservoirs (600 fish total). The number of translocated fish will not exceed 3,000 fish, which is the capacity of the currently identified recipient waterbody (Tule Lake). The salvage effort will likely translocate less than 10 percent of the sucker populations in the respective reservoirs.

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

### 8.1.1 Action 1: Reservoir and River Sampling

Lost River and shortnose suckers will be sampled in the Hydroelectric Reach reservoirs and the Klamath River in 2017 and 2018. Sampling in both the reservoirs and the Klamath River is anticipated to improve the number of fish encounters since suckers may not spawn every year (Buettner 2000) and the current population demographics are unknown.

Reservoir sampling will be completed in fall of 2017 and fall of 2018 and river sampling will be completed in spring 2018. The intent of the sampling is to document the abundance and genetics of Lost River and shortnose suckers in the Hydroelectric Reach. Sampling will include placing trammel nets in the reservoirs (reservoir sampling) and in Klamath River segments upstream of the reservoirs (river sampling) to determine the abundance and genetics of suckers in the Hydroelectric Reach. Electrofishing or other means of trapping suckers may also be employed if trammel netting is ineffective. Captured fish will be marked with a PIT tag (Burdick 2013), fin clipped for genetic material, measured, and released. Recaptured fish will be used to estimate the size of sucker populations, and fin clips will be used to determine the genetics of the sampled fish. Summary reports will be prepared following each sampling effort and the ATWG will meet to review the sampling data and determine if additional sampling is necessary. Collected data will be stored in a database managed by USFWS or USGS.

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

### 8.1.2 Action 2: Sucker Salvage and Relocation

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

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

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

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

### 8.2.1 AR-6 Affected Species

Species identified in AR-6 include:

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

### 8.2.2 Anticipated Dam Decommissioning Effects on AR-6 Species

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

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

| Species | Life Stage | Likely Effects | Worst Effects |
|---|---|---|---|
| Lost River & Shortnose Suckers | All | Loss of reservoir populations | Loss of reservoir populations |

*Source: USBR and CDFG 2012*

The following section includes a description of species-specific effects adapted from the 2012 EIS/R (Reclamation and CDFG 2012; Vol. I, pp. 3.3-166 to 3.3-168) and other literature.

#### 8.2.2.1 Lost River Suckers and Shortnose Suckers

Lost River and shortnose suckers are endemic to the Upper Klamath Basin (Moyle 2002). The Lost River sucker historically occurred in Upper Klamath Lake (Williams et al. 1985) and its tributaries, and the Lost River watershed, Tule Lake, Lower Klamath Lake, and Sheepy Lake (Moyle 1976). Shortnose suckers historically occurred throughout Upper Klamath Lake and its tributaries (Williams et al. 1985; Miller and Smith 1981). The present distribution of both species includes Upper Klamath Lake and its tributaries (Buettner and Scoppettone 1990), Clear Lake Reservoir and its tributaries (USFWS 1993), Tule Lake, Lost River up to Anderson-Rose Dam (USFWS 1993), and the Klamath River downstream to Copco Reservoir and probably to Iron Gate Reservoir (USFWS 1993). Shortnose sucker occur in Gerber Reservoir and its tributaries, but Lost River sucker do not.

The dam decommissioning project will eliminate existing reservoir habitat used by Lost River and shortnose suckers. The Lost River and shortnose suckers that have been observed in the Hydroelectric Reach reservoirs are believed to be fish that originated in Upper Klamath Lake and moved down through Lake Euwana and the Hydroelectric Reach (Buettner and Scoppettone 1991; Markle et al. 1999; Desjardins and Markle 2000). The populations are not thought to represent a viable, self-supporting populations (Buettner et al. 2006; USFWS 2012), and no longer interact with Upper Klamath Lake populations. The Hydroelectric Reach habitat is not designated critical habitat for either species, and Hydroelectric Reach populations are not part of the species' recovery units (USFWS 2012).

### 8.2.3 2012 EIS/R AR-6 Actions

The 2012 EIS/R AR-6 plan (Vol. I, pp. 3.3-247 to 3.3-248) directed a multi-step process that included a telemetry study to determine sucker locations in the Hydroelectric Reach reservoirs, followed by salvaging Lost River and shortnose suckers during the reservoir drawdowns, and releasing the salvaged suckers into Upper Klamath Lake. If deemed feasible prior to dam decommissioning, Klamath smallscale suckers were to be collected in a 2-mile reach downstream from J.C. Boyle Dam and transported for release into Spencer Creek immediately downstream of the Spencer Creek hook-up road (upper limits for sucker in Spencer Creek; Reclamation and CDFG 2012).

### 8.2.4 KRRC Review of AR-6 for Feasibility and Appropriateness

The KRRC assessed the feasibility and appropriateness of AR-6 through multiple planning meetings held with the ATWG between May and August 2017. During these meetings, current information on Klamath River fisheries was presented and information on other dam removal projects conducted in the western United States were reviewed to understand how the aquatic ecosystem might respond as discussed above. Major concerns voiced by the ATWG regarding the 2012 AR-6 included:

- Genetic integrity of salvaged suckers and effects on recipient populations.
- Relocation site availability.
- Klamath smallscale sucker salvage.
- Designated critical habitat and sink populations.
- Telemetry study feasibility and benefit.
- 2012 EIS/R baseline population estimates and effects uncertainty.

The following sections provide additional information regarding AR-6 feasibility and appropriateness based on fisheries literature and ATWG input.

#### 8.2.4.1 Genetic Integrity of Salvaged Suckers and Effects on Recipient Populations

Klamath reservoir sucker populations have not been formally studied since the late 1990s (see Beak Consultants 1987; 1988; Desjardins and Markle 2000). Current population sizes, age class distribution, and genetic composition of Lost River and shortnose suckers are unknown, although genetic introgression between Lost River and shortnose suckers and Klamath smallscale suckers is suspected (Beak Consultants 1987; Markle et al. 1999). USFWS is concerned that relocating hybridized Lost River and shortnose suckers into Upper Klamath Lake could compromise the genetic integrity of recovery unit populations in Upper Klamath Lake. As Klamath smallscale suckers are very rare in Upper Klamath Lake (one has been found in Upper Klamath Lake; Markle et al. 1999), hybridized Lost River-Klamath smallscale suckers or shortnose-Klamath smallscale suckers in Upper Klamath Lake would create a novel sucker hybrid not known to exist in designated critical habitat (i.e., Klamath Basin upstream from Keno Dam). However, Markle et al. (1999) found more genetic similarity between Lost River suckers and Klamath smallscale suckers, and shortnose suckers and Klamath largescale suckers, although there also geographic-related differences among individuals within the respective species (e.g., Lost River suckers from Lost River and the Upper Klamath subbasins had meristic differences). Markle et al. (1999) concluded that Klamath Basin suckers are part of a species complex, or syngameon, defined as groups of interbreeding species that maintain their ecological, morphological, genetic, and evolutionary integrity in spite of hybridization (Templeton 1989 *cited in* Markle et al. 1999). In these hybrid species complexes, species integrity may be maintained by selection.

Based on the unknown genetic composition of suckers in the Hydroelectric Reach, it was concluded that relocating salvaged suckers to Upper Klamath Lake could threaten recovery populations and alternative release locations are necessary.

#### 8.2.4.2 Relocation Site Availability

Salvaged sucker relocation sites must be isolated from Lost River and shortnose sucker populations inhabiting critical habitat or recovery areas in order to maintain the genetic integrity and health of recovery populations. Although it is unlikely that Lost River and shortnose suckers would have disease and parasite loads different from suckers in Upper Klamath Lake, such concerns further require the separation of salvage fish from recovery populations in the Upper Klamath Basin.

Tule Lake is the most likely relocation site for salvaged suckers. Tule Lake is an agricultural sump that is maintained by agricultural return flow. USFWS currently uses Tule Lake as a relocation site for Lost River and shortnose suckers salvaged from other areas in the basin, and the lake currently has the capacity for an additional 2,000 to 3,000 relocated suckers (J. Rasmussen, USFWS, personal communication, 2017). Management of Tule Lake is complicated by multiple user groups and the periodic need to draw down the reservoir for sediment maintenance. USFWS is currently investigating other potential sucker relocation sites in the Upper Klamath Basin.

We recommend that salvaged suckers be relocated to Tule Lake or another isolated waterbody until Hydroelectric Reach sucker genetics are better understood.

#### 8.2.4.3 Klamath Smallscale Sucker Salvage

Klamath smallscale sucker is a riverine sucker species that historically inhabited the Klamath River below the Keno reef, and the adjacent Rogue River basin (Markle et al. 1999). The species is not known to inhabit Upper Klamath Lake or Upper Klamath Basin tributaries. Klamath smallscale sucker salvage would require sorting and releasing Klamath smallscale suckers at different locations than Lost River and shortnose suckers since the listed suckers are lake-type suckers (Buettner and Scoppettone 1991). ODFW also expressed concern with releasing salvaged Klamath smallscale suckers into Spencer Creek due to competition with the existing Spencer Creek sucker population (T. Wise, ODFW, personal communication, 2017). Although included in the original AR-6, Klamath smallscale sucker is not a federal or state listed species, and is not recognized as a tribal trust species. Therefore, we recommend Klamath smallscale sucker be removed from consideration in the updated AR-6 plan.

#### 8.2.4.4 Designated Critical Habitat and Sink Populations

Hydroelectric Reach reservoirs and Klamath River downstream from Keno Dam were not designated as critical habitat by USFWS (2012). The sucker populations inhabiting the Klamath reservoirs are part of the Upper Klamath Lake Recovery Unit, however, they are sink populations that will likely never be viable and therefore are not actively managed for recovery (USFWS 2012). From a federal regulatory perspective, recovery of Lost River and shortnose suckers does not require preservation of the Hydroelectric Reach reservoirs or the sucker populations within.

#### 8.2.4.5 Telemetry Study

Based on research in Upper Klamath Lake and past studies in the Klamath River reservoirs, USFWS and the U.S. Geological Survey (USGS) are in support of a multi-stage sampling and salvage effort that would use passive integrated transponder (PIT) tag technology to mark suckers. Lost River and shortnose suckers would be netted during a two-year sampling effort (2017 and 2018) and marked to estimate population sizes and demographics for suckers in the Hydroelectric Reach reservoirs. Sampling would occur in the reservoirs in the fall and in reaches of the Klamath River upstream of the reservoirs in the spring. Fall sampling would focus on shallow areas in the reservoirs and spring sampling would target sucker spawning migrations as fish leave the reservoirs and enter river reaches for spawning (Janney et al. 2009; Hewitt et al. 2014). Genetic material collected during the sampling phase would be used to develop genetic profiles of reservoir suckers and inform the sucker relocation effort. Suckers would be relocated during salvage efforts in the spring and fall of 2019. Based on this information, we have concluded the proposed PIT tag study will be more informative and less costly to implement relative to the originally proposed telemetry study.

#### 8.2.4.6 2012 EIS/R Baseline Population Estimates

Desjardins and Markle (2000) provided the most comprehensive population estimates for suckers in the Hydroelectric Reach reservoirs. The number of adult shortnose suckers was estimated to be highest in Copco Reservoir (n=165), followed by J.C. Boyle (n=50), and then Iron Gate (n=22). Larger and older individuals dominated Copco and Iron Gate reservoirs and little size structure was detected. J. C. Boyle tended to have smaller adult shortnose suckers and many size classes were present. It appeared that recruitment of young-of-the-year suckers only occurred in J.C. Boyle with downstream reservoirs recruiting older individuals, perhaps those that had earlier recruited to J.C. Boyle Reservoir.

No new baseline population data have been produced for suckers inhabiting the Hydroelectric Reach reservoirs. However, anecdotal evidence (B. Tinniswood, ODFW, personal communication, 2017) suggests more suckers may inhabit the reservoirs than previously anticipated (e.g., Buettner and Scoppettone 1991; Beak Consultants 1987). USFWS's Abernathy Fish Technology Center, Longview, Washington, is also currently undertaking a genetic analysis of Lost River, shortnose, and other basin sucker species to identify genetic markers that may be used to differentiate suckers in the future. The Abernathy lab is anticipated to produce a report on sucker genetics by summer of 2018.

## 8.3 AR-6 Summary

The Klamath River dam decommissioning project is anticipated to have significant short-term effects on Lost River and shortnose suckers in the Hydroelectric Reach. Because the reservoirs will be restored to free-flowing historical conditions and the special-status suckers are lake-type suckers, individuals of these species that remain in the Hydroelectric Reach following dam removal are not expected to survive. The 2012 EIS/R AR-6 measure included a telemetry study to assess potential sucker locations in the Hydroelectric Reach, followed by a sucker salvage effort to remove fish from the reservoirs and transport them to Upper Klamath Lake for release. Several concerns were identified with the 2012 AR-6 plan, including the genetic integrity of Hydroelectric Reach suckers, relocation site availability, the need to salvage Klamath smallscale suckers, and the feasibility and benefit of the proposed telemetry study. We concluded that the basis of these concerns could result in the originally proposed AR-6 measure negatively affecting the recovery of Lost River and shortnose sucker populations in Upper Klamath Lake. Therefore, it was determined that additional actions in the form of an updated AR-6 are warranted.

The updated AR-6 plan, prepared by the KRRC and supported by the ATWG, includes two primary actions including reservoir and river sampling, and sucker salvage and release into appropriate waterbodies selected by fisheries managers. The proposed actions are anticipated to maximize the survival of Lost River and shortnose suckers currently inhabiting the Hydroelectric Reach. The number of translocated fish will not exceed 3,000 fish, which is the capacity of the currently identified recipient waterbody (Tule Lake). The salvage effort will likely translocate less than 10 percent of the sucker populations in the respective reservoirs.

# 9. AR-7 Freshwater Mussels

The objective of AR-7 is to address reservoir drawdown and dam removal effects on freshwater mussels located in the Klamath River in the Hydroelectric Reach and downstream from Iron Gate Dam (RM 192.9). The 2012 EIS/R AR-7 measure focused conducting a freshwater mussel relocation pilot study followed by the salvage and relocation of freshwater mussels prior to reservoir drawdown. Salvaged mussels were to be held in a temporary location for later placement following reservoir drawdown, and placed in locations that would not be affected by the reservoir drawdown. Based on a review of the provided information herein, the KRRC and the ATWG concluded that a moderate scale freshwater mussel relocation effort is warranted. The updated AR-7 includes a freshwater mussel reconnaissance in 2018 followed by a limited freshwater mussel salvage in 2019 prior to reservoir drawdown. Freshwater mussels will be salvaged from the 8-mile long Iron Gate Dam (RM 192.9) to Cottonwood Creek (RM 184.9) reach, and translocated to the Klamath River between the upstream extent of J.C. Boyle Reservoir (RM 233.0) and Keno Dam (RM 238.2).

## 9.1 Proposed Updated AR-7

Based on a review of the original 2012 EIS/R AR-7 measure presented in Section 9.2, input from the ATWG, and current freshwater mussels literature, the KRRC concluded that an updated AR-7 is necessary to offset the anticipated short-term effects of dam decommissioning on freshwater mussels. The updated AR-7 includes a reconnaissance, salvage, and relocation of freshwater mussels from the 8-mile reach between Iron Gate Dam and the Cottonwood Creek confluence with the Klamath River. The monitoring and adaptive management plan has two specific actions.

- **Action 1**: A reconnaissance will be completed in 2018 to assess the distribution and density of freshwater mussels in the 8-mile long bedload deposition reach from Iron Gate Dam (RM 192.9) downstream to the Cottonwood Creek confluence (RM 184.9). The reconnaissance will confirm mussel beds identified in the 2007-2010 surveys and estimate abundance at a subset of the mussel beds in the reach.
- **Action 2**: Based on the reconnaissance, a portion of the freshwater mussels located between Iron Gate Dam and Cottonwood Creek will be salvaged and relocated to reduce dam decommissioning effects to the mussel community. Approximately 15,000 to 20,000 mussels are planned for translocation to appropriate habitats in the Klamath River between the upstream extent of J.C. Boyle Reservoir (RM 233.0) and Keno Dam (RM 238.2). The proposed number of translocated mussels is likely less than 10 percent of freshwater mussels in the mainstem Klamath River in the Hydroelectric Reach and downstream from Iron Gate Dam.

The proposed actions are intended to reduce Project effects on freshwater mussels located downstream from Iron Gate Dam. The following sections provide additional detail on the proposed actions.

### 9.1.1 Action 1: Freshwater Mussel Reconnaissance

The KRRC will prepare a reconnaissance plan to assess freshwater mussels in the Iron Gate Dam to Cottonwood Creek reach in 2018. Habitat conditions will also be evaluated from the upstream extent of J.C. Boyle Reservoir (RM 233.0) upstream to Keno Dam (RM 238.2) to determine the habitat capacity for translocated mussels. An existing freshwater mussel data set (base data for Davis et al. 2013), compiled by the Karuk Tribe, USFWS, and other collaborators from 2007 to 2010 for the Klamath River downstream from Iron Gate Dam, will be reviewed and used to plan the reconnaissance. The reconnaissance will confirm mussel beds identified in the 2007-2010 surveys and estimate abundance at a subset of the mussel beds locations. Habitat metrics in the potential translocation reach will be evaluated to maximize translocation success. The freshwater mussel reconnaissance and translocation reach habitat assessment are anticipated to take 5 days

### 9.1.2 Action 2: Freshwater Mussel Salvage and Relocation

The KRRC will coordinate and implement a freshwater mussel salvage plan with freshwater mussel specialists. Based on the reconnaissance, a portion of the freshwater mussels located between Iron Gate Dam and Cottonwood Creek will be salvaged and relocated to reduce dam decommissioning effects to the freshwater mussel community. The freshwater mussel salvage and translocation effort is anticipated to require 10 days. The percentage of the existing mussel beds that will be salvaged and translocated is predicated on the available habitat in the Klamath River from the upstream extent of J.C. Boyle Reservoir to Keno Dam, and the abundance of mussels between Iron Gate Dam and Cottonwood Creek. Approximately 15,000 to 20,000 mussels are planned for translocation. The proposed number of translocated mussels is likely less than 10 percent of freshwater mussels in the mainstem Klamath River in the Hydroelectric Reach and downstream from Iron Gate Dam.

## 9.2 Summary of the 2012 EIS/R AR-7, Dam Removal Benefits and Effects, and Recent Fisheries Literature

The following sections review the components of the 2012 EIS/R AR-7 measure, anticipated dam removal effects and benefits on freshwater mussels, and current freshwater mussels literature.

### 9.2.1 AR-7 Affected Species

Species identified in AR-7 include:

- Oregon floater (Anodonta oregonensis)
- California floater (A. californiensis)
- Western ridged mussel (Gonidea angulata)
- Western pearlshell mussel (Margaritifera falcata)

### 9.2.2 Anticipated Dam Decommissioning Effects on AR-7 Species

Short-term effects of dam removal (prolonged exposure to high suspended sediment levels and bedload movement) are predicted to be deleterious to freshwater mussels in the

Hydroelectric Reach and in the lower Klamath River downstream from Iron Gate Dam (Reclamation and CDFG 2012). Substantial freshwater mussel population reductions are expected due to sediment effects and possibly low dissolved oxygen levels. The change in hydrological properties following dam removal may also disrupt the current distribution of freshwater mussels downstream from Iron Gate Dam (Davis et al. 2013). Table 9-1 includes the likely and worst-case effects on freshwater mussel species in the Klamath River.

**Table 9-1 2012 EIS/R anticipated effects summary for freshwater mussels**

| Species | Life Stage | Likely Effects | Worst Effects |
|---|---|---|---|
| California Floater<br>Oregon Floater<br>Western Ridged<br>Western Pearlshell | All | Substantial reduction in populations | Substantial reduction in populations |

*Source: USBR and CDFG 2012*

The following sections include descriptions of anticipated effects to freshwater mussels adapted from the 2012 EIS/R (Reclamation and CDFG 2012; Vol. 1, pp. 3.3-173 to 3.3-175) and augmented with information from other freshwater mussel studies.

#### 9.2.2.1 Freshwater Mussels

Past studies evaluated Klamath River Basin freshwater mussel age structure, growth rates, and size distribution (*G. angulata*; Tennant 2010); population distribution and habitat use (Krall 2010; Davis et al. 2013; May and Pryor 2015); and habitat associations (Westover 2010; Davis et al. 2013). Klamath River mussels are long lived (from 10 to more than 100 years, depending on species) and may not reach sexual maturity until 4 years of age or more. *Anodonta* species are found primarily downstream from Iron Gate Dam, and likely benefit from the stable hydrology and fine sediment deposits attributed to hydroregulation below the dam (Davis et al. 2013). *G. angulata* is the most abundant freshwater mussel in the Klamath River and the species is widely distributed between Iron Gate Dam and the Trinity River (Westover 2010; Davis et al. 2013). *M. falcata* is the least abundant freshwater mussel found in the Klamath River and seems to be mostly found downstream from the confluence of the Salmon River (Westover 2010; Davis et al. 2013).

Freshwater mussel tolerance of high suspended sediment, low dissolved oxygen, and bedload deposition are not well understood. Vannote and Minshall (1982) evaluated freshwater mussels in an aggrading river system in Idaho and concluded that *G. angulata* appear to be better adapted for aggrading rivers based on siphon positions, shell morphology, and foot placement in the underlying substrate. *M. falcata* seemed to be less adapted for aggrading rivers due to a less developed siphon for filtering water. *M. falcata* also rarely burrow into substrate more than 25-40 percent of the valve length which may increase the mussel's susceptibility to scour (Vannote and Minshall 1982). *G. angulata* migrate vertically in the channel bed and are capable of maintaining position near the channel bed surface (Vannote and Minshall 1982). *M. falcata* are not known to migrate and are therefore more susceptible to sediment burial. *Anodonta* species are likewise susceptible to sediment scour and burial due to their thinner shells. Mussels that are dislodged from their normal vertical position and fall onto their sides may not regain the normal position and may perish (Vannote and Minshall 1982).

Mussels play important roles in aquatic ecosystems. Mussels influence water quality, nutrient cycling, and habitat and are also known as "ecosystem engineers" that actively modify their environment (Xerces Society 2009; Lopes-Lima et al. 2016; Lummer et al. 2016). They filter fine sediment and organic particles, create byproducts that are food items for macroinvertebrates, and comprise the greatest proportion of animal biomass in some waterbodies (Xerces Society 2009). In the Klamath River Basin, freshwater mussels filter and sequester toxins including toxigenic algae microsystins (Kann et al. 2010) and mercury (Bettaso and Goodman 2010). Filtration of waterborne toxins may result in bioaccumulation in freshwater mussels leading to human consumption risks (Bettaso and Goodman 2010; Kann et al. 2010).

