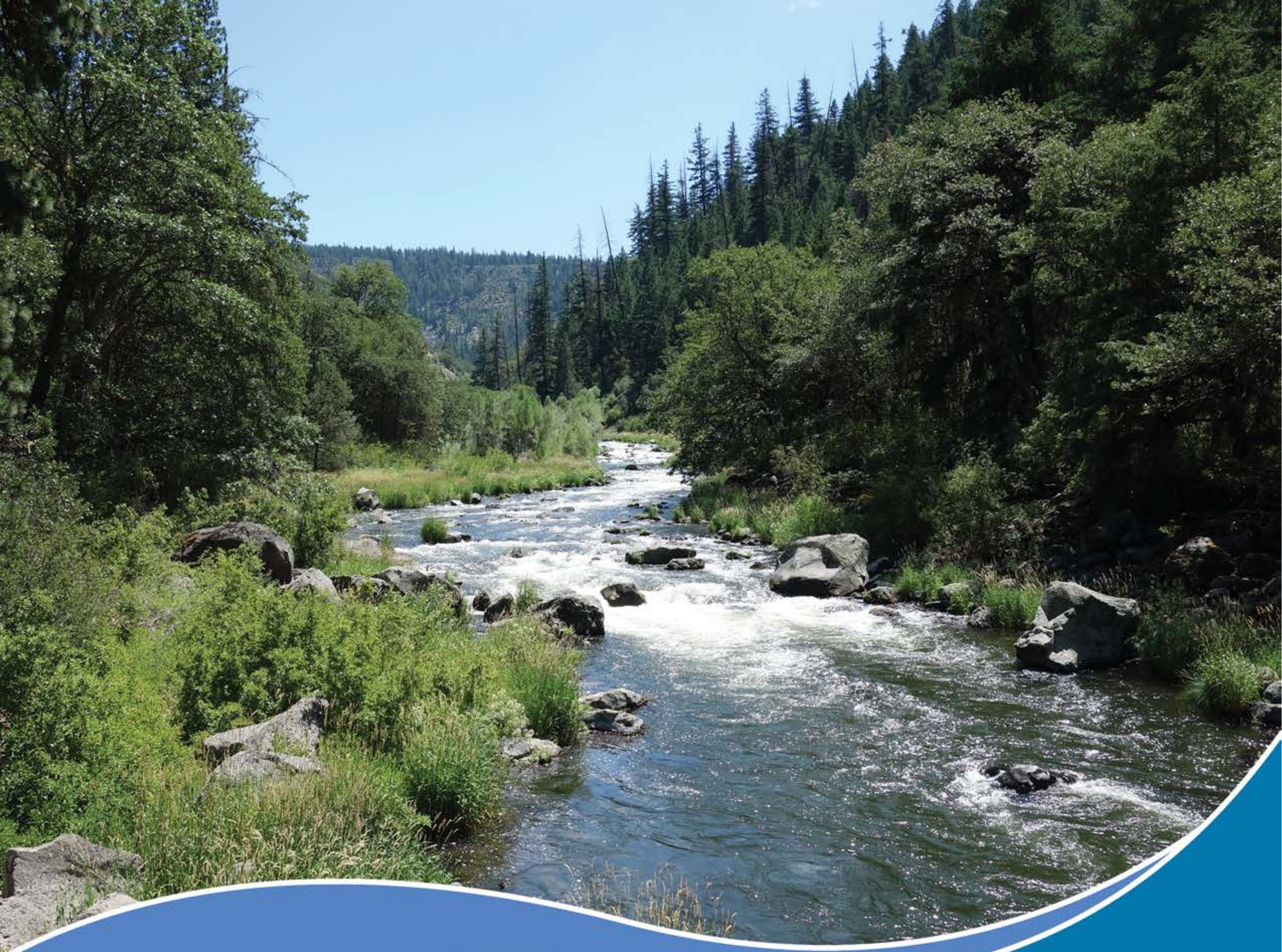

Definite Plan for the Lower Klamath Project

Appendix F - Reservoir Drawdown Modeling Output

KLAMATH RIVER RENEWAL CORPORATION

June 2018

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Prepared for:

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Chapter 1: Drawdown Analysis

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1. DRAWDOWN ANALYSIS

KRRC conducted detailed analysis of the proposed drawdown using the USACE Hydrologic Engineering Center River Analysis System (HEC-RAS) model (version 5.0.3). KRRC used the model 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, KRRC divided the Klamath River 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. The following sections discuss input sources and data.

1.1 Topography/Bathymetry

KRRC generally obtained the cross-section bathymetry in the HEC-RAS model 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, KRRC only used the data for Reach 1 and Reach 2 as described above.

Stage-storage relationships were determined using output from the HEC-RAS model for each of the three large reservoirs, Iron Gate Reservoir, Copco Lake, and J.C. Boyle Reservoir. KRRC compared the HEC-RAS storage curves 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, KRRC adjusted (shifted up) the cross-section elevations upstream of each of the dams until the stage-storage relationships in the HEC-RAS model matched the stage-storage curves from the Detailed Plan.

1.2 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. KRRC obtained these flows 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). Definite Plan Section 4.6.1 provides a comparison between the USGS measured data at Keno and the SRH1-D data used in the model. 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.

KRRC simulated water years 1961 through 2009 in the model. KRRC determined the maximum 15-day total flow volume for each water year so that the years could be ranked based on hydrologic conditions (Table 1-1).

Table 1-1: 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.

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Chapter 2: J.C. Boyle Reservoir

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2. 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, 2021 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), KRRC assumed that the concrete stoplogs on the first 9.5- by 10-foot diversion culvert will be removed and the culvert will open.
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 will 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.

2.1 Results

Figures 2-1 through 2-49 show results from the simulations of J.C. Boyle. 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. The historical hydrology record shows about 15 percent of the years have a maximum January or February flow that exceeds 5,000 cfs and would 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), J.C. Boyle 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 all water years, any increase in peak flows with drawdown compared to peak flows without drawdown is small due to the relatively limited amount of attenuation associated with the existing reservoir.

KRRC does not anticipate that sediment concentrations resulting from the proposed drawdown procedure and associated hydraulics would differ from those previously estimated (USBR 2012c).

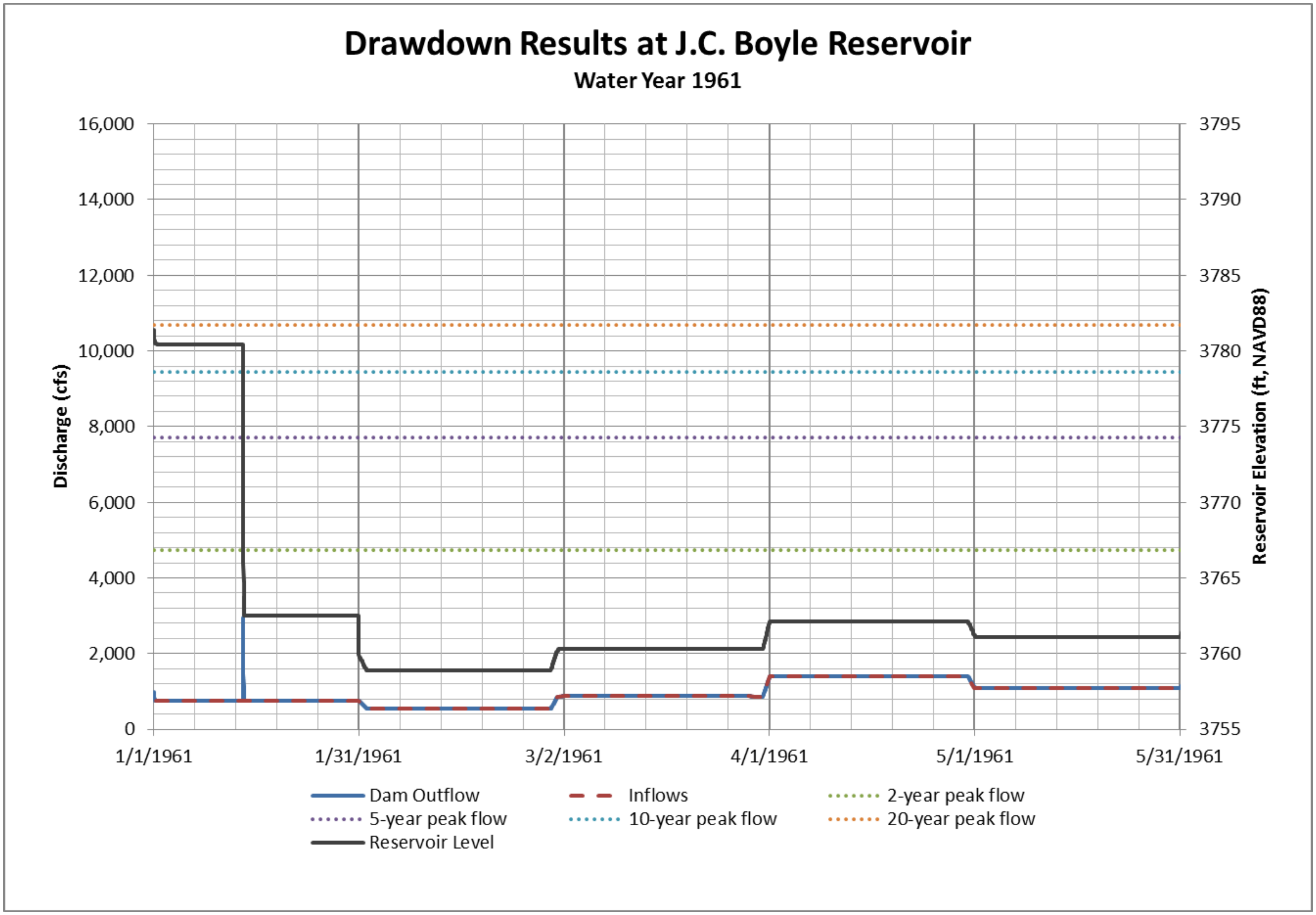

Figure 2-1 J.C. Boyle Reservoir Drawdown, Water Year 1961

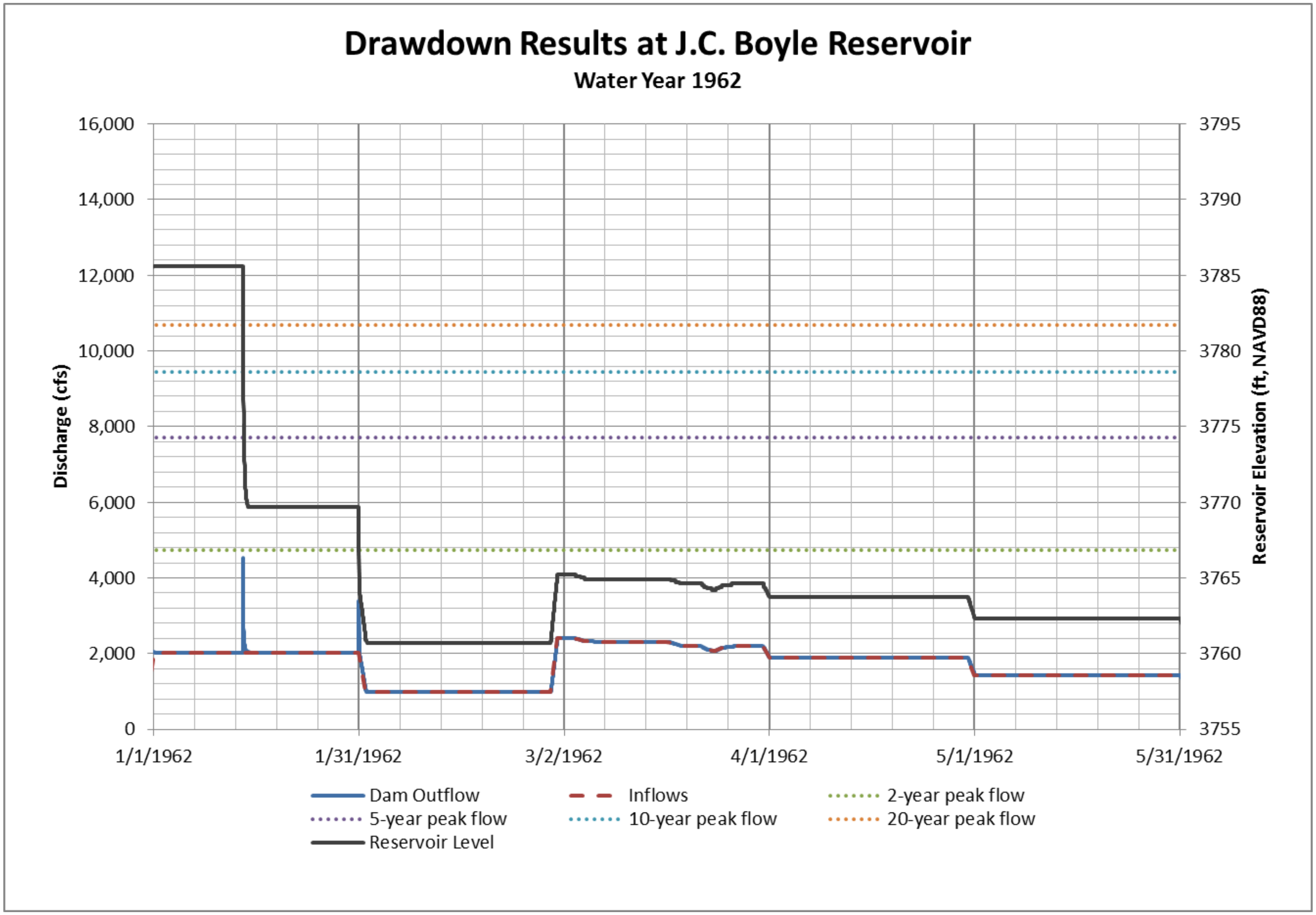

Figure 2-2 J.C. Boyle Reservoir Drawdown, Water Year 1962

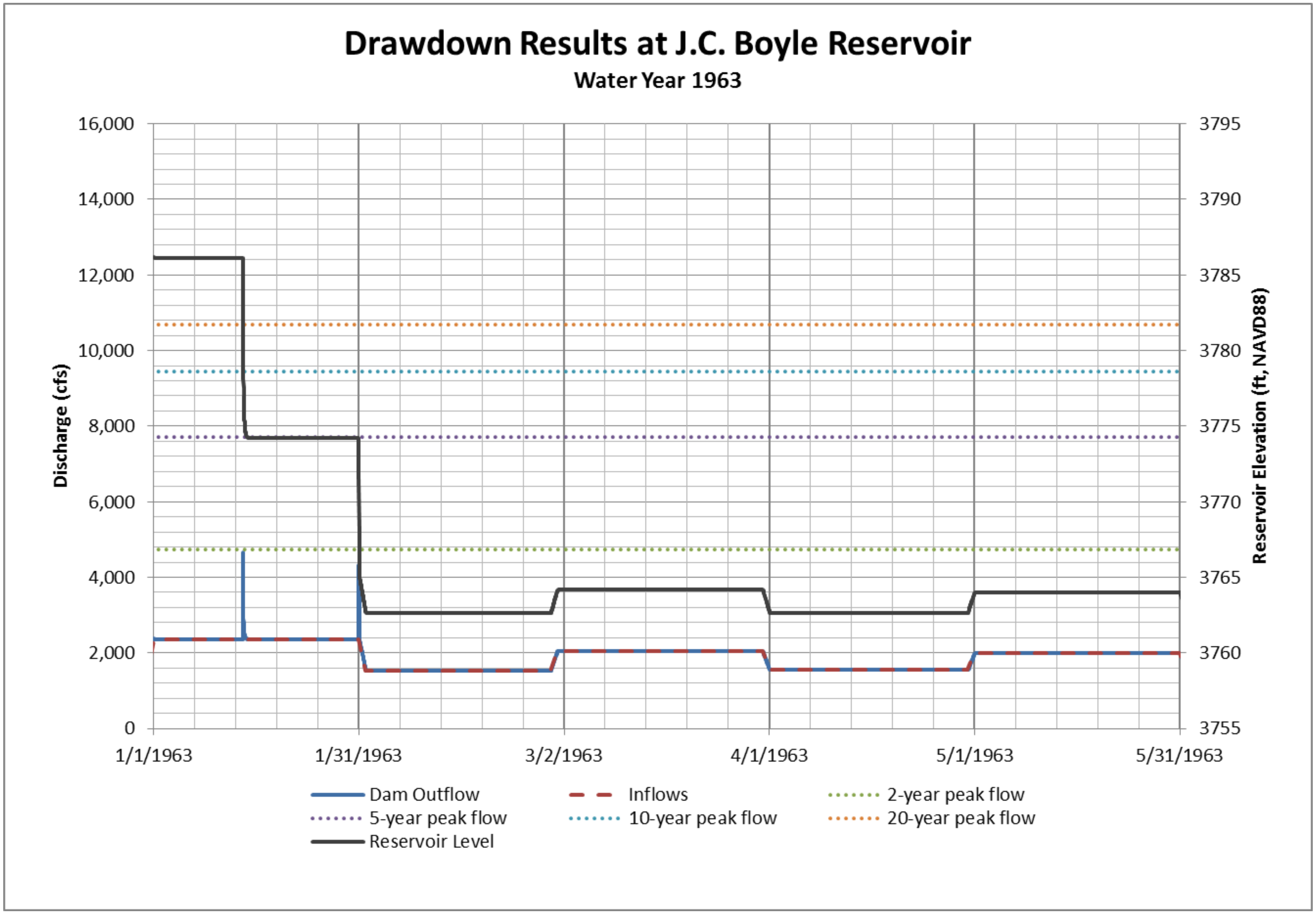

Figure 2-3 J.C. Boyle Reservoir Drawdown, Water Year 1963

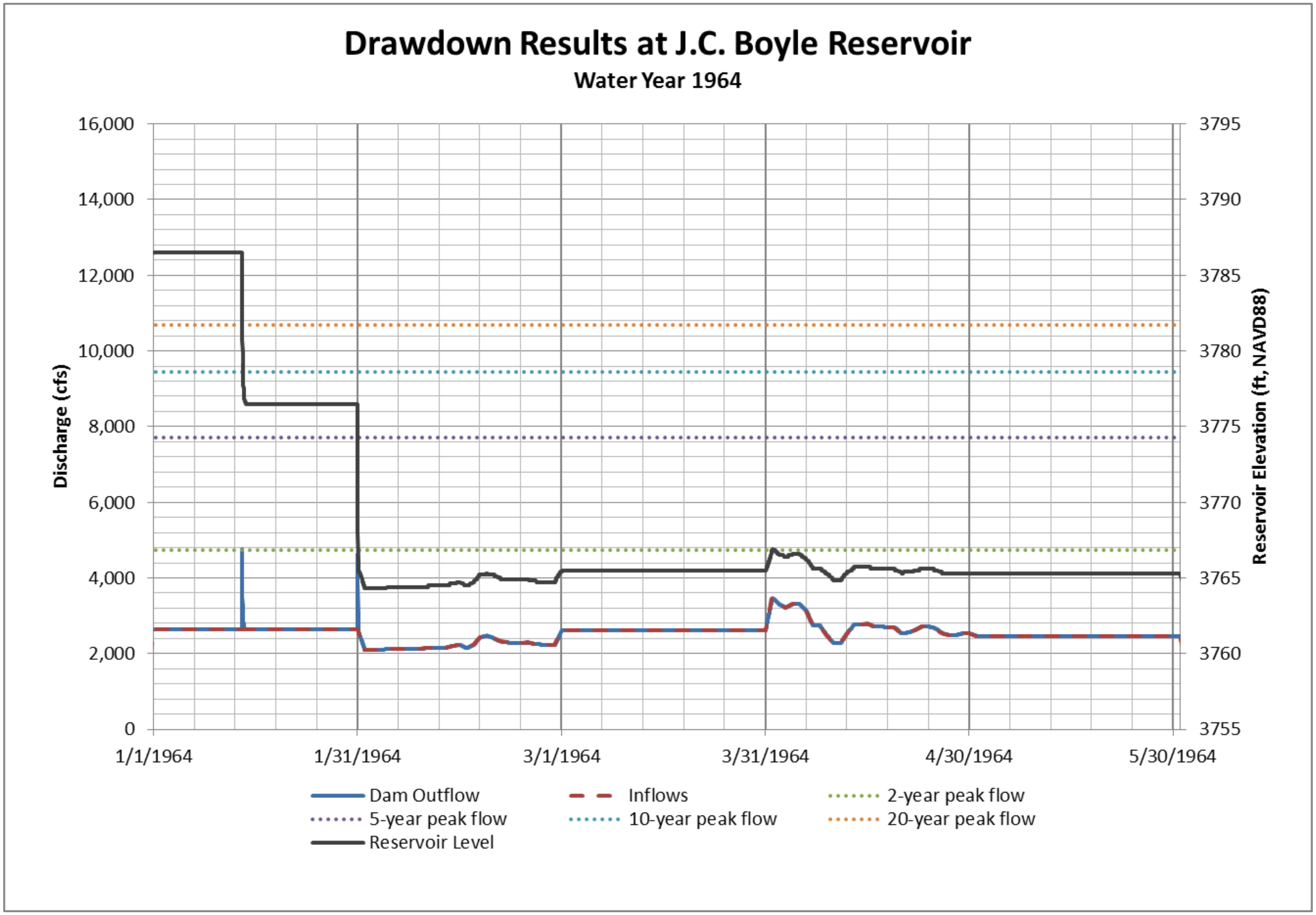

Figure 2-4 J.C. Boyle Reservoir Drawdown, Water Year 1964

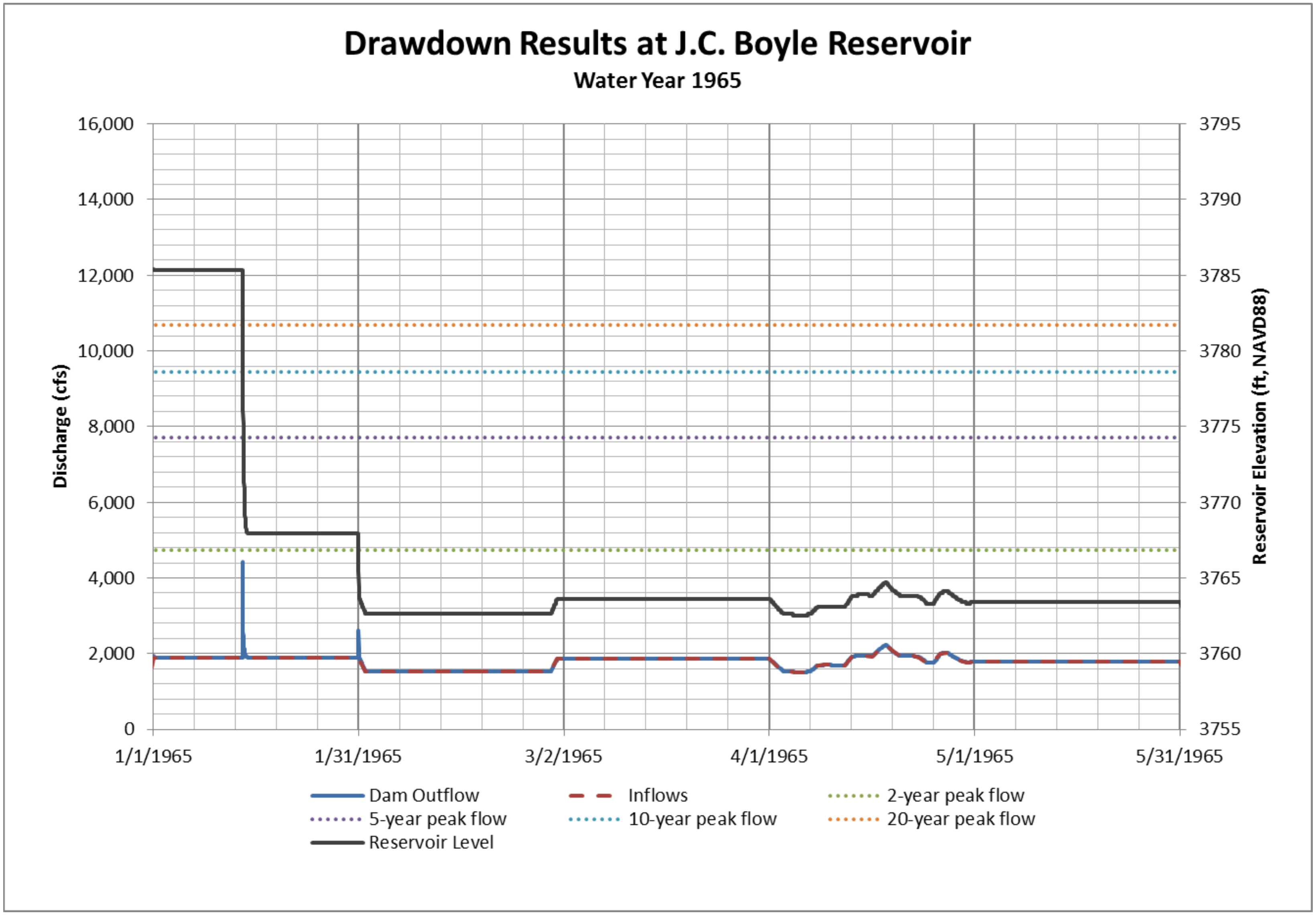

Figure 2-5 J.C. Boyle Reservoir Drawdown, Water Year 1965

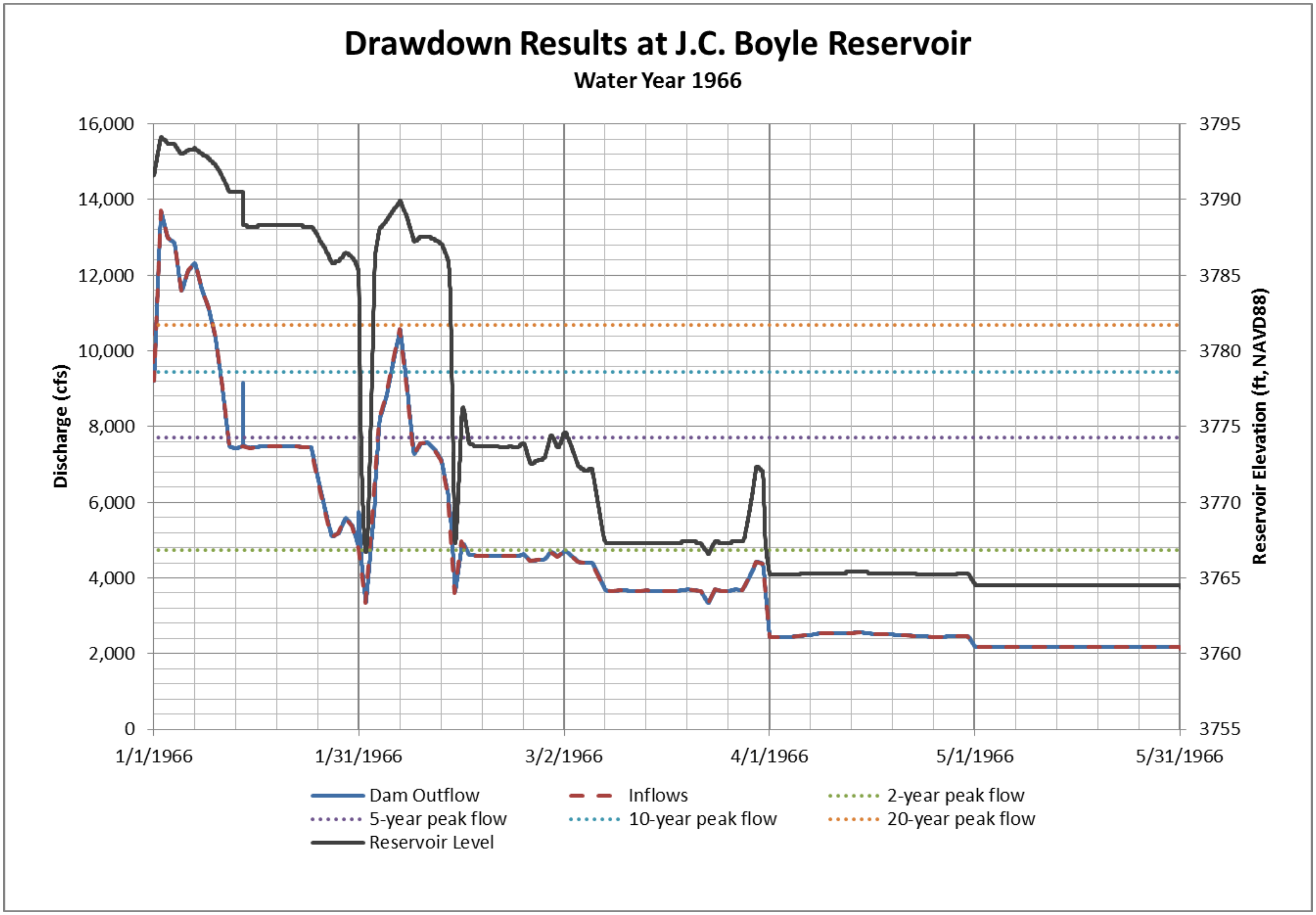

Figure 2-6 **J.C. Boyle Reservoir Drawdown, Water Year 1966 (Wettest Year)**

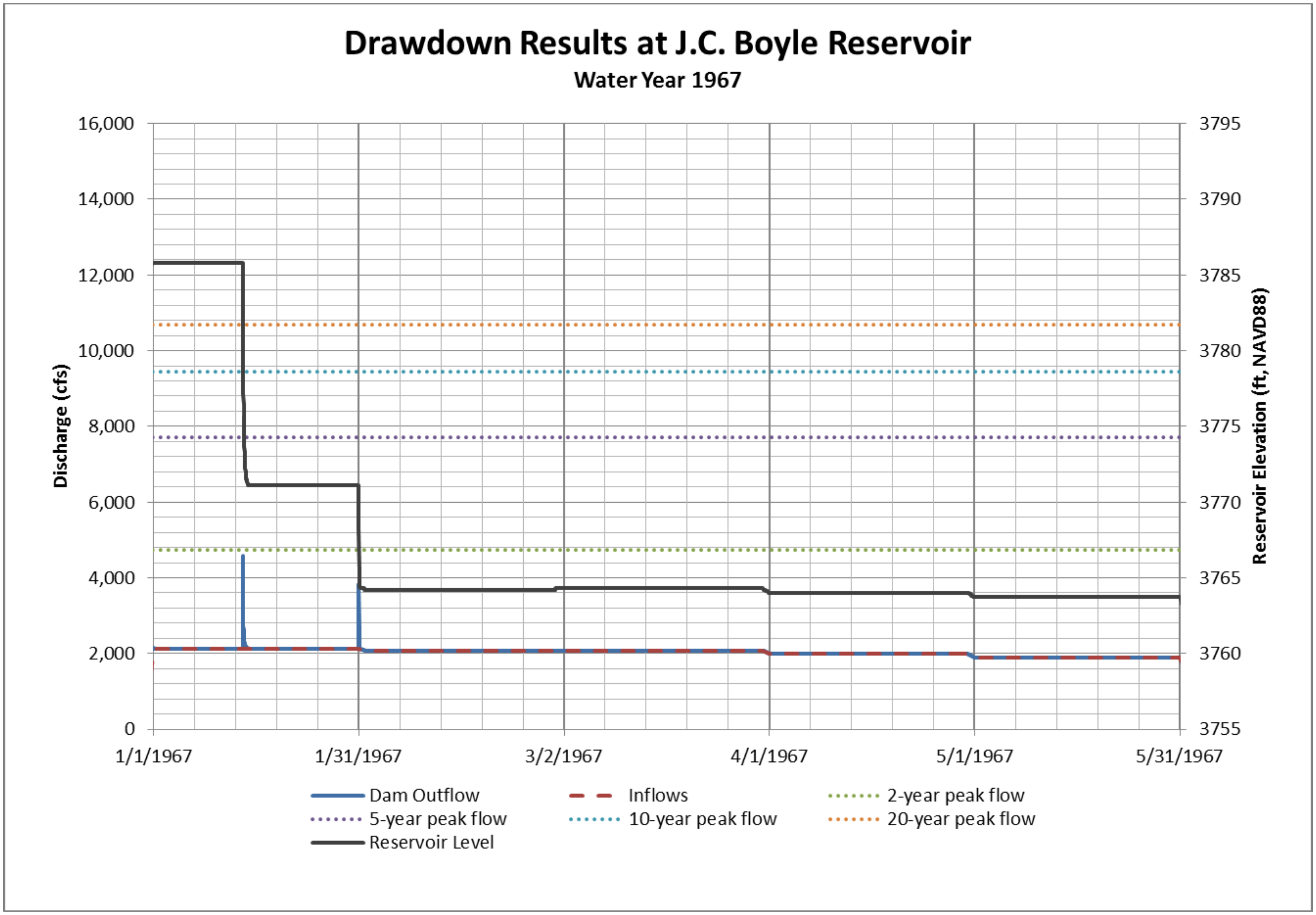

Figure 2-7 J.C. Boyle Reservoir Drawdown, Water Year 1967

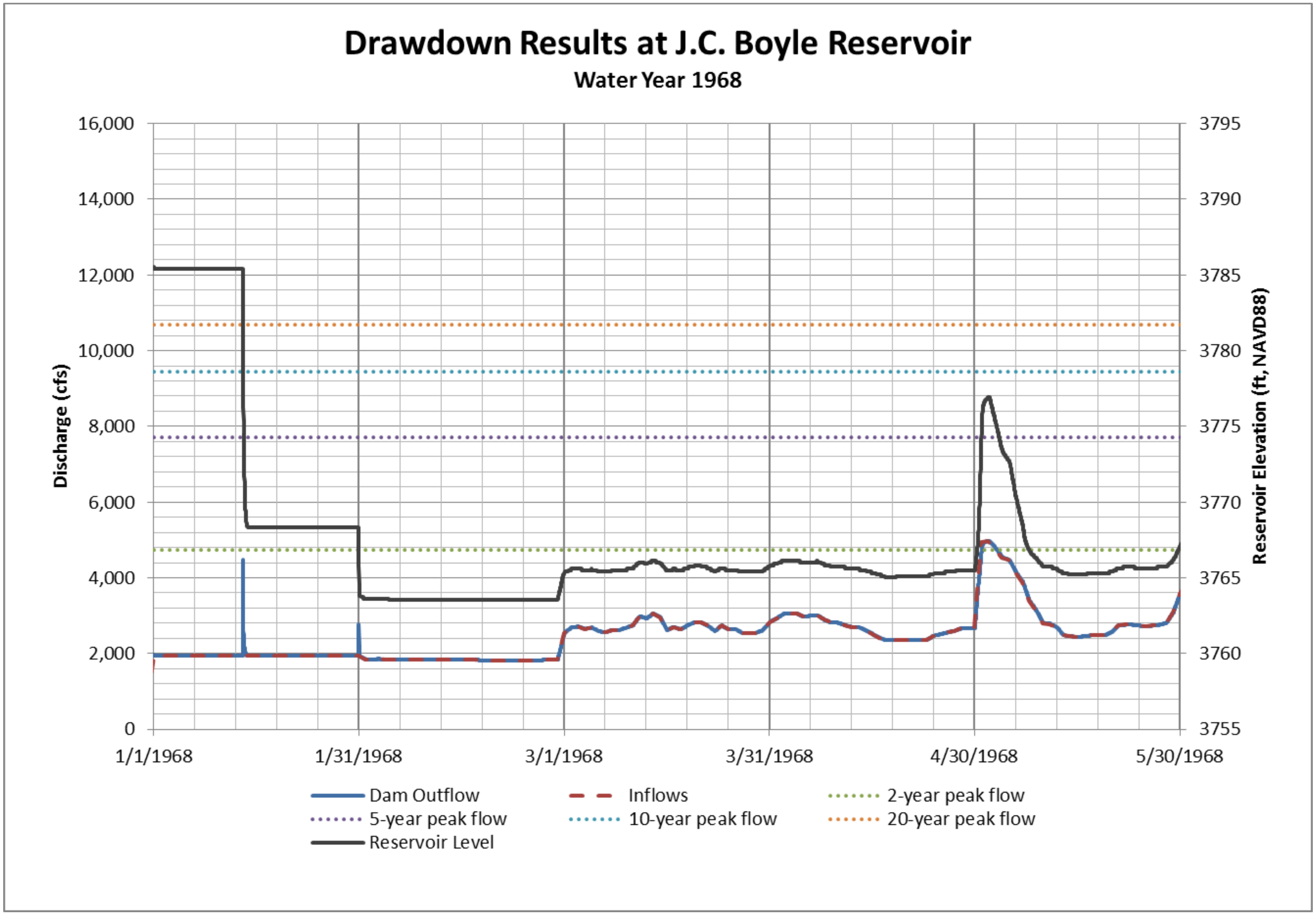

Figure 2-8 J.C. Boyle Reservoir Drawdown, Water Year 1968

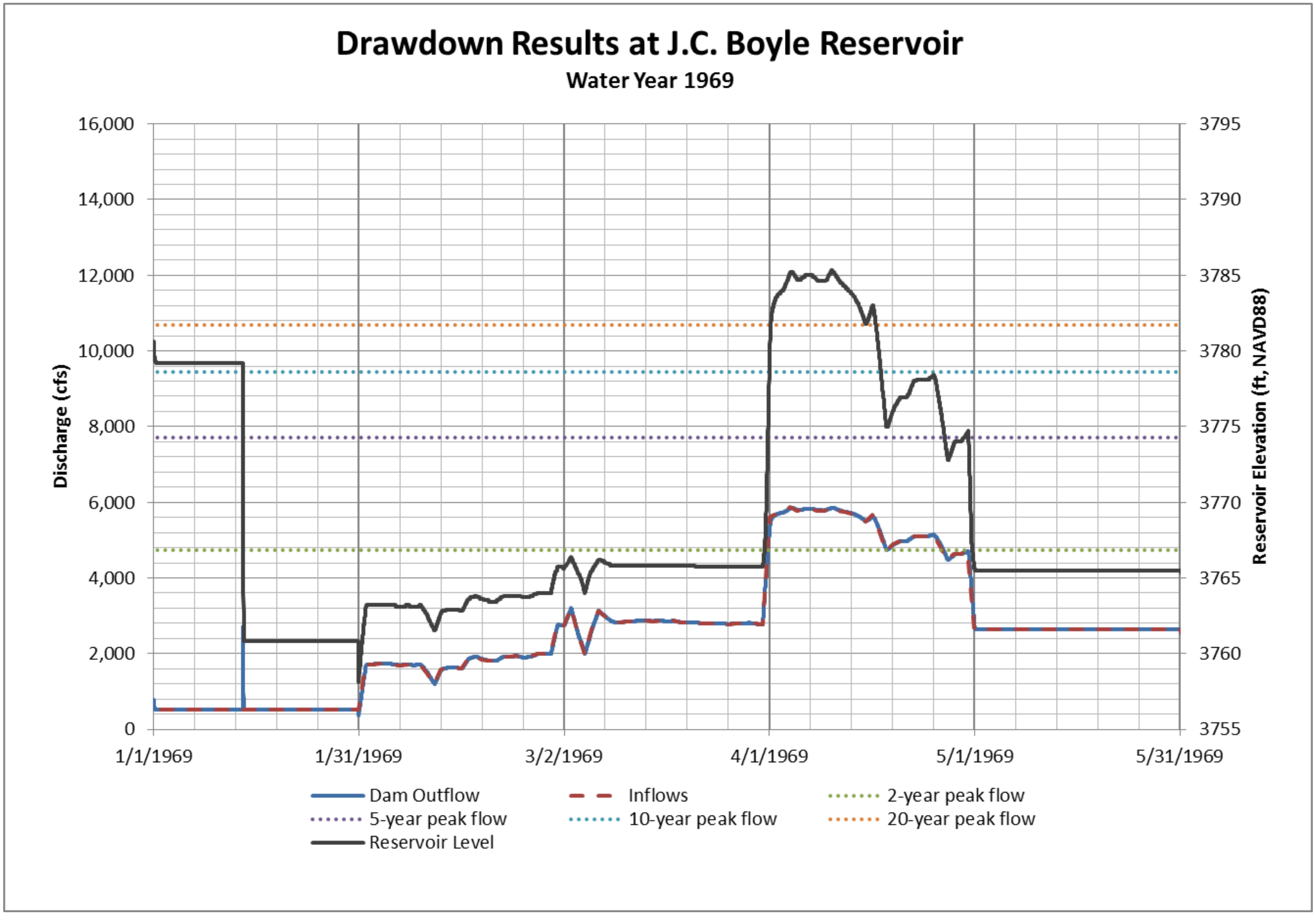

Figure 2-9 J.C. Boyle Reservoir Drawdown, Water Year 1969

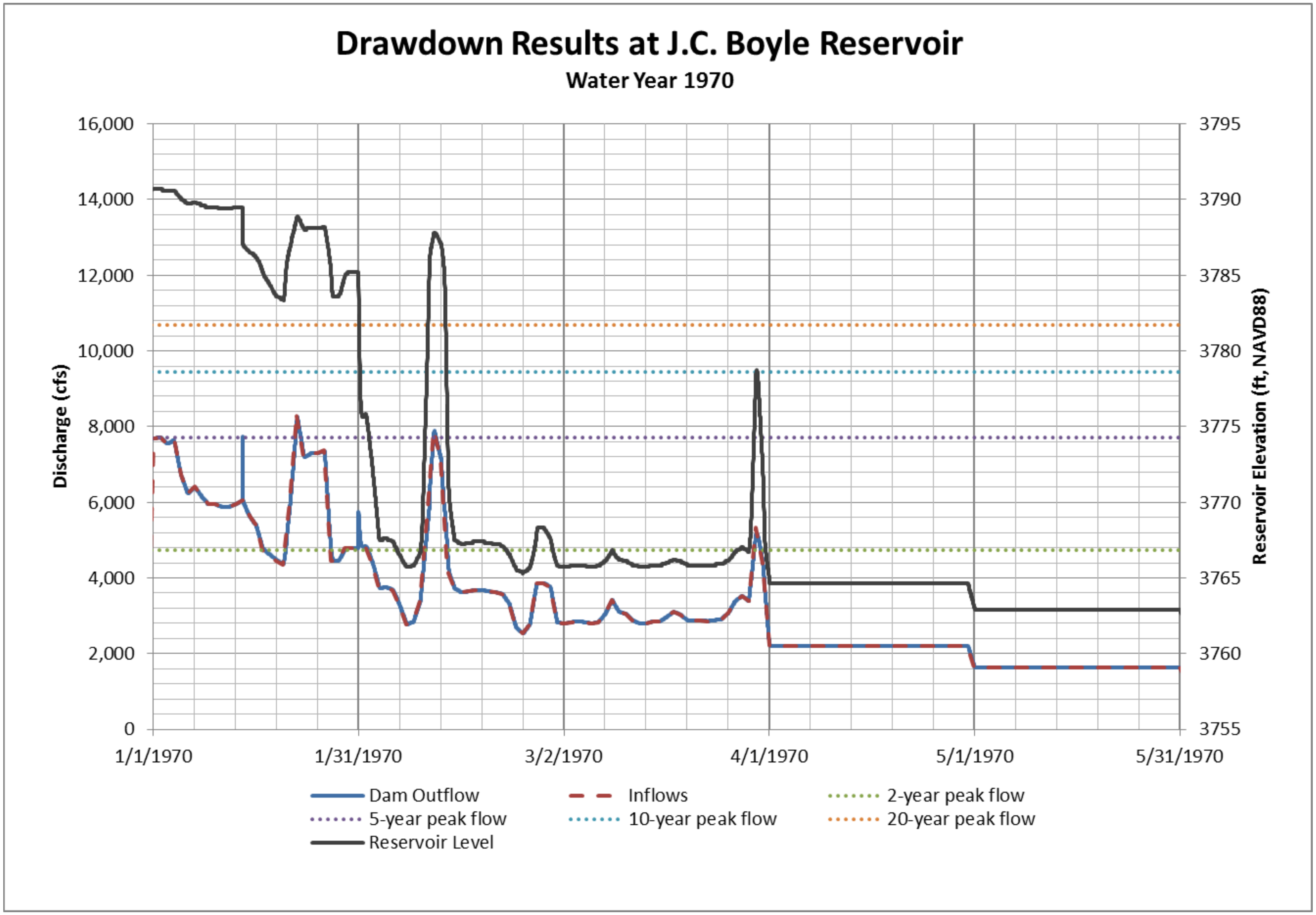

Figure 2-10 J.C. Boyle Reservoir Drawdown, Water Year 1970 (Above Normal Year)