The dam decommissioning project is anticipated to result in high suspended sediment levels and bedload deposition in the 8 miles of the Klamath River between Iron Gate Dam and Cottonwood Creek. Extremely poor water quality due to high suspended sediment concentrations is expected in the first 2 miles of the Klamath River downstream from Iron Gate Dam (Reclamation and CDFG 2012). Fine sediment effects on freshwater mussels include gill clogging, possible growth reduction, and impairment to mussel larval stages (Lummer et al. 2016). Due to both the anticipated deleterious high suspended sediment concentrations and low dissolved oxygen levels, freshwater mussels downstream from Iron Gate Dam may experience substantial mortality with the most significant impacts anticipated to mussels located immediately downstream from Iron Gate Dam.

Over the long-term, freshwater mussels are expected to benefit from the dam decommissioning through the conversion of Hydroelectric Reach reservoirs to gravel bed rivers which will restore freshwater mussel habitat, reduce water quality and water temperature impairments related to the reservoirs, and restore access for anadromous and resident host fish species that will distribute freshwater mussel larvae throughout the Klamath River upstream from Iron Gate Dam. However, due to the long time freshwater mussels take to reach sexual maturity, the recolonization and/or growth of existing freshwater mussel populations upstream of Iron Gate Dam may be slow and may not be readily noticeable for some time.

### 9.2.3 2012 EIS/R AR-7 Actions

The 2012 EIS/R AR-1 plan (Vol. I, pp. 3.3-248 to 3.3-249) directed the salvage of freshwater mussels from the Hydroelectric Reach and downstream from Iron Gate Dam. Salvaged mussels were to be relocated to suitable instream habitat unaffected by high suspended sediment concentrations, or could be placed in temporary facilities and returned to the Klamath River following the dam decommissioning project. A salvage and relocation pilot study was also suggested to assess salvage feasibility and relocated mussel survival. Based on the pilot study results, a detailed salvage and relocation plan was to be developed.

### 9.2.4 KRRC Review of AR-7 for Feasibility and Appropriateness

The KRRC assessed the feasibility and appropriateness of AR-7 through multiple planning meetings held with the ATWG between May and August 2017. During these meetings, current information on Klamath River fisheries was presented and information on other dam removal projects conducted in the western United States was reviewed to understand how the aquatic ecosystem might respond, as discussed above. Concerns voiced by the ATWG regarding the 2012 AR-7 included:

- Unfamiliarity with successful freshwater mussel relocation efforts.
- Disease transmission concerns.

The following sections provide additional information regarding AR-7 feasibility and appropriateness, based on fisheries literature and ATWG input.

#### 9.2.4.1 Unfamiliarity with Successful Freshwater Mussel Relocation Efforts

The ATWG was unfamiliar with successful freshwater mussel translocation efforts. Anecdotal information discussed during the ATWG planning meeting (Yreka, CA, May 23, 2017) alluded to low translocation success for the Elwha Dam Removal Project and highway construction projects. Additional information was acquired by the KRRC on the Elwha Dam Removal Project freshwater mussel (*M. falcata*) translocation. Freshwater mussels were translocated to two sites and remained in one site prior to the dam removal project (P. Crain, U.S. Park Service, personal communication, 2017). The relocated freshwater mussels had high survival following the translocation and prior to the dam removals. Subsequent events that impacted the translocated mussels resulted in high mussel mortality. The events included raccoon predation due to shallow habitat at the first translocation site, and excessive sediment deposition at a side channel translocation site. The third monitored site was an artificial outfall channel from the water treatment facility that went dry due to inadvertent project operations. Mussels that remained in the Elwha River downstream from Elwha Dam are suspected to have experienced high mortality due to excessive sediment deposition following dam removal, followed by channel scour during the post-dam sediment sorting process.

Freshwater mussel translocation project monitoring results are not well represented in the fisheries literature. Unpublished freshwater mussel translocation monitoring manuscripts were reviewed to better understand the range of potential translocation success. Fernandez (2013) described the translocation success of 265 individual *M. falcata* in coastal southwest Washington. Between 55 percent and 95 percent of the transplanted *M. falcata* were accounted for in the translocation sites between one and three years following the translocation.

Seventeen percent of *G. angulata* translocated to a site downstream of a channel reconstruction project on the Upper Truckee River, were relocated three years after the translocation effort.

A review of translocation projects found mean mortality of relocated mussels was 49 percent based on an average recovery rate of 43 percent (Cope and Waller 1995). Cope and Waller (1995) found that survival of relocated mussels was generally poor and the factors influencing the survival of relocated mussels were poorly understood. For mussel relocation to be successful, more consideration must be given to habitat characterization at both the source and translocation sites. Olden et al. (2010) and Germano et al. (2015) offer considerations for successful freshwater organism and wildlife translocation efforts, respectively Luzier and Miller (2009) offer suggestions and considerations for freshwater mussel translocations.

#### 9.2.4.2 Disease Transmission Concerns

The role of freshwater mussels in freshwater disease transmission is not well understood. Freshwater mussels are known to provide habitat for polychaete works, one of the hosts in the life *C. shasta*. Polychaetes have been infrequently collected from freshwater mussel shells in the Hydroelectric Reach of the Klamath River (PacifiCorp 2004). Mussels may serve as a vector for other fish pathogens like *Flavobacterium columnare* and *Ichthyophthirius multifiliis* that are endemic to the Klamath River Basin (K. Kwak, CDFW, personal communication 2017).

Freshwater mussels inhabit the Klamath River upstream from Iron Gate Dam (Byron and Tupen 2017) and in tributaries upstream (Byron and Tupen 2017) and downstream from Iron Gate Dam (Davis et al. 2013; Howard et al. 2015; May and Pryor 2015), disease transmission may be less of a concern.

## 9.3 AR-7 Summary

The Klamath River dam decommissioning project is anticipated to have significant short-term effects, but long-term benefits for freshwater mussels. The 2012 EIS/R AR-7 mitigation plan included a freshwater mussel salvage and relocation pilot study followed by an informed salvage and relocation plan prior to the dam decommissioning. The updated AR-7 measure includes completing a reconnaissance of existing freshwater mussels from Iron Gate Dam to Cottonwood Creek and potential relocation habitat between the upstream extent of J.C. Boyle Reservoir and Keno Dam. Freshwater mussels will be salvaged and relocated in 2019 prior to the reservoir drawdown. Approximately 15,000 to 20,000 mussels are planned for translocation. The proposed number of translocated mussels is likely less than 10 percent of freshwater mussels in the mainstem Klamath River in the Hydroelectric Reach and downstream from Iron Gate Dam.

# 10. References

## 10.1 10.1 Introduction

U.S. Bureau of Reclamation [USBR], and California Department of Fish and Game [CDFG]. 2012. Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report. Volume I and Volume II. 3063 pp. https://klamathrestoration.gov/Draft-EIS-EIR/download-draft-eis-eir.

## 10.2 Dam Removal Benefits and Effects

Allen, M.B, R.O. Engle, J.S. Zendt, F.C. Shrier, J.T. Wilson, and P.J. Connolly. 2016. Salmon and steelhead in the White Salmon River after the removal of Condit Dam – planning efforts and recolonization results. Fisheries 41:190-203.

Anderson J.H., P.L. Faulds, K.D. Burton, M.E. Koehler, W.I. Atlas, and T.P. Quinn. 2015. Dispersal and productivity of Chinook (Oncorhynchus tshawytscha) and coho (Oncorhynchus kisutch) salmon colonizing newly. Can. J. Fish. Aquat. Sci. 72(3):454-465.

Anderson, J. H., G.R. Pess, P.M. Kiffney, T.R. Bennett, P.L. Faulds, W.I. Atlas, T.P. Quinn. 2013. Dispersal and tributary immigration by juvenile coho salmon contribute to spatial expansion during colonization. Ecology of Freshwater Fish 22:30-42.

Anderson, J. H., and T. P. Quinn. 2007. Movements of adult coho salmon (Oncorhynchus kisutch) during colonization of newly accessible habitat. Canadian Journal of Fisheries and Aquatic Sciences 64:1143–1154

Bartholow, J.M., S.G. Campbell, and M. Flug. 2004. Predicting the thermal effects of dam removal on the Klamath River. Environmental Management 34:856-874.

Bartholow, J.M., S.G. Campbell, and M. Flug. 2005. Predicting the thermal effects of dam removal on the Klamath River. Environmental Management 34:856-874.

Bartholomew, J.L., and J.S. Foott. 2010. Compilation of information relating to myxozoan disease effects to inform the Klamath Basin Restoration Agreement. Department of Microbiology, Oregon State University, Corvallis, and U.S. Fish and Wildlife Service, California-Nevada Fish Health Center.

Beeman, J.W., Stutzer, G.M., Juhnke, S.D., Hetrick, N.J. 2008. Survival and migration behavior of juvenile coho salmon in the Klamath River relative to discharge at Iron Gate Dam, 2006. Open-File Report 2008-1332. U.S. Geological Survey.

Burton, KD., L.G. Lowe, H.B. Berge, H.K. Barnett, and P.L. Faulds. 2013. Comparative dispersal patterns for recolonizing Cedar River Chinook salmon above Landsburg Dam, Washington, and the source population below the dam. Trans. Am. Fish. Soc. 142:703–716.

California Department of Fish and Game [CDFG]. 1965. California Fish and Wildlife Plan, Volume III, Supporting Data, Part B. Inventory (Salmon-Steelhead and Marine Resources): 429 pp.

Cech, J.J., Jr. and Myrick, C.A. (1999) Steelhead and chinook salmon bioenergetics: temperature, ration, and genetic effects. Technical Completion Report. UCAL-WRC-W-885, University of California Water Resources Center, Davis, CA, 72 pp.

Chapman, D.W. 1981. Pristine production of anadromous salmonids – Klamath River. Final consultant report to the Bureau of Indian Affairs. Bureau of Indian Affairs, U.S. Department of the Interior, Portland, Oregon. July 1981.

Coots, M. 1977. Klamath River Anadromous Fisheries. Draft comments prepared in reference to the People vs. Ederhardt case in Del Norte County Superior Court., California Department of Fish and Game: 63 p.

Cunanan, M. 2009. Historic anadromous fish habitat estimates for Klamath River mainstem and tributaries under Klamath Hydropower reservoirs. U.S. Fish and Wildlife Service, Arcata, California.

Department of the Interior [DOI]. 2007. Modified terms and conditions, and prescriptions for fishways filed pursuant to sections 4(e) and 18 of the Federal Power Act with the Federal Energy Regulatory Commission for the Klamath River Hydroelectric Project No. 2082. Bureau of Land Management, Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service. Sacramento, California.

Department of the Interior, U. S. Department of Commerce, and National Marine Fisheries Service [NOAA Fisheries]. 2013. Klamath Dam Removal Overview Report for the Secretary of the Interior an Assessment of Science and Technical Information, Version 1.1, March 2013.

Dunsmoor L.K., and C.W. Huntington. 2006. Suitability of environmental conditions within Upper Klamath Lake and the migratory corridor downstream for use by anadromous salmonids. Technical Memorandum. Klamath Tribes, Chiloquin, Oregon.

Engle, R. O., J. Skalicky, and J. Poirier. 2013. Translocation of lower Columbia River fall Chinook Salmon (Oncorhynchus tshawytscha) in the year of Condit Dam removal and year one postremoval assessments. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, 2011 and 2012 Report, Vancouver, Washington.

Federal Energy Regulatory Commission [FERC]. 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027. FERC/EIS-0201F. FERC, Office of Energy Projects, Division of Hydropower Licensing, Washington, DC.

Federal Energy Regulatory Commission [FERC]. 1963. Opinion and order for petition to require licensee to construct, operate, and maintain a fish hatchery, amending license, and directing revised filings, Opinion No. 381, Issued March 14, 1963. Washington D.C., Formerly Federal Power Commission: 1-13.

Fortune, J.D., A.R. Gerlach, and C.J. Hanel. 1966. A study to determine the feasibility of establishing salmon and steelhead in the Upper Klamath Basin. Oregon State Game Commission and Pacific Power and Light Company, Portland, Oregon.

Greig, S.M., D.A. Sear, and P.A. Carling. 2005. The impact of fine sediment accumulation on the survival of incubating salmon progeny: Implications for sediment management. Science of the Total Environment 344: 241-258.

Hamilton, J. et al. 2011. Synthesis of the Effects to Fish Species of Two Management Scenarios for the Secretarial Determination on Removal of the Lower Four Dams on the Klamath River – Final Draft. Prepared by the Biological Subgroup (BSG) for the Secretarial Determination (SD) Regarding Potential Removal of the Lower Four Dams on the Klamath River.

Hatten, J. R., T.R. Batt, J.J. Skalicky, R. Engle, G J. Barton, R.L. Fosness, and J. Warren. 2015. Effects of dam removal on Tule fall Chinook salmon spawning habitat in the White Salmon River, Washington. River Research and Applications 32(7): 1481-1492.

Huntington, C.W. 2004. Klamath River flows within the J.C. Boyle Bypass and below the J.C. Boyle Powerhouse. Clearwater BioStudies, Canby, Oregon.

Huntington, C.W. 2006. Estimates of anadromous fish runs above the site of Iron Gate Dam. Clearwater BioStudies, Inc., Canby, Oregon.

Kiffney, P.M., G.R. Pess, J.H. Anderson, P. Faulds, K. Burton, and S.C. Riley. 2009. Changes in fish communities following recolonization of the Cedar River, WA USA by Pacific salmon after 103 years of local extirpation. River Res. Appl. 25 (4):438–452.

Levasseur, M., N.E. Bergeron, M.F. Lapointe, and F. Berube. 2006. Effects of silt and very fine sand dynamics in Atlantic salmon (Salmo salar) redds on embryo hatching success. Canadian Journal of Fisheries and Aquatic Sciences 63:1450-1459.

Liermann, M., G. Pess, M. McHenry, J. McMillan, M. Elofson, T. Bennett, and R. Moses. 2017. Relocation and Recolonization of Coho Salmon in Two Tributaries to the Elwha River: Implications for Management and Monitoring, Transactions of the American Fisheries Society 146:(5)955-966.

McHenry, M., G. Pess, J. Anderson, and H. Hugunin. 2017. Spatial distribution of Chinook Salmon (Oncorhynchus tshawytscha) spawning in the Elwha River, Washington State during dam removal and early stages of recolonization (2012-2016).

Department of the Interior, U. S. Department of Commerce, National Marine Fisheries Service [NOAA Fisheries]. 2007. Magnuson-Stevens Reauthorization Act Klamath River Coho Salmon Recovery Plan. Prepared by Rogers, F.R., I.V. Lagomarsino and J.A. Simondet for the National Marine Fisheries Service, Long Beach, California. 48 p.

Department of the Interior, U. S. Department of Commerce, and National Marine Fisheries Service [NOAA Fisheries]. 2013. Klamath Dam Removal Overview Report for the Secretary of the Interior an Assessment of Science and Technical Information, Version 1.1, March 2013.

North Coast Regional Water Quality Control Board (NCRWQCB). 2010. Action plan for the Klamath River Total Maximum Daily Loads addressing temperature, dissolved oxygen, nutrient, and microcystin impairments in the Klamath River, California, and Site-specific objectives for dissolved oxygen in the Klamath River in California, and implementation plans for the Klamath and Lost River basins. NCRWQCB, Santa Rosa, California. Sykes, G.E., C.J. Johnson, and J.M. Shrimpton. 2009. Temperature and flow effects on migration timing of Chinook salmon smolts. Transactions of the American Fisheries Society 138:1252-1265.

Oregon Department of Fish and Wildlife [ODFW]. 2011. Rogue River Chinook salmon spawning redd survey data. Unpublished data.

PacifiCorp. 2004. Klamath Hydroelectric Project (FERC project no. 2082): fish resources. Final technical report Prepared by PacifiCorp, Portland, Oregon.

Spina, A. P. 2007. Thermal ecology of juvenile steelhead in a warm-water environment. Environmental Biology of Fishes 80:23–34.

Tonra, C.M., K. Sager-Fradkin, S.A. Morley, J.J. Duda, and P.P. Marra. 2015. The rapid return of marine-derived nutrients to a freshwater food web following dam removal. Biological Conservation 192:130-134.

True, K., Voss, A., and J.S. Foott. 2016. Myxosporean parasite Prevalence of infection in Klamath River Basin juvenile Chinook salmon, April–July 2015. California–Nevada Fish Health Center, US Fish and Wildlife Service, Anderson, California.

U.S. Bureau of Reclamation [USBR]. 2011. Appendix E – an analysis of potential suspended sediment effects on anadromous fish in the Klamath Basin. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado. 70 pp.

U.S. Bureau of Reclamation [USBR], and California Department of Fish and Game [CDFG]. 2012. Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report. Volume I and Volume II. 3063 pp. https://klamathrestoration.gov/Draft-EIS-EIR/download-draft-eis-eir.

U.S. Fish and Wildlife Service [USFWS]. 2016. Response to Request for Technical Assistance – Prevalence of C. shasta Infections in Juvenile and Adult Salmonids. Unpublished memo to D. Hillemeier, Yurok Tribal Fisheries, and Craig Tucker, Karuk Department of Natural Resources. 17 pp.

**Personal Communication**

T. Williams, NOAA Fisheries. September 6, 2017. Personal communication with T. Brandt regarding dam removal benefits for adult and juvenile salmonids, and additional input regarding Aquatic Mitigation Measures.

## 10.3 AR-1 Mainstem Spawning

Ackerman, N.K., B. Pyper, S. Cramer, and I. Courter. 2006. Estimation of returns of naturally produced coho to the Klamath River – review draft Technical Memorandum #1 of 8 Klamath Coho Integrated Modeling Framework Technical Memorandum Series.

Bigelow, M. D. Portz, and Z. Jackson. 2013. Trap and Haul of Adult Fall Run Chinook. Final 2014 Monitoring and Analysis Plan. San Joaquin River Restoration Program. 31 pp.

Bjornn, T., and D. Reiser. 1991. Habitat requirements of salmonids in streams. In Meehan, W. ed., Influences of Forest and Rangeland Management on Salmonids Fishes and Their Habitat. American Fisheries Society Special Publication 19. pp. 83-138.

Busby, P.J., T.C. Wainwright, and R.S. Waples. 1994. Status review for Klamath Mountains Province steelhead. NOAA Technical Memorandum NMFS-NWFSC-19. National Marine Fisheries Service, Seattle, Washington.

California Department of Fish and Wildlife [CDFW]. 2016 Annual Report – Iron Gate Hatchery, 2015 – 2016. 38 pp.

California Department of Fish and Wildlife [CDFW]. 2017. Unpublished data – coho salmon spawning returns to Bogus Creek, Shasta River, and Scott River.

Carter, K. 2005. The effects of dissolved oxygen on steelhead trout, coho salmon, and Chinook salmon-Biology and function by life stage: California Regional Water Quality Control Board North Coast Region report, 9 p.

Chapman J.M., C.L. Proulx, M.A. Veilleux, C. Levert, S. Bliss, M.E. Andre, N.W.R. Lapointe, and S.J. Cooke. 2014. Clear as mud: a meta-analysis on the effects of sedimentation on freshwater fish and the effectiveness of sediment-control measures. Water Res 56:190–202.

Fortune, J.D., A.R. Gerlach, and C.J. Hanel. 1966. A study to determine the feasibility of establishing salmon and steelhead in the Upper Klamath Basin. Oregon State Game Commission and Pacific Power and Light Company, Portland, Oregon.

Geist, D.R., A.H. Colotelo, T.J. Linley, K.A. Wagner, and A.L. Miracle. 2016. Physical, physiological, and reproductive effects on adult fall Chinook Salmon due to passage through a novel fish transport system. Journal of Fish and Wildlife Management 7(2):1-12.

Goodman, D.H., and S.B. Reid. 2012. Pacific Lamprey (Entosphenus tridentatus) Assessment and Template for Conservation Measures in California. U.S. Fish and Wildlife Service, Arcata, California. 117 pp.

Hopelain, J.S. 1998. Age, growth, and life history of Klamath Basin steelhead trout (Oncorhynchus mykiss irideus) as determined from scale analysis. Inland Fisheries Administration Report 98-3. California Department of Fish and Game, Sacramento.

Huntington, C.W. 2004. Klamath River flows within the J.C. Boyle Bypass and below the J.C. Boyle Powerhouse. Clearwater BioStudies, Canby, Oregon.

Huntington, C.W. 2006. Estimates of anadromous fish runs above the site of Iron Gate Dam. Clearwater BioStudies, Inc., Canby, Oregon.

Keefer M.L., G.A. Taylor, D.F. Garletts, G.A. Gauthier, T.M. Pierce, and C.C. Caudill. 2010. Prespawn mortality in adult spring Chinook salmon outplanted above barrier dams. Ecol. Freshw. Fish 19(3):361-372.

Kinziger, A.P., M. Hellmair, D.G. Hankin, and J. Carlos Garza. 2013. Contemporary Population Structure in Klamath River Basin Chinook Salmon Revealed by Analysis of Microsatellite Genetic Data, Transactions of the American Fisheries Society, 142(5):1347-1357.

Kjelland, M.E., C.M. Woodley, T.M. Swannack, and D.L. Smith. 2015. A review of the potential effects of suspended sediment on fishes: potential dredging-related physiological, behavioral, and transgenerational implications. Environ Syst Decis 35:334-350.

Magneson, M.D., and S. Gough. 2006. Mainstem Klamath River coho salmon redd surveys 2001 to 2005. Arcata Fisheries Data Series Report DS 2006-7. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.

Magneson, M.D., and K. Wright. 2010. Mainstem Klamath River fall Chinook salmon redd survey 2009. Arcata Fisheries Data Series Report DS 2010-19. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.

Mann, R.D., C.C. Caudill, M.L. Keefer, A.G. Roumasset, C.B. Schreck, and M.L. Kent. 2011. Migration behavior and spawning success of spring Chinook salmon in Fall Creek and the North Fork Middle Fork Willamette River: Relationships among fate, fish condition, and environmental factors, 2010. Technical Report 2011-8-DRAFT. 85 pp.