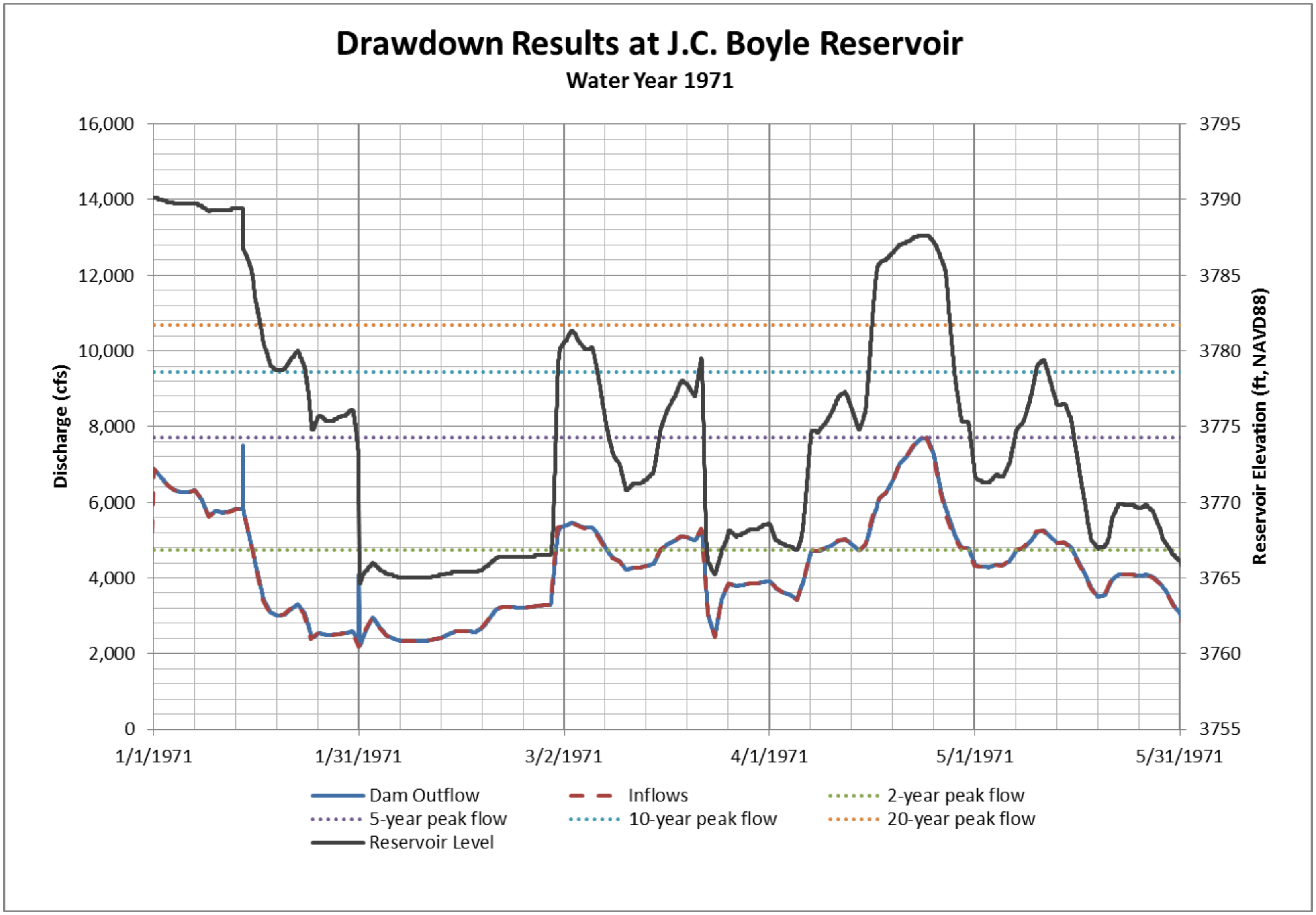

Figure 2-11 J.C. Boyle Reservoir Drawdown, Water Year 1971

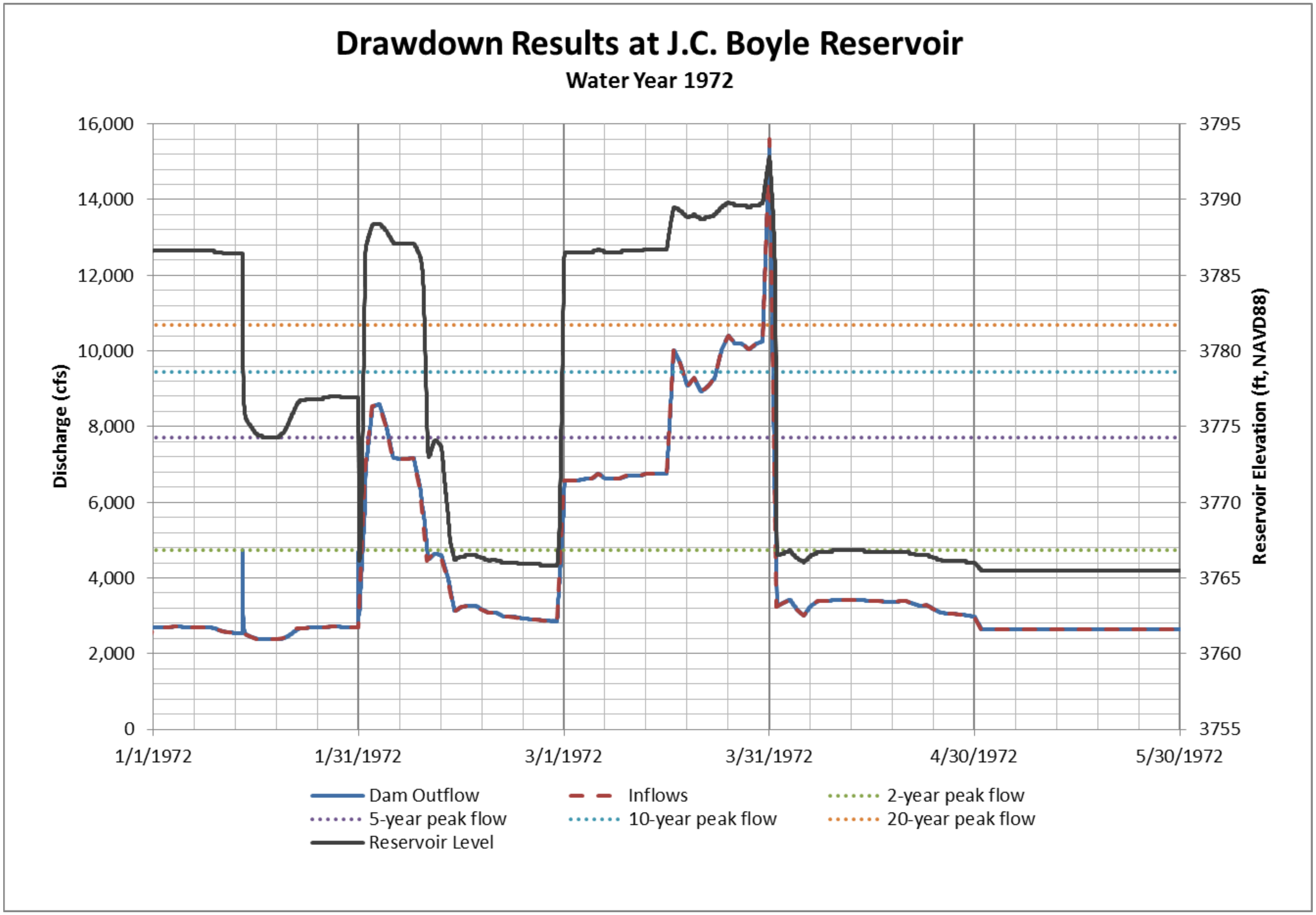

Figure 2-12 J.C. Boyle Reservoir Drawdown, Water Year 1972

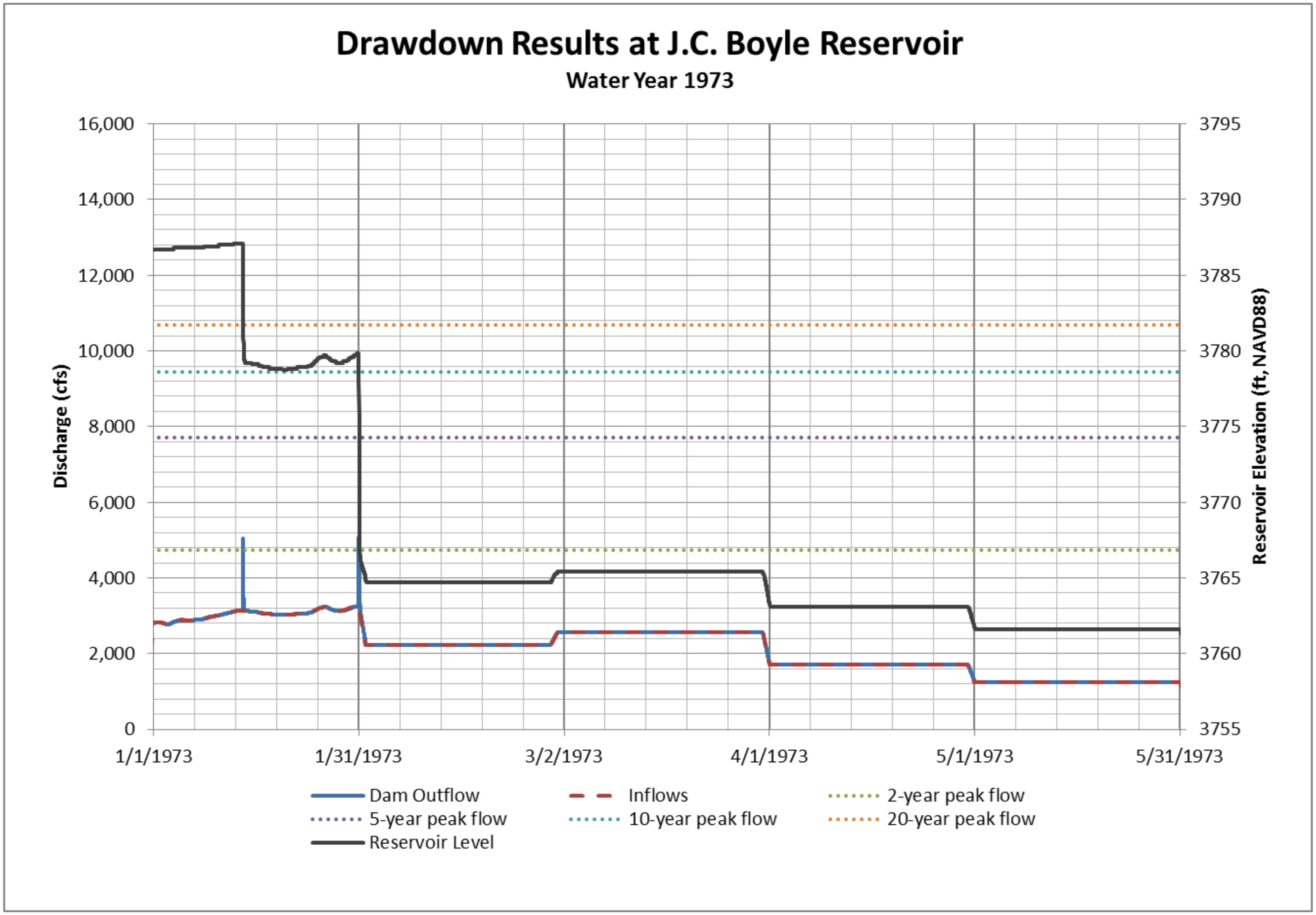

Figure 2-13 J.C. Boyle Reservoir Drawdown, Water Year 1973 (Median Year)

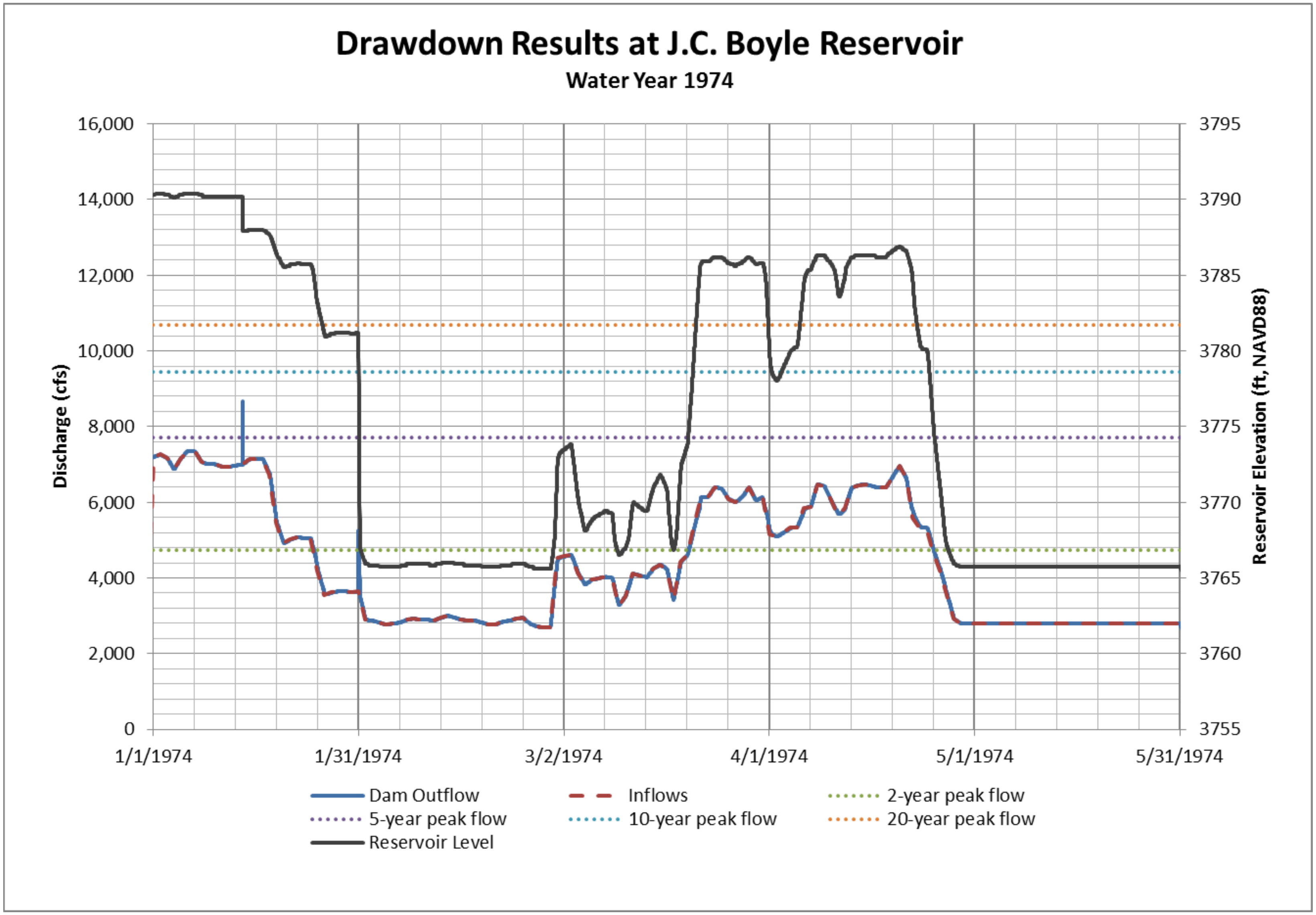

Figure 2-14 J.C. Boyle Reservoir Drawdown, Water Year 1974

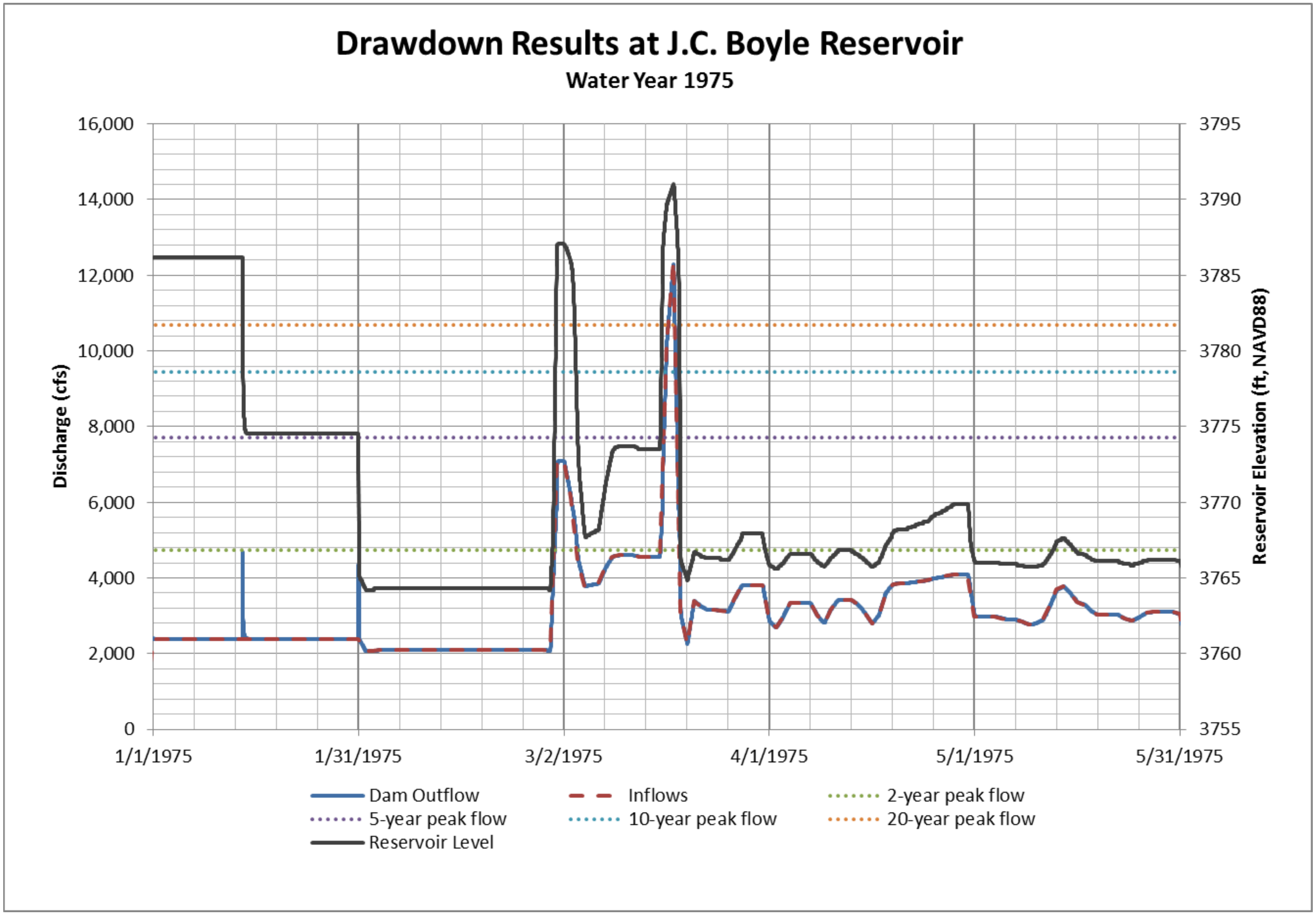

Figure 2-15 J.C. Boyle Reservoir Drawdown, Water Year 1975

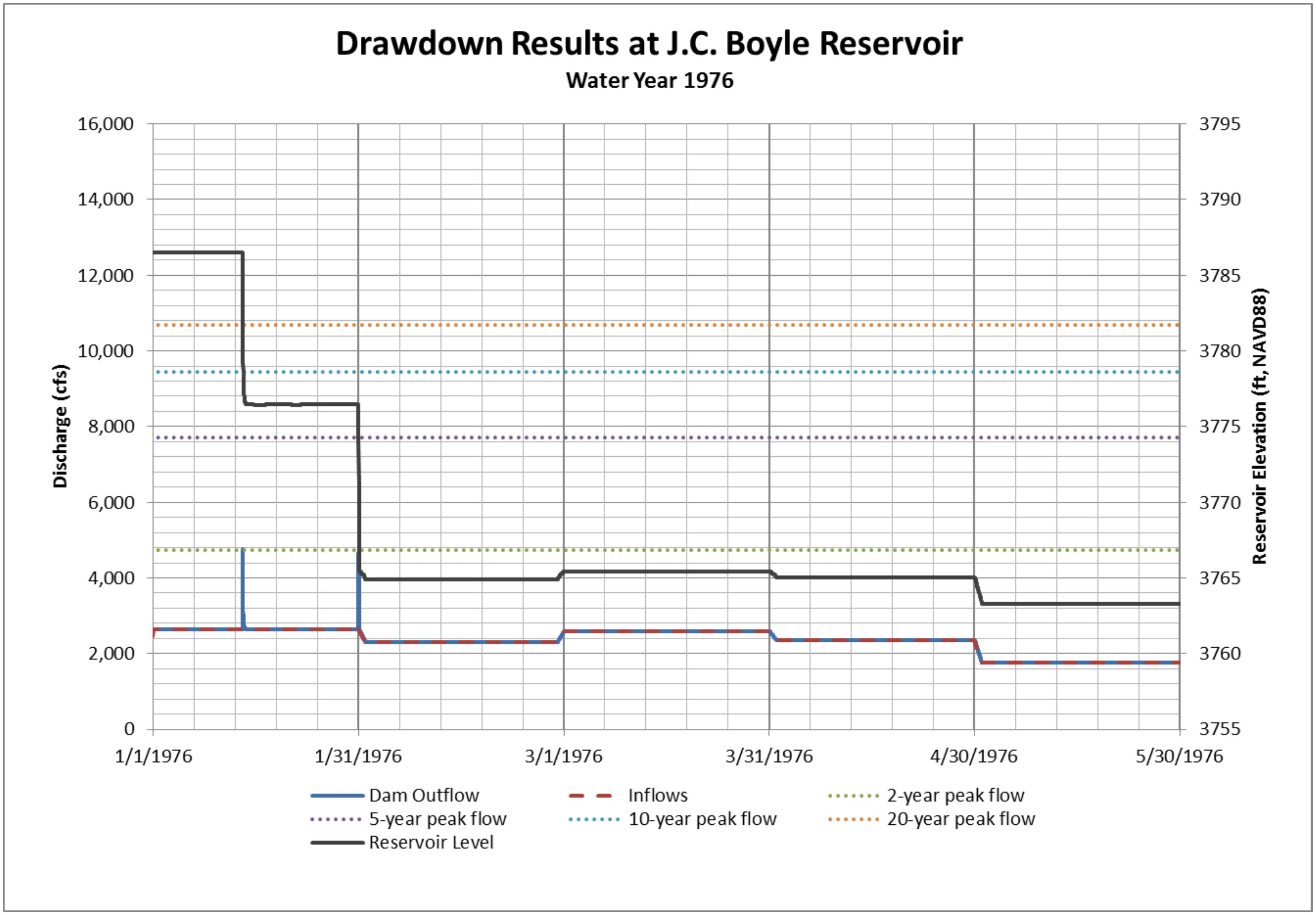

Figure 2-16 J.C. Boyle Reservoir Drawdown, Water Year 1976

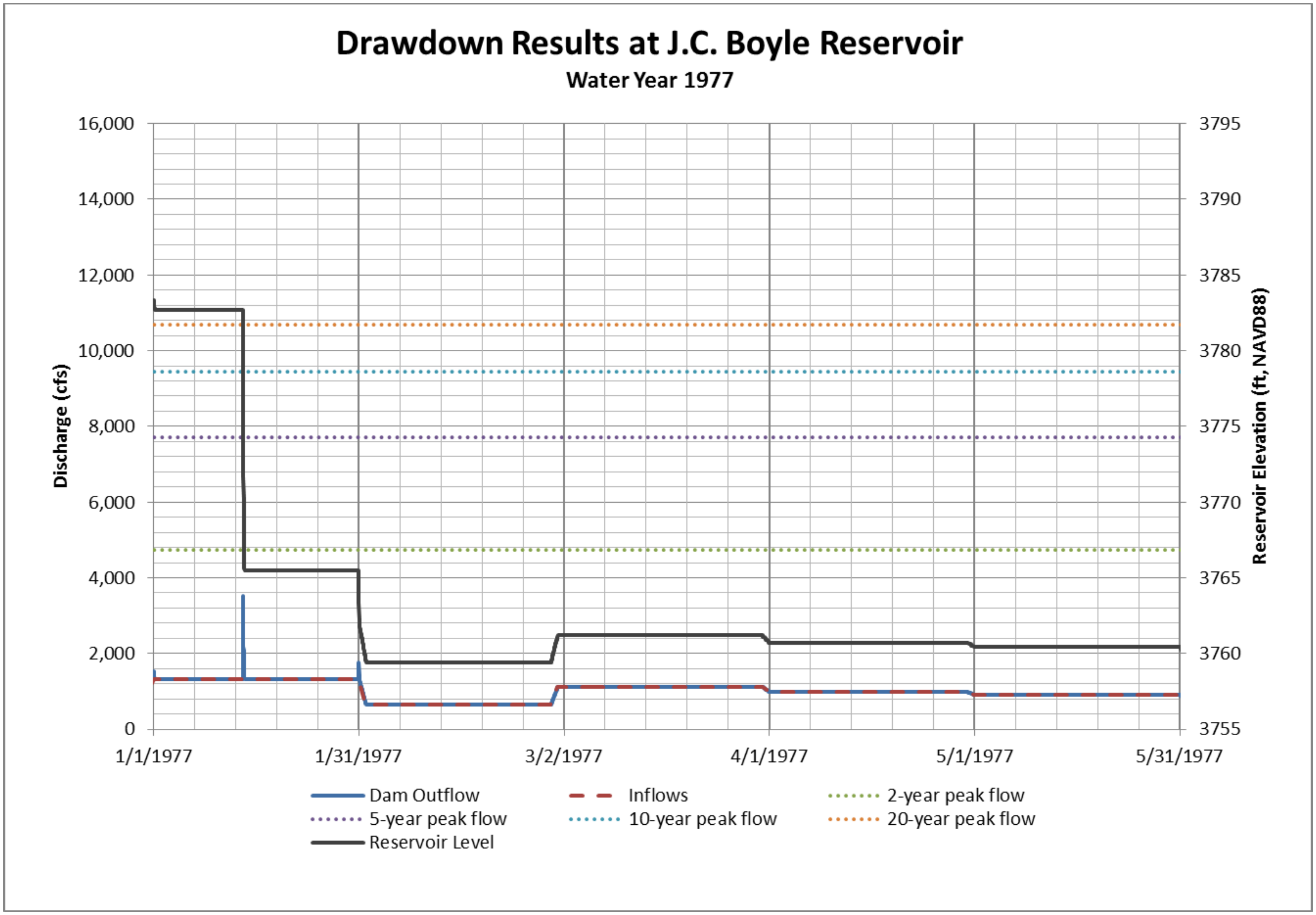

Figure 2-17 J.C. Boyle Reservoir Drawdown, Water Year 1977

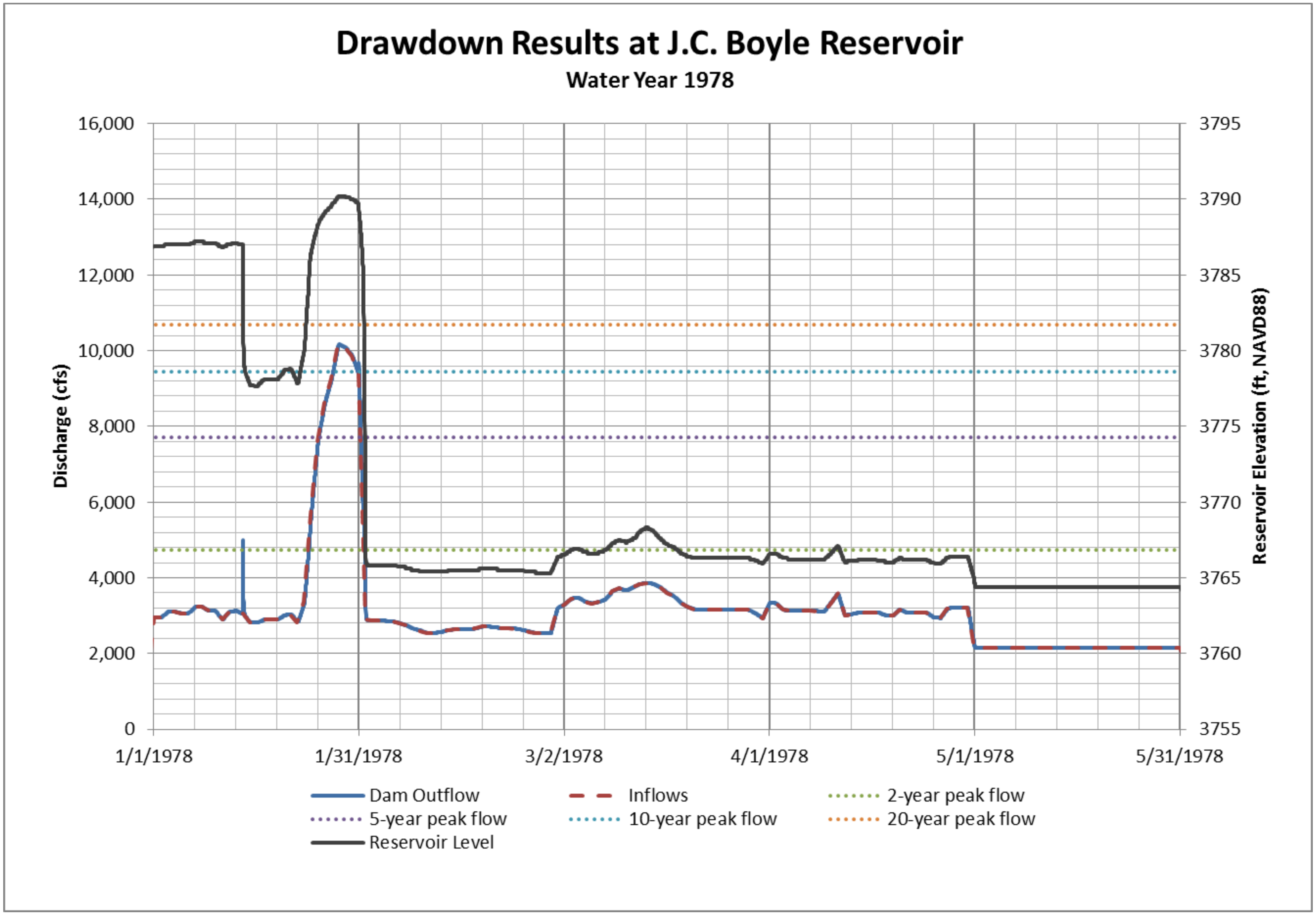

Figure 2-18 J.C. Boyle Reservoir Drawdown, Water Year 1978

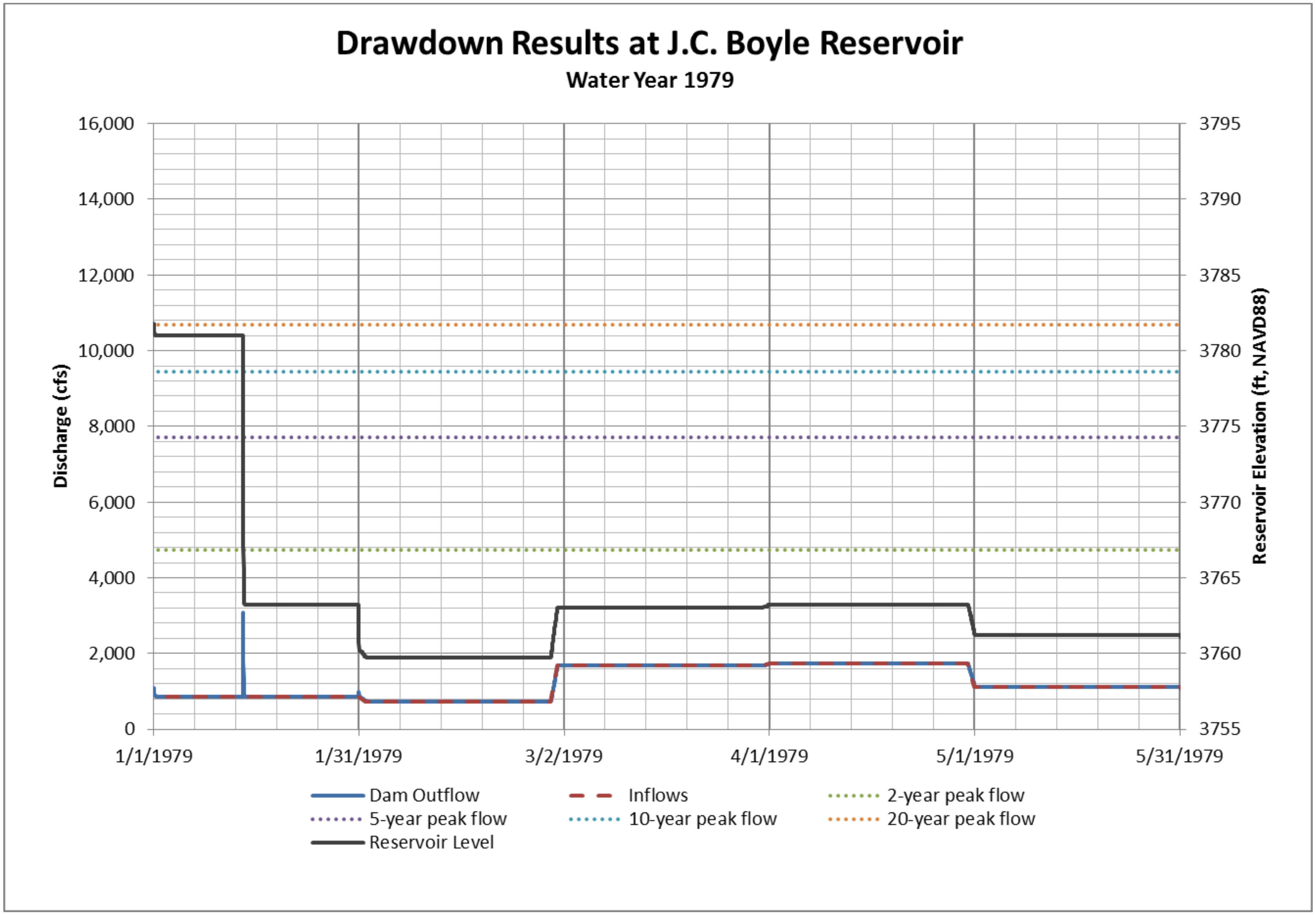

Figure 2-19 J.C. Boyle Reservoir Drawdown, Water Year 1979 (Dry Year)

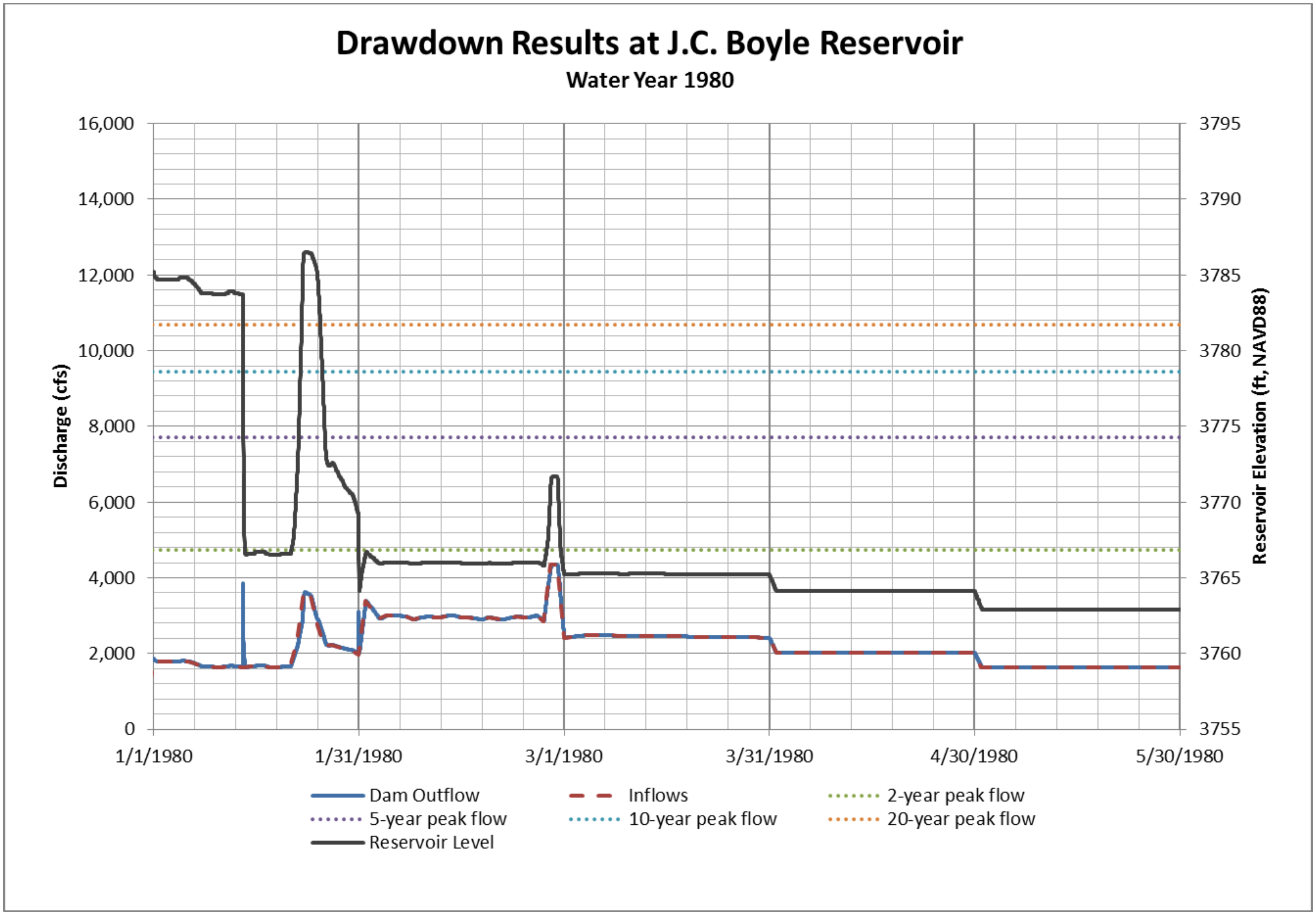

Figure 2-20 J.C. Boyle Reservoir Drawdown, Water Year 1980

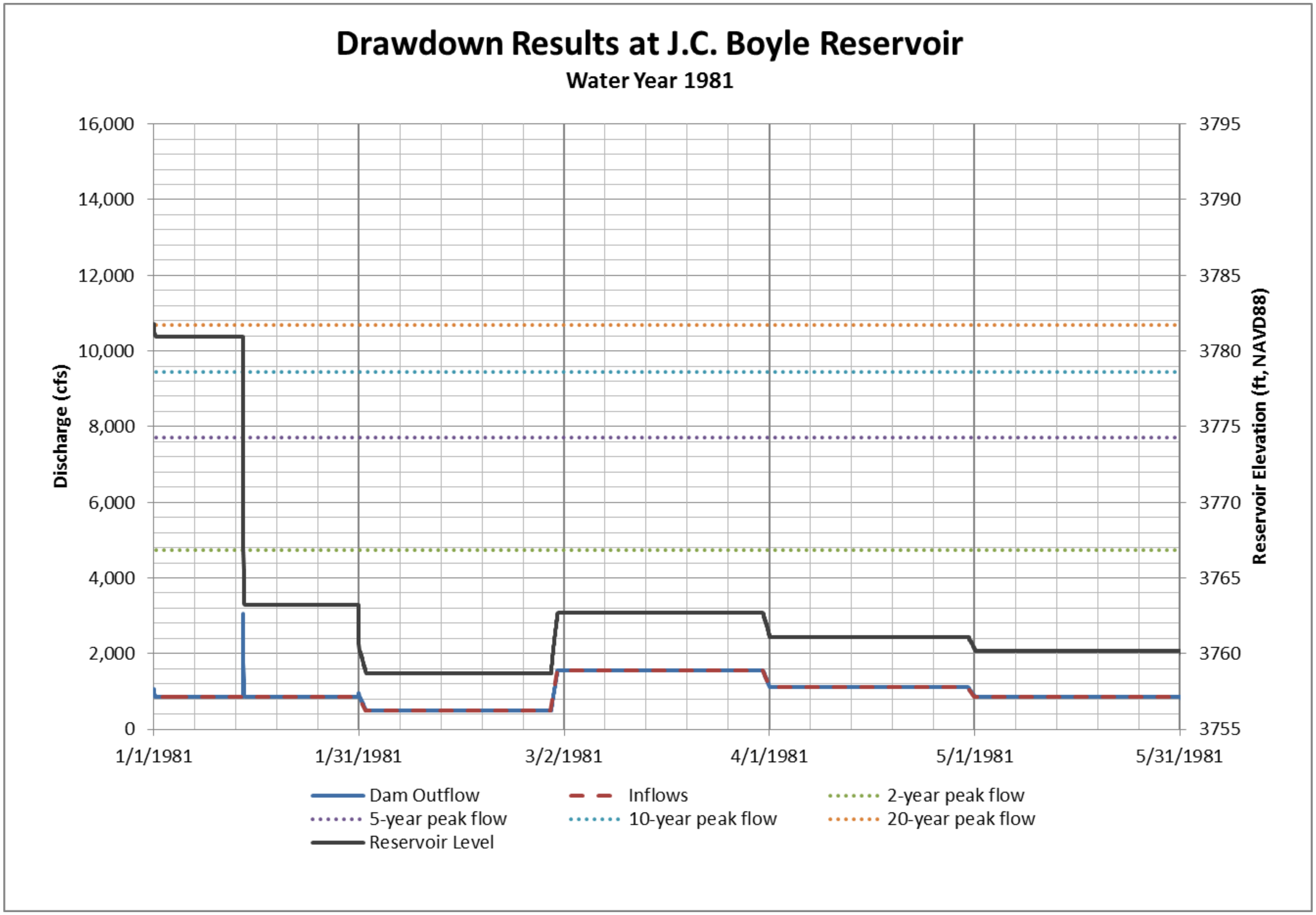

Figure 2-21 J.C. Boyle Reservoir Drawdown, Water Year 1981

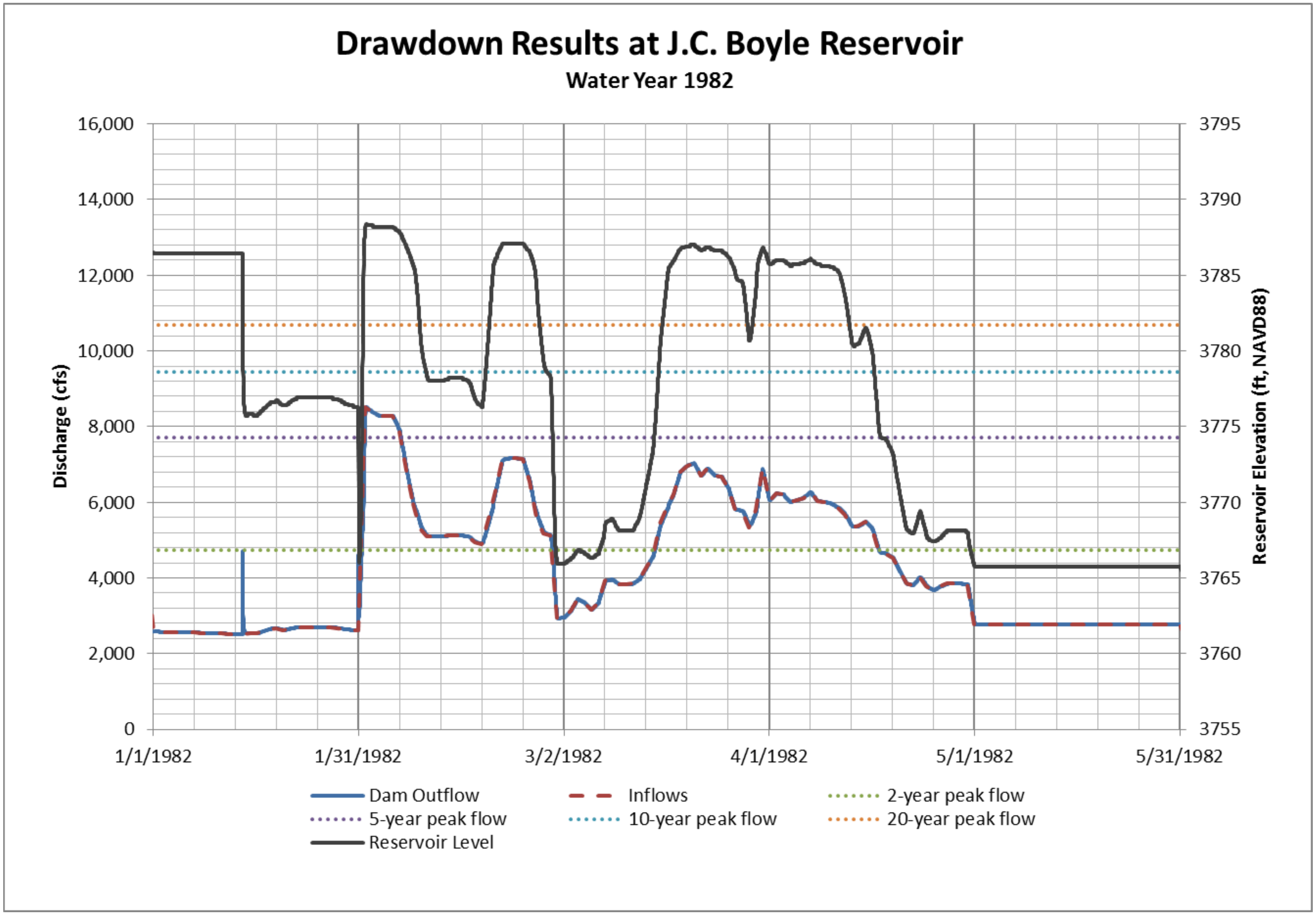

Figure 2-22 J.C. Boyle Reservoir Drawdown, Water Year 1982

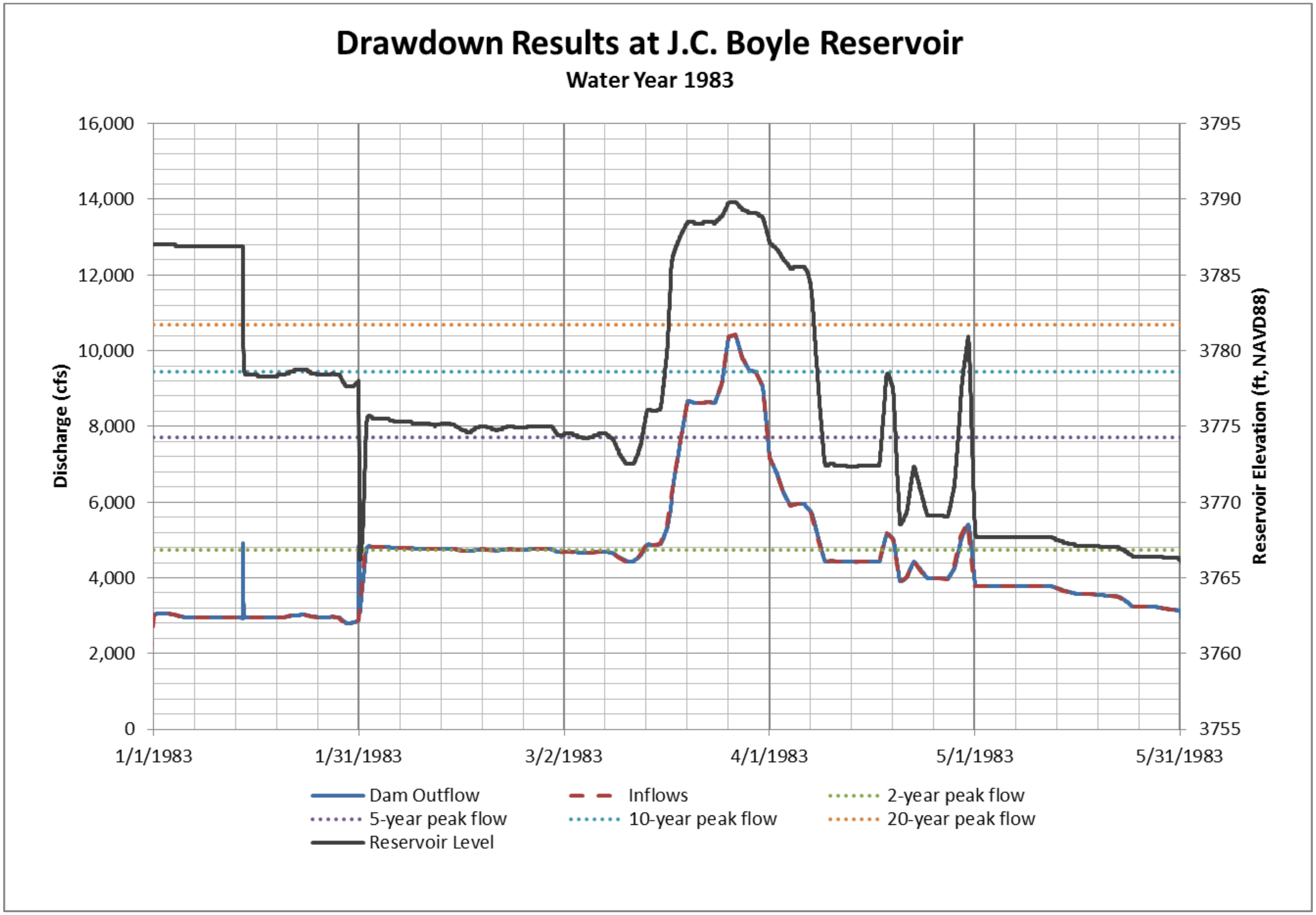

Figure 2-23 J.C. Boyle Reservoir Drawdown, Water Year 1983

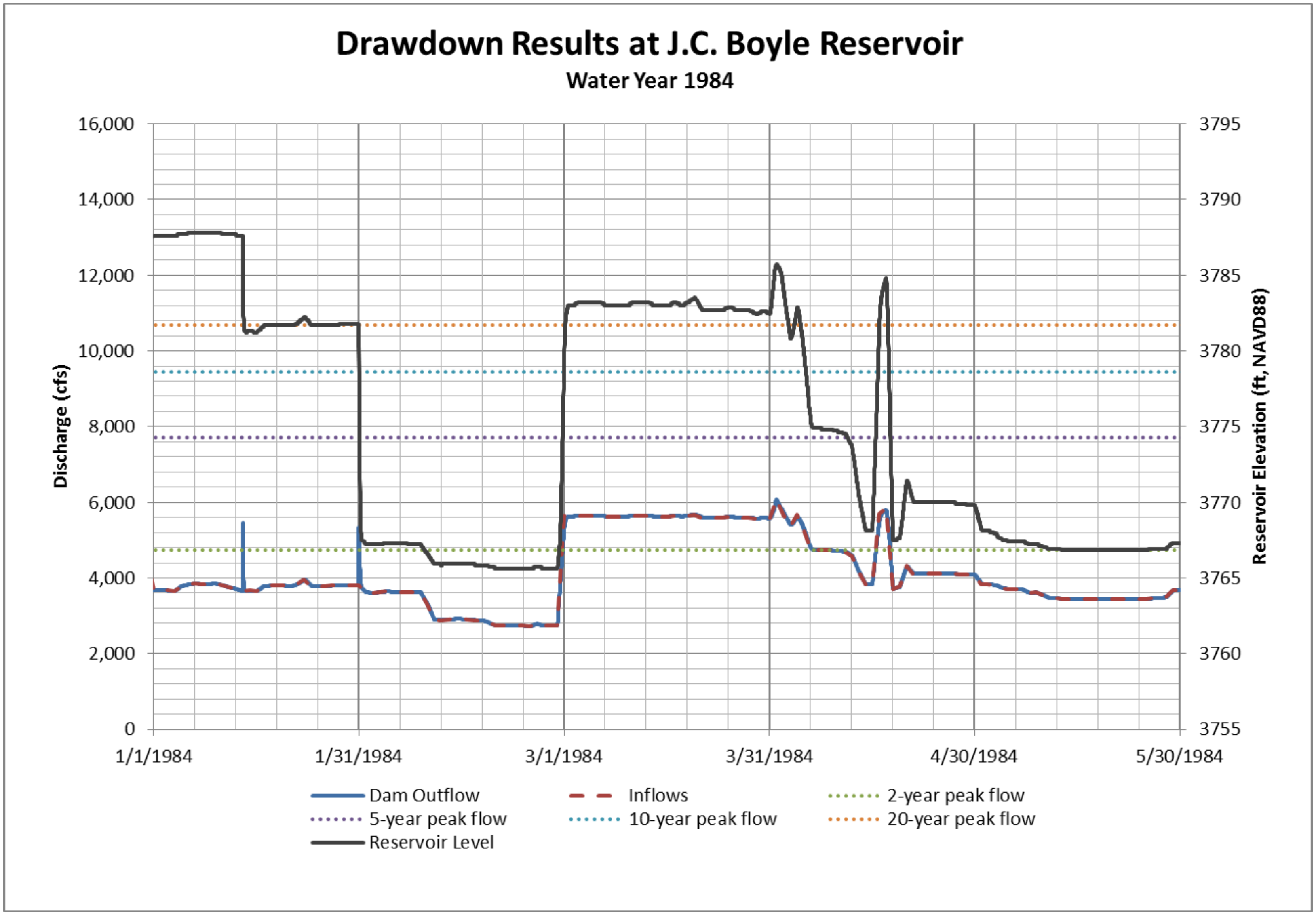

Figure 2-24 J.C. Boyle Reservoir Drawdown, Water Year 1984

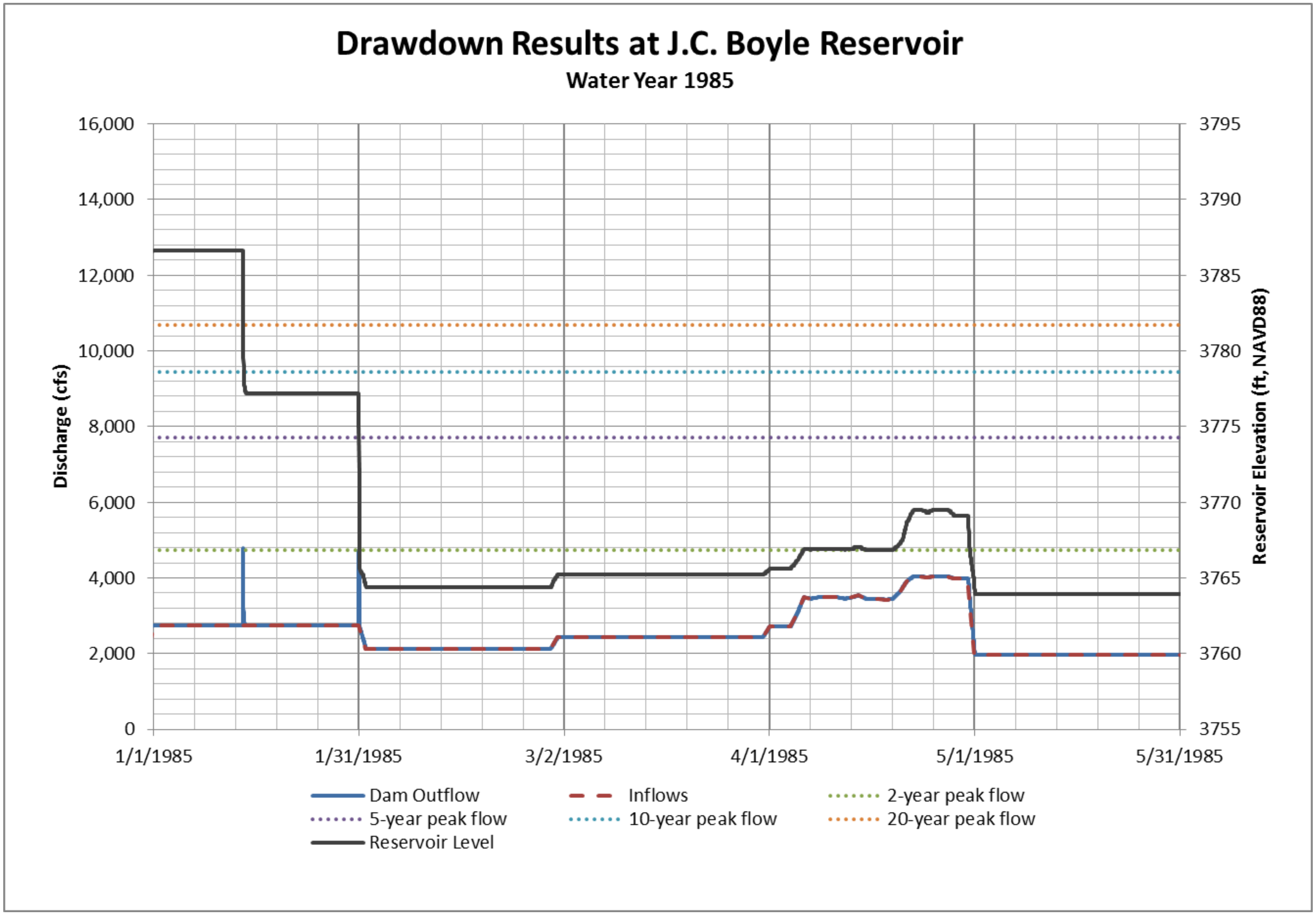

Figure 2-25 J.C. Boyle Reservoir Drawdown, Water Year 1985

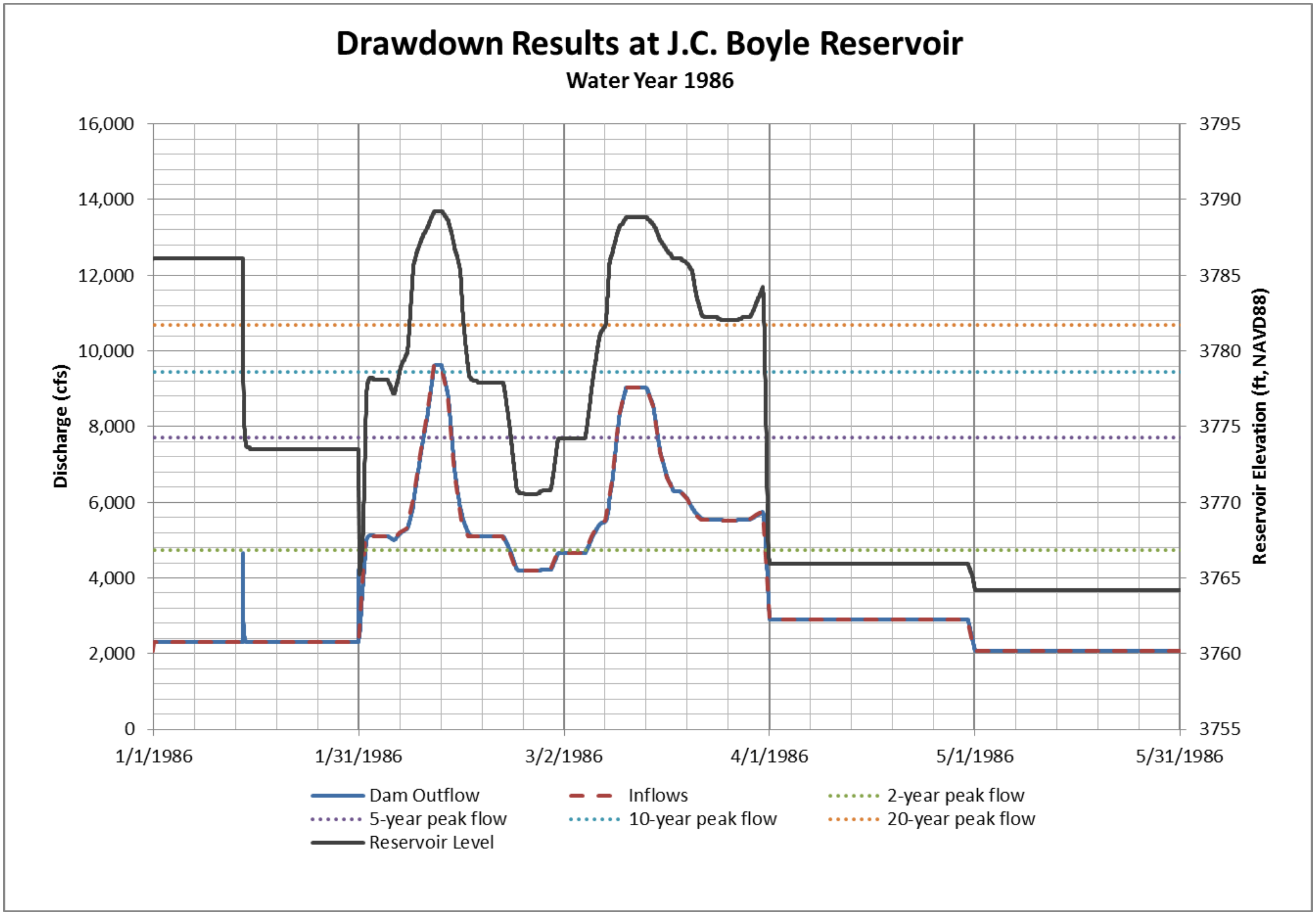

Figure 2-26 J.C. Boyle Reservoir Drawdown, Water Year 1986 (Wet Year)