McHenry, M., G. Pess, J. Anderson, and H. Hugunin. 2017. Spatial distribution of Chinook Salmon (Oncorhynchus tshawytscha) spawning in the Elwha River, Washington State during dam removal and early stages of recolonization (2012-2016).

Mesa, M.G., L.P. Gee LP, L.K. Weiland, and H.E. Christiansen. 2013. Physiological responses of adult rainbow trout experimentally released through a unique fish conveyance device. North American Journal of Fisheries Management 33:1179-1183.

National Oceanic and Atmospheric Administration - National Marine Fisheries Service [NOAA]. 2010. Biological opinion on the operation of the Klamath Project between 2010 and 2018. Prepared for Bureau of Reclamation by NOAA Fisheries Service, Southwest Region.

National Oceanic and Atmospheric Administration - National Marine Fisheries Service [NOAA]. 2014. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (Oncorhynchus kisutch). National Marine Fisheries Service. Arcata, CA.

Newcombe, C.P., and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16:693–727.

U.S. Bureau of Reclamation [USBR], and California Department of Fish and Game [CDFG]. 2012. Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report. Volume I and Volume II. 3063 pp. https://klamathrestoration.gov/Draft-EIS-EIR/download-draft-eis-eir.

U.S. Fish and Wildlife Service [USFWS]. 2016. Response to Request for Technical Assistance – Prevalence of C. shasta Infections in Juvenile and Adult Salmonids. Unpublished memo. 17 pp.

U.S. Fish and Wildlife Service [USFWS]. 2017. Unpublished coho salmon redd count data.

Washington State Department of Ecology (WDOE). 2002. Evaluating Criteria for the Protection of Freshwater Aquatic Life in Washington's Surface Water Quality Standards: Dissolved Oxygen. Draft Discussion Paper and Literature Summary. Publication Number 00-10-071. 90 pp.

**Personal Communication**

N. Hetrick. USFWS. Unpublished table regarding likely suspended sediment effects on post dam removal adult returns provided by email August 18, 2017.

T. Wise. ODFW. May 23, 2017. ODFW anadromous salmonid reintroduction plan discussion.

T. Williams, NOAA Fisheries. September 6, 2017. Personal communication with T. Brandt regarding dam removal benefits for adult and juvenile salmonids, and additional input regarding Aquatic Mitigation Measures.

K. Pomeroy. CDFW. September 27, 2017. Iron Gate Hatchery annual production 2001-2017.

## 10.4 AR-2 Outmigrating Juveniles

Allen, M.B., and P.J. Connolly. 2011. Current use and productivity of fish in the lower White Salmon River, Washington, prior to the removal of Condit Dam: U.S. Geological Survey Open-File Report 2011-1087, 32 p.

Antonetti. A., and E. Partee. 2012. Blue Creek Chinook outmigration monitoring – 2012 Technical Memorandum. 15 pp.

Barton, B.A., R.E. Peter, and C.R. Paulencu. 1980. Plasma cortisol levels of fingerling rainbow trout (Salmo gairdneri) at rest and subjected to handling, confinement, transport, and stocking. Canadian Journal of Fisheries and Aquatic Sciences 37:805– 811.

Beeman, J., S. Juhnke, G. Stutzer, and K. Wright. 2012, Effects of Iron Gate Dam discharge and other factors on the survival and migration of juvenile coho salmon in the lower Klamath River, northern California, 2006–09: U.S. Geological Survey Open-File Report 2012-1067, 96 pp.

Bjornn, T. and D. Reiser. 1991. Habitat requirements of salmonids in streams. In Meehan, W. ed., Influences of Forest and Rangeland Management on Salmonids Fishes and Their Habitat. American Fisheries Society Special Publication 19. pp. 83-138.

Carter, K. 2005. The effects of dissolved oxygen on steelhead trout, coho salmon, and Chinook salmon-Biology and function by life stage: California Regional Water Quality Control Board North Coast Region report, 9 p.

Chesney, W.R., C.C. Adams, W.B. Crombie, H.D. Langendork, S.A. Stenhouse, K.M. Kirkby. 2009. Shasta river juvenile coho habitat and migration study. Prepared for U.S. Bureau of Reclamation, Klamath Area Office by California Department of Fish and Game.

Courter, I., S.P. Cramer, R. Ericksen, C. Justice, and B. Pyper. 2008. Klamath coho life-cycle model version 1.3. Prepared by Cramer Fish Sciences for USDI Bureau of Reclamation, Klamath Basin Area Office. http://www.fishsciences.net/projects/klamathcoho/model.php.

Goodman, D.H., and S.B. Reid. 2012. Pacific Lamprey (Entosphenus tridentatus) Assessment and Template for Conservation Measures in California. U.S. Fish and Wildlife Service, Arcata, California. 117 pp.

Hillemeier D., T. Soto, S. Silloway, A. Corum, M. Kleeman, and L. Lestelle. 2009. The role of the Klamath River mainstem corridor in the life history and performance of juvenile coho salmon ( Oncorhynchus kisutch ) May 2007 - May 2008. Submitted to U.S. Bureau of Reclamation, Mid - Pacific Region, Klamath Area Office, Klamath Falls, Oregon.

Huntington, C.W. 2006. Estimates of anadromous fish runs above the site of Iron Gate Dam. Clearwater BioStudies, Inc, Canby, Oregon.

Gunnerød, T.B., N.A. Hvidsten, and T.G. Heggberget. 1988. Open sea releases of Atlantic salmon smolts, Salmo salar, in Central Norway, 1973-¬-83. Canadian Journal of Fisheries and Aquatic Sciences 45:1340-1345.

Heggberget, T.G., N.A. Hvidsten, T.B. Gunnerød, P.I. Møkkelgjerd. 1991. Distribution of adult recaptures from hatchery-reared Atlantic salmon (Salmo salar) smolts released in and off-shore of the River Surna, western Norway. Aquaculture 98:89–96.

Jetter, C.N. and W.R Chesney. 2016. Shasta and Scott River Outmigration Study, 2016 Report. California Department of Fish and Wildlife Anadromous Fisheries Resource Assessment and Monitoring Program. August 2016

Keefer, M.L., and C.C. Caudill. 2014. Homing and straying by anadromous salmonids: a review of mechanisms and rates. Fish Biol. Fisheries 24:333–368

Kenaston, K. R., R.B. Lindsay, and R.K. Schroeder. 2001. Effect of acclimation on the homing and survival of hatchery winter steelhead. North American Journal of Fisheries Management 21(4):765-773.

Newcombe, C.P., and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16:693–727.

Serl, J., and C. Morrill. 2010. Summary report for the 1996 to 2009 seasonal operation of the Cowlitz Falls fish facility and related Cowlitz Falls anadromous reintroduction program activities. Washington Department of Fish and Wildlife.

Servizi J.A., and D.W. Martens. 1992. Sublethal responses of coho salmon (Oncorhynchus kisutch) to suspended sediments. Can J Fish Manag Aquat Sci 49:1389–1395.

Sigler, J.W., T.C. Bjornn, and F.H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Transactions of the American Fisheries Society 113:142-150.

Solazzi, M.F., S.L. Johnson, B. Miller, T. Dalton, and K.A. Leader. 2003. Salmonid life-cycle monitoring project 2002. Oregon Department of Fish and Wildlife, Monitoring Program Report OPSW-ODFW-2003–2, Portland

Specker, J.L., and C.B. Schreck. 1980. Stress responses to transportation and fitness for marine survival in coho salmon (Oncorhynchus kisutch) smolts. Canadian Journal of Fisheries and Aquatic Sciences 37:765–769.

Soto T. A., A. Corum, H. Voight, D. Hillemeier, and L. Lestelle. 2009. The role of the Klamath River mainstem corridor in the life history and performance of juvenile coho salmon (Oncorhynchus kisutch ). Draft report to U.S. Bureau of Reclamation.

Stillwater Sciences. 2010. Potential Responses of Coho Salmon and Steelhead Downstream of Iron Gate Dam to No-Action and Dam-Removal Alternatives for the Klamath Basin Prepared for U.S. Bureau of Reclamation in support of the Biological Subgroup for the Klamath Basin Secretarial Determination. August 2010.

Stutzer, G.M., J. Ogawa, N.J. Hetrick, T. Shaw. 2006. An initial assessment of radio telemetry for estimating juvenile coho survival, migration behavior, and habitat use in response to Iron Klamath Coho Life Cycle Model – Technical Memorandum #2 Draft for Review Cramer 22 Fish Sciences Gate Dam discharge on the Klamath River, Oregon. U.S. Fish and Wildlife Service, Arcata Fisheries Technical Report, TR2006-05.

U.S. Bureau of Reclamation [USBR]. 2011. Appendix E – an analysis of potential suspended sediment effects on anadromous fish in the Klamath Basin. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado. 70 pp.

U.S. Bureau of Reclamation [USBR], and California Department of Fish and Game [CDFG]. 2012. Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report. Volume I and Volume II. 3063 pp. https://klamathrestoration.gov/Draft-EIS-EIR/download-draft-eis-eir.

U.S. Fish and Wildlife Service [USFWS]. 2016. Response to Request for Technical Assistance – Prevalence of C. shasta Infections in Juvenile and Adult Salmonids. Unpublished memo. 17 pp.

Wallace M. 2004. Natural vs. hatchery proportions of juvenile salmonids migrating through the Klamath River estuary and monitor natural and hatchery juvenile salmonid emigration from the Klamath Basin. July 1, 1998 through June 30, 2003. Final performance report. Federal Aid in Sport Fish Restoration Act. Project no. F-51-R-6. Arcata, California.

Washington State Department of Ecology (WDOE). 2002. Evaluating Criteria for the Protection of Freshwater Aquatic Life in Washington's Surface Water Quality Standards: Dissolved Oxygen. Draft Discussion Paper and Literature Summary. Publication Number 00-10-071. 90 pp.

**Personal Communication**

T. Soto. May 23, 2017. AR-2 Juvenile outmigration and relocation discussion.

## 10.5 AR-3 Fall Pulse Flows

Ackerman, N.K., B. Pyper, S. Cramer, and I. Courter. 2006. Estimation of returns of naturally produced coho to the Klamath River – review draft Technical Memorandum #1 of 8 Klamath Coho Integrated Modeling Framework Technical Memorandum Series.

Allen, M.B, R.O. Engle, J.S. Zendt, F.C. Shrier, J.T. Wilson, and P.J. Connolly. 2016. Salmon and steelhead in the White Salmon River after the removal of Condit Dam – planning efforts and recolonization results. Fisheries 41:190-203.

Anderson J.H., P.L. Faulds, K.D. Burton, M.E. Koehler, W.I. Atlas, and T.P. Quinn. 2015. Dispersal and productivity of Chinook (Oncorhynchus tshawytscha) and coho (Oncorhynchus kisutch) salmon colonizing newly. Can. J. Fish. Aquat. Sci. 72(3):454-465.

Bartholow, J.M., S.G. Campbell, and M. Flug. 2004. Predicting the thermal effects of dam removal on the Klamath River. Environmental Management 34:856-874.

Benson, R.L., S. Turo, and B.W. McCovey Jr. 2007. Migration and Movement Patterns of Green Sturgeon (Acipenser medirostris) in the Klamath and Trinity rivers, California, USA. Environmental Biology of Fishes 79: 269 - 279.

Bjornn, T. and D. Reiser. 1991. Habitat requirements of salmonids in streams. In Meehan, W. ed., Influences of Forest and Rangeland Management on Salmonids Fishes and Their Habitat. American Fisheries Society Special Publication 19. pp. 83-138.

Burton, KD., L.G. Lowe, H.B. Berge, H.K. Barnett, and P.L. Faulds. 2013. Comparative dispersal patterns for recolonizing Cedar River Chinook salmon above Landsburg Dam, Washington, and the source population below the dam. Trans. Am. Fish. Soc. 142:703–716.

Carter, K. 2005. The effects of dissolved oxygen on steelhead trout, coho salmon, and Chinook salmon-Biology and function by life stage: California Regional Water Quality Control Board North Coast Region report, 9 p.

Chapman J.M., C.L. Proulx, M.A. Veilleux, C. Levert, S. Bliss, M.E. Andre, N.W.R. Lapointe, and S.J. Cooke. 2014. Clear as mud: a meta-analysis on the effects of sedimentation on freshwater fish and the effectiveness of sediment-control measures. Water Res 56:190–202.

Dunsmoor L.K., and C.W. Huntington. 2006. Suitability of environmental conditions within Upper Klamath Lake and the migratory corridor downstream for use by anadromous salmonids. Technical Memorandum. Klamath Tribes, Chiloquin, Oregon.

Engle, R. O., J. Skalicky, and J. Poirier. 2013. Translocation of lower Columbia River fall Chinook Salmon (Oncorhynchus tshawytscha) in the year of Condit Dam removal and year one postremoval assessments. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, 2011 and 2012 Report, Vancouver, Washington.

Federal Energy Regulatory Commission [FERC]. 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027. FERC/EIS-0201F. FERC, Office of Energy Projects, Division of Hydropower Licensing, Washington, DC.

Greig, S.M., D.A. Sear, and P.A. Carling. 2005. The impact of fine sediment accumulation on the survival of incubating salmon progeny: Implications for sediment management. Science of the Total Environment 344: 241-258.

Hatten, J.R., T.R. Batt, J.J. Skalicky, R. Engle, G J. Barton, R.L. Fosness, and J. Warren. 2015. Effects of dam removal on Tule fall Chinook salmon spawning habitat in the White Salmon River, Washington. River Research and Applications 32(7): 1481-1492.

Hopelain, J.S. 1998. Age, growth, and life history of Klamath Basin steelhead trout (Oncorhynchus mykiss irideus) as determined from scale analysis. Inland Fisheries Administration Report 98-3. California Department of Fish and Game, Sacramento.

Huntington, C.W. 2004. Klamath River flows within the J.C. Boyle Bypass and below the J.C. Boyle Powerhouse. Clearwater BioStudies, Canby, Oregon.

Huntington, C.W. 2006. Estimates of anadromous fish runs above the site of Iron Gate Dam. Clearwater BioStudies, Inc., Canby, Oregon.

Huntington, C., E. Claire, F. Espinosa Jr, and R. House. 2006. Reintroduction of Anadromous Fish to the Upper Klamath Basin; an Evaluation and Conceptual Plan. Prepared for Klamath Tribes and Yurok Tribes. 63 pp.

Kiffney, P.M., G.R. Pess, J.H. Anderson, P. Faulds, K. Burton, and S.C. Riley. 2009. Changes in fish communities following recolonization of the Cedar River, WA USA by Pacific salmon after 103 years of local extirpation. River Res. Appl. 25 (4):438–452.

Kjelland, M.E., C.M. Woodley, T.M. Swannack, and D.L. Smith. 2015. A review of the potential effects of suspended sediment on fishes: potential dredging-related physiological, behavioral, and transgenerational implications. Environ Syst Decis 35:334-350.

Klimley, P., P.J. Allen, J.A. Israel and J.T. Kelly. 2007. The Green Sturgeon and its Environment: Past, Present, and Future. Environmental Biology of Fishes 79:3-4, 415-421.

Levasseur, M., N.E. Bergeron, M.F. Lapointe, and F. Berube. 2006. Effects of silt and very fine sand dynamics in Atlantic salmon (Salmo salar) redds on embryo hatching success. Canadian Journal of Fisheries and Aquatic Sciences 63:1450-1459.

Liermann, M., G. Pess, M. McHenry, J. McMillan, M. Elofson, T. Bennett, and R. Moses. 2017. Relocation and Recolonization of Coho Salmon in Two Tributaries to the Elwha River: Implications for Management and Monitoring, Transactions of the American Fisheries Society 146:(5)955-966.

Magneson, M.D., and S. Gough. 2006. Mainstem Klamath River coho salmon redd surveys 2001 to 2005. Arcata Fisheries Data Series Report DS 2006-7. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.

Magneson, M.D., and K. Wright. 2010. Mainstem Klamath River fall Chinook salmon redd survey 2009. Arcata Fisheries Data Series Report DS 2010-19. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.

Mann, R.D., C.C. Caudill, M.L. Keefer, A.G. Roumasset, C.B. Schreck, and M.L. Kent. 2011. Migration behavior and spawning success of spring Chinook salmon in Fall Creek and the North Fork Middle Fork Willamette River: Relationships among fate, fish condition, and environmental factors, 2010. Technical Report 2011-8-DRAFT. 85 pp.

McCovey, B.W. Jr. 2008. Klamath River Green Sturgeon Acoustic Biotelemetry Monitoring, FY 2007 Final Report. Yurok Tribal Fisheries Program. Yurok Tribal Fisheries Program. pp. 16.

McCovey, B.W. Jr. 2010. Klamath River Green Sturgeon Acoustic Tagging and Biotelemetry Monitoring, 2009 Final Technical Report. March 2010. Yurok Tribal Fisheries Program.

McHenry, M., G. Pess, J. Anderson, and H. Hugunin. 2017. Spatial distribution of Chinook Salmon (Oncorhynchus tshawytscha) spawning in the Elwha River, Washington State during dam removal and early stages of recolonization (2012-2016).

National Oceanic and Atmospheric Administration - National Marine Fisheries Service [NOAA] and U.S. Fish and Wildlife Service [USFWS]. 2013. Biological Opinions on the effects of proposed Klamath Project operations from May 31, 2013 through March 31, 2023, on five federally listed threatened and endangered species: National Marine Fisheries Service, Southwest Region.

National Oceanic and Atmospheric Administration - National Marine Fisheries Service [NOAA]. 2010. Biological opinion on the operation of the Klamath Project between 2010 and 2018. Prepared for Bureau of Reclamation by NOAA Fisheries Service, Southwest Region.

National Oceanic and Atmospheric Administration - National Marine Fisheries Service [NOAA]. 2014. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (Oncorhynchus kisutch). National Marine Fisheries Service. Arcata, CA.

National Oceanic and Atmospheric Administration - National Marine Fisheries Service [NOAA]. 2017. Unpublished data – potential fish passage and habitat restoration opportunities.

National Research Council. 2004. Endangered and Threatened Fishes in the Klamath River Basin: Causes of Decline and Strategies for Recovery. Washington, DC: The National Academies Press.

Newcombe, C.P., and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16:693–727.

Oregon Department of Fish and Wildlife [ODFW]. 2011. Rogue River Chinook salmon spawning redd survey data. Unpublished data.

PacifiCorp. 2004. Klamath Hydroelectric Project (FERC project no. 2082): fish resources. Final technical report Prepared by PacifiCorp, Portland, Oregon.

U.S. Bureau of Reclamation [USBR]. 2011. Appendix E – an analysis of potential suspended sediment effects on anadromous fish in the Klamath Basin. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado. 70 pp.

U.S. Bureau of Reclamation [USBR]. 2012. Hydrology, hydraulics and sediment transport studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration, Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado.

U.S. Bureau of Reclamation [USBR], and California Department of Fish and Game [CDFG]. 2012. Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report. Volume I and Volume II. 3063 pp. https://klamathrestoration.gov/Draft-EIS-EIR/download-draft-eis-eir.

Tonra, C.M., K. Sager-Fradkin, S.A. Morley, J.J. Duda, and P.P. Marra. 2015. The rapid return of marine-derived nutrients to a freshwater food web following dam removal. Biological Conservation 192:130-134.

U.S. Fish and Wildlife Service [USFWS]. 2016. Response to Request for Technical Assistance – Prevalence of C. shasta Infections in Juvenile and Adult Salmonids. Unpublished memo. 17 pp.

U.S. Fish and Wildlife Service [USFWS]. 2017. Unpublished coho salmon redd count data.

Washington State Department of Ecology (WDOE). 2002. Evaluating Criteria for the Protection of Freshwater Aquatic Life in Washington's Surface Water Quality Standards: Dissolved Oxygen. Draft Discussion Paper and Literature Summary. Publication Number 00-10-071. 90 pp.

**Personal Communication**

B. McCovey. Yurok Tribe. May 23, 2017, Yreka, CA. Green sturgeon outmigration.

## 10.6 AR-4 Iron Gate Hatchery Management

Allen, M.B, R.O. Engle, J.S. Zendt, F.C. Shrier, J.T. Wilson, and P.J. Connolly. 2016. Salmon and steelhead in the White Salmon River after the removal of Condit Dam – planning efforts and recolonization results. Fisheries 41:190-203.

Anderson J.H., P.L. Faulds, K.D. Burton, M.E. Koehler, W.I. Atlas, and T.P. Quinn. 2015. Dispersal and productivity of Chinook (Oncorhynchus tshawytscha) and coho (Oncorhynchus kisutch) salmon colonizing newly. Can. J. Fish. Aquat. Sci. 72(3):454-465.

Bartholow, J.M., S.G. Campbell, and M. Flug. 2004. Predicting the thermal effects of dam removal on the Klamath River. Environmental Management 34:856-874.

Barton, B.A., R.E. Peter, and C.R. Paulencu. 1980. Plasma cortisol levels of fingerling rainbow trout (Salmo gairdneri) at rest and subjected to handling, confinement, transport, and stocking. Canadian Journal of Fisheries and Aquatic Sciences 37:805– 811.Beeman, J., Juhnke, S., Stutzer, G., and Wright, K., 2012, Effects of Iron Gate Dam discharge and other factors on the survival and migration of juvenile coho salmon in the lower Klamath River, northern California, 2006–09: U.S. Geological Survey Open-File Report 2012-1067, 96 p.

Burton, KD., L.G. Lowe, H.B. Berge, H.K. Barnett, and P.L. Faulds. 2013. Comparative dispersal patterns for recolonizing Cedar River Chinook salmon above Landsburg Dam, Washington, and the source population below the dam. Trans. Am. Fish. Soc. 142:703–716.

California Department of Fish and Wildlife [CDFW] and PacifiCorp. 2014. Hatchery and genetic management plan for Iron Gate Hatchery coho salmon. Prepared for National Oceanic and Atmospheric Administration – National Marine Fisheries Service. 163 pp.

Dunsmoor L.K., and C.W. Huntington. 2006. Suitability of environmental conditions within Upper Klamath Lake and the migratory corridor downstream for use by anadromous salmonids. Technical Memorandum. Klamath Tribes, Chiloquin, Oregon.