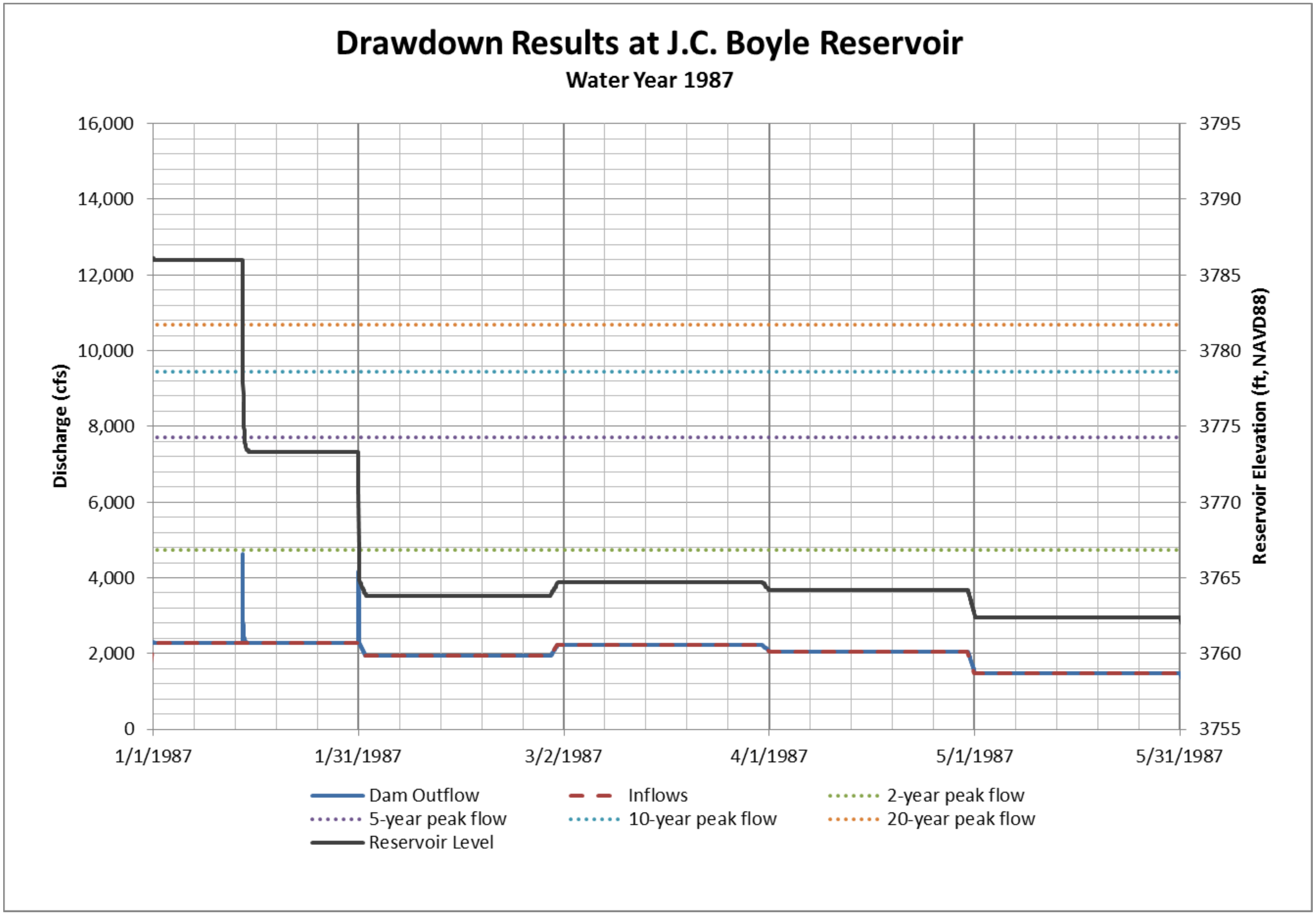

Figure 2-27 J.C. Boyle Reservoir Drawdown, Water Year 1987

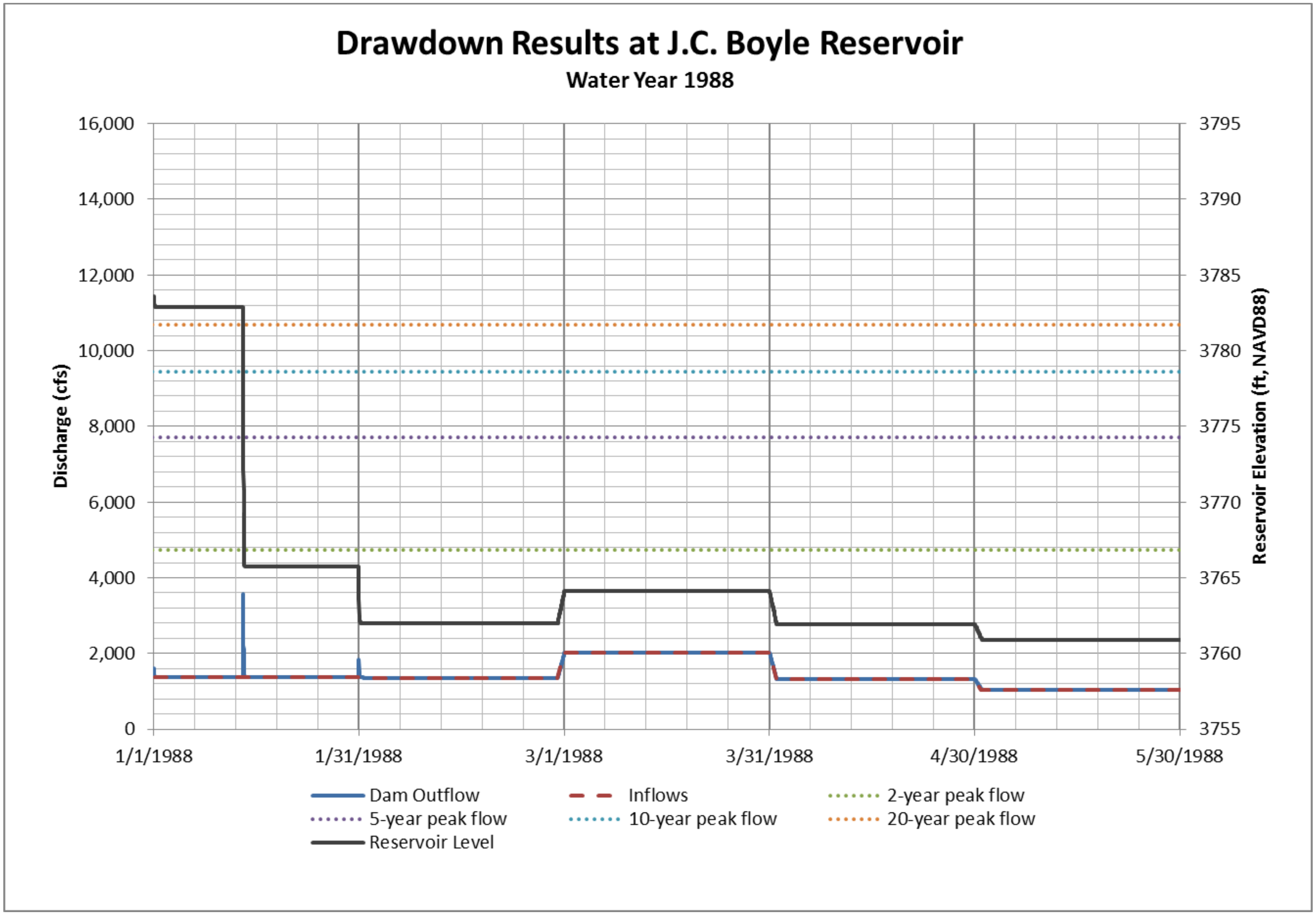

Figure 2-28 J.C. Boyle Reservoir Drawdown, Water Year 1988

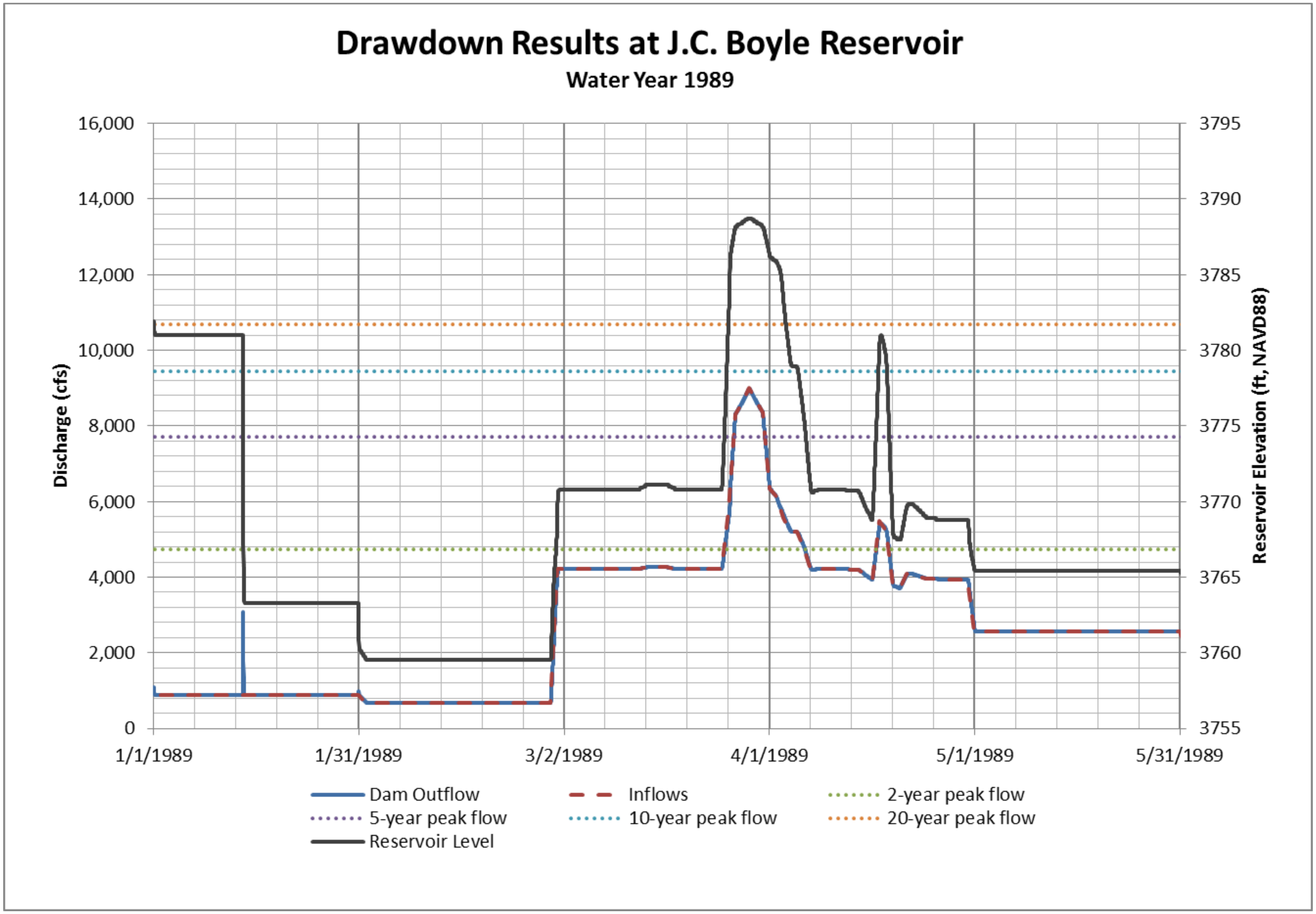

Figure 2-29 J.C. Boyle Reservoir Drawdown, Water Year 1989

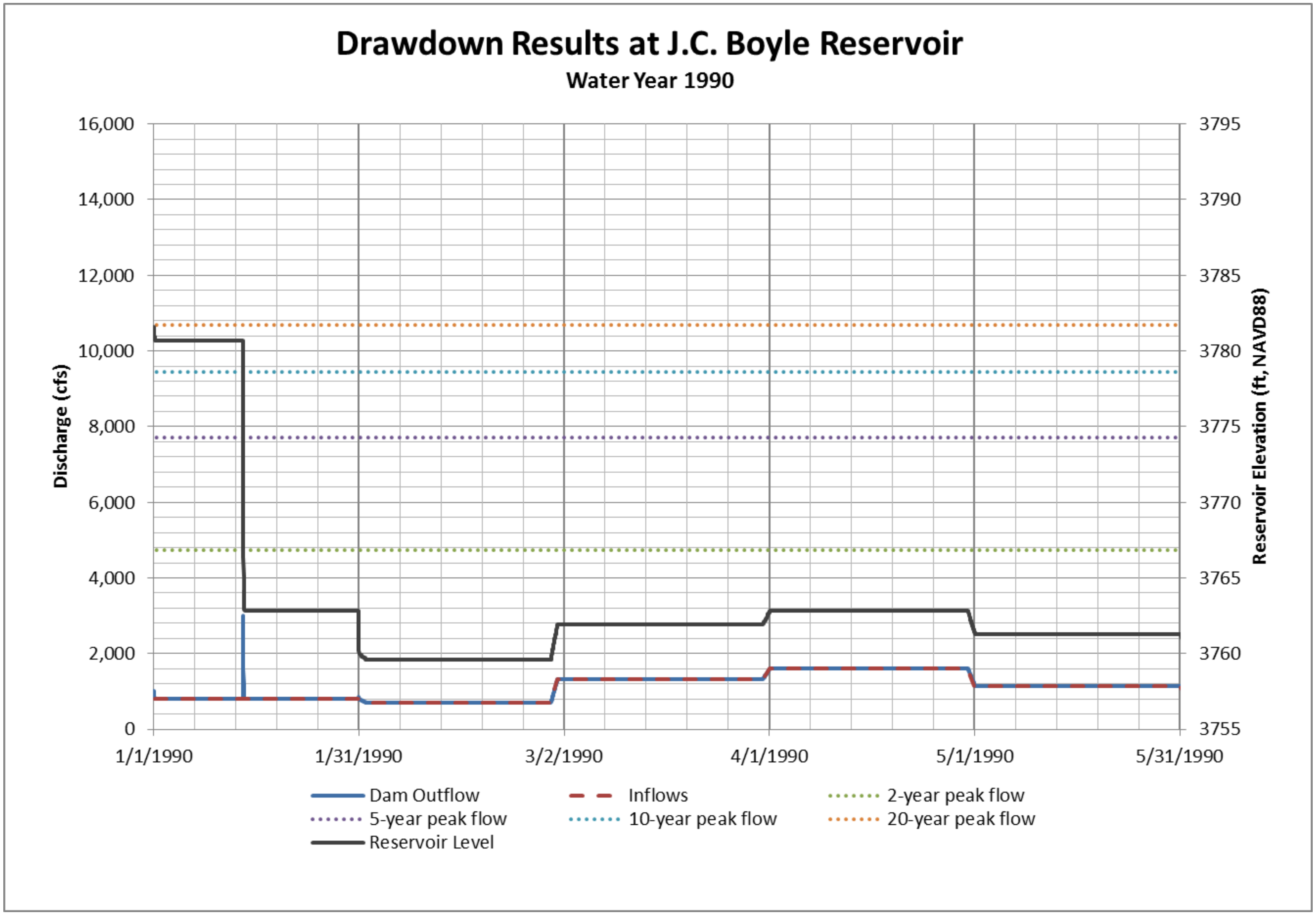

Figure 2-30 J.C. Boyle Reservoir Drawdown, Water Year 1990

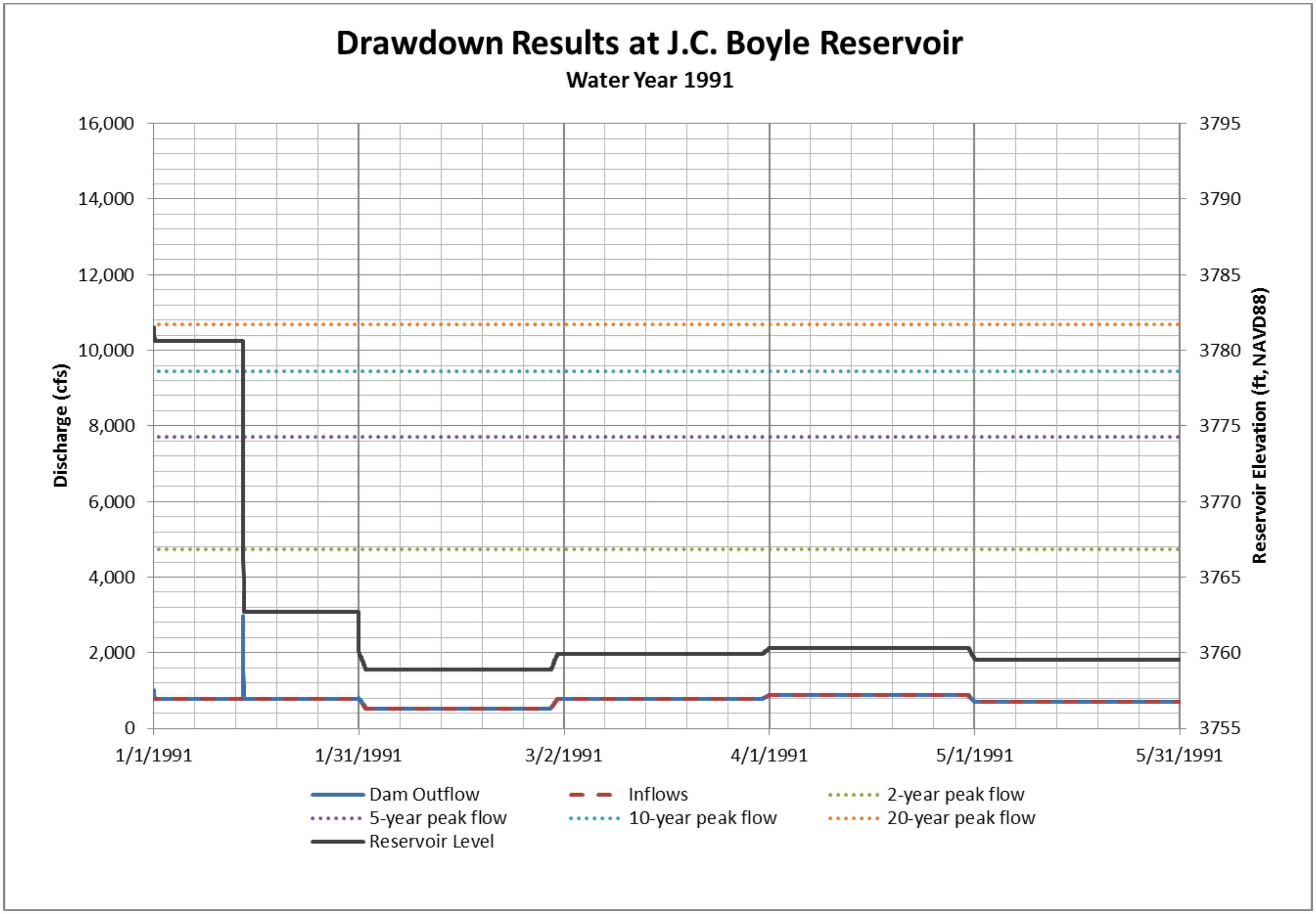

Figure 2-31 J.C. Boyle Reservoir Drawdown, Water Year 1991

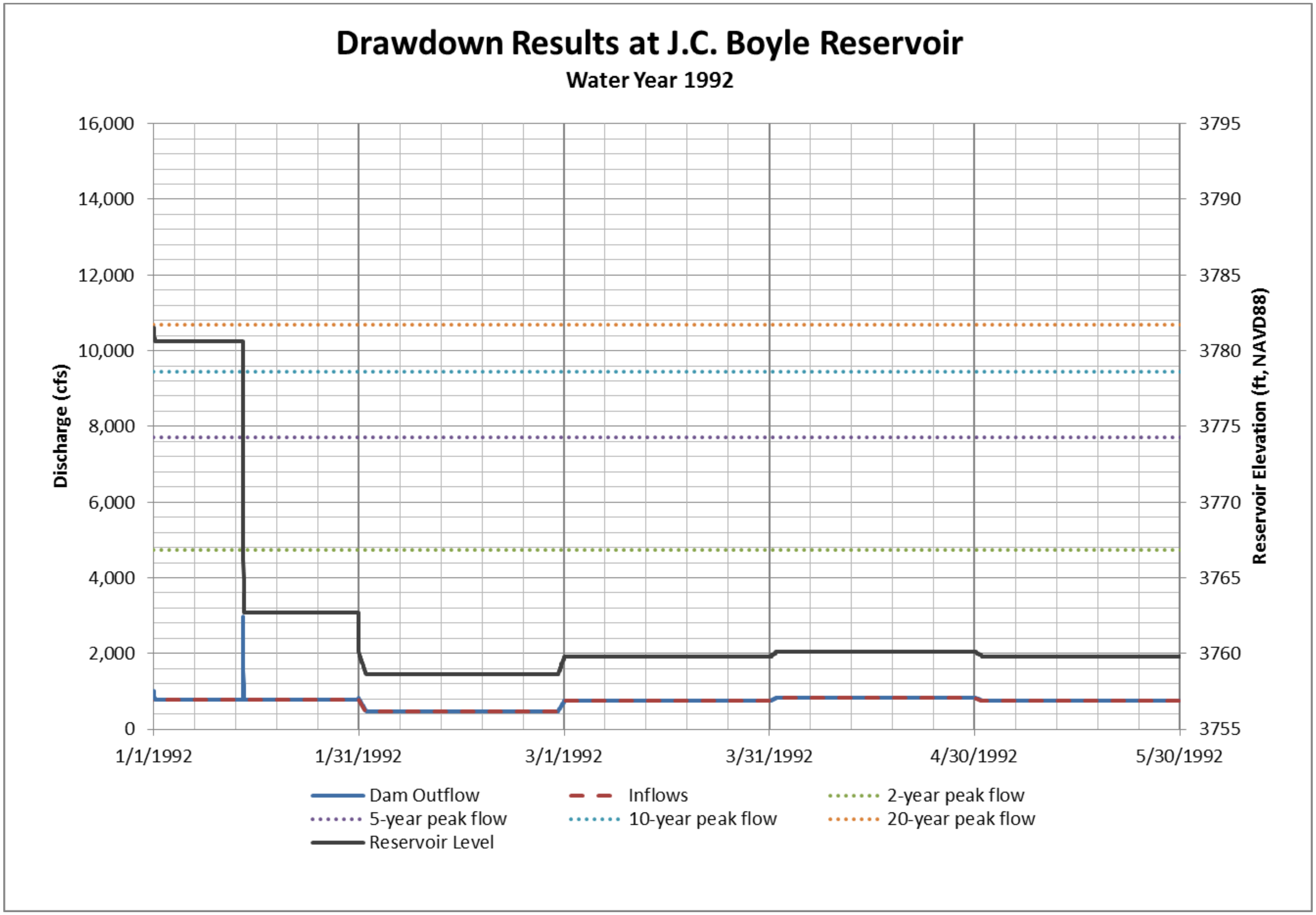

Figure 2-32 J.C. Boyle Reservoir Drawdown, Water Year 1992

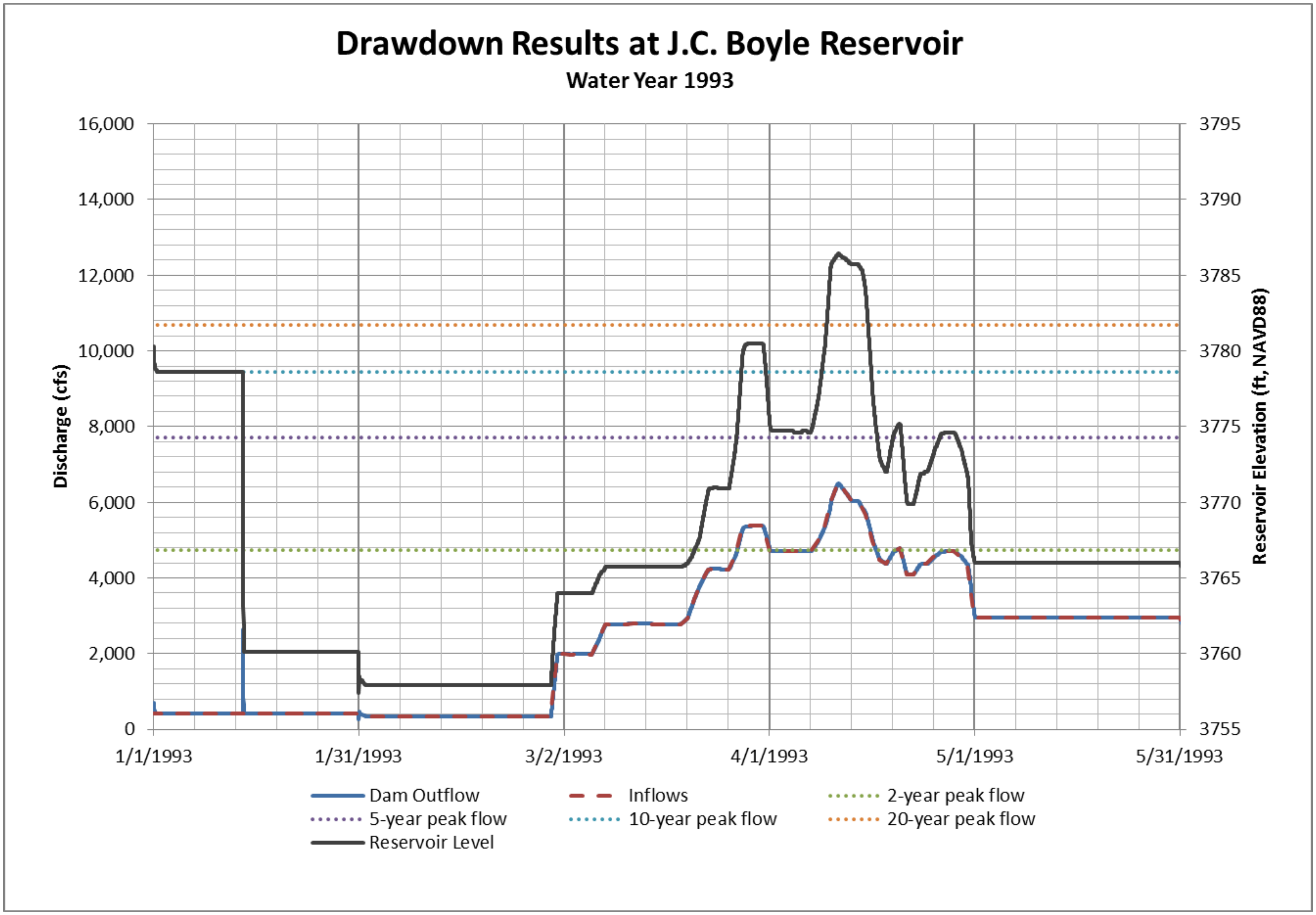