Engle, R. O., J. Skalicky, and J. Poirier. 2013. Translocation of lower Columbia River fall Chinook Salmon (Oncorhynchus tshawytscha) in the year of Condit Dam removal and year one postremoval assessments. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, 2011 and 2012 Report, Vancouver, Washington.

Federal Energy Regulatory Commission [FERC]. 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027. FERC/EIS-0201F. FERC, Office of Energy Projects, Division of Hydropower Licensing, Washington, DC.

Gunnerød, T.B., N.A. Hvidsten, and T.G. Heggberget. 1988. Open sea releases of Atlantic salmon smolts, Salmo salar, in central Norway, 1973-83. Canadian Journal of Fisheries and Aquatic Sciences 45(8):1340-1345.

Hatten, J.R., T.R. Batt, J.J. Skalicky, R. Engle, G J. Barton, R.L. Fosness, and J. Warren. 2015. Effects of dam removal on Tule fall Chinook salmon spawning habitat in the White Salmon River, Washington. River Research and Applications 32(7): 1481-1492.

Heggberget, T.G., N.A. Hvidsten, T.B. Gunnerød, and P.I. Møkkelgjerd. 1991. Distribution of adult recaptures from hatchery-reared Atlantic salmon (Salmo salar) smolts released in and off-shore of the River Surna, western Norway. Aquaculture, 98: 89-96.

Huntington, C.W. 2004. Klamath River flows within the J.C. Boyle Bypass and below the J.C. Boyle Powerhouse. Clearwater BioStudies, Canby, Oregon.

Huntington, C.W. 2006. Estimates of anadromous fish runs above the site of Iron Gate Dam. Clearwater BioStudies, Inc., Canby, Oregon.

Keefer, M.L. and C.C. Caudill. 2014. Homing and straying by anadromous salmonids: a review of mechanisms and rates. Fish Biol. Fisheries 24:333–368

Kenaston, K.R., R.B. Lindsay, and R.K. Schroeder. 2001. Effect of acclimation on the homing and survival of hatchery winter steelhead. North American Journal of Fisheries Management 21(4):765-773.

Kiffney, P.M., G.R. Pess, J.H. Anderson, P. Faulds, K. Burton, and S.C. Riley. 2009. Changes in fish communities following recolonization of the Cedar River, WA USA by Pacific salmon after 103 years of local extirpation. River Res. Appl. 25 (4):438–452.

Levasseur, M., N.E. Bergeron, M.F. Lapointe, and F. Berube. 2006. Effects of silt and very fine sand dynamics in Atlantic salmon (Salmo salar) redds on embryo hatching success. Canadian Journal of Fisheries and Aquatic Sciences 63:1450-1459.

Liermann, M., G. Pess, M. McHenry, J. McMillan, M. Elofson, T. Bennett, and R. Moses. 2017. Relocation and Recolonization of Coho Salmon in Two Tributaries to the Elwha

River: Implications for Management and Monitoring, Transactions of the American Fisheries Society 146:(5)955-966.

Matthews, G.M., D.L. Park, S. Achord, and T.E. Ruehle. 1986. Static seawater challenge test to measure relative stress levels in spring chinook salmon smolts. Trans. Am. Fish. Soc. 115(2):236-244.

McHenry, M., G. Pess, J. Anderson, and H. Hugunin. 2017. Spatial distribution of Chinook Salmon (Oncorhynchus tshawytscha) spawning in the Elwha River, Washington State during dam removal and early stages of recolonization (2012-2016).

Oregon Department of Fish and Wildlife [ODFW]. 2011. Rogue River Chinook salmon spawning redd survey data. Unpublished data.

PacifiCorp. 2004. Klamath Hydroelectric Project (FERC project no. 2082): fish resources. Final technical report Prepared by PacifiCorp, Portland, Oregon.

Solazzi, M.F., S L. Johnson, B. Miller, T. Dalton, and K.A. Leader. 2003. Salmonid life-cycle monitoring project 2002. Oregon Department of Fish and Wildlife, Monitoring Program Report OPSW-ODFW-2003–2, Portland

Specker, J.L., and C.B. Schreck. 1980. Stress responses to transportation and fitness for marine survival in coho salmon (Oncorhynchus kisutch) smolts. Canadian Journal of Fisheries and Aquatic Sciences 37:765–769.

Tonra, C.M., K. Sager-Fradkin, S.A. Morley, J.J. Duda, and P.P. Marra. 2015. The rapid return of marine-derived nutrients to a freshwater food web following dam removal. Biological Conservation 192:130-134.

U.S. Bureau of Reclamation [USBR]. 2011. Appendix E – an analysis of potential suspended sediment effects on anadromous fish in the Klamath Basin. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado. 70 pp.

U.S. Bureau of Reclamation [USBR], and California Department of Fish and Game [CDFG]. 2012. Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report. Volume I and Volume II. 3063 pp. https://klamathrestoration.gov/Draft-EIS-EIR/download-draft-eis-eir.

U.S. Fish and Wildlife Service [USFWS]. 2016. Response to Request for Technical Assistance – Prevalence of C. shasta Infections in Juvenile and Adult Salmonids. Unpublished memo. 17 pp.

## 10.7 AR-5 Pacific Lamprey Ammocoetes

Anderson J.H., P.L. Faulds, K.D. Burton, M.E. Koehler, W.I. Atlas, and T.P. Quinn. 2015. Dispersal and productivity of Chinook (Oncorhynchus tshawytscha) and coho

(Oncorhynchus kisutch) salmon colonizing newly. Can. J. Fish. Aquat. Sci. 72(3):454-465.

Bartholow, J.M., S.G. Campbell, and M. Flug. 2005. Predicting the thermal effects of dam removal on the Klamath River. Environmental Management 34:856-874.

Burton, K.D., L.G. Lowe, H.B. Berge, H.K. Barnett, and P.L. Faulds. 2013. Comparative dispersal patterns for recolonizing Cedar River Chinook salmon above Landsburg Dam, Washington, and the source population below the dam. Trans. Am. Fish. Soc. 142:703–716.

Dunsmoor L.K., and C.W. Huntington. 2006. Suitability of environmental conditions within Upper Klamath Lake and the migratory corridor downstream for use by anadromous salmonids. Technical Memorandum. Klamath Tribes, Chiloquin, Oregon.

Engle, R. O., J. Skalicky, and J. Poirier. 2013. Translocation of lower Columbia River fall Chinook Salmon (Oncorhynchus tshawytscha) in the year of Condit Dam removal and year one postremoval assessments. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, 2011 and 2012 Report, Vancouver, Washington.

Federal Energy Regulatory Commission [FERC]. 2006. Licensing for the continued operation of PacifiCorp's Klamath Hydroelectric Project, located principally on the Klamath River, in Klamath County, Oregon and Siskiyou County, California, FERC Project No. 2082. Draft environmental impact statement. Prepared by FERC, Office of Energy Projects, Washington, DC.

Federal Energy Regulatory Commission [FERC]. 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027. FERC/EIS-0201F. FERC, Office of Energy Projects, Division of Hydropower Licensing, Washington, DC.

Goodman, D.H., and N.J. Hetrick. 2017. Technical Memorandum. Response to Request for Technical Assistance – Distribution of Pacific Lamprey in the reach immediately downstream of Iron Gate Dam, Klamath River. September 5, 2017.

Goodman, D.H., and S.B. Reid. 2012. Pacific Lamprey (Entosphenus tridentatus) Assessment and Template for Conservation Measures in California. U.S. Fish and Wildlife Service, Arcata, California. 117 pp.

Goodman, D.H., and S.B. Reid. 2015. Regional Implementation Plan for Measures to Conserve Pacific Lamprey (Entosphenus tridentatus), California - North Coast Regional Management Unit. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR 2015-21, Arcata, California. 35 pp.

Greig, S.M., D.A. Sear, and P.A. Carling. 2005. The impact of fine sediment accumulation on the survival of incubating salmon progeny: Implications for sediment management. Science of the Total Environment 344: 241-258.

Hatten, J. R., T.R. Batt, J.J. Skalicky, R. Engle, G J. Barton, R.L. Fosness, and J. Warren. 2015. Effects of dam removal on Tule fall Chinook salmon spawning habitat in the White Salmon River, Washington. River Research and Applications 32(7): 1481-1492.

Huntington, C.W. 2004. Klamath River flows within the J.C. Boyle Bypass and below the J.C. Boyle Powerhouse. Clearwater BioStudies, Canby, Oregon.

Huntington, C.W. 2006. Estimates of anadromous fish runs above the site of Iron Gate Dam. Clearwater BioStudies, Inc, Canby, Oregon.

Huntington, C., E. Claire, F. Espinosa Jr, and R. House. 2006. Reintroduction of Anadromous Fish to the Upper Klamath Basin; an Evaluation and Conceptual Plan. Prepared for Klamath Tribes and Yurok Tribes. 63 pp.

Jolley, J.C., G.S. Silver, and T.A. Whitesel. 2013. Occurrence, detection, and habitat use of larval lamprey in the Lower White Salmon River and mouth: post-Condit Dam removal, 2012 Annual Report. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA. 22 pp

Jolley, J.C., G.S. Silver, J.E. Harris, E.C. Butts, and C. Cook-Tabor. 2016. Occupancy and Distribution of Larval Pacific Lamprey and Lampetra spp. in Wadeable Streams of the Pacific Northwest. U.S. Fish and Wildlife Service, Columbia River Fish and Wildlife Conservation Office, Vancouver, WA. 35 pp

Jolley, J.C., G.S. Silver, J. J. Skalicky, J.E. Harris, and T.A. Whitesel. 2016. Evaluation of Larval Pacific Lamprey Rearing in Mainstem Areas of the Columbia and Snake Rivers Impacted by Dams. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA. 33 pp.

Kiffney, P.M., G.R. Pess, J.H. Anderson, P. Faulds, K. Burton, and S.C. Riley. 2009. Changes in fish communities following recolonization of the Cedar River, WA USA by Pacific salmon after 103 years of local extirpation. River Res. Appl. 25 (4):438–452.

Kjelland, M.E., C.M. Woodley, T.M. Swannack, and D.L. Smith. 2015. A review of the potential effects of suspended sediment on fishes: potential dredging-related physiological, behavioral, and transgenerational implications. Environ Syst Decis 35:334-350.

Kostow, K. 2002. Oregon Lampreys: Natural history status and analysis management issues. Oregon Department of Fish and Wildlife.

Levasseur, M., N.E. Bergeron, M.F. Lapointe, and F. Berube. 2006. Effects of silt and very fine sand dynamics in Atlantic salmon (Salmo salar) redds on embryo hatching success. Canadian Journal of Fisheries and Aquatic Sciences 63:1450-1459.

Liermann, M., G. Pess, M. McHenry, J. McMillan, M. Elofson, T. Bennett, and R. Moses. 2017. Relocation and Recolonization of Coho Salmon in Two Tributaries to the Elwha River: Implications for Management and Monitoring, Transactions of the American Fisheries Society 146:(5)955-966.

Li, W., M.J. Siefkes, A.P. Scott, and J.H. Teeler. 2003. Sex pheromone communication in the sea lamprey: implications for integrated management. Journal of Great Lakes Research 29, Supplement 1:85-94.

McHenry, M., G. Pess, J. Anderson, and H. Hugunin. 2017. Spatial distribution of Chinook Salmon (Oncorhynchus tshawytscha) spawning in the Elwha River, Washington State during dam removal and early stages of recolonization (2012-2016).

Morley, S. A., H. J. Coe, J. J. Duda, L. S. Dunphy, M. L. McHenry, B. R. Beckman, M. Elofson, E. M. Sampson, and L. Ward. 2016. Seasonal variation exceeds effects of salmon carcass additions on benthic food webs in the Elwha River. Ecosphere 7(8):e01422. 10.1002/ecs2.1422

Oregon Department of Fish and Wildlife [ODFW]. 2008. A Plan for the Reintroduction of Anadromous Fish in the Upper Klamath Basin. 56 pp.

Oregon Department of Fish and Wildlife [ODFW]. 2011. Rogue River Chinook salmon spawning redd survey data. Unpublished data.

PacifiCorp. 2004. Klamath Hydroelectric Project (FERC project no. 2082): fish resources. Final technical report Prepared by PacifiCorp, Portland, Oregon.

Petersen, R.S. 2006. The role of traditional ecological knowledge in understanding a species and river system at risk: Pacific Lamprey in the lower Klamath Basin. Master of Arts in applied Anthropology Thesis. 182 pp.

Bureau of Reclamation [USBR]. 2012. Hydrology, hydraulics and sediment transport studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration, Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado.

Schultz, L., M.P. Mayfield, G.T. Sheoships, L.A. Wyss, B.J. Clemens, B. Chasco, and C.B. Schreck. 2014. The distribution and relative abundance of spawning and larval Pacific lamprey in the Willamette River Basin. Final Report to the Columbia Inter-Tribal Fish Commission for project years 2011-2014. 113 pp.

Stone, J., J. Pirtle, and S. Barndt. 2002. Evaluate habitat use and population dynamics of lampreys in Cedar Creek, Annual Report 2001, Bonneville Power Administration, Contract No. 00004672, Project No. 200001400, 44 pp.

Tonra, C.M., K. Sager-Fradkin, S.A. Morley, J.J. Duda, and P.P. Marra. 2015. The rapid return of marine-derived nutrients to a freshwater food web following dam removal. Biological Conservation 192:130-134.

U.S. Department of the Interior (USDI). USBR and CDFG. 2012. Klamath Facilities Removal Final Environmental Impact Statement/ Environmental Impact Report (Vol. I). Report prepared by the US Department of Interior through the Bureau of Reclamation (USBR), and California Department of Fish and Game (CDFG), Sacramento, California. State Clearinghouse # 2010062060. 2092 pp.

U.S. Fish and Wildlife Service [USFWS]. 2010. Unpublished data – Klamath River lamprey ammocoete surveys. D. Goodman, personal communication, July 2017.

Zaroban, D. W., Mulvey, M. P., Maret, T. R., Hughes, R. M. and Merrit, G. D. 1999. Classification of species attributes for Pacific Northwest freshwater fishes. Northwest Science, 73(2): 81–93.

**Personal Communication**

T. Soto. Karuk Tribe. May 23, 2017. AR-5 Pacific lamprey ammocoete relocation discussion.

T. Wise. ODFW. May 23, 2017. ODFW anadromous salmonid reintroduction plan discussion.

## 10.8 AR-6 Sucker Salvage and Relocation

Beak Consultants Incorporated. 1987. Shortnose and Lost River sucker studies: Copco Reservoir and the Klamath River. Unpublished manuscript. Project No. D3060.01. Portland, Oregon, 37 pp. and appendix.

Beak Consultants Incorporated. 1988. Shortnose and Lost River sucker studies: Larval sucker study between Copco Reservoir and the proposed Salt Caves diversion pool. Unpublished manuscript. Project No. 73060.03. Portland, Oregon, 36 pp. and appendix.

Buettner, M.E., and G.G. Scoppettone. 1990. Life history and status of Catostomids in Upper Klamath Lake, Oregon: Completion report. Reno Field Station, National Fisheries

Buettner, M.E. and G.G. Scoppettone. 1991. Distribution and information on the taxonomic status of the shortnose sucker (Chasmistes brevirostris) and Lost River sucker (Deltistes luxatus ) in the Klamath River Basin, California. Completion Report. National Fisheries Research Center, reno field Station, Nevada, 100 pp.

Buettner, M.E. 2000. Analysis of Tule Lake water quality and sucker telemetry, 1992-1995. U.S. Bureau of Reclamation, Mid-Pacific Region, Klamath Basin Area Office. 47 pp.

Buettner, M., R. Larson, J. Hamilton, and G. Curtis. 2006. Contribution of Klamath reservoirs to federally listed sucker populations and habitat. U.S. Fish and Wildlife Service, Yreka, California.

Burdick, S.M. 2013. Assessing movement and sources of mortality of juvenile catostomids using passive integrated transponder tags, Upper Klamath Lake, Oregon—Summary of 2012 effort: U.S. Geological Survey Open-File Report 2013-1062, 12 pp.

Desjardins, M., and D.F. Markle. 2000. Distribution and biology of suckers in lower Klamath reservoirs. 1999 Final Report submitted to PacifiCorp. 78 pp.

Hewitt, D.A., E.C. Janney, B.S. Hayes, and A.C. Harris. 2014. Demographics and run timing of adult Lost River (Deltistes luxatus) and shortnose (Chasmistes brevirostris) suckers in Upper Klamath Lake, Oregon, 2012: U.S. Geological Survey Open-File Report 2014-1186, 44 pp.

Janney, E.C., B.C. Hayes, D.A. Hewitt, P.M. Barry, A.C. Scott, J.P. Koller, M.A. Johnson, and G. Blackwood. 2009. Demographics and 2008 run timing of adult Lost River (Deltistes luxatus) and shortnose (Chasmistes brevirostris) suckers in Upper Klamath Lake, Oregon, 2008: U.S. Geological Survey Open-File Report 2009-1183, 32 pp.

Levasseur, M., N.E. Bergeron, M.F. Lapointe, and F. Berube. 2006. Effects of silt and very fine sand dynamics in Atlantic salmon (Salmo salar) redds on embryo hatching success. Canadian Journal of Fisheries and Aquatic Sciences 63:1450-1459.

Markle, D.F., M.R. Cavalluzzi, T.E. Dowling, and D. Simon. 1999. Ecology of Upper Klamath Lake shortnose and Lost river suckers – The Klamath Basin sucker species complex. Submitted to U.S. Biological Resources Division – U.S. Geological survey and Klamath Project – U.S. Bureau of Reclamation. 35 pp.

Miller, R.R., and G.R. Smith. 1981. Distribution and evolution of Chasmistes (Pisces:Catostomidae) in western North America. Occasional Papers of the Museum of Zoology, University of Michigan 696:1-48.

Moyle, P.B. 1976. Inland fishes of California. University of California Press, Berkeley and Los Angeles.

Moyle, P.B. 2002. Inland fishes of California. University of California Press, Berkeley, California.

Templeton, A.R. 1989. The meaning of species and speciation; a genetic perspective. Pp. 3-27 in D. Otte and J.A. Endler. Speciation and its consequences. Sinauer Assoc. Inc., Sunderland, Massachusetts, 679 pp.

U.S. Bureau of Reclamation [USBR]. 2012. Hydrology, hydraulics and sediment transport studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration, Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado.

U.S. Bureau of Reclamation [USBR], and California Department of Fish and Game [CDFG]. 2012. Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report. Volume I and Volume II. 3063 pp. https://klamathrestoration.gov/Draft-EIS-EIR/download-draft-eis-eir.

U.S. Fish and Wildlife Service [USFWS]. 1993. Shortnose sucker (Chasmistes brevirostris) and Lost River (Deltistes luxatus) Sucker Recovery Plan. Portland, Oregon.

U.S. Fish and Wildlife Service [USFWS]. 2012. Revised recovery plan for the Lost River sucker (Deltistes luxatus) and shortnose sucker (Chasmistes brevirostris). U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, California. xviii + 122 pp.

Williams, J.E., D.B. Bowman, J.E. Brooks, A.A. Echelle, R.J. Edwards, D.A. Hendrickson, and J.J. Landye. 1985. Endangered aquatic ecosystems in North American deserts with a list of vanishing fishes of the region. Journal of the Arizona-Nevada Academy of Science 20:1-62.

**Personal Communication**

B. Tinniswood. ODFW. June 19, 2017. Observed sucker spawning migration April 2017 upstream from Topsy Reservoir. Comments provided during ATWG planning meeting.

J. Rasmussen. USFWS. May 24, 2017 and June 19, 2017. Recipient waterbody capacity. Comments provided during ATWG planning meeting.

T. Wise. ODFW. May 23, 2017. Klamath smallscale sucker salvage concerns. Comments provided during ATWG planning meeting.

## 10.9 AR-7 Freshwater Mussels

Bartholow, J.M., S.G. Campbell, and M. Flug. 2004. Predicting the thermal effects of dam removal on the Klamath River. Environmental Management 34:856-874.

Bettaso, J.B., and D.H. Goodman. 2010. A Comparison of Mercury Contamination in Mussel and Ammocoete Filter Feeders. Journal of Fish and Wildlife Management: November 2010, Vol. 1, No. 2, pp. 142-145.

Byron, E., and J. Tupen. 2017. Mussels of the Upper Klamath River, Oregon and California. California Fish and Game 103(1):21-26.

Cope, W.G., and D.L. Waller. 1995. Evaluation of freshwater mussel relocation as a conservation and management strategy. Regulated Rivers: Research & Management 11:147-155.

Davis, E.A., A.T. David, K.M. Norgaard, T.H. Parker, K. McKay, C. Tennant, T. Soto, K. Rowe, and R. Reed. 2013. Distribution and abundance of freshwater mussels in the mid Klamath Subbasin, California. Northwest Science, 87(3):189-206. 2013.

Dunsmoor L.K., and C.W. Huntington. 2006. Suitability of environmental conditions within Upper Klamath Lake and the migratory corridor downstream for use by anadromous salmonids. Technical Memorandum. Klamath Tribes, Chiloquin, Oregon.

Federal Energy Regulatory Commission [FERC]. 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027. FERC/EIS-0201F. FERC, Office of Energy Projects, Division of Hydropower Licensing, Washington, DC.

Fernandez, M.K. 2013. Transplants of western pearlshell mussels to unoccupied streams on Willapa National Wildlife Refuge, southwestern Washington. Journal of Fish and Wildlife Management 4(2):316-325.

Germano, J.M., K.J. Field, R.A. Griffiths, S. Clulow, J. Foster, G. Harding, and R.R. Swaisgood. 2015. Mitigation-driven translocations: are we moving wildlife in the right direction? Front Ecol Environ 2015; 13(2):100–105.

Greig, S.M., D.A. Sear, and P.A. Carling. 2005. The impact of fine sediment accumulation on the survival of incubating salmon progeny: Implications for sediment management. Science of the Total Environment 344: 241-258.

Howard, J. 2013. Upper Truckee Airport Reach freshwater mussel (Margaritifera falcata) relocation: two years later. Unpublished manuscript. 36 pp.

Howard, J.K., J. L. Furnish, J. BrimBox, and S. Jepsen. 2015. The decline of the native freshwater mussels (Bivalvia: Unionoida) in California as determined from his¬torical and current surveys. California Fish and Game 101(1):8-23.