Figure 2-33 J.C. Boyle Reservoir Drawdown, Water Year 1993

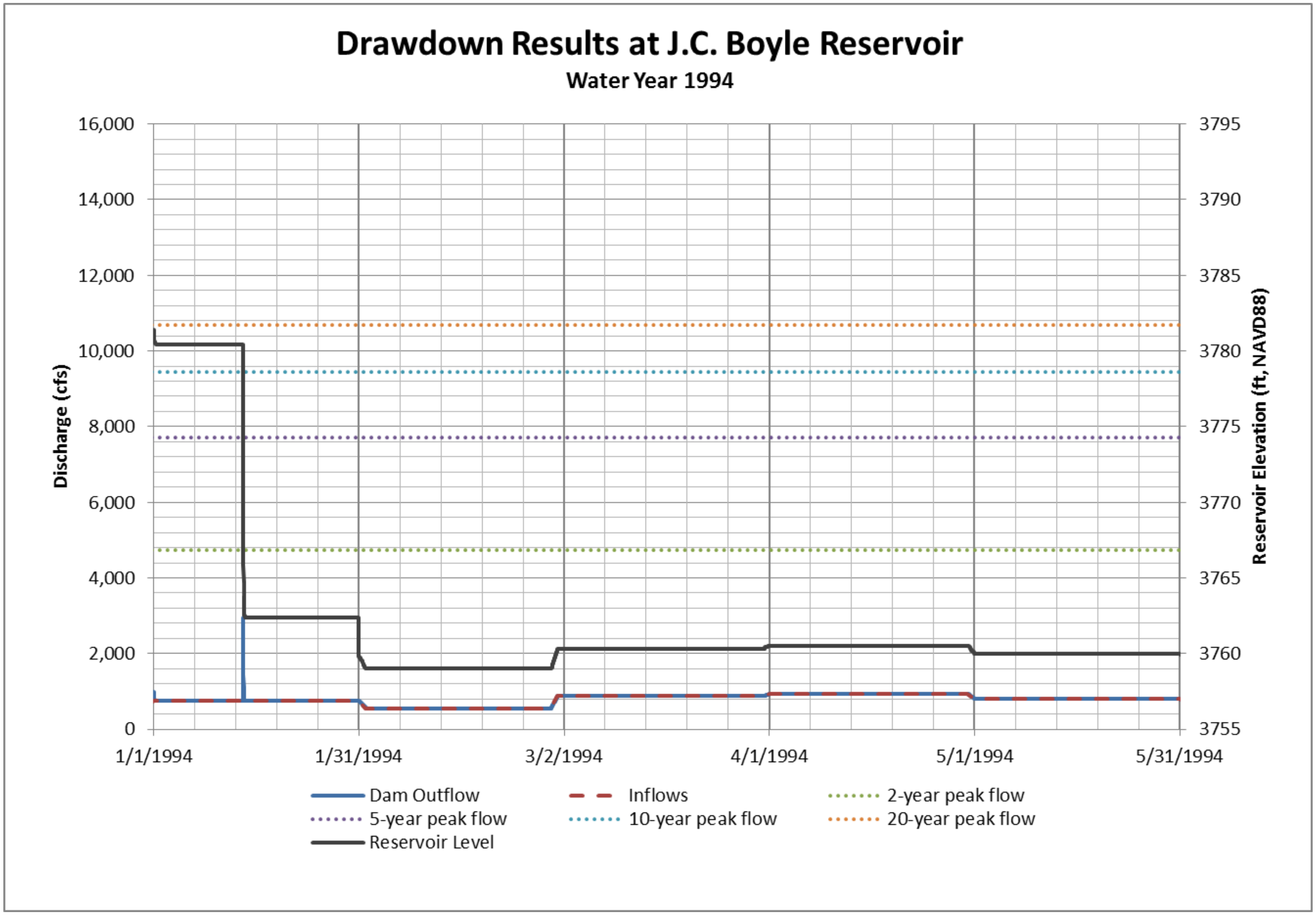

Figure 2-34 J.C. Boyle Reservoir Drawdown, Water Year 1994

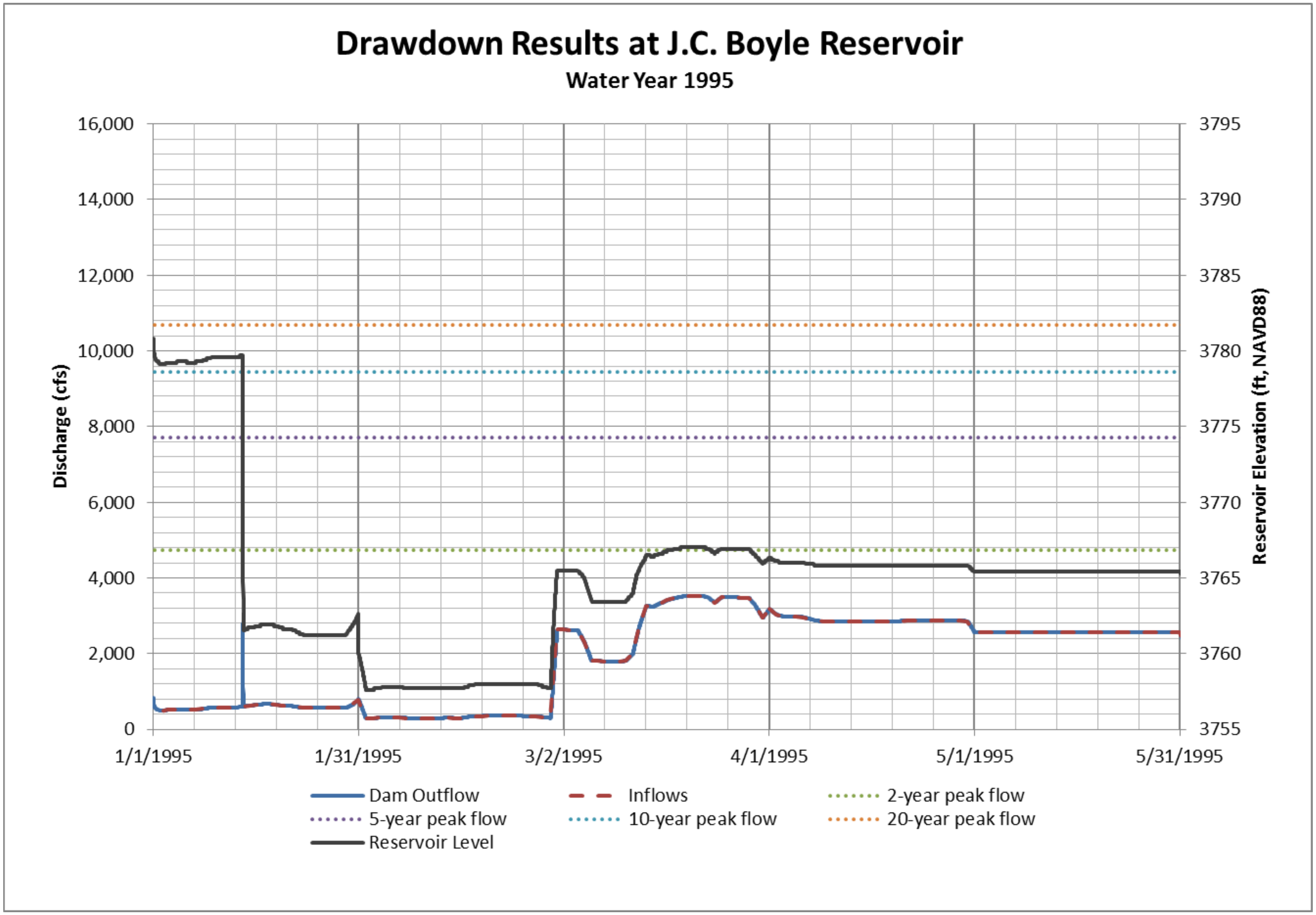

Figure 2-35 J.C. Boyle Reservoir Drawdown, Water Year 1995

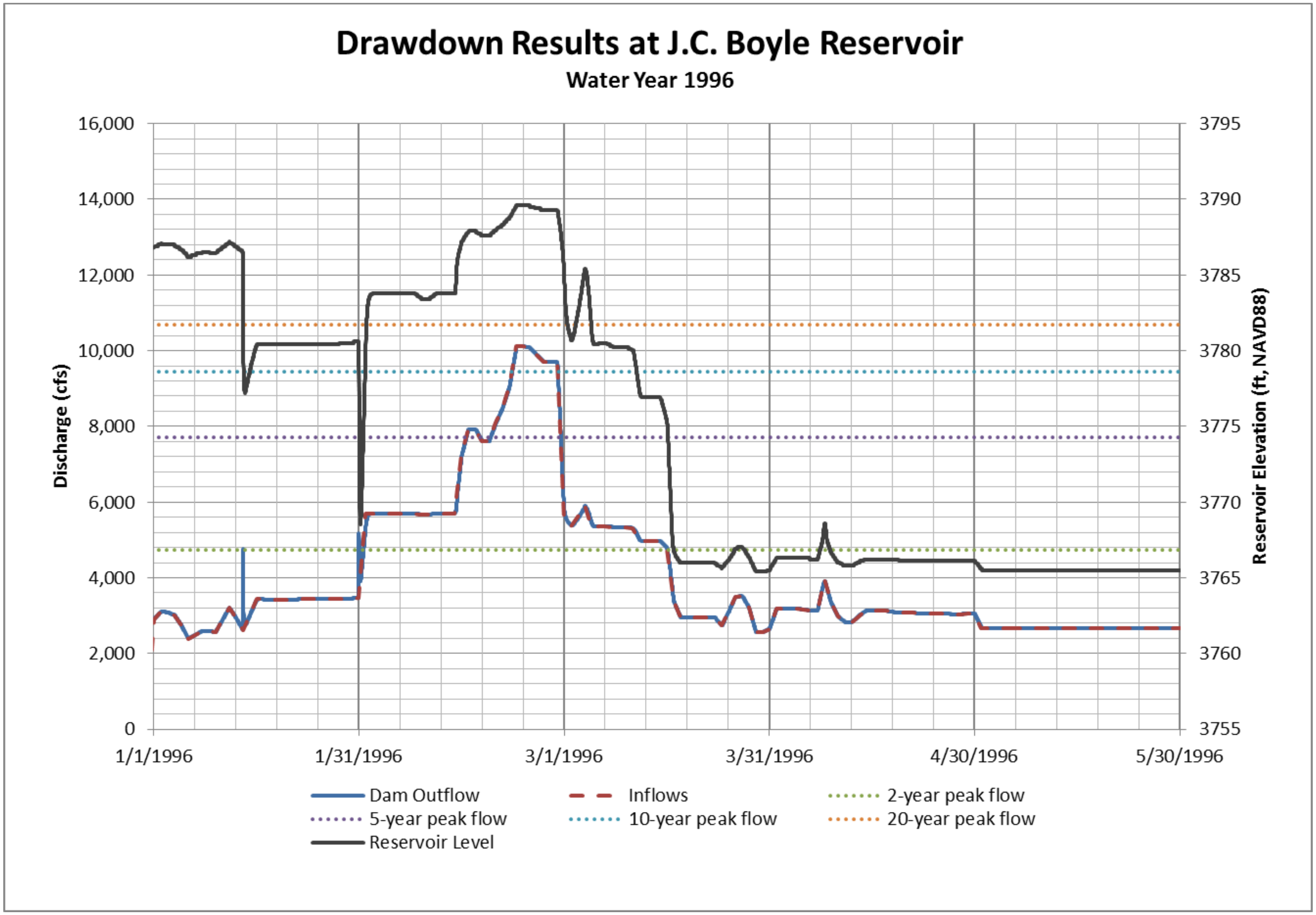

Figure 2-36 J.C. Boyle Reservoir Drawdown, Water Year 1996

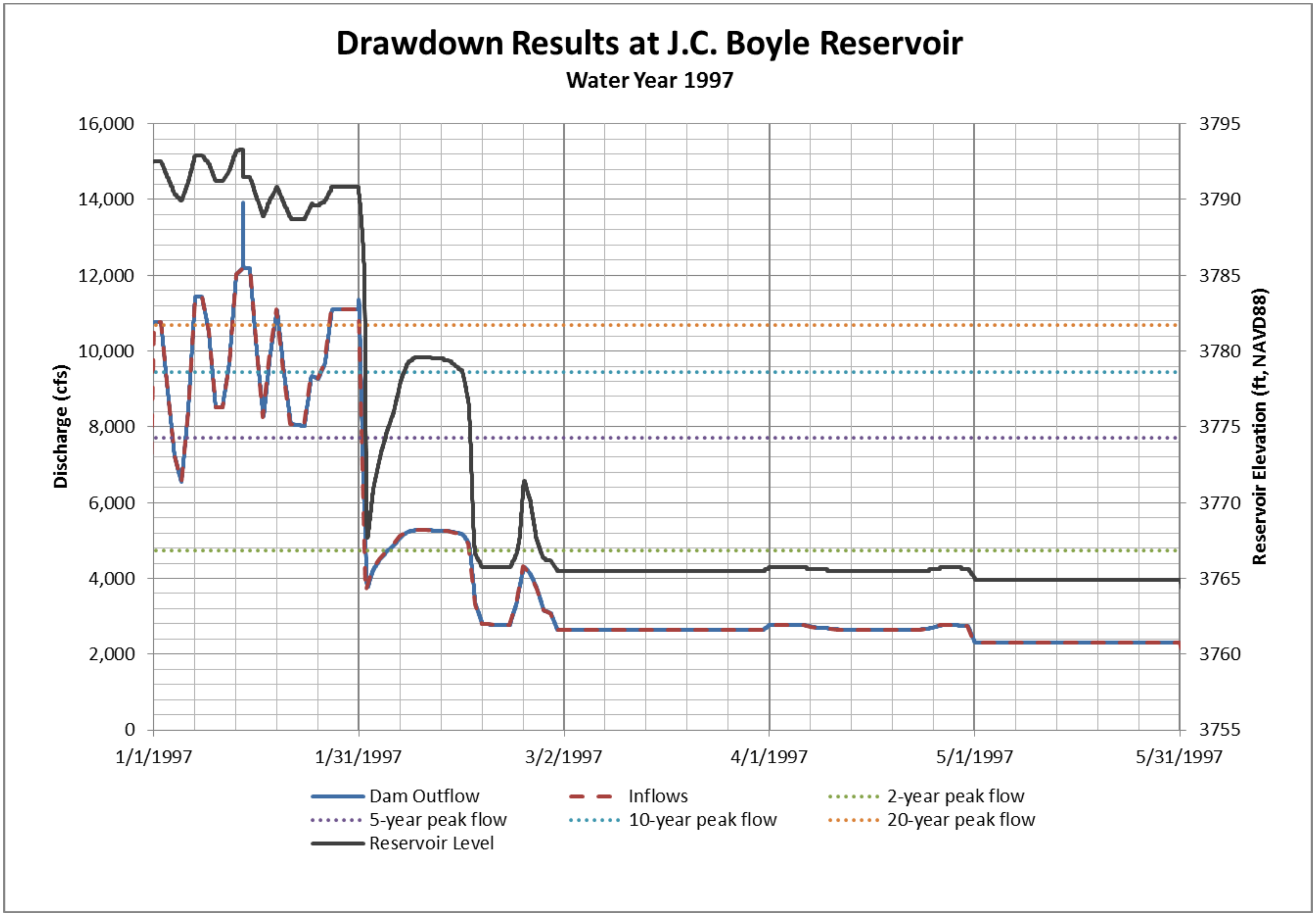

Figure 2-37 J.C. Boyle Reservoir Drawdown, Water Year 1997

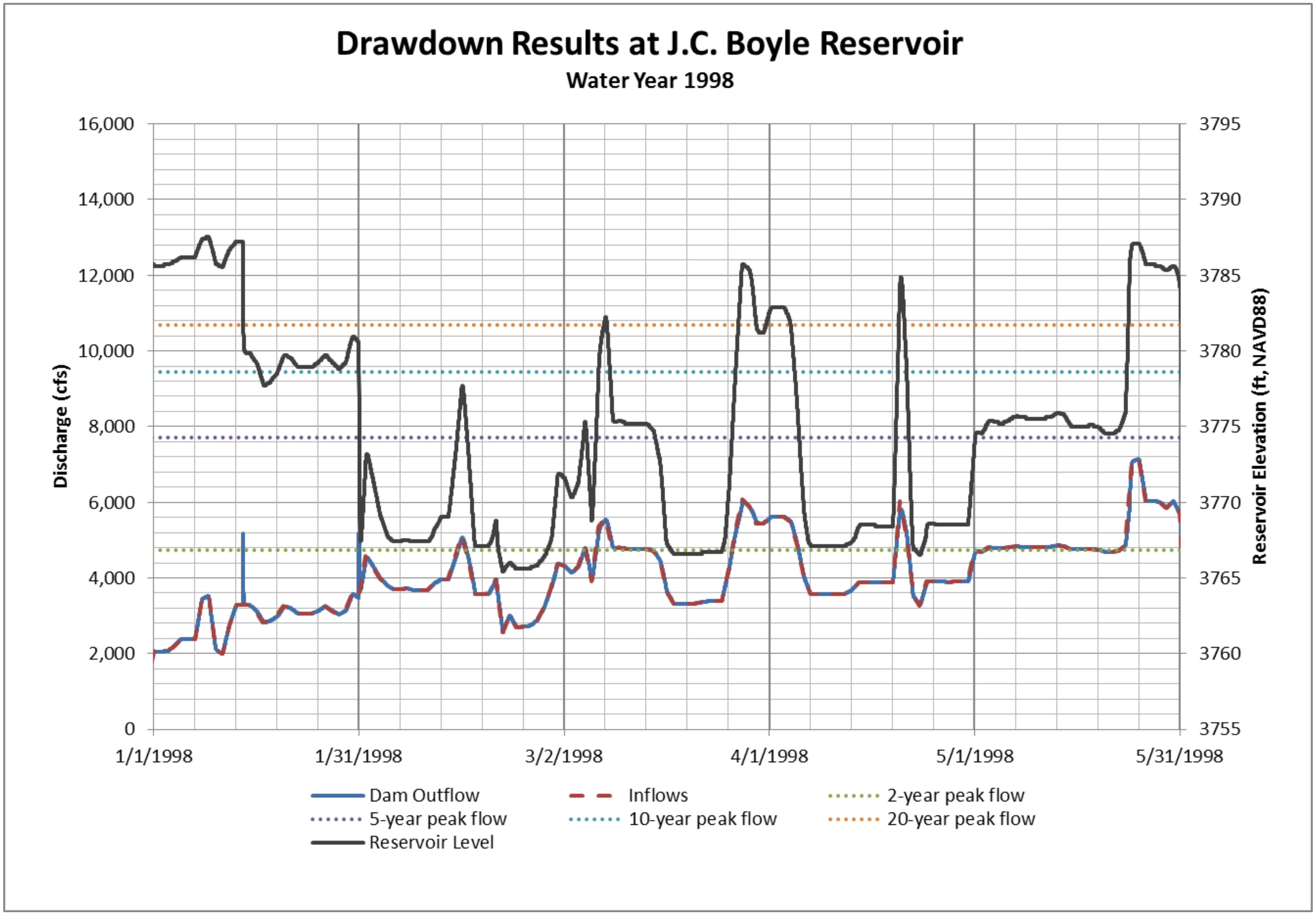

Figure 2-38 J.C. Boyle Reservoir Drawdown, Water Year 1998

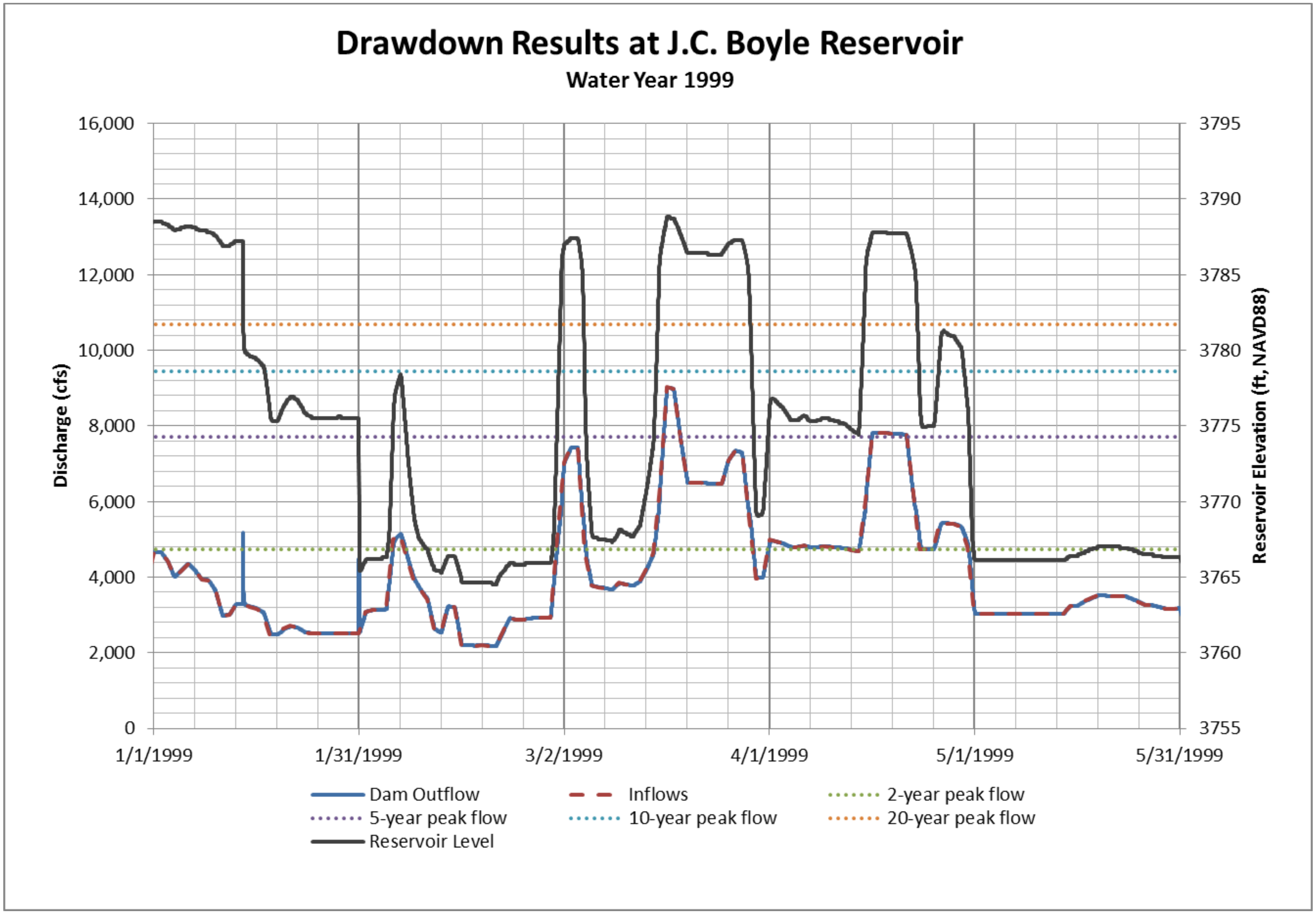

Figure 2-39 J.C. Boyle Reservoir Drawdown, Water Year 1999

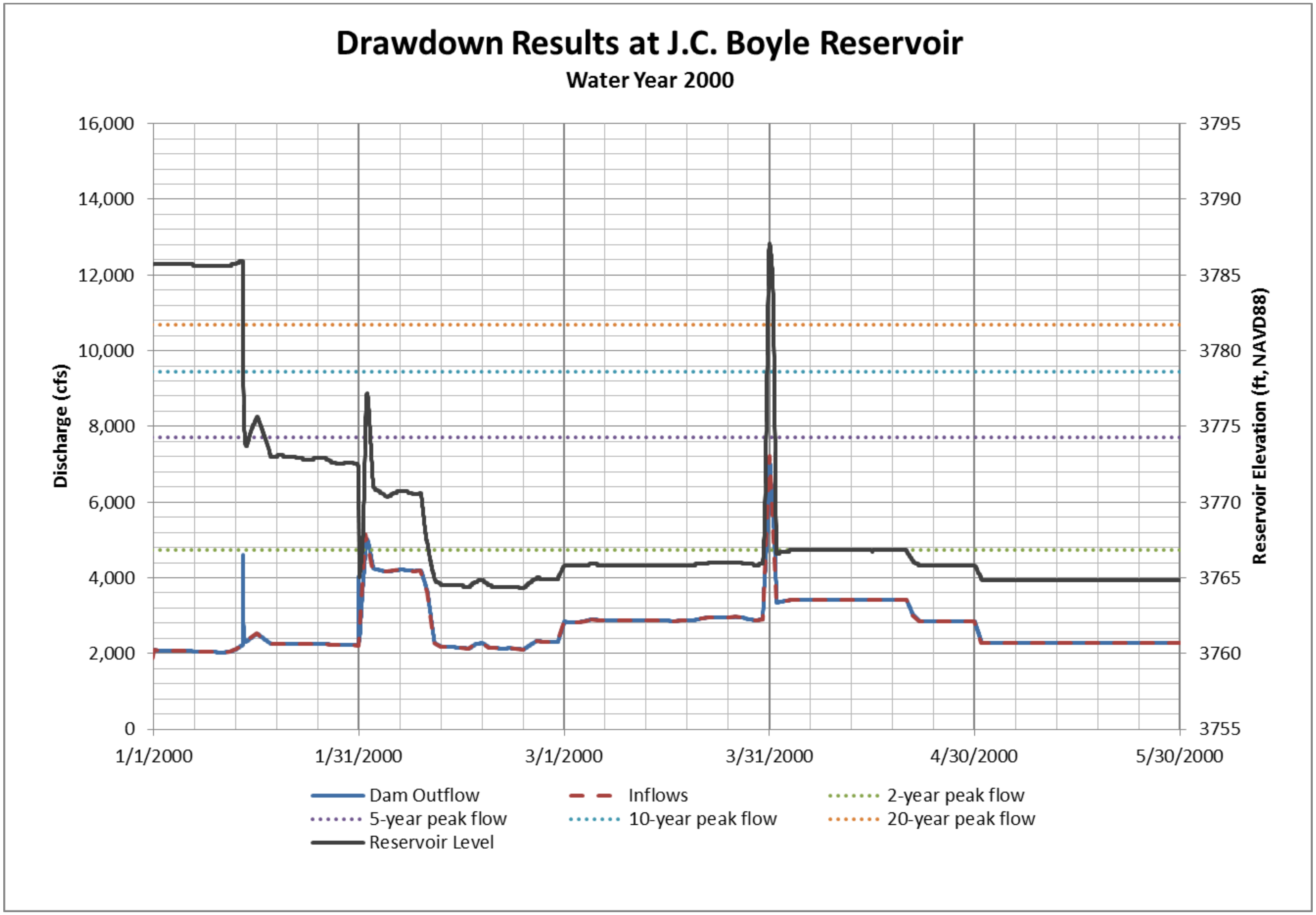