Huntington, C.W. 2004. Klamath River flows within the J.C. Boyle Bypass and below the J.C. Boyle Powerhouse. Clearwater BioStudies, Canby, Oregon.

Huntington, C.W. 2006. Estimates of anadromous fish runs above the site of Iron Gate Dam. Clearwater BioStudies, Inc., Canby, Oregon.

Kann, J., S. Corum, and K. Fetcho. 2010. Microsystin bioaccumulation in Klamath River freshwater mussel tissue: 2009 results. Aquatic Ecosystem Sciences LLC, Ashland, OR. Unpublished manuscript. 37 pp.

Krall, M. 2010. Freshwater mussel abundance and habitat in the Klamath River of Northern California. Bachelor of Arts thesis submitted to Biology Department, Whitman College. 36 p.

Levasseur, M., N.E. Bergeron, M.F. Lapointe, and F. Berube. 2006. Effects of silt and very fine sand dynamics in Atlantic salmon (Salmo salar) redds on embryo hatching success. Canadian Journal of Fisheries and Aquatic Sciences 63:1450-1459.

Lopes-Lima, M., Sousa, R., Geist, J., Aldridge, D.C., Araujo, R., Bergengren, J., et al. 2016. Conservation status of freshwater mussels in Europe: state of the art and future challenges. Biological Reviews http://dx.doi.org/10.1111/brv.12244.

Lummer, E., K. Auerswald, and J. Geist. 2016. Fine sediment as environmental stressor affecting freshwater mussel behavior and ecosystem services. Science of the Total Environment 571:1340-1348.

Luzier, C., and S. Miller. 2009. Freshwater mussel relocation guidelines. A product of the Pacific Northwest Native Freshwater Mussel Workgroup. 7 pp.

May, C. L., and B.S. Pryor. 2016. Explaining Spatial Patterns of Mussel Beds in a Northern California River: The Role of Flood Disturbance and Spawning Salmon. River research and applications.

Olden, J.D., M.J. Kennard, J.J. Lawler, and N.L Poff. 2010. Challenges and opportunities in implementing managed relocation for conservation of freshwater species. Conservation Biology 25(1):40-47.

PacifiCorp. 2004. Klamath Hydroelectric Project (FERC project no. 2082): fish resources. Final technical report Prepared by PacifiCorp, Portland, Oregon.

Tennant, C. 2010. Freshwater mussels of the Klamath River: a personal and scientific account. Bachelor of Arts thesis submitted to Biology Department, Whitman College. 45 p.

U.S. Bureau of Reclamation [USBR]. 2012. Hydrology, hydraulics and sediment transport studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration, Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado.

U.S. Bureau of Reclamation [USBR], and California Department of Fish and Game [CDFG]. 2012. Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report. Volume I and Volume II. 3063 pp. https://klamathrestoration.gov/Draft-EIS-EIR/download-draft-eis-eir.

U.S. Fish and Wildlife Service [USFWS]. 2016. Response to Request for Technical Assistance – Prevalence of C. shasta Infections in Juvenile and Adult Salmonids. Unpublished memo. 17 pp.

Vannote, R.L., and G.W. Minshall. 1982. Fluvial processes and local lithology controlling abundance, structure, and composition of mussel beds. Proc. Natl. Acad. Sci. USA 79:4103-4107.

Westover, M. 2010. Freshwater mussel distribution, abundance and habitat use in the middle Klamath River. Bachelor of Science thesis submitted to Biology Department, Whitman College. 45 p.

Xerces Society. 2009. Freshwater mussels of the Pacific Northwest. Second Edition. 60 pp.

Xerces Society. 2012. Margaritifera falcata (Gould, 1850) Western pearlshell, Bivalvia: Margaritiferidae. Profile prepared by Sarina Jepsen, Caitlin LaBar, and Jennifer Zarnoch. 24 pp.

**Personal Communication**

P. Crain. U.S. National Park Service. September 15, 2017. Phone call with T. Brandt regarding Elwha Dam Removal Project freshwater mussel relocation effort.

K. Kwak. CDFW. September 15, 2017. Email communication with C. Bean (CDFW) provided to T. Brandt regarding freshwater mussel pathogen concerns.

# Appendix I Road & Bridge Structure Data and Long-Term Improvements

| Access Roads and Haul Routes of Significance | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name of Road | Dam | County / State | Jurisdiction | FHWA Classification | Notes | Recommended Improvements | Temporary Traffic Control (Y/N) |
| The Dalles California Highway (US 97) | J.C. Boyle | Klamath, Oregon | ODOT | Rural principal arterial | Two lane State highway system, AC paved road with a soft shoulder. Proposed haul route to transport materials from J.C. Boyle Dam. | Rehabilitate pavement where damage occurs due to hauling or mobilization/demobilization of construction equipment. Rehabilitation includes pavement overlay and/or localized pavement replacement within existing roadway prism. | Y (during pavement rehab) |
| Green Springs Highway (OR66) | J.C. Boyle | Klamath, Oregon | ODOT | Rural minor arterial | Soft shoulder for most part and a few locations with HMA. | Rehabilitate pavement between JC Boyle Dam Access Road and Keno Worden Road where damage occurs due to hauling or mobilization/demobilization of construction equipment. Rehabilitation includes pavement overlay and/or localized pavement replacement within existing roadway prism. | Y (during pavement rehab) |
| Keno Worden Road | J.C. Boyle | Klamath, Oregon | County | Rural minor collector | Most of the segment is a soft gravel shoulder. Steep side slopes in some areas. Rolling terrain. Overhead utility poles found along a portion the road. | Rehabilitate pavement where damage occurs due to hauling or mobilization/demobilization of construction equipment. Rehabilitation includes pavement overlay and/or localized pavement replacement within existing roadway prism. | Y (during pavement rehab) |
| Topsy Grade Road | J.C. Boyle | Klamath, Oregon | Unknown | n/a | Gravel road from OR66 becoming HMA for a portion alongside the Topsy Campground. | Rehabilitate pavement where damage occurs due to hauling or mobilization/demobilization of construction equipment. Rehabilitation includes pavement overlay and/or localized pavement replacement within existing roadway prism. | Y (during repair/regrading) |
| J.C. Boyle Dam Access Road from OR66 | J.C. Boyle | Klamath, Oregon | Unknown | n/a | | Regrade uneven or rutted areas of road surface. Minor widening in parts to allow two-way traffic. | N |
| J.C. Boyle Left abutment access road | J.C. Boyle | Klamath, Oregon | Unknown | n/a | | None. | N |
| J.C Boyle Disposal Access Road | J.C. Boyle | Klamath, Oregon | Unknown | n/a | | Regrade uneven or rutted areas of road surface. Minor widening in parts to allow two-way traffic. | N |
| Concrete flume access road to powerhouse | J.C. Boyle | Klamath, Oregon | Unknown | n/a | Very narrow road immediately adjacent to concrete flume. Side slopes on river side are very steep or nearing vertical. To be used for access only, not hauling. Not recommended as a two-way haul route unless concrete flume has been completely removed. | Rehabilitate pavement where damage occurs due to hauling or mobilization/demobilization of construction equipment. Rehabilitation includes pavement overlay and/or localized pavement replacement within existing roadway prism. | Y (during pavement rehab) |
| J.C. Boyle Powerhouse Road | J.C. Boyle | Klamath, Oregon | Unknown | n/a | Access road from forebay to powerhouse. | None. | N |
| Interstate 5 (I-5) | Copco 1,2, Iron Gate | Siskiyou, California | Caltrans | Interstate freeway | Rolling and mountainous terrain . | None. | N |
| Copco Road between Copco 1 access road to Copco Road Bridge/Ager Beswick Road | Copco 1 | Siskiyou, California | County | Minor collector | From Fall Creek Rd to Copco Rd bridge. Unpaved dirt road, very low volume of traffic. | Replace culverts after construction where needed. Only pickup trucks will use road during construction. | Y (during culvert replacement) |
| Copco Road between Ager Road and Lakeview Road | Copco 1,2 and Iron Gate | Siskiyou, California | County | Minor collector | From Ager Rd to Lakeview Rd. Poorly striped. No striped shoulder. | Rehabilitate pavement where damage occurs due to hauling or mobilization/demobilization of construction equipment. Rehabilitation includes pavement overlay and/or localized pavement replacement within existing roadway prism | Y (during pavement rehab) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Copco Road between Lakeview Road and Daggett Road | Copco 1,2 and Iron Gate | Siskiyou, California | County | Minor collector | From Lakeview Rd to Daggett Road. Poorly striped. No striped shoulder. | Rehabilitate pavement where damage occurs due to hauling or mobilization/demobilization of construction equipment. Rehabilitation includes pavement overlay and/or localized pavement replacement within existing roadway prism | Y (during pavement rehab) |
| Copco Road between Daggett Road and Copco No.1 Access Road | Copco 1 | Siskiyou, California | County | Minor collector | Very low traffic. | Rehabilitate pavement following completion of hauling and demobilization of construction equipment. Rehabilitation includes pavement overlay and/or localized pavement replacement within existing roadway prism. | Y (during pavement rehab) |
| Ager Beswick Road | Copco 1 | Siskiyou, California | County | Minor collector | From Copco Bridge to Ager Rd intersection. | None to main road. Minor improvements to extend boat ramp to remove barge after removal or spillway. | N |
| Copco 1 access road from dam to Copco Road | Copco 1 | Siskiyou, California | Unknown | n/a | The lower side of access road is very steep with no barrier protection. | Grub, clear and regrade to allow a wider road for construction and hauling trucks. | Y |
| Copco Road between Lakeview Road and Daggett Road | Copco 2 | Siskiyou, California | County | Minor collector | From Lakeview Rd to Daggett Rd. Poorly striped. No striped shoulder | Rehabilitate pavement where damage occurs due to hauling or mobilization/demobilization of construction equipment. Rehabilitation includes pavement overlay and/or localized pavement replacement within existing roadway prism. | Y (during pavement rehab) |
| Daggett Road | Copco 2 | Siskiyou, California | Private | n/a | Located just behind a gate off of Copco Road. This is a pinch point on the Daggett Road that connect to Copco Road. This is a potential haul route to transport demolished materials from Copco 2 powerhouse. | "One way" roadside sign along with advance warning signs will be needed to provide warning to truck drivers. Periodic road maintenance will be required during construction on Daggett Road leading to Copco 2 powerhouse. | Y ("one-way" signs) |
| Lakeview Road from Copco Road to disposal site | Iron Gate | Siskiyou, California | Unknown | n/a | One way hauling traffic. | Road maintenance is anticipated in some areas during construction, where the existing surface will be damaged due to construction trucks. | Y (during pavement rehab) |
| Powerhouse access road | Iron Gate | Siskiyou, California | Unknown | n/a | From the bridge it is a gravel road up to the gate, after the gate it is an AC paved road to the Iron Gate Powerhouse. A large stockpile area is available on the right side of Lakeview Road bridge that can be used during construction. Access road can be used for hauling material from the Iron Gate powerhouse. | Maintenance to ensure adequate accessibility during construction. This road will not be needed following hauling and demobilization activities. | N |
| Left abutment access road | Iron Gate | Siskiyou, California | Unknown | n/a | The original haul route from the upstream borrow area to the dam would be reopened for construction. This would allow two-way traffic to the north side of the disposal area. The road is swing gate controlled and can be used as a haul route to remove materials from the Iron Gate dam structure. | Restoration at completion of dam removal. | N |
| Dam to disposal access road (Lakeview Road) | Iron Gate | Siskiyou, California | Unknown | n/a | Gravel road, width varying from 16' - 24' wide and fairly in stable condition. This road can be used as a haul route to remove materials from the Iron Gate dam site. Minor regrading could allow use as a two way access road. | Maintenance to ensure adequate accessibility during construction. This road will not be needed following hauling and demobilization activities. | N |
| Copco Road from I-5 to Ager Road | Copco 1,2 and Iron Gate | Siskiyou, California | County | Major collector | From I5 to Ager Road. | Rehabilitate pavement where damage occurs due to hauling or mobilization/demobilization of construction equipment. Rehabilitation includes pavement overlay and/or localized pavement replacement within existing roadway prism. | Y (during pavement rehab) |

## Intersection Field Observations

| Intersection | Dam | Control | Notes | Improvements | Temporary Traffic Control (Y/N) |
|---|---|---|---|---|---|
| Dalles California highway (US 97) / Keno Worden Road | J.C. Boyle | 1-way stop | T-intersection; approximately 200ft from level rail road crossing controlled by flashing lights and gates. | None. | N |
| Keno Worden Road / Green Springs Hwy (OR66) | J.C. Boyle | 1-way stop | T-intersection; continue on Route 66 from Keno Worden Road to go J.C. Boyle Dam. | None. | N |
| Green Springs Hwy ( OR66 - Oregon) / Topsy Grade Rd | J.C. Boyle | 2-way stop | Topsy Grade Rd paved approximately 150ft before intersection. Adequate signage and striping. | None. | N |
| Green Springs Hwy (OR66) / Dam Access Road | J.C. Boyle | 1-way stop | Located on the north side of dam. Inadequate intersection signage and configuration, near curve in mainline. Needs improvements. | Minor widening and tree removal to improve sight distance and accommodate truck turning. Provide temporary advance warning signs to notify or trucks entering/exiting OR66 at the intersection. | Y (during widening and tree removal) |
| Copco Road / Copco 1 access road | Copco 1 | None | AB intersection, not stop controlled, low volume of traffic. | None. | N |
| Copco Road / Quail Lane | Copco 1 | None | Intersection to Copco Br. No stop sign, no striping, low volume intersection, low speed. | None. | N |
| Copco Road / Ager Beswick Road | Copco 1 | n/a | Intersection to Copco Br. No stop sign, no striping, low volume intersection, low speed. | None. | N |
| Patricia Ave / Ager Beswick Road | Copco 1 | 1-way stop | Poor striping and pavement markings, tree blocking sight distance. | Remove Tree | N |
| Copco Road / Daggett Road | Copco 2 | n/a | Poor AC pavement on Daggett Rd at intersection, low volume, no stop sign, no stop bar, OK sight distance. Should add stop control prior to dam removals. Gate located 200ft from intersection. | Provide stop sign and stop bar. | Y |
| Copco Road / Fall Creek Road | Copco 2 | n/a | AB intersection, not stop controlled, low volume. | None. | N |
| Copco Road / Lakeview Road | Iron Gate | n/a | No signage, poor AC pavement at intersection, should add stop control prior to dam removals. | Provide stop sign and stop bar. | Y (area near bridge replacement, may need flaggers during new bridge construction) |
| Lakeview Road / Powerhouse Access | Iron Gate | 1-way stop | AB Intersection, no striping. 5 legs at intersection. Should reconfigure and improve stop control prior to construction. | Provide stop sign at powerhouse access road approach. | Y (area near bridge replacement, may need flaggers during new bridge construction) |

| Structure Field Observations | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bridge Name | Dam | Road | Bridge No. | As-Builts | Year Built | Haul or Access | Deck Width | Lane 1 Width | Lane 2 Width | Span | Notes | Recommended Improvements | Temporary Traffic Control (Y/N) |
| Spencer bridge | J.C. Boyle | Green Springs Hwy (OR66), Oregon | 19789 | Yes | 2005 | Haul | 42.54' | 12' | 12' | 3 spans @ 557.74' total | Reinforced concrete deck on continuous steel plate girders, excellent condition. Also include 8' shoulder on each side. | Assess eastern embankment and abutment after reservoir drawdown. May need outer layer riprap repair based on assessment of erosion following the drawdown. | N |
| Timber bridge | J.C. Boyle | JC Boyle Dam Access | n/a | Partial | | Access | 18' | 16' | None | 100' | Wood deck on rolled beams, fair condition | None, remove post-project. | N |
| Concrete bridge | J.C. Boyle | Unnamed Road over Spencer Creek | | | | | | | | | Noted the gabion walls next to the bridge are in good condition. No railing on the bridge. | None, not impacted by the project. | N |
| Unknown cattle bridge | Copco 1 | Private Access | | | | | | | | | Unknown cattle bridge - 2.3mi upstream from Copco bridge | None. | N |
| Copco Road bridge | Copco 1 | Copco Rd - Ager Beswick Rd | 2C0039 | Yes | 1988 | Haul | 24.67' | 12' | 12' | 202.5' | 4' deep CIP PS concrete box | None, though should be monitored for post project erosion and provide new protection if need be. | N |
| Daggett Road bridge | Copco 2 | Daggett Rd | | Partial | 1983 | Haul | 14' | 12' | | 42', 72', 58' 61' | Timber deck on steel girders | Full replacement. New bridge will be constructed adjacent to existing alignment for similar length and width to be determined based on the future demand. Roadway approaches will be realigned to conform to new bridge. | N |
| Fall Creek Bridge | Copco 2 | Copco Rd | 2C0198 | No | 1969 | Access | 25' | 12' | 12' | | AC on deck in poor condition, wood railing in poor condition. Connection only to power plant/grid station. | Replace on existing location. Provide temporary bridge and detour road upstream of existing bridge during bridge replacement. | Y |
| Lakeview Road bridge | Iron Gate | Lakeview Rd | 2C0255 | No, but have Inspection Report | 1960 | Haul | 14.4' | 12' | | 9 spans @ 24.9' Total = 272' | Reinforced concrete deck on steel simply supported beams. Bents are timber pile extensions with timber or steel caps. Overall width is 17'. Posted load limits | Replace. New bridge will be constructed adjacent to existing alignment for similar length and width to be determined based on the future demand. Roadway approaches will be realigned to conform to new bridge. Approach roadways will be realigned to conform to new bridge. | Y (traffic control during pavement conform work at approach roadways) |
| Jenny Creek bridge | Iron Gate | Copco Rd | 2C0280 | Yes, but only GP & FP | 2008 | Haul | 27.33' | 12' | 12' | 113.5' | PC PS deck bulb tee girders, AC in good condition, MBGR in good condition | Full replacement. New bridge parallel to existing bridge with longer/multiple spans so that abutments are placed in areas less susceptible to erosion. | Y (during pavement conform work at approach roadways to new bridge) |
| Brush Creek bridge | Iron Gate | Copco Rd | 2C0224 | Yes | 1976 | Haul | 24.5' | 12' | 12' | 25' | 18" concrete slab bridge | None, this bridge is located on the haul route (Copco Rd) and potential for some minor pavement rehabilitation post-project condition. Post project erosion is not expected to impact abutments. | Y (during pavement rehab) |
| Dry Creek bridge (Fish Hook) | Iron Gate | Copco Rd | 2C0144 | No | 1960 | Haul | 30.75' | 14' | 14' | 24.5' | Timber deck and girders with AC overlay | Replacement to be provided in existing location. Provide temporary bridge and detour road upstream of bridge during replacement. | Y |
| Pedestrian bridge - private | Klamath River | None | | No | | n/a | | | | | Deteriorated, not in use. Should be removed. | Remove, unsafe condition. | N |
| Pedestrian bridge - campground | Klamath River | None | | No | | n/a | | | | | Well maintained. In flood plain | None. Possible removal or rehabilitation post-project. | N |
| Railroad bridge | Klamath River | None | | No | | n/a | | | | | Central Oregon and Pacific RR Bridge | Possible scour mitigation post-project. | N |
| Cottonwood Creek Bridge | Klamath River | Copco Rd | 2C0257 | No | 1980 | Haul | 32' | 12' | 12' | 89' | Purple permit capacity for all trucks | None. | N |

| Culvert Field Observations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Description | Dam | Road | No. of Pipes | Culvert Size(s) | Type of Pipe | Notes | Recommended Improvements | Temporary Traffic Control (Y/N) |
| Topsy Grade Road at Unnamed Creek | J.C. Boyle | Topsy Grade Rd | 3 | 24" each | Unknown (possibly CMP) | PacifiCorp staff confirmed there is a pipe culvert connecting both sides of the road and conveying water through the culvert. As built plans indicate 3-24" culverts. Pipe type unknown. | Potentially some minor post project improvements including removal of sediment and/or debris, redirection of flows through the culvert to the original downstream side, and erosion protection of downstream embankment. | Y (during erosion protection installation) |
| Unnamed Road at Unnamed Drainage | J.C. Boyle | Unnamed | 2 | 36" each | CMP | Both sides of culverts silted. Located well above lake water level. | Possible rock slope protection on downstream embankment. Culvert clean up to remove silt and some vegetation. | Y (during erosion protection installation culvert cleanup) |
| Copco Road at Beaver Creek | Copco 1 | Copco Rd | 1 | 60" | CMP | Length of pipe is about 30 feet long with 1.5 feet cover under the Copco Rd. The gravel/dirt road is about 13 feet wide and is in a fairly stable condition. | Culvert is located above R.W.S so no major impact is anticipated. However, if scope allows after construction, recommend installing rock slope protection at the downstream side and remove any sediment or debris from culvert. | Y (during erosion protection installation culvert cleanup) |
| Copco Rd at East Fork Beaver Creek | Copco 1 | Copco Rd | 1 | 60" | CMP | Length of pipe is about 30 feet long with 1.5 feet cover under the Copco Rd. The gravel/dirt road is about 13 feet wide and is in a fairly stable condition. | Culvert is located above R.W.S so no impact is anticipated. However, if scope allows after the construction, recommend installing rock slope protection at the downstream side and remove any sediment or debris from culvert. | Y (during erosion protection installation culvert cleanup) |
| Copco Road at Raymond Gulch | Copco 1 | Copco Rd | 1 | 60" | CMP | Length of pipe is about 20 feet long with 0.5 feet cover under the Copco Rd. The gravel/dirt road is about 11 feet wide and is in a fairly stable condition. | Culvert is located above R.W.S so no impact is anticipated. However, if scope allows after the construction, recommend installing rock slope protection at the downstream side and remove any sediment or debris from culvert. | Y (during erosion protection installation culvert cleanup) |
| Patricia Avenue at West Fork Unnamed Creek | Copco 1 | Patricia Ave | 1 | 36" | CMP | The culvert is located beneath Patricia Avenue. The AC paved road is about 20 feet wide and is in a good condition. Posted speed limit is 25mph. | Culvert is located above R.W.S so no impact is anticipated an no improvement required. If scope allows after construction, recommend installing rock slope protection and remove any sediment or debris from culvert. | Y (during erosion protection installation culvert cleanup) |
| Patricia Avenue at East Fork Unnamed Creek | Copco 1 | Patricia Ave | 1 | 36" | CMP | The culvert is located under Patricia Avenue. The AC paved road is about 20 feet wide and it is in good condition. Posted speed limit is 25mph. | Culvert is located above R.W.S so no impact is anticipated and no improvement required. If scope allows after construction, recommend installing rock slope protection and remove any sediment or debris from culvert. | Y (during erosion protection installation culvert cleanup) |
| Culvert at Deer Creek | Copco 1 | Ager Beswick Rd | Unknown | Unknown | Unknown | The location is covered with heavy vegetation, so unable to take measurement of the culvert. The AC paved road is about 22 feet wide and in very good condition. Posted speed limit is 30mph. | Culvert is located above R.W.S so no impact is anticipated and no improvement required. | N |
| Culvert at Indian Creek | Copco 1 | Ager Beswick Rd | Unknown | Unknown | Unknown | The location is covered with heavy vegetation, so unable to take measurement of the culvert. The AC paved road is about 22 feet wide and in very good condition. Posted speed limit is 30mph. | Culvert is located above R.W.S so no impact is anticipated and no improvement required. | N |
| Daggett Road at Fall Creek | Copco 2 | Daggett Rd | 1 | 10ft | CMP | Length of pipe is about 32 feet long with 3 feet cover under Daggett Road. The gravel road is about 16 feet wide and is located just behind a gate off of Copco Road. This is a pinch point on the Daggett Road that connects to Copco Road. This is a potential haul route to transport materials from the Copco 2 Power House. | One way control roadside sign with advance warning signs may be needed to provide caution to truck drivers. | Y |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Copco Road at Scotch Creek | Iron Gate | Copco Rd | 1 | 36" | CMP | Pipe about 2 feet above water level. | Replace with larger box culvert along existing alignment. Provide rip rap armoring on downstream side. Provide temporary detour road upstream during replacement. | Y |
| Copco Road 200' east of Scotch Creek drainage | Iron Gate | Copco Rd | 2 | 18", 12" | CMP | | Assess post project for damage due to construction traffic loads over pipe. May require repair or replacement. | Y (during pipe replacement/repair) |
| Small cross culverts between Brush Creek and Scotch Creek | Iron Gate | Copco Rd | Multiple | 12"-18" | CMP | Pipes spaced every 200' to 300'. | Assess post project for damage due to construction traffic loads over pipe. May require pipe repair or replacement. | Y (during pipe replacement/repair) |
| Copco Rd at Camp Creek | Iron Gate | Copco Rd | 1 | 10' | CMP arched | Water in culvert. | Replace with a single span bridge along existing alignment. Provide temporary detour road upstream during replacement. | Y (during pipe replacement/repair) |

# Appendix J Fire Management Plan

AECOM

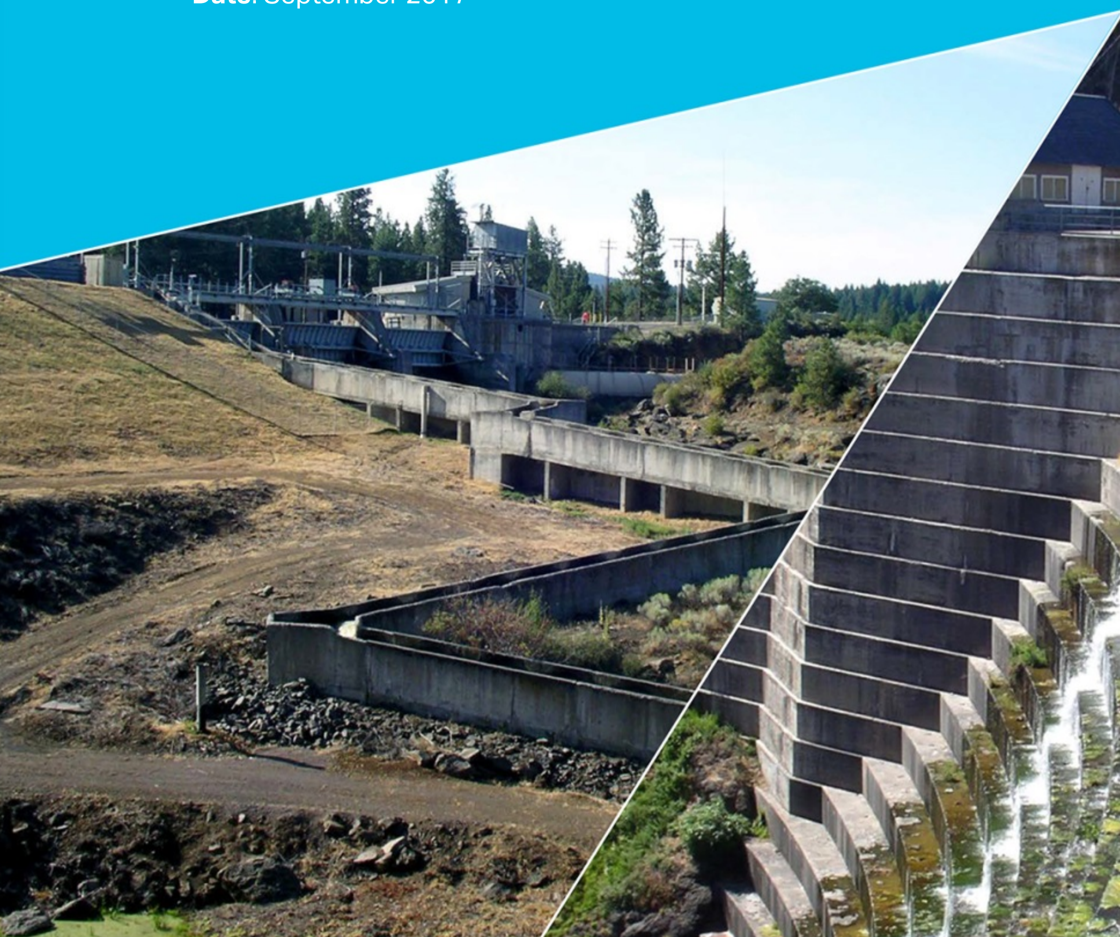
# Klamath River Renewal Project

## California Environmental Quality Act (CEQA) and California and Oregon 401 Water Quality Certifications Technical Support Document Appendix J – Fire Management Plan

**Submitted to:** California State Water Resource Control Board and Oregon Department of Environmental Quality

**Submitted by:** Klamath River Renewal Corporation

**Date**: September 2017



**Prepared for:**

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California State Water Resources Control Board
Oregon Department of Environmental Quality

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# Table of Contents



# Figures

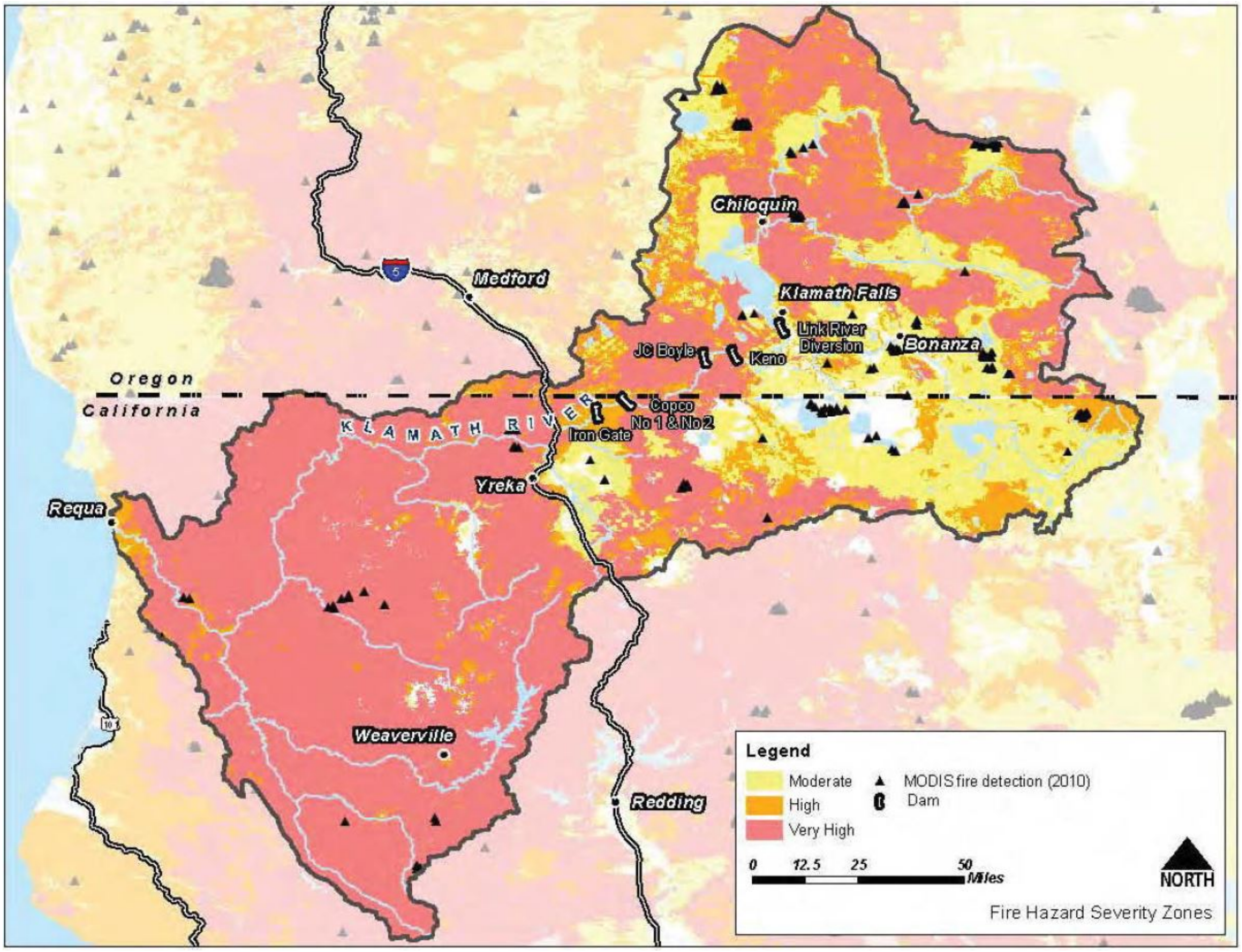


# Tables

# 1. Need for Fire Management Plan

The areas surrounding the four Klamath River dams are at risk of wildfires particularly during the dry season, and the risk of triggering a fire associated with construction and demolition activities necessitates the development and implementation of a Fire Management Plan (FMP) to effectively prevent and respond to fires. California Department of Forestry and Fire Protection (Cal Fire) categorizes the fire threat in the area as high to very high (Cal Fire, 2007). Fire hazard mapping using the MODerate-resolution Imaging Spectroradiometers by the US Forest Service Remote Sensing Application Center (USFS 2010) shows the distribution of fire threats in the Klamath basin (Figure 1), and Klamath County has identified Wildland Urban Interfaces (WUI), where fire damage hazards are high (Wildland Fire Technologies, 2016). There is an associated ranking system associated with WUIs and J.C. Boyle dam, which is partially located in the Keno WUI Community and has the highest value in Klamath County and WUI rating of High.

Construction and dam removal activities potentially increase the risk of fire if not properly managed. Activities of concern include accidental spills of flammable material, spark generation in vegetated open space, and use of equipment and machinery that generates heat such as welding, grinding, and use of generators. Agencies dealing with fire prevention and suppression in the project area have developed regulations and management methods to combat the increased risk of fire associated with construction activities. The FMP is developed in accordance with the standards of and in consultation with the local, state, and federal fire suppression agencies. The following sections describe the relevant agencies, their jurisdictions and regulatory requirements, and the FMP components to ensure the safe execution of the Klamath Dams Decommissioning.




*Source: USBR 2012*

**Figure 1-1 Map of fire hazard in the Klamath River basin generated using the MODerate-resolution Imaging Spectroradiometers by the USFS.**

# 2. Fire Suppression Agencies

The FMP requires coordination with multiple city, county, state, and federal fire suppression agencies including USDA Forest Service (USFS), Bureau of Land Management (BLM), the Oregon Department of Forestry (ODF) Klamath-Lake District, Cal Fire - Siskiyou Unit, local districts of Klamath and Jackson Counties in Oregon and Siskiyou County in California, and local city and volunteer fire stations (Table 2-1). Fire safety and suppression resources are available from the various agencies in the event of a fire.

### Table 2-1 Fire protection agencies in the project area

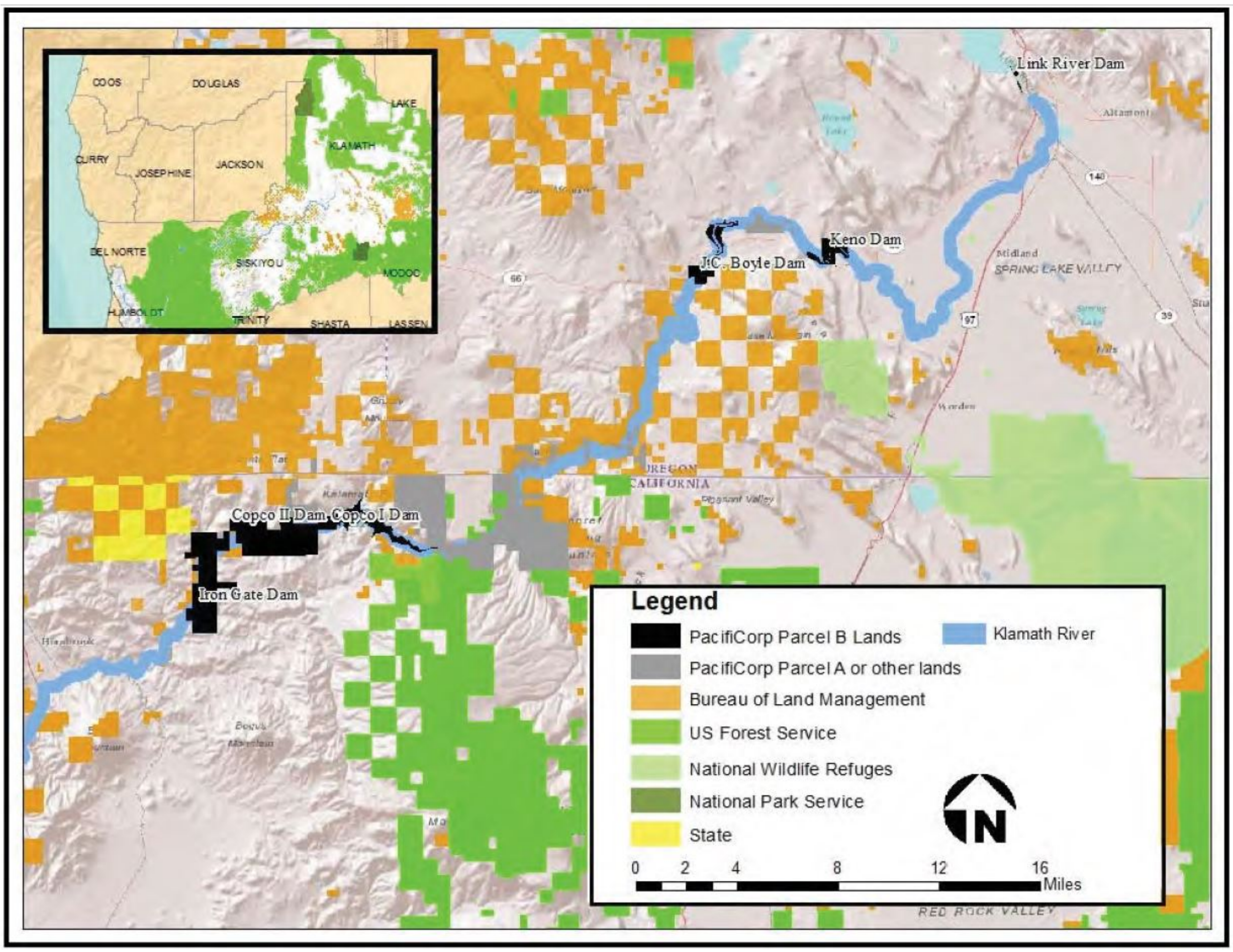
| Agency | Federal/State/Local | Jurisdiction |
|---|---|---|
| USDA Forest Service | Federal | National Forests, federally managed land |
| Bureau of Land Management | Federal | BLM lands, federally managed land |
| Cal Fire | State of California | State Resource Lands, California |
| Oregon Department of Forestry | State of Oregon | State Resource Lands, Oregon, BLM land in Klamath River Canyon |
| Klamath County Fire District | Local, County of Klamath | Unincorporated County Lands and the City of Klamath Falls |
| Colestin Rural Fire District | Local, County of Jackson | County Fire District in Jackson County, Oregon |
| Siskiyou County Fire Protection Districts: Copco Lake, Hornbrook, Montague, South Yreka, Tulelake, Etna, Ft. Jones, Weed | Local, County | Unincorporated County Lands throughout Siskiyou County, California |
| Mount Shasta Fire Department | Local, City of Mount Shasta | Mt. Shasta Municipal Boundaries |
| Yreka Fire Department | Local, City of Yreka | City of Yreka Municipal Boundaries |

*Source: USBR and CDFW 2012*

The USFS and BLM are the two federal agencies responsible for fire support and suppression in the project vicinity. Both agencies provide wildfire protection primarily on land under their direct ownership and management but will provide support and assistance to other agencies when requested. Federal land near the project area is primarily limited to several BLM parcels along the Klamath River downstream of J.C. Boyle and along Iron Gate and Copco reservoirs (Figure 2). BLM land near the project area in Oregon, including the Klamath River Canyon, is managed for fire by ODF Klamath-Lake District (KLD).

The Oregon and California State forestry and fire prevention agencies (ODF and Cal Fire) are the primary fire protection providers in the unincorporated areas in the project area. ODF and Cal Fire enforce their respective state laws and regulations and coordinate fire support with the local agencies. Cal Fire, operates and works with local city, county, and volunteer fire departments. Fire management in Siskiyou County is operated as the Cal Fire Siskiyou Unit. The Iron Gate and Copco project sites are located within the Siskiyou County Unit Shasta Valley Battalion 2 area, and the river flows through Battalion 3. Cal Fire stations in the project area include the City of Yreka and Hornbrook, which is located 10 miles west of Iron Gate dam. The J.C. Boyle project area in Oregon is under the jurisdiction of ODF KLD. The ODF KLD is a member of the South Central Oregon Fire Management Partnership (SCOFMP), which is a cooperative group of agencies including USFS, BLM, US Fish and Wildlife, and Crater Lake National Park. The SCOFMP shares resources to manage fire in the region, which primarily comprises Klamath and Lake counties. Dispatch responsibilities for the SCOFMP are with the Lakeview Interagency Fire Center (LIFC).

The city-operated fire stations in the project area include the Yreka and Mount Shasta Fire Departments in California. Many county fire stations are present throughout the project area, and are associated with Klamath and Jackson counties in Oregon and Siskiyou County in California (Table 1).




*Source: USBR and CDFW 2012*

**Figure 2-1 Land ownership in the project vicinity. Figure from EIS/EIR (2012).**

# 3. Regulations and Requirements

The FMP is developed to meet the regulations and requirements set forth by the fire suppression agencies in the project area (Figure 2). Most of the dam deconstruction and reservoir management will take place on private land. ODF and Cal Fire handle state regulations for fire management with regard to various construction related activities. BLM and USFS manage their respective lands, and regulations only need to be met for construction taking place on federal land. There are several BLM parcels along the Klamath River adjacent to but not in the project footprint. In Oregon, the BLM lands east of the Cascades crest and west of Hwy 97 are managed by ODF KLD and regulated for fire according to ODF rules. This area includes the Klamath Canyon project area. In California, a few BLM parcels are located near the Copco project footprint. In these locations, BLM generally defers to restrictions corresponding to the Predicted (or Designated) Activity Levels (PALs) set by the USFS Klamath National Forest and relies on Cal Fire for direct protection responsibilities (Brodhead, L., personal communication 2017.08.29). For logging operations on BLM land in California, contractual fire prevention and suppression measures vary between projects but must typically conform to general of Cal Fire and USFS regulations and the input from a BLM Authorized Agent assigned to the contract (Brodhead, L., personal communication 2017.08.29). The USFS owns land that is near Copco reservoir but outside of the project footprint. Therefore, the FMP does not address specific USFS fire prevention and suppression requirements outlined in the Code of Federal Regulations (CFR).

## 3.1 Oregon Department of Forestry – Klamath Lake Unit

Oregon law prescribes regulations and minimum requirements for fire prevention and suppression that are applicable in each ODF Fire Protection District during fire season. Oregon fire season is declared by each ODF district and is typically between early June and to mid to late October. The laws and requirements for all ODF districts are provided in Table 2.

ODF districts west of the Cascades crest have industrial operations requirements and restrictions that correspond to four adjective classes Industrial Fire Precautionary Levels (IFPL). A different system is in place for ODF districts east of the Cascades crest, such as the ODF Klamath-Lake District. Construction operations must follow the regulations in Table 2 for all levels of fire danger during fire season. Additional restrictions are enforced when fire hazard is classified as “extreme.” ODF does not have general restrictions or requirements when work is performed outside of the fire season.

If necessary, a permit will be obtained from the ODF state forester for construction activities that involve heavy machinery. The permit is the “Permit for Power-Driven Machinery (PDM),” which is described by Oregon law ORS 477.625. There are fire prevention requirements that accompany the permit that are dependent on the Fire Danger Level (FDL). The PDM permit relates requirements for fire prevention and suppression preparedness to type of machinery and fire hazard. The requirements are more restrictive during “Extreme” adjective class FDL and include the suspension of the operation of tracked machinery between the hours of 1 pm and 8 pm as prescribed by the PDM (ORS 477.625(1a), OAR 629-043-0026(5)). The use of tracked equipment is expected at the project sites and, if a PDM was required, would be subject to these restrictions during extreme fire danger. ODF typically informs PDM permit holders of changes in fire hazard and operation requirements. PDM permits expire at each new calendar year and must be renewed.

The ODF forester can grant waivers from the fire prevention and suppression requirements, including the PDM, in some instances. Waivers may be granted in certain project areas for favorable weather conditions, topographic setting, and/or alternate methods and equipment proposed by the operator that provide equal or better fire prevention and suppression.