Figure 2-40 J.C. Boyle Reservoir Drawdown, Water Year 2000

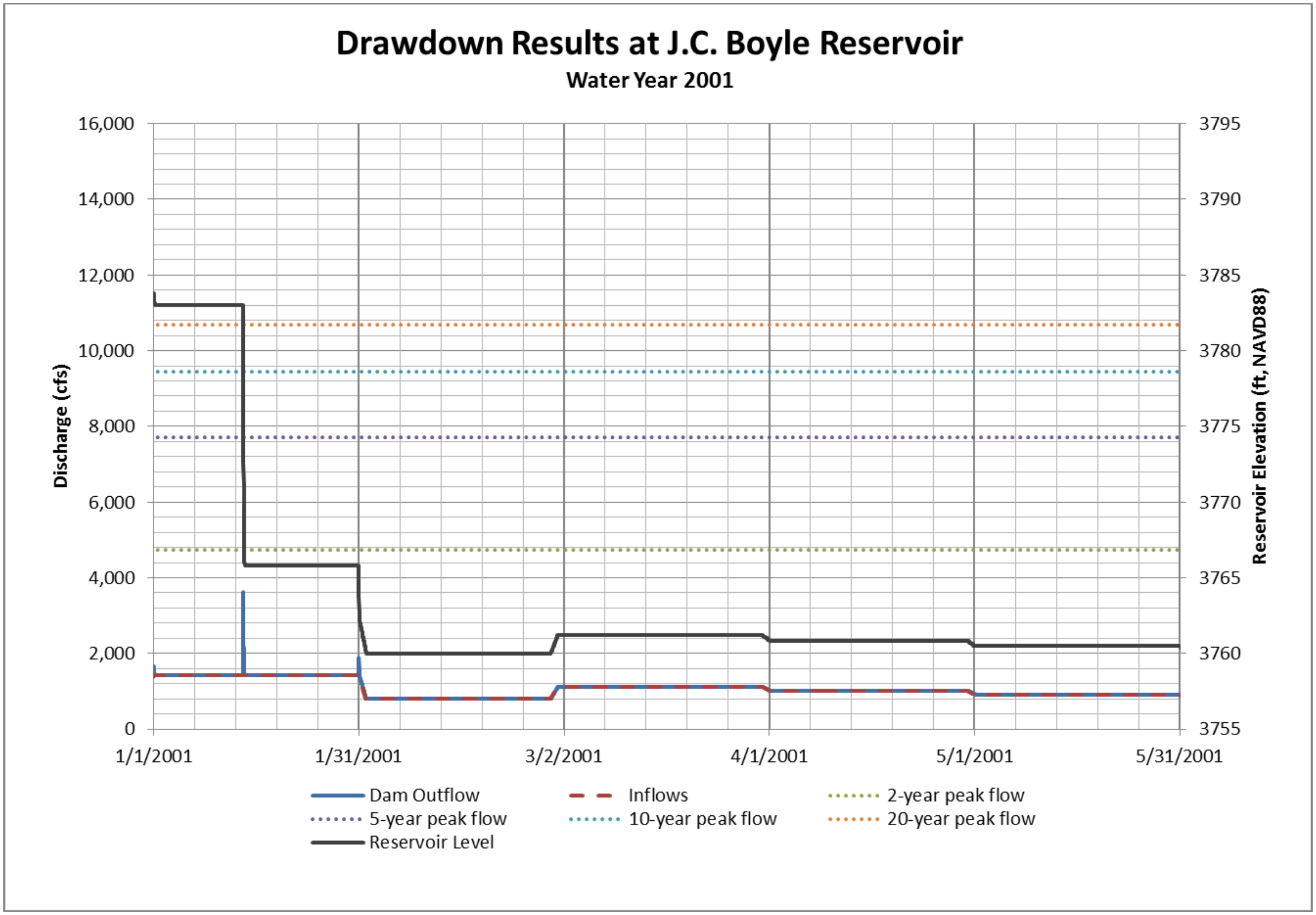

Figure 2-41 J.C. Boyle Reservoir Drawdown, Water Year 2001

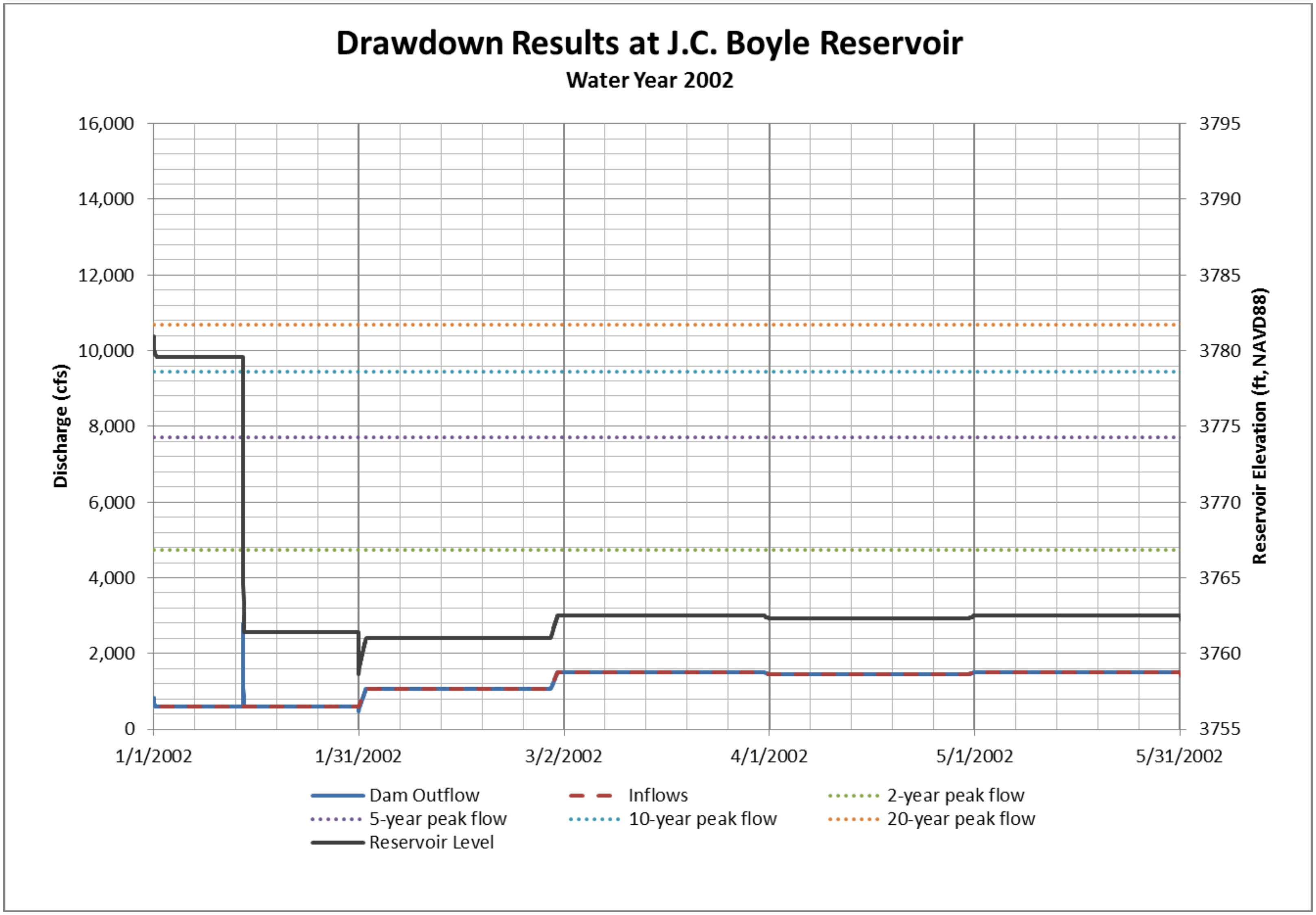

Figure 2-42 J.C. Boyle Reservoir Drawdown, Water Year 2002

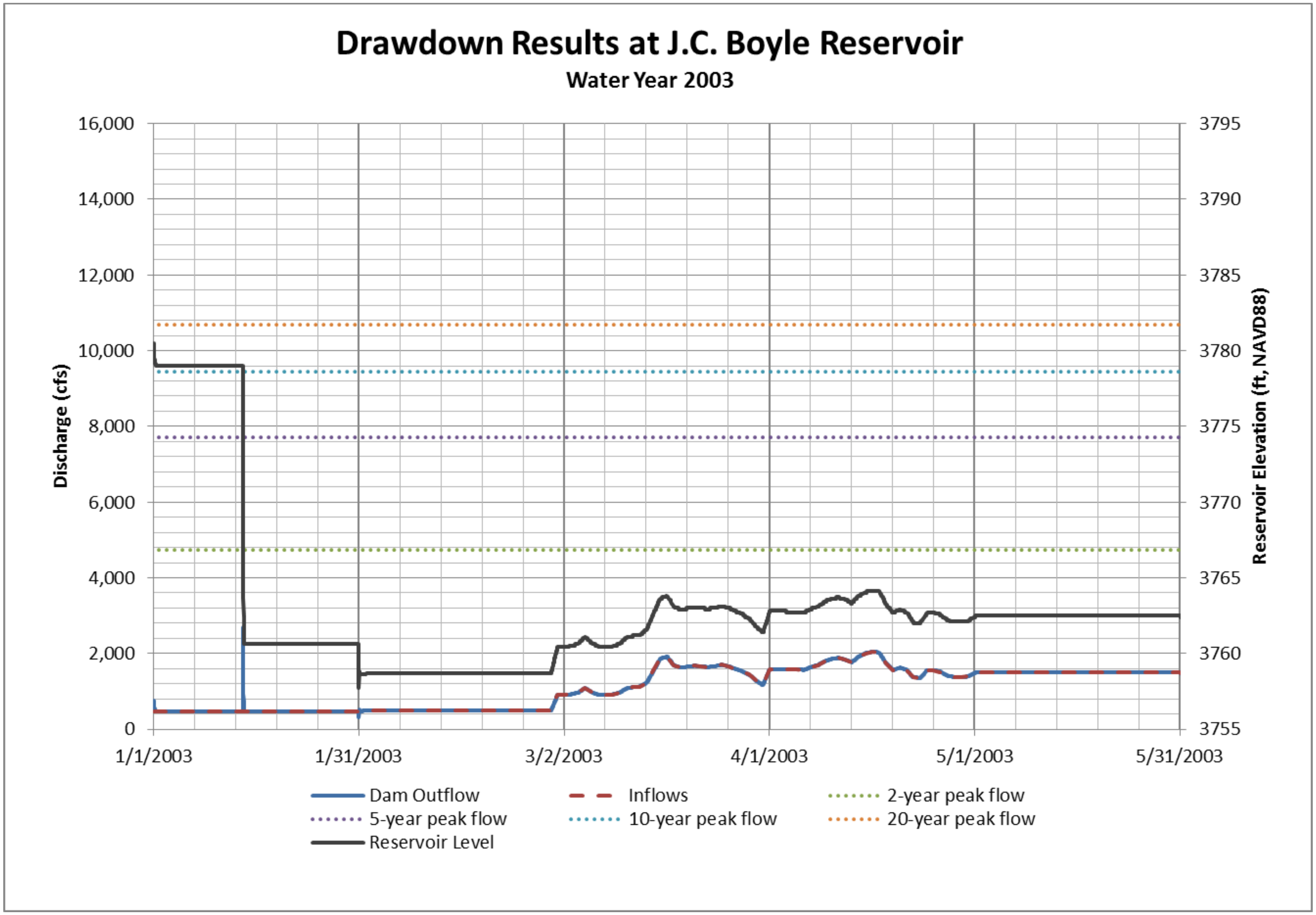

Figure 2-43 J.C. Boyle Reservoir Drawdown, Water Year 2003

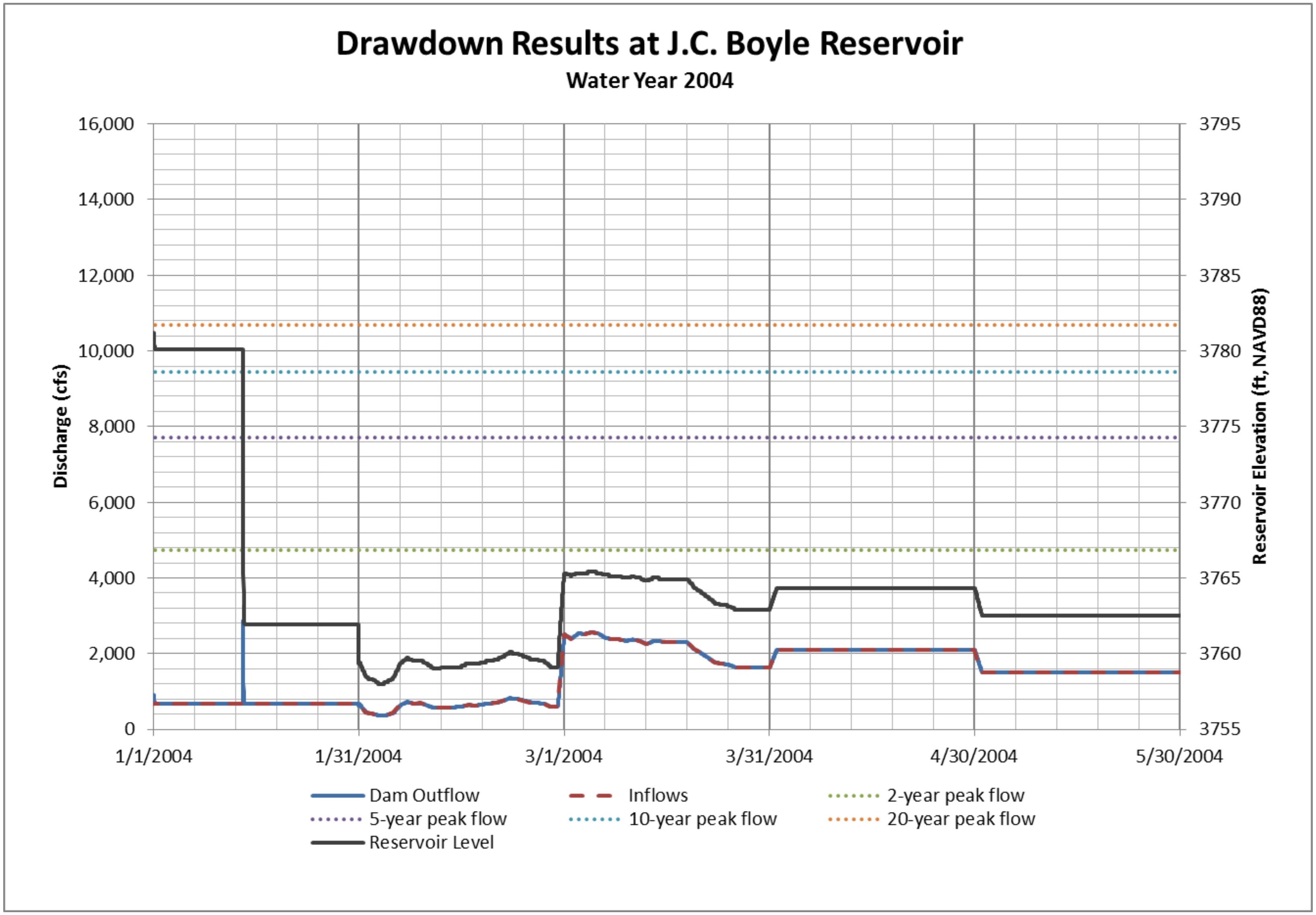

Figure 2-44 J.C. Boyle Reservoir Drawdown, Water Year 2004

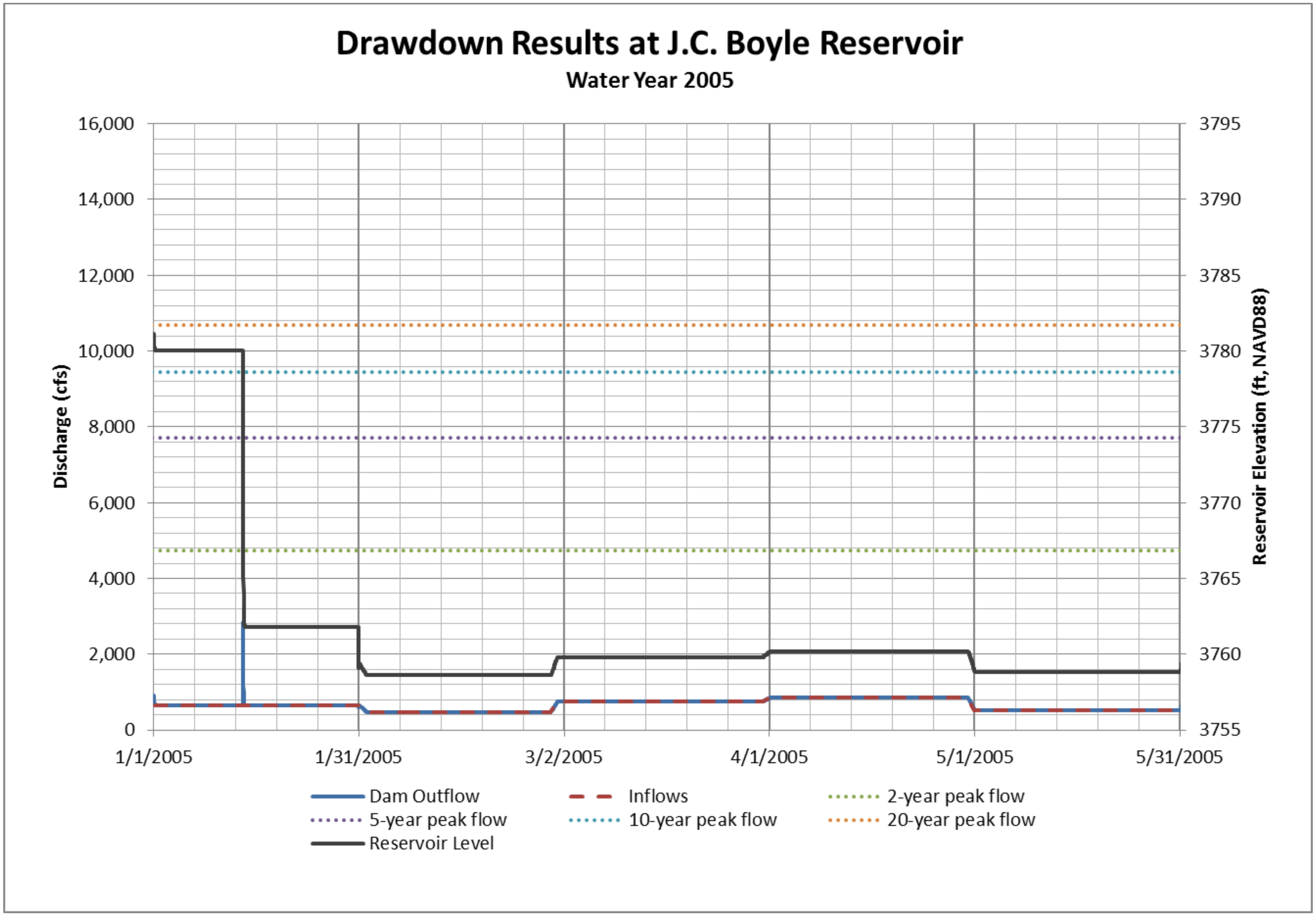

Figure 2-45 J.C. Boyle Reservoir Drawdown, Water Year 2005

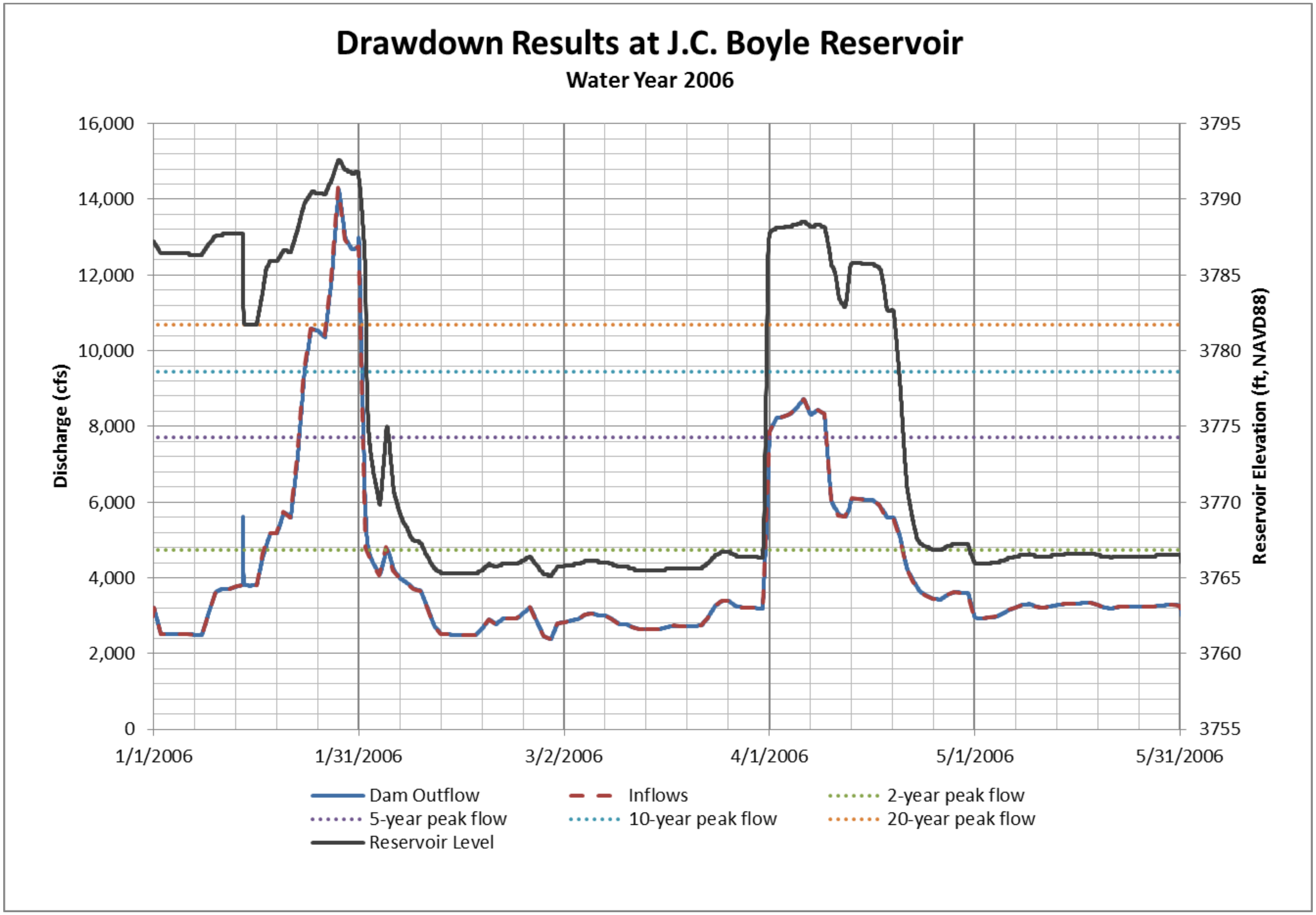

Figure 2-46 J.C. Boyle Reservoir Drawdown, Water Year 2006 (Wet Year)