### Table 3-1 2017 ODF fire season minimum requirements

| Topic | Law | Description |
|---|---|---|
| No Smoking | ORS 477.510 | No smoking while working or traveling in an operation area |
| Hand Tools | ORS 477.655, OAR 629-043-0025 | Supply hand tools for each operation site - 1 tool per person with a mix of pulaskis, axes, shovels, hazel hoes.<br>Store all hand tools for fire in a sturdy tool box clearly identified as containing firefighting tools. Supply at least one box for each operation area. Crews of 4 or less are not required to have a fire tools box as long as each person has a shovel, suitable for fire-fighting and available for immediate use while working on the operation. |
| Fire Extinguishers | ORS 477.655, OAR 629-43-0025 | Each internal combustion engine used in an operation, except power saws, shall be equipped with a chemical fire extinguisher rated as not less than 2A:10BC (5 pound). |
| Power Saws | ORS 477.640, OAR 629-043-0036 | Power saws must meet Spark Arrester Guide specifications - a stock exhaust system and screen with < .023 inch holes.<br>The following shall be immediately available for prevention and suppression of fire:<br>- One gallon of water or pressurized container of fire suppressant of at least eight ounce capacity<br>- 1 round pointed shovel at least 8 inches wide with a handle at least 26 inches long<br>- The power saw must be moved at least 20' from the place of fueling before it is started. |
| Fire Tools, Extinguishers for Trucks | ORS 477.655, OAR 629-043-0025 | Equip each truck driven in forest areas for industrial purposes with:<br>- 1 round pointed shovel at least 8 inches wide, with a handle at least 26 inches long<br>- 1 axe or Pulaski with 26 inch handle or longer<br>- 1 fire extinguisher rated not less than 2A:10BC (5 pound). |
| Spark Arresters and Mufflers | ORS 477.645, OAR 629-043-0015 | All non-turbo charged engines must meet Spark Arrester Guide specifications except:<br>- Fully turbo charged engines.<br>- Engines in motor vehicles operating on improved roads equipped with an adequate muffler and exhaust system.<br>- Engines in light trucks (26,000 GVW or less) that are equipped with an adequate muffler and an exhaust system.<br>- Engines in heavy trucks (greater than 26,000 GVW) that are equipped |

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| | | with an adequate muffler and exhaust system.<br>- If a truck engine is not fully turbo-charged, then the exhaust must extend above the cab and discharge upward or to the rear, or to the end of the truck frame.<br>- Water pumping equipment used exclusively for fighting fire.<br>- Engines of 50 cubic inch displacement or less, except ATV's and motorcycles, shall be equipped with an adequate muffler and an exhaust system.<br>- Engines in ATV's and motorcycles must be equipped with an adequate muffler and exhaust system or an approved screen, which completely encloses exhaust system.<br>- Power saws. (See power saw requirements) |
| Pump, Hose, and Water Supply | ORS 477.650, 477.625, OAR 629-043-0026, 629-43-0020 | Supply a pump, hose and water supply for equipment used on an operation.<br>- Pump must be maintained ready to operate and capable to provide a discharge of not less than 20 gallons per minute at 115 psi at pump level. Note: Volume pumps will not produce the necessary pressure to effectively attack a fire start. Pressure pumps are recommended.<br>- Water supply shall be a minimum of 300 gallons if a self-propelled engine. Water supply shall be a minimum of 500 gallons if not self-propelled (pond, stream, tank, sump, etc.)<br>- One water supply is adequate as long as the operator can deliver water to the fire within 10 minutes<br>- Provide enough hose (500 feet minimum) not less than 3/4" inside diameter to reach areas where power driven machinery has worked. Note: Should a fire occur, the operator must be able to position the water supply in a location where enough hose is available to reach the area worked by power driven machinery. This includes mobile equipment as well as motorized carriages and their moving lines. Moving lines are defined as main lines and haul back lines. This can be achieved in many ways, including the practice of having a water tank and hose attached to a piece of equipment, like a skidgen or skidder, that can get the water to the fire.<br>- Water supply, pump, and at least 250' of hose with nozzle must be maintained as a connected, operating unit ready for immediate use. |
| Fire Watch Service | ORS 477.665, OAR 629-043-0030 | Each operation area is to have a fire watch. Fire watch shall be on duty during any breaks (up to 3 hours) and for three hours after all power-driven machinery used by the operator has been shut down for the day. The ODF Klamath-Lake District has specific fire watch duration prescriptions based on Fire Danger Level adjective class.<br>- Low = 1 hr fire watch<br>- Moderate = 2 hrs<br>- High to Extreme = 3 hrs<br>Fire watch shall:<br>- Be physically capable and experienced to operate firefighting equipment.<br>- Have facilities for transportation and communications to summon assistance.<br>- Observe all portions of the operation on which activity occurred during |

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| | | the day.<br>Upon discovery of a fire, Fire watch personnel must: First report the fire, summon any necessary firefighting assistance, describe intended fire suppression activities and agree on a checking system; then, after determining a safety zone and an escape route that will not be cut off if the fire increases or changes direction, immediately proceed to control and extinguish the fire, consistent with firefighting training and safety. |
| Operation Area Fire Prevention | ORS 477.625, OAR 629-043-0026 | - Keep all power driven machinery free on excess flammable material which may create a risk of fire.<br>- Avoid line-rub on rock or woody material, which may result in sparks or sufficient heat to cause ignition of a fire.<br>- Disconnect main batteries from powered components (other than what may be necessary to retain computer memory) through a shut-off switch or other means or leave equipment on ground cleared of flammable material. |

*Source: ODF 2010, 2017*

## 3.2 Cal Fire – Siskiyou Unit

California law prescribes regulations and minimum requirements for fire prevention and suppression that are applicable during fire season in all lands within the Cal Fire jurisdiction. The California Public Resources Code (PRC) requires preventative fire measures (Table 3) that are imposed during the time where a Burn Permit is required under PRC-4423. For Zone B, which includes northern California counties, this period usually begins May 1 and persists until proclamation of the termination of fire season by the fire director. Cal Fire does not require a permit for the use of equipment and heavy machinery on a construction site. State forest and fire laws may be enforced by USFS, BLM, NPS, and certain county fire departments in addition to Cal Fire personnel. The California Code of Regulations (CCR) has specific and generally applicable regulations that pertain to fire prevention and suppression, e.g., requirements for smoking during fire season, but there are no associated permits required. The CCR, PRC, and FRC regulations pertaining to construction sites and logging operations in California and the associated best management practices are described in detail in the Cal Fire Industrial Operations Fire Prevention Guide (1999).

### Table 3-2 California Public Resources Code Fire precautionary measures*

| Topic | Law | Description |
|---|---|---|
| Fire Causing Equipment | PRC-4427 | No person shall use or operate any motor, engine, boiler, stationary equipment, welding equipment, cutting torches, tarpots, or grinding devices from which a spark, fire, or flame may originate, which is located on or near any forest-covered land, brush-covered land, or grass-covered land, without doing both of the following:<br>(a) First clearing away all flammable material, including snags, from the area around such operation for a distance of 10 feet.<br>(b) Maintain one serviceable round point shovel with an overall length of not less than 46 inches and one backpack pump water-type fire extinguisher fully equipped and ready for use at the immediate area |

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| | | during the operation.<br>This section does not apply to portable powersaws and other portable tools powered by a gasoline-fueled internal combustion engine. |
| Use of Internal Combustion Engines | PRC-4428 | No person shall use or operate any vehicle, machine, tool or equipment powered by an internal combustion engine operated on hydrocarbon fuels, in any industrial operation located on or near any forest, brush, or grass-covered land between April 1 and December 1 of any year, or at any other time when ground litter and vegetation will sustain combustion permitting the spread of fire, without providing and maintaining, for firefighting purposes only, suitable and serviceable tools.<br>(a) A sealed box of tools shall be located, within the operating area, at a point accessible in the event of fire. This fire toolbox shall contain: one backpack pump-type fire extinguisher filled with water, two axes, two McLeod fire tools, and a sufficient number of shovels so that each employee at the operation can be equipped to fight fire.<br>(b) One or more serviceable chainsaws of three and one-half or more horsepower with a cutting bar 20 inches in length or longer shall be immediately available within the operating area, or, in the alternative, a full set of timber-felling tools shall be located in the fire toolbox, including one crosscut falling saw six feet in length, one double-bit ax with a 36-inch handle, one sledge hammer or maul with a head weight of six, or more, pounds and handle length of 32 inches, or more, and not less than two falling wedges.<br>(c) Each rail speeder and passenger vehicle shall be equipped with one shovel and one ax, and any other vehicle used on the operation shall be equipped with one shovel. Each tractor used in such operation shall be equipped with one shovel. |
| Fire Fighting Tools | PRC-4429 | In an area of any industrial or other operations on or near any forest-covered land or brush-covered land, there shall be provided and maintained at all times, in a specific location, for firefighting purposes only, a sufficient supply of serviceable tools to equip 50% of the able-bodied personnel for fighting fires.<br>- Tools shall be included shovels, axes, saws, backpack pumps, and scraping tools.<br>- One serviceable headlight adaptable for attachment to at least one-half of the tractor-bulldozers used on the operation.<br>- A sufficient number of canteens and flashlights to equip a third of the able-bodied personnel. |
| Water Pumps | PRC-4430 | The use or operation of any steam-operated engine or machine equipment, located on or near forest-covered land or brush-covered land, requires<br>- One adequate force pump or water under pressure equivalent to a pump, and not less than 200 feet of hose not less than one inch in diameter for each steam-operated engine or equipment.<br>- The pump or water pressure shall be capable of applying a minimum of 40 pounds pressure at the nozzle on 200 feet of hose, such nozzle to be 0.25 inch or larger in diameter.<br>- If two steam-operated engines or steam equipment are customarily operated within 100 feet of each other, only one engine or piece of |

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| | | equipment need be equipped with pump and hose. |
| Gas Powered Saws | PRC-4431 | No person shall use or operate or cause to be operated any portable saw, auger, drill, tamper, or other portable tool powered by a gasoline-fueled internal combustion engine on or near any forest-covered land, brush-covered land, or grass-covered land, within 25 feet of any flammable material, without providing and maintaining at the immediate locations of use or operation of the saw or tool, for firefighting purposes one serviceable round point shovel, with an overall length of not less than 46 inches, or one serviceable fire extinguisher.<br>The Director of Forestry and Fire Protection shall by administrative regulation specify the type and size of fire extinguisher necessary to provide at least minimum assurance of controlling fire caused by use of portable power tools under various climatic and fuel conditions.<br>The required fire tools shall at no time be farther from the point of operation of the power saw or tool than 25 feet with unrestricted access for the operator from the point of operation. |
| Spark Arresters | PRC-4442 | (a) No person shall use, operate, or allow to be used or operated, any internal combustion engine which uses hydrocarbon fuels on any forest-covered land, brush-covered land, or grass-covered land unless the engine is equipped with a spark arrester maintained in effective working order or the engine is constructed, equipped, and maintained for the prevention of fire.<br>(b) Spark arresters affixed to the exhaust system of engines or vehicles shall not be placed or mounted in such a manner as to allow flames or heat from the exhaust system to ignite any flammable material.<br>(c) A spark arrester is a device constructed of nonflammable materials specifically for the purpose of removing and retaining carbon and other flammable particles over 0.0232 of an inch in size from the exhaust flow of an internal combustion engine that uses hydrocarbon fuels or which is qualified and rated by the United States Forest Service.<br>(d) Engines used to provide motive power for trucks, truck tractors, buses, and passenger vehicles, except motorcycles, are not subject to this section if the exhaust system is equipped with a muffler.<br>(e) Turbocharged engines are not subject to this section if all exhausted gases pass through the rotating turbine wheel, there is no exhaust bypass to the atmosphere, and the turbocharger is in effective mechanical condition. |
| Exclusion of Outdated, Handheld Internal Combustion Equipment | PRC-4443 | No person shall use, operate, or cause to be operated on any forest-covered land, brush-covered land, or grass-covered land any handheld portable, multi-position, internal-combustion engine manufactured after June 30, 1978, which is operated on hydrocarbon fuels, unless it is constructed and equipped and maintained for the prevention of fire. |

* Measures are applicable during any times of the year when burning permits are required unless otherwise stated.

# 4. Contacts

The contractor will be in frequent contact with the pertinent fire suppression agencies during construction to discuss fire hazards, prevention, suppression, and contingency plans. The contractor and a designated Safety Officer will identify the nearest local fire stations to the current operation areas and ensure their emergency contact information for each agency is posted at the project site. The contractor and Safety Officer will ensure the emergency information is available to fire watch personnel and on-site workers.

In Oregon, the primary contact agency is ODF Klamath-Lake District (KLD). The KLD Unit Forester and Stewardship Forester are the preferred contacts for development of detailed, site-specific fire management plans, the identification of resources in the project area, project management, and fire suppression. KLD will be the first contact agency in the event of a fire at the Oregon project site.

In California, the primary contact agency is Cal Fire Siskiyou Unit (CFSU). The CFSU Prevention Specialist is the preferred contact for developing detailed, site-specific fire management plans, the identification of resources in the project area, project management, and fire suppression. CFSU will be the first contact agency in the event of a fire at the California project sites.

# 5. Fire Management Plan

## 5.1 Responsibilities

The Klamath River Renewal Corporation (KRRC) contractor ("Contractor" hereafter) will designate an individual as "Safety Officer" to be available and on-call 24 hours a day, 7 days a week in the event of a fire. The Safety Officer will be the primary on-site communication linkage to ODF and Cal Fire foresters and will be responsible for managing all on-site fire prevention and suppression documentation, including the contact information of local emergency services, such as local fire departments and hospitals. The Safety Officer will be responsible for instructing other workers in the required fire prevention and suppression measures, including the use of fire suppression equipment and the protocols in the event of a fire, and for communicating current fire hazards and any changes in prevention and suppression methods on a daily basis. A table of emergency contact agencies, their jurisdictions, and phone numbers will be clearly posted at each project site in case of fire. In the event of a fire, the Safety Officer is responsible for first contacting ODF or Cal Fire and following with appropriate local and federal fire agencies and then initiating fire suppression protocols. The Safety Officer will ensure that all fire suppression equipment is well-maintained and located in proper position within the construction site.

In the event of a fire, the Safety Officer will immediately contact LIFC dispatch and ODF KLD in Oregon or CFSU and subsequently any other pertinent fire suppression agencies. The Safety Officer will then initiate and command fire control activities on the site until relieved by fire suppression professionals. The goal is to immediately and aggressively extinguish any fire that occurs during construction of the project without sacrificing the safety of the workers. If the equipment on-site is judged incapable of suppressing the fire, the Safety Officer will initiate an evacuation of the project site.

The Contractor and Safety Officer will work with ODF KLD and CFSU foresters to develop broad scale contingency plans for fire containment within their respective jurisdictions in the project areas. It is common on large construction projects for the contractor to meet regularly with ODF and Cal Fire foresters to discuss project progress and updates as they pertain to fire prevention and suppression. The location, condition, and importance of existing fuel breaks will be evaluated, and the relevant fire suppression agencies will be alerted if fuel breaks need to be modified to envelope the work area. The location of water resources for fire suppression will be identified, and the Contractor will inform state foresters of any modifications to existing water resources due to dam removal activities, e.g., the drawdown of the reservoirs.

## 5.2 Fire Prevention and Suppression Measures and Equipment

The FMP includes both fire prevention and response methods that are consistent with the policies and standards of the various local, county, state, and federal jurisdictions. Precautionary, pre-suppression, and suppression measures will be taken to ensure public safety in the project vicinity and comply with the fire season regulations and requirements set forth by ODF (Table 2) and Cal Fire (Table 3). The contractor will work closely with ODF Klamath-Lake District Unit Forester and Stewardship Forester and the Cal Fire Siskiyou Unit

Forester to develop effective communication links, evolving plans for fire prevention and suppression, and suppression actions in the event of a fire. ODF KLD will likely assign a Stewardship Forester to the project area for the duration of the project.

The Contractor will obtain, if applicable, the ODF Permit for Power-Driven Machinery (PDM) under Oregon statute ORS 477.625. Operation hours of tracked machinery are limited by the PDM permit during extreme fire danger, and these machines will accordingly suspend operations between the hours of 1 pm to 8 pm when required. Additional measures must be taken to keep machinery and the work area clear of excess flammable material. If acquired, the PDM permit will be renewed annually, if needed, until project completion. California does not have restrictions on the hours of operation of equipment and machinery.

A fire watch will take place on work breaks and following the completion of each work day to monitor the operation site for fire. The fire Watchman will be trained in the appropriate responses in the event of a fire, and these include contacting fire suppression authorities and actively suppressing the fire. ODF KLD prescribes fire watch duration based on FDL. Low fire danger requires a 1-hour fire watch, medium requires 2 hours, and high and extreme require 3 hours. ODF alerts all PDM permit holders of upcoming changes in FDL.

A primary feature of the FMP is preparedness for fire prevention and response in compliance with Oregon and California state regulations (Table 2 and Table 3, respectively). All construction vehicles and crews will be outfitted with the appropriate type and number of fire suppression tools, including but not limited to shovels, axes, and fire extinguishers. All required vehicles and machinery will be equipped with functional spark arresters and/or mufflers, where applicable, and spark arrester ports will be routinely cleaned. Gas powered saws, if operated at the project site, will maintain the required fire suppression equipment as prescribed by Oregon and California. Water pumping systems conforming to the Oregon and California requirements for water volume, hose dimensions, and pumping rates will be located on-site to suppress fires. Best management practices for smoking will be developed by the Safety Officer in accordance with ORS and CCR regulations.

The Contractor and Safety Officer will conduct work using best management practices in addition to compliance with all federal, state, and local laws. The Contractor will ensure that effective communication lines are established to the various fire suppression agencies, particularly ODF Klamath-Lake District and Cal Fire Siskiyou County Unit. All equipment will be maintained to the working standards of the manufacturer and be kept clean of flammable material and debris. This includes ensuring that the batteries and hydraulic and fuel lines are in good condition. Equipment will be stored overnight in locations cleared of flammable material. Work areas will be cleared of dried vegetation to reduce risk of fire.

## 5.3 Additional Areas of Concern

Local and regional weather patterns and antecedent moisture conditions can significantly impact fire hazards and fire behavior. Lightning is a leading cause of wildfire in Siskiyou County, and most of the larger fires are categorized as wind-driven fires (Siskiyou County, 2016). Current and antecedent temperature and precipitation conditions directly influence the amount and condition of fuels. The Contractor will consult with ODF and Cal Fire foresters about anticipated weather conditions that may increase fire hazards and frequently update operations and fire response plans to changing environmental conditions. It is possible for favorable weather conditions to result in ODF foresters granting waivers of certain fire prevention and suppression requirements.

The Contractor will consult local and state fire management plans where available and communicate with local and state fire suppression agencies to identify existing resources and infrastructure in the project areas that are at risk in the event of a fire.

### Table 5-1 Fire services in the project area

| County | Fire Protection Services |
|---|---|
| Siskiyou County, CA | Fire protection is provided by 9 incorporated cities fire protection districts: Yreka, Fort Jones, Etna, Weed, Mt. Shasta, Dorris, Dunsmuir, Montague, and Tulelake.<br>Other nearby fire protection districts and stations in Siskiyou County include Copco Lake Fire Protection District, Hornbrook Fire Protection District, Butte Valley Fire Protection District, Mayten Fire Protection District, and Grenada Fire Protection District. (Siskiyou County, 2016) |
| City of Yreka, CA | Fire services are provided by the Yreka Fire Volunteer Department (City of Yreka 2010d; City of Yreka 2010e). |
| Klamath County, OR | Klamath County is served by 17 fire districts including Klamath County Numbers 1 through 5, Keno, Chiloquin, Central Cascades, Crescent, Oregon Outback, Chemult, Bonanza, Bly, Malin, and Merrill (Klamath County, 2016). |
| Jackson County, OR | Fire protection services provided by Jackson County include Ashland and Medford Fire and Rescue Stations and Jackson County Fire District Stations. Nearby services are provded by Colestin Rural Fire Protection District and Greensprings Rural Fire District. |

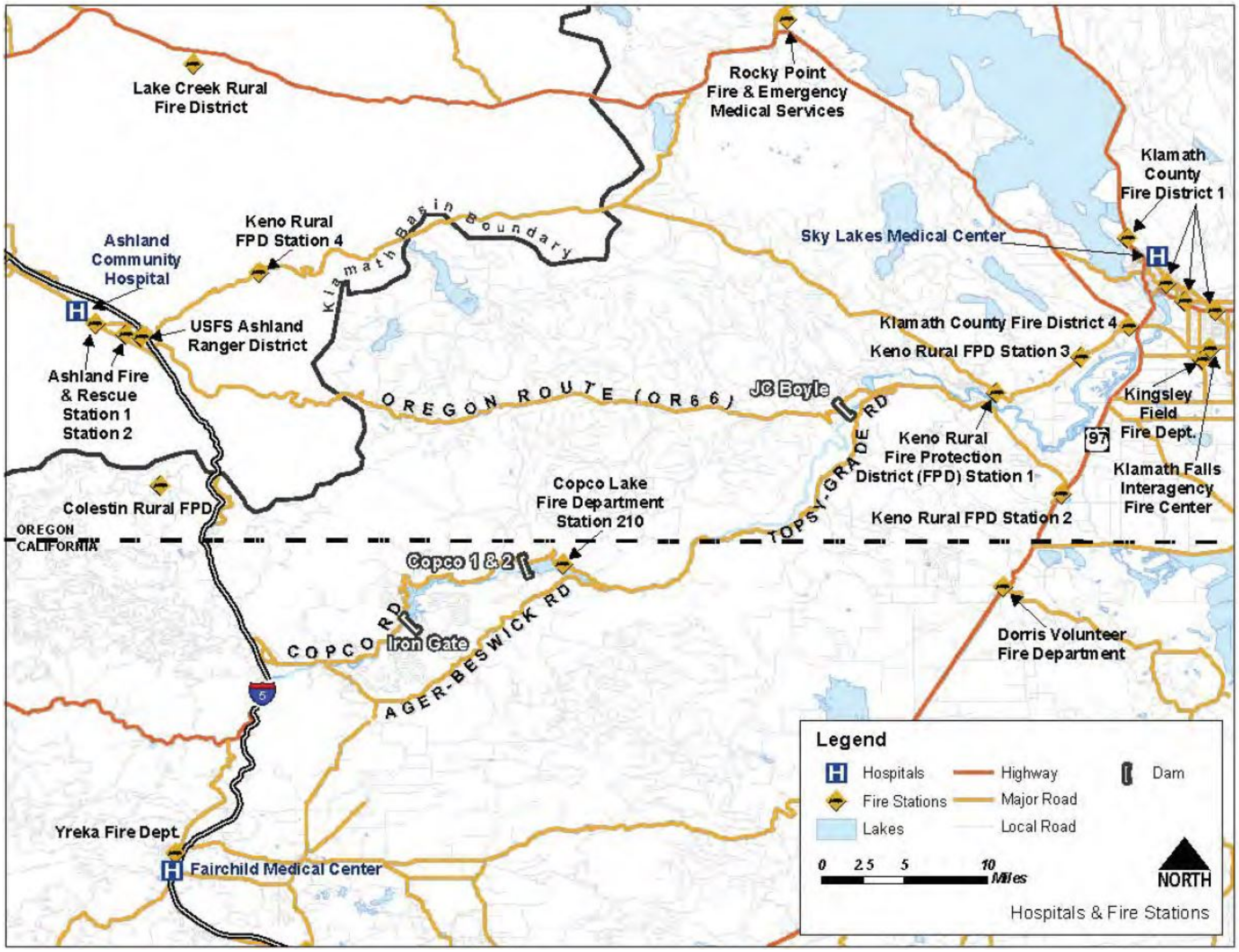
## 5.4 Fire Suppression Resources

The Contractor is responsible for working with local and state fire agencies to locate necessary fire suppression infrastructure and emergency resources. Several of the fire suppression agencies have fire management and suppression plans that identify resources at risk and resources for fire suppression within their respective jurisdictions and outline protocols that would be initiated in the event of a fire. SCOFMP has developed a plan and set of operation protocols for fire support in the area (South Central Oregon Fire Management Partnership, 2015). Klamath County has a Community Wildfire Protection Plan document and companion database to support wildfire prevention and suppression planning efforts in the county (Wildland Fire Technologies, 2016). Cal Fire Siskiyou Unit has a Unit Strategic Fire Plan that describes fire prevention goals and resources and guides fire management and fire suppression tactics (Siskiyou County, 2016).

The Contractor and Safety Officer will provide the location of nearby fire stations, hospitals, access roads, evacuation routes, and water sources (Figure 3) to all employees. Due to the rural nature and the low concentration of roads in the area, most roads are used as evacuation routes in the event of fire or other emergencies. The Safety Officer will ensure that water tanks intended for fire suppression are full during operation hours and the fire watch period at the end of each work day. The location of and access to the closest water sources will be identified if fire suppression tanks need to be refilled during fire suppression. The Safety Officer will communicate with local fire suppression agencies to identify water sources (e.g., fire hydrants, reservoirs, rivers) and access points proximal to the operation areas, and supplement scarce water resources with water storage tanks as needed.

In the California project areas, CFSU provides fire suppression resources and coordinates with additional local fires suppression entities (Table 4). It has a Cal Fire- and USFS-staffed Emergency Command Center located at the Siskiyou Unit Headquarters in Yreka that handles dispatching services for Cal Fire, USFS, 30 local government departments, and 5 ambulance companies (Siskiyou County, 2016). The Siskiyou Unit is divided into 4 battalions, and the project area is in Battalion 2 (Shasta Valley), which has Cal Fire stations in Yreka and Hornbook. For the Copco and Iron Gate dams, the closest fire stations in the area is Copco Lake Fire Department Station 210, which services the area surrounding the Copco 1 reservoir, and Yreka Fire Department. Jackson County, Oregon, has several nearby fire districts, including Ashland and Jackson County Fire Districts and Colestin Rural Fire District, that can provide additional fire suppression resources.

In the Oregon project areas, ODF KDL is primarily responsible for organizing fire prevention and suppression, and stations and districts that service Oregon are in Table 4. ODF KLD operates within the SCOFMP and shares resources and responsibilities with the other agencies therein. Dispatch responsibilities for SCOFMP are handled by LIFC. Klamath County has 17 fire districts and 30 fire stations. Jackson County has several nearby fire districts also capable of providing fire suppression resources, including Greensprings Rural Fire District, Jackson County Fire Districts, and Ashland fire stations. For J.C. Boyle dam, the closest station is the Keno Rural Fire Protection District (FPD) Station 1, which is located approximately 6 miles to the east and hosts 2 fire engines, an ambulance, and a water tender among other equipment.



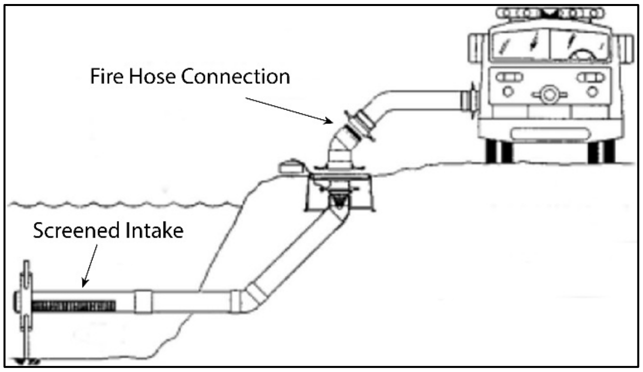

*Source: USBR 2012*

## Figure 5-1 Map of hospitals, fire stations, and major fire routes near the Klamath Dams

# 6. Water Supply Assessment Post-Dam Removal

The reservoirs provide a source of water for helicopter fire suppression crews fighting fires in the project vicinity, and this resource will be reduced following removal of the dams and drawdown of the reservoirs. Following removal, helicopter crews are still able to extract water from the Klamath River (both the current channel and the channel reaches to be exposed in the current reservoirs following drawdown), Ewauna Lake, and Upper Klamath Lake (EIS, 2012). However, most helicopter water tanks require 3 feet of water depth to be filled, so only select portions of the Klamath River will be able to be utilized by helicopters. Response and travel times between water tank fills for helicopter crews would be expected to increase with the loss of the reservoirs (EIS, 2012). Fire suppression efforts near J.C. Boyle will not experience significant increases in travel time given that Ewauna and Upper Klamath Lakes are located approximately 13 miles away. With typical fire fighting helicopter speeds between 90 and 140 mph (Jarrell, J., personal communication 2017.09.25), increases in round-trip travel time are a maximum of 15 minutes would result from the removal of J.C. Boyle. Analysis of aerial photos shows the presence of deep pools with suitable conditions for helicopter filling in the currently free-flowing reaches of the Klamath River around three reservoirs, particularly in the reaches between Copco and J.C. Boyle reservoirs and downstream of Iron Gate Dam. Maximum travel time increases to utilize the Klamath River for refilling are expected to be similarly on the order of 15 minutes, and potentially even less if pools are present in the former reservoirs post-removal.

To compensate for the loss of reservoir water supply, additional water supplies and access points will need to be developed for fire suppression following the removal of the dams. Flows in the Klamath River and tributaries are not expected to change post-removal, so firefighting crews can still use the river as a water supply. The potential of pool features for helicopter water filling will be evaluated in the field and used to generate a map of resources that can be used by air-based firefighting crews. To assist ground-based firefighting efforts, this plan proposes the development of sites for installation of permanent dry hydrants from which water trucks and fire engines could draw directly from the Klamath River and larger tributaries. Dry hydrants are passive, unpressurized systems with a screened intake placed in the channel above the channel bed in a location of satisfactory depth (during dry conditions), flow rate, and channel stability and an above-ground fire hose connection to which truck-mounted pumps can be connected (Figure 4). Dry hydrants are commonly used as water supply for fighting fires in rural areas. Typical dry hydrants and fire truck pumps can supply over 1,500 gallons per minute, which is sufficient for rapid filling of typical water tankers and firefighting apparatus.

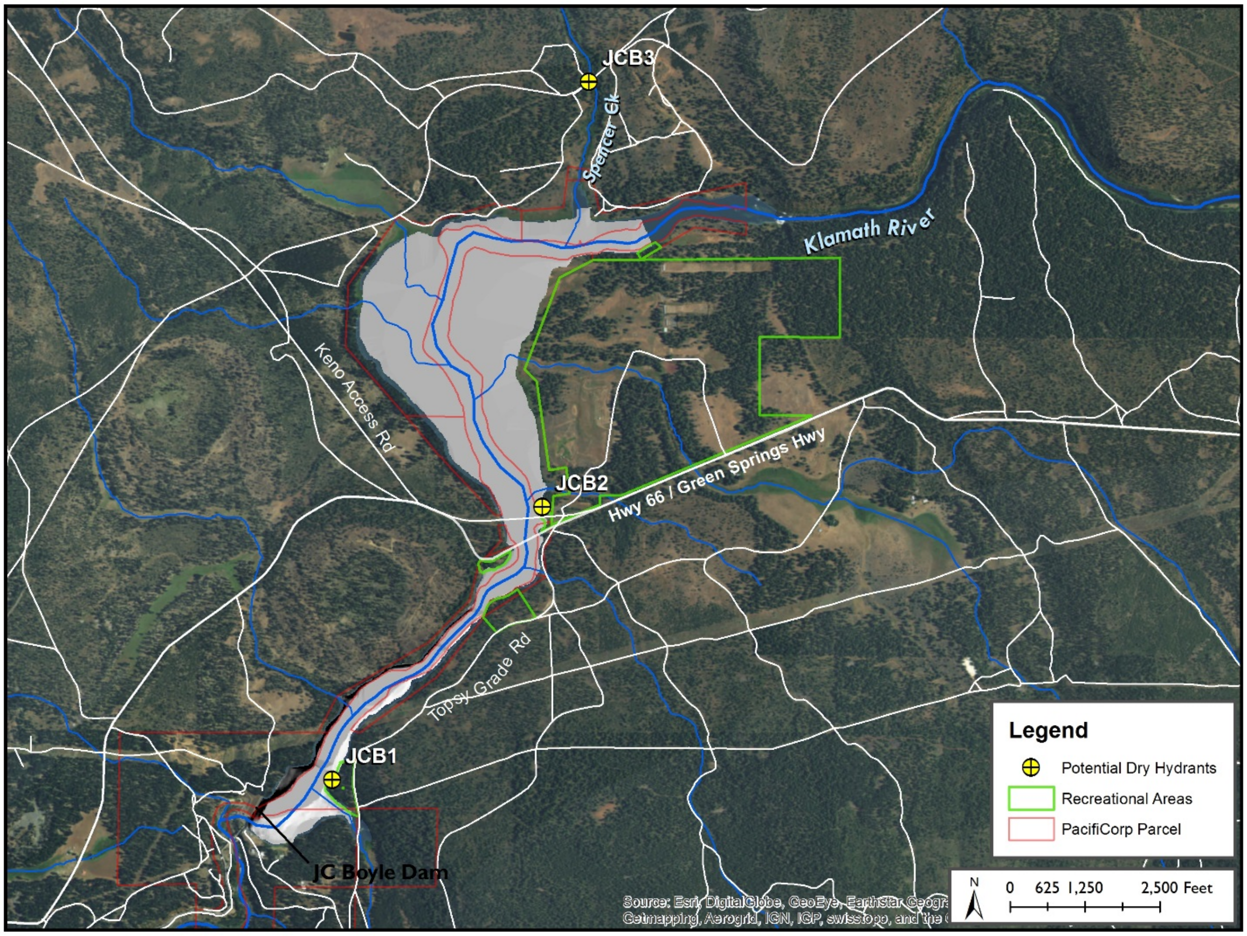



*Adapted from ettfire.com*

**Figure 6-1 Diagram of dry hydrant system**

Potential sites for the dry hydrants were selected that leverage existing, permanent infrastructure (e.g., fire stations, bridges, roads, boat launches), offer proximity and ease of access to current or anticipated post-removal Klamath River or tributary channels, and are within Pacificorp or state-owned property boundaries. Bridges and crossings are desirable given the increased certainty of access to water post-removal and the ability to utilize the structure for mounting the dry hydrant rather than excavating earthen material for pump installation.

At J.C. Boyle, three potential dry hydrant locations were identified (Figure 5). JCB1 is sited at Topsy Campground along Topsy Grade Road, where the valley is wider and more accessible. JCB2 is located on Highway 66 and could utilize the bridge for dry hydrant placement. JCB3 is located at a bridge over Spencer Creek, which maintains sufficient flow rate in the summers for dry hydrant pumping.

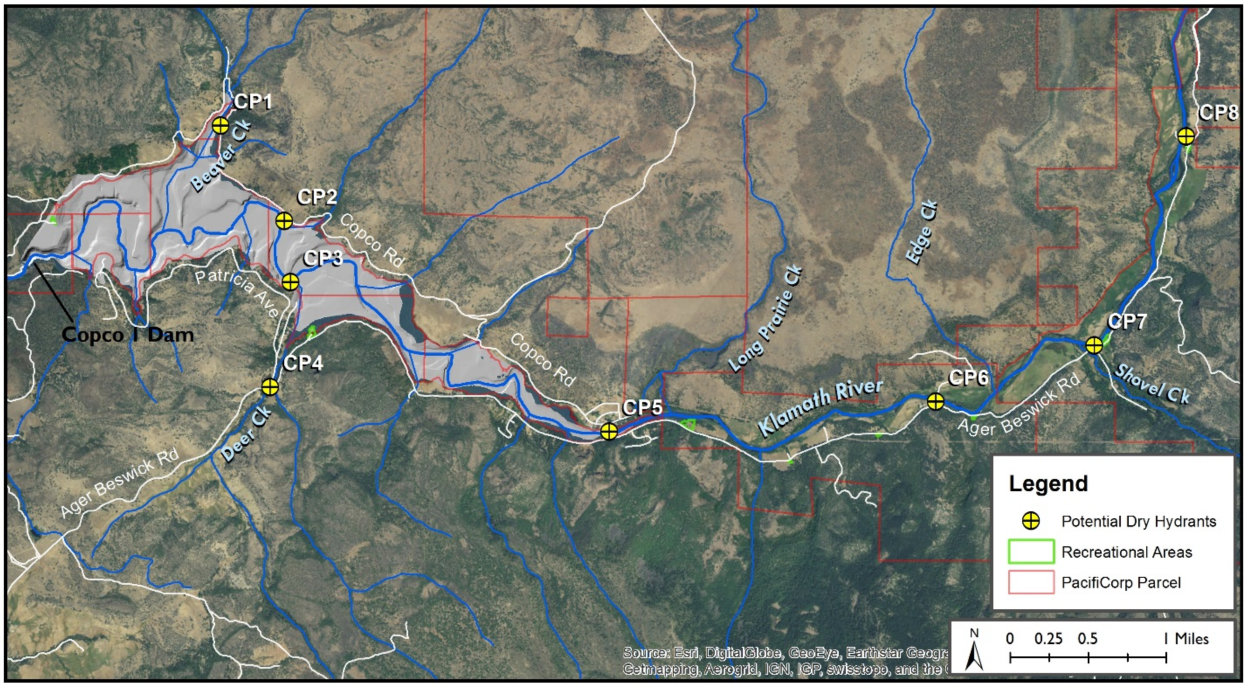



*Historical topographic surface beneath the reservoir and historic Klamath River centerline are shown for reference.*

## Figure 6-2 Locations of potential dry hydrants for J.C. Boyle Reservoir

At Copco and the reach of the Klamath River upstream of the reservoir, eight potential dry hydrant sites were identified (Figure 6). Access to the mainstem Klamath River upstream of Copco No. 1 after removal will be limited if the channel reoccupies the historical alignment as predicted. The historical Klamath River had a sinuous planform in the Copco Reservoir, and the mainstem will likely be either far from existing roads or difficult to access because the presence of steep, high relief bluffs particularly near the Copco No. 1 Dam site.

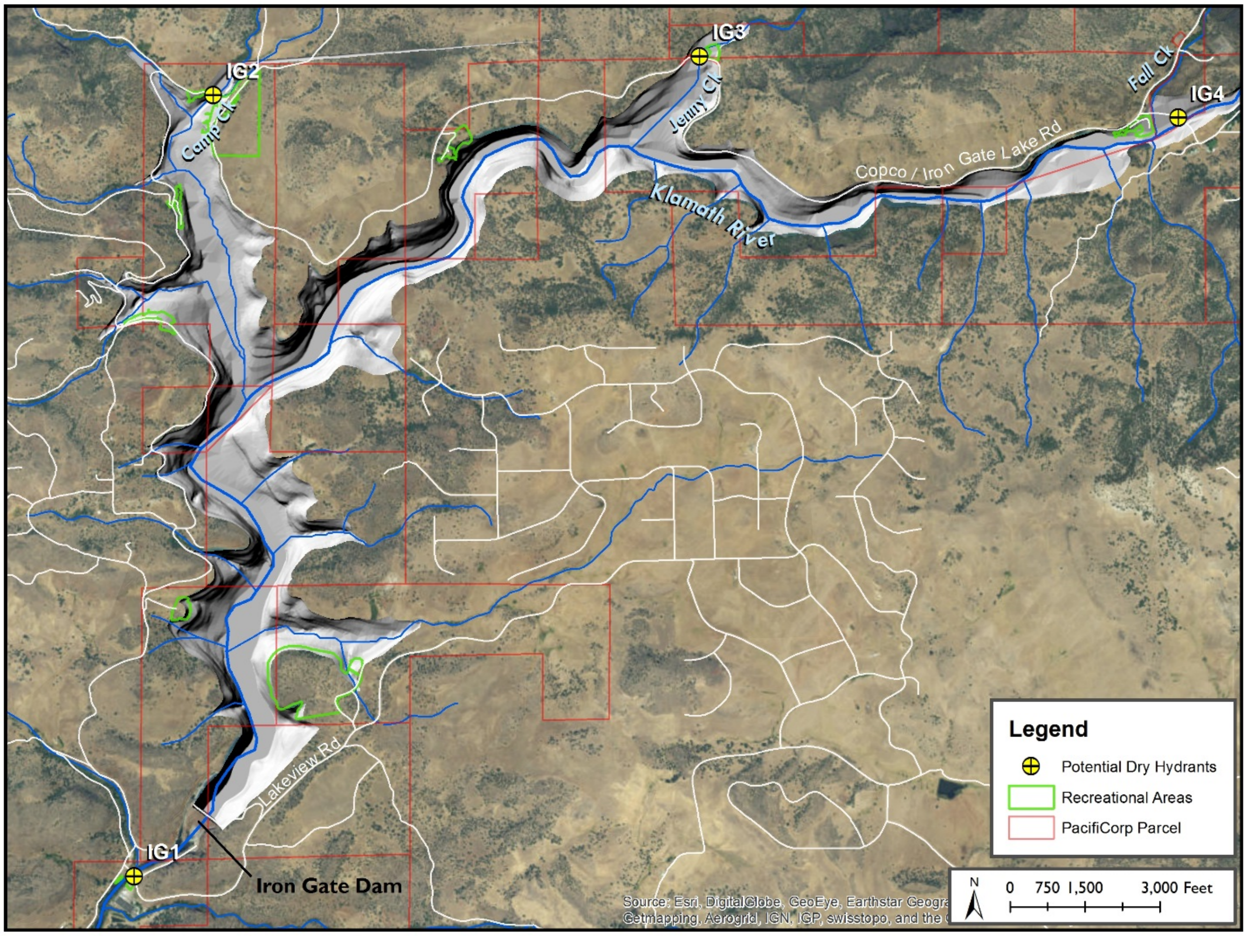
CP1 is located along Copco Road adjacent to where Beaver Creek is expected to run post-removal, but, if flow is sufficient, could be moved to where Copco Road crosses Beaver Creek upstream of the confluence with East Beaver Creek. CP2 is along the historical Klamath River and Copco Road downstream of Raymond Gulch at a location where the valley topography is locally expected to be less steep. CP3 is located near the historical confluence of the Klamath River and Deer Creek off Patricia Avenue, where historic topography is locally less steep and a Copco Lake Fire Station is nearby. CP4 is sited where Ager Beswick Road crosses Deer Creek. CP5 is at the Copco Road bridge over the Klamath River at the eastern margin of the reservoir and is situated adjacent to the Copco Lake Fire Department Station A. CP6 is located on a bridge over the Klamath River upstream of the current influence of the dam that is accessible off Ager Breswick Road. CP7 is located on a small bridge over the Klamath River off Ager Breswick Road and immediately upstream of the Shovel Creek confluence. CP8 is located at a fishing access area off Ager Breswick Road where a rapid holds grade to maintain a deeper pool for water extraction.




*Historical topographic surface beneath the reservoir and historic Klamath River centerline are shown for reference.*

**Figure 6-3 Locations of potential dry hydrants for Copco Lake**

At Iron Gate, four potential dry hydrant locations were identified (Figure 7). IG1 is sited at the Lakeview Rd bridge crossing over the Klamath River, downstream of Iron Gate dam and adjacent to the Iron Gate hatchery. IG2 is located in the vicinity of the Camp Creek campground where Copco / Iron Gate Lake Road crosses Camp Creek. IG3 is located at the bridge where Copco / Iron Gate Lake Road crosses Jenny Creek. IG4 is sited at the Daggett road bridge crosses the Klamath River, which is adjacent to the Fall Creek confluence and Copco / Iron Gate Lake Road.




*Historical topographic surface beneath the reservoir and historic Klamath River centerline are shown for reference.*

## Figure 6-4 Locations of potential dry hydrants for Iron Gate Reservoir

# 7. References

Cal Fire 2007. Fire and Resource Assessment Program. 2007. Fire Hazard Severity Zones [computer file]. Sacramento, CA.

Cal Fire 1999. Industrial Operations Fire Prevention Field Guide.

Siskiyou County 2016. Unit Strategic Fire Plan: Siskiyou Unit. Yreka, CA.

South Central Oregon Fire Management Partnership 2015. South Central Oregon Interagency Fire Danger Operating Plan.

USBR and CDFW 2012. U.S. Bureau of Reclamation and California Department of Fish and Wildlife. *Klamath Facilities Removal – Final Environmental Impact Statement/Environmental Impact Report* (EIS/R). December.

USFS 2010. U.S. Forest Service, Remote Sensing Applications Center. MODIS Active Fire Detections for the CONUS [computer file]. Salt Lake City, Utah.

Wildland Fire Technologies, Inc. 2016. Klamath County Community Wildfire Protection Plan 2016 update. Klamath Falls, OR

aecom.com