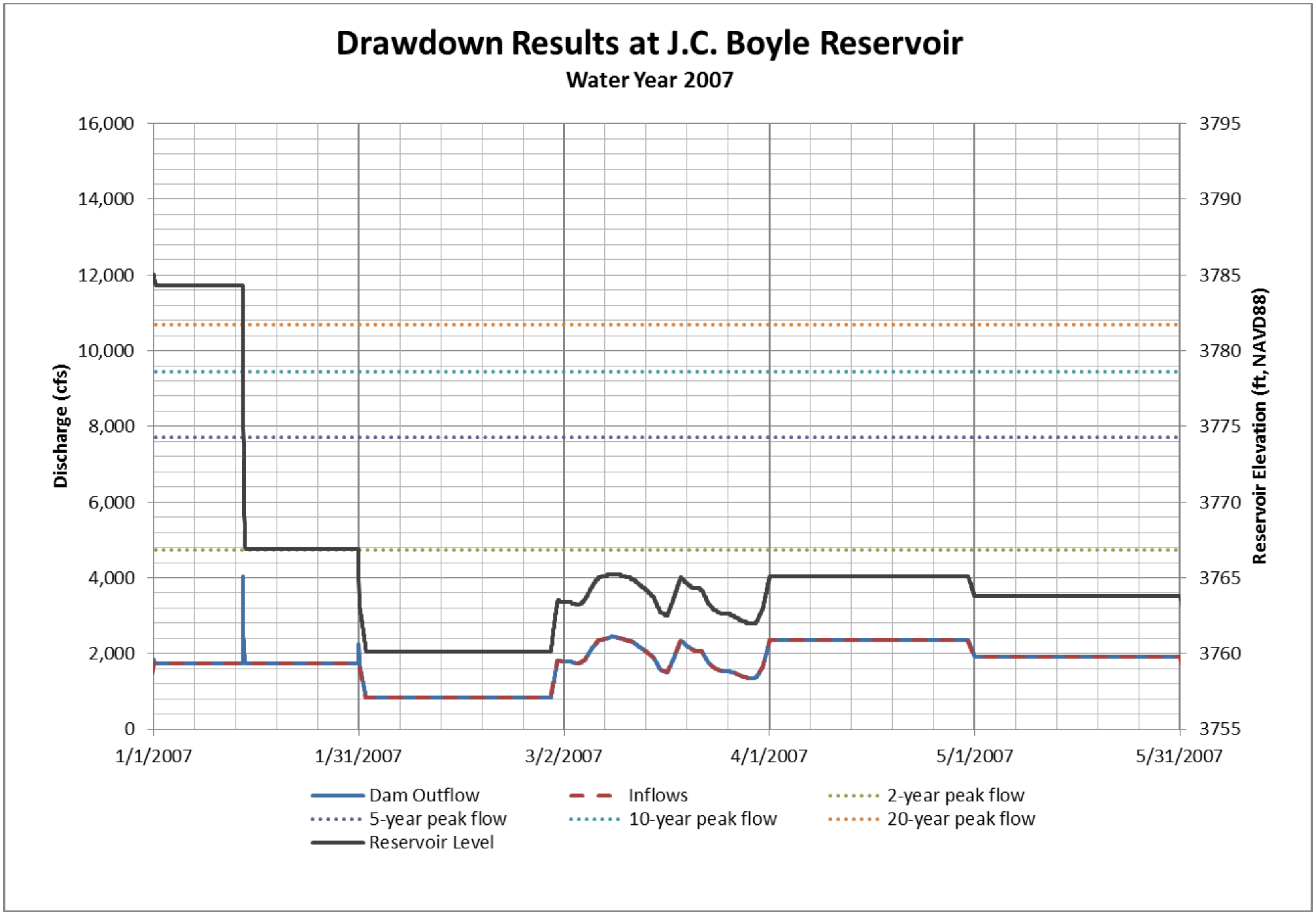

Figure 2-47 J.C. Boyle Reservoir Drawdown, Water Year 2007

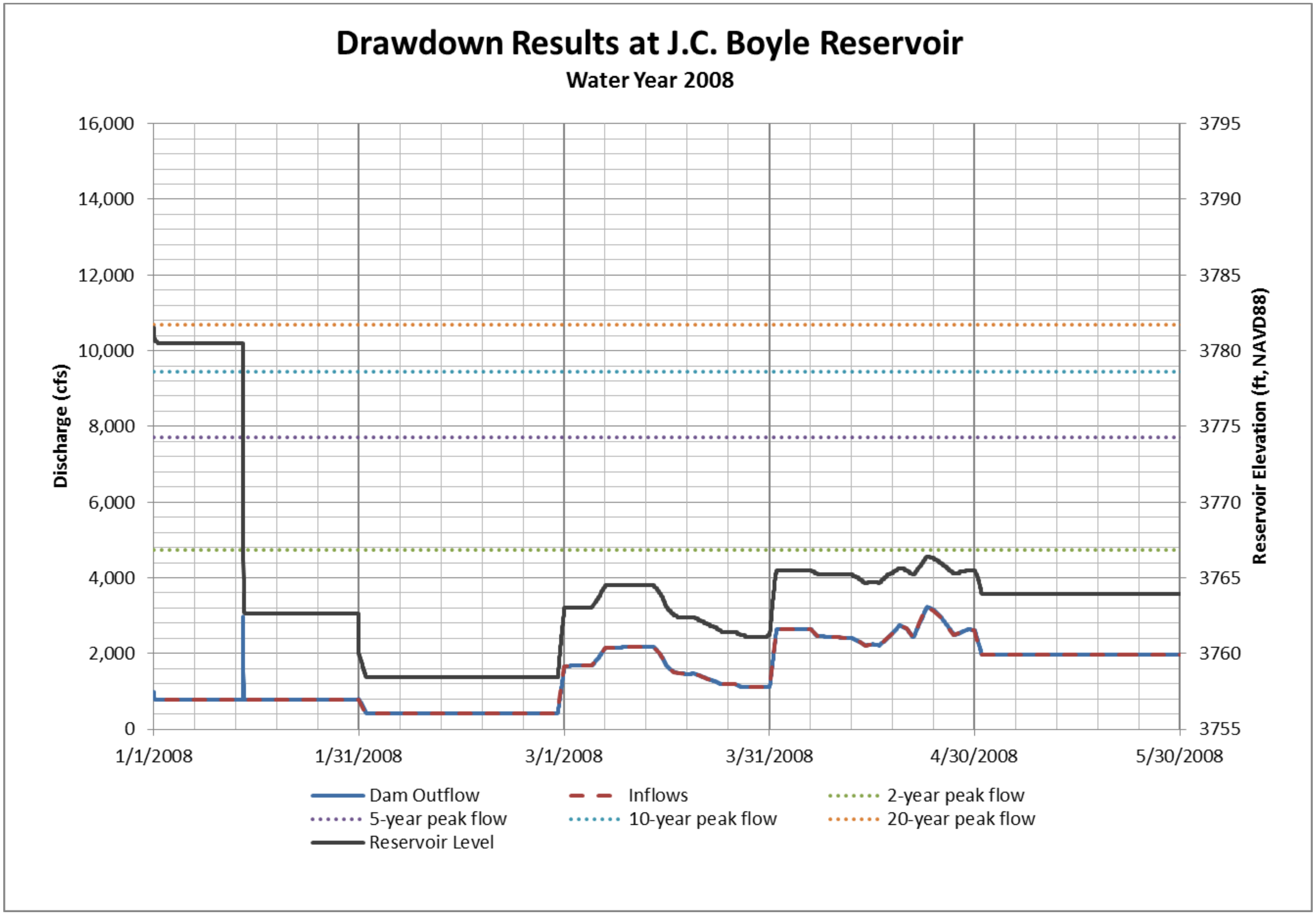

Figure 2-48 J.C. Boyle Reservoir Drawdown, Water Year 2008

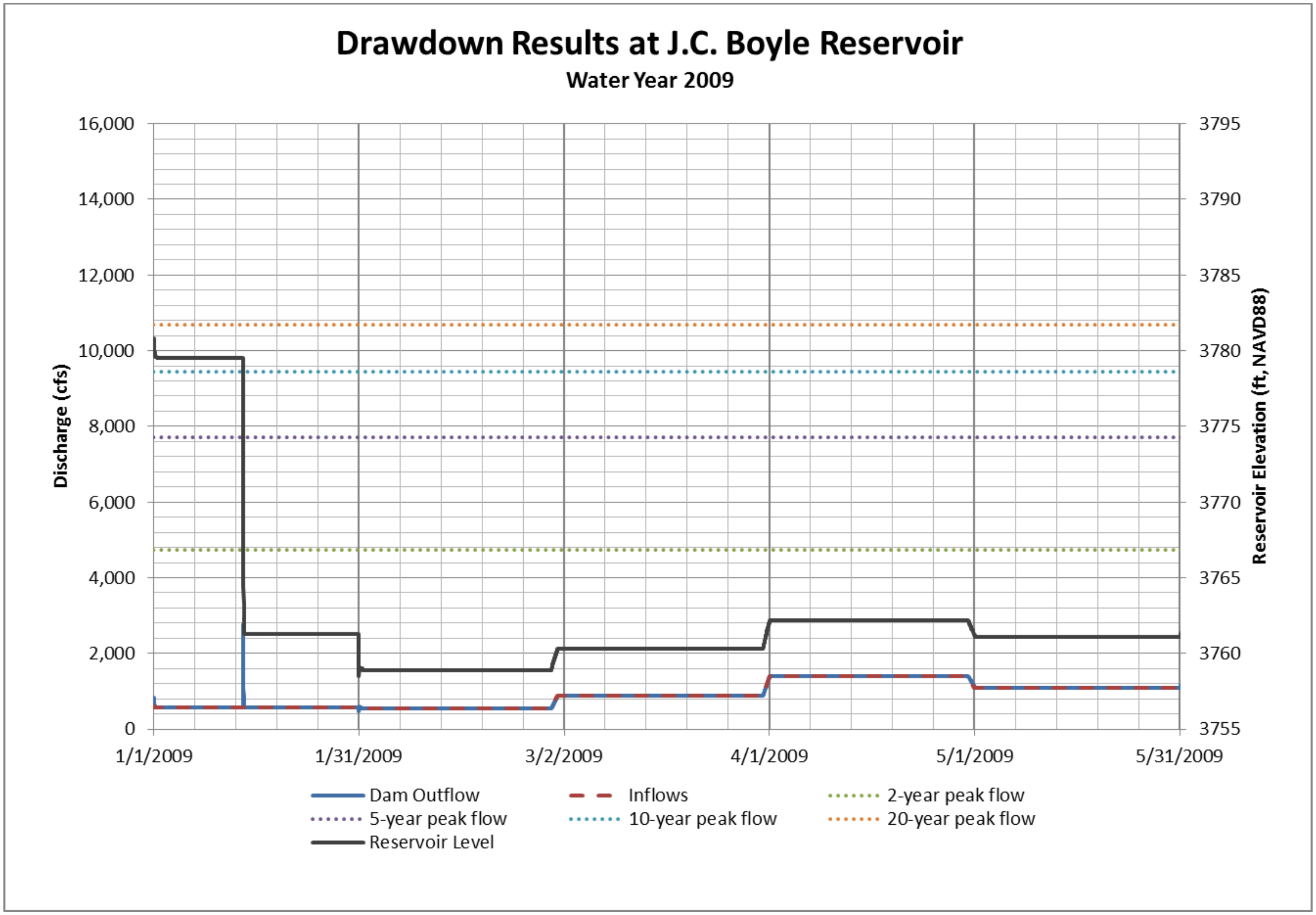

Figure 2-49 J.C. Boyle Reservoir Drawdown, Water Year 2009

Chapter 3: Copco 1 Reservoir

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3. COPCO 1 RESERVOIR

KRRC analyzed two options for reservoir drawdown at Copco No. 1: Option 1 includes dam notching and Option 2 does not include dam notching. KRRC proposes Option 2 as the proposed action, but KRRC also analyzed Option 1 because it was the method originally proposed in the Detailed Plan. 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, KRRC proposes Option 2 for Copco No. 1 drawdown. The following discusses drawdown of Copco Lake separately for the two tunnel modification options described in Definite Plan Section 4.2.2.

3.1 Option 1 (for comparison only) - 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, KRRC assumes that by January 1, 2021 (the start of the simulation), following the two-month initial drawdown period beginning November 1, 2020, the water level would be at the spillway crest.
2. The model assumes the three 6-foot gates on the diversion tunnel to be open at the start of the simulation.
3. Until completion of the last notch, the model assumes that the 6-foot gates will be closed down to limit the maximum rate of drawdown to 5 feet per day. Once the last notch was complete, the model assumes that the 6-foot gates will be left open.
4. In order to fully draw down the reservoir, the model includes notching 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. The model lowers the dam crest 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, KRRC assumed that the Contractor will lower the dam crest 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 will be once the lowering was complete (18 feet above the notch elevation). KRRC assumed that the lowered crest will need to be above the water level for construction to continue. KRRC assumed the minimum time needed before starting the next notch is 5 days. This would allow for completion of 13 notches by March 1, assuming no construction delays.
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.

3.2 Option 2 (proposed action) – Diversion Tunnel Modified to Increase Capacity

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

1. For modeling purposes, KRRC assume that by January 1, 2021 (the start of the simulation), following the two-month initial drawdown period beginning November 1, 2020, the water level would be at the spillway crest.
2. The model assumes that the large gate on the 14- by 16-foot diversion tunnel will 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 will be over the spillway.
3. On January 15, 2021, the model assumes the gate on the diversion tunnel opens.
4. The model assumes that the diversion tunnel gate will 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, the model assumes that the drawdown rate is no longer 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 of 2597.0 feet is nearly 12,000 cfs. As water levels increase above the spillway crest, KRRC assumes closure of the gate to limit the total discharge to 13,000 cfs to avoid high water levels that could 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.

3.3 Results

Figures 3-2 through 3-50 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, KRRC proposes 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 Contractor could start the next notch 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 3-1 shows the length of time that high water levels delay the first and last notch. 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.

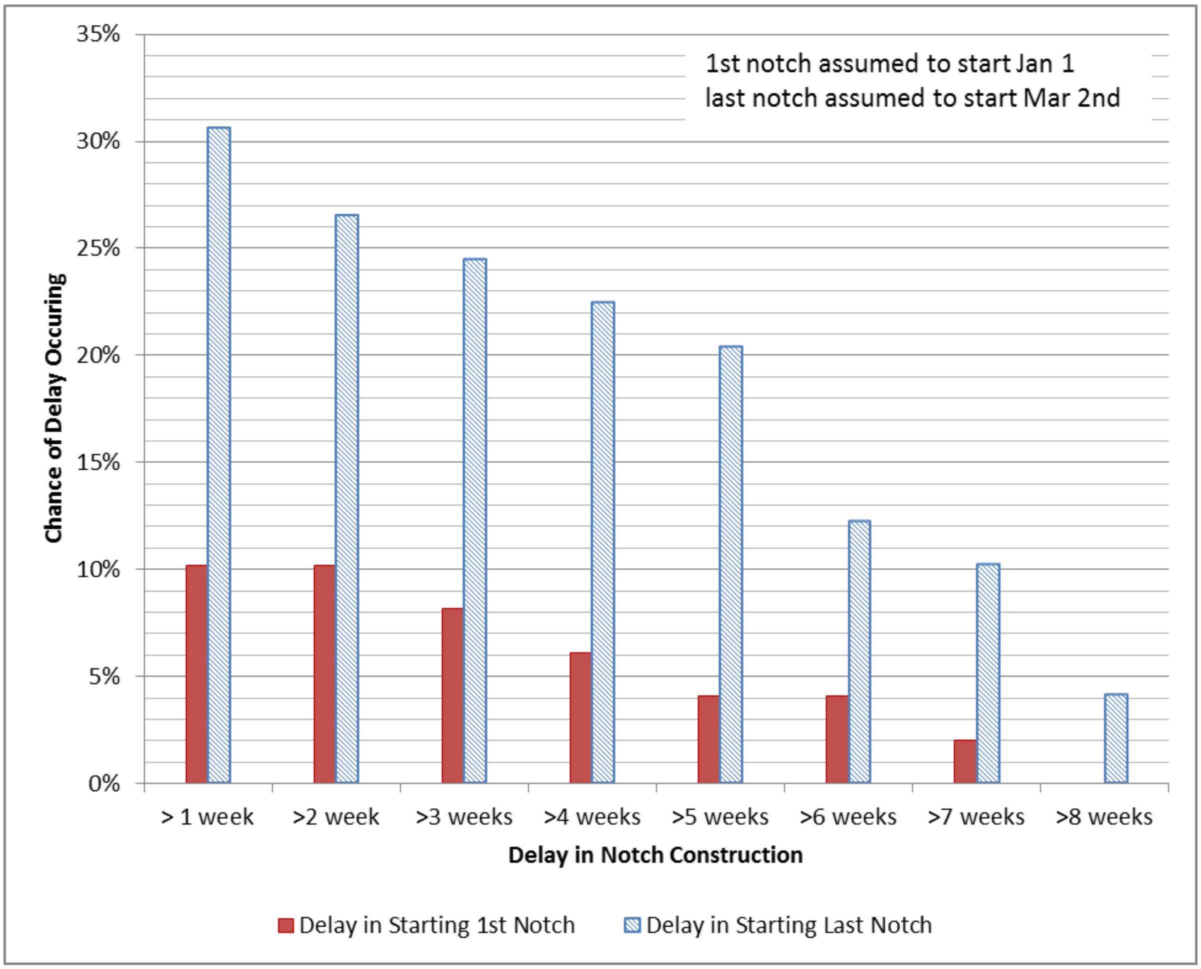

Figure 3-1 Graph Showing the Chance of a Delay in the Construction of the First and Last Notches in Copco No. 1 Dam

During representative dry years (e.g., 1973 and 1979), the reservoir was easily drawn down by the end of February, 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 by the end of 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.

KRRC does not anticipate that sediment concentrations resulting from the proposed drawdown procedure and associated hydraulics would differ from those previously estimated (USBR 2012c).

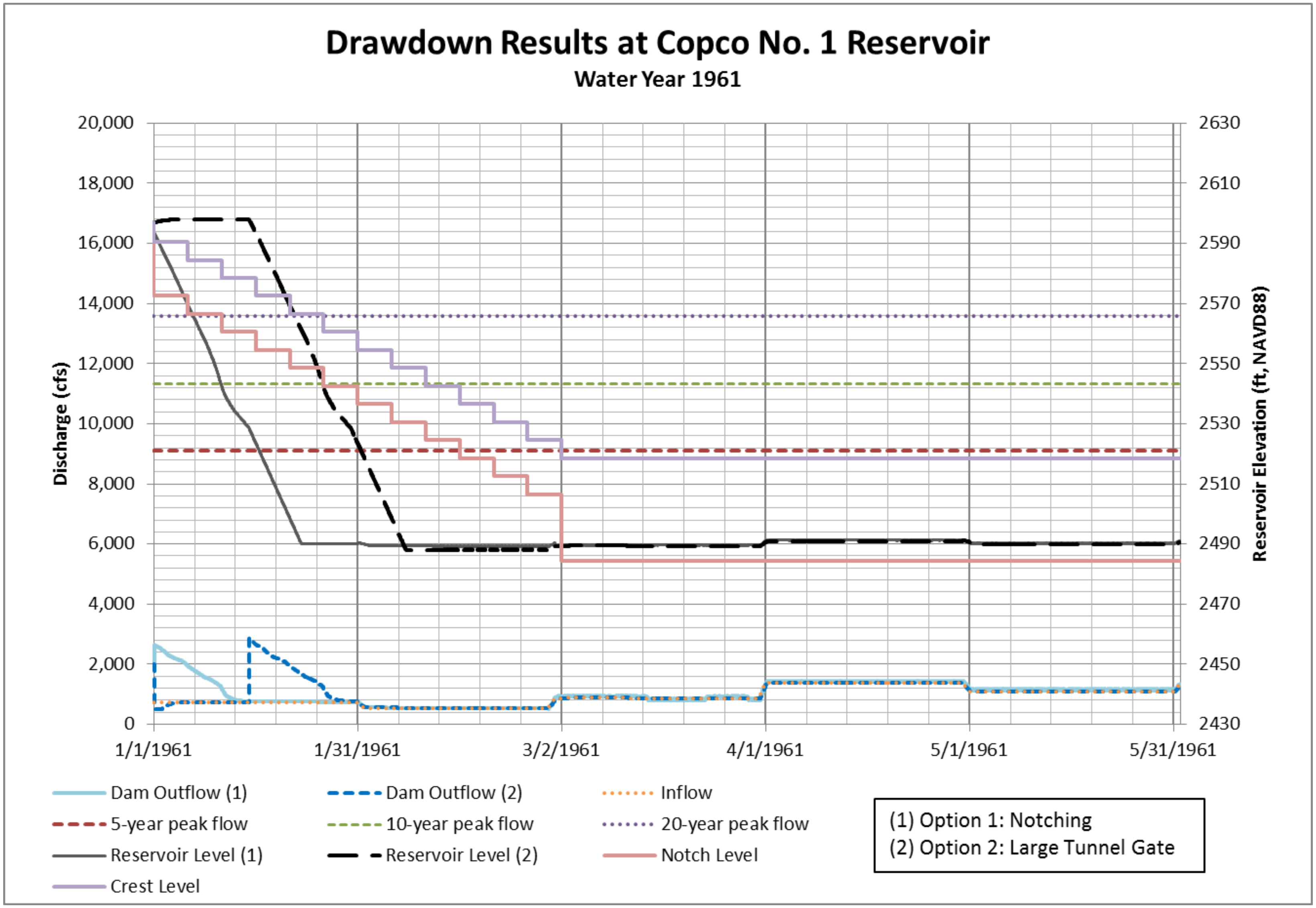

Figure 3-2 Copco No. 1 Reservoir Drawdown, Water Year 1961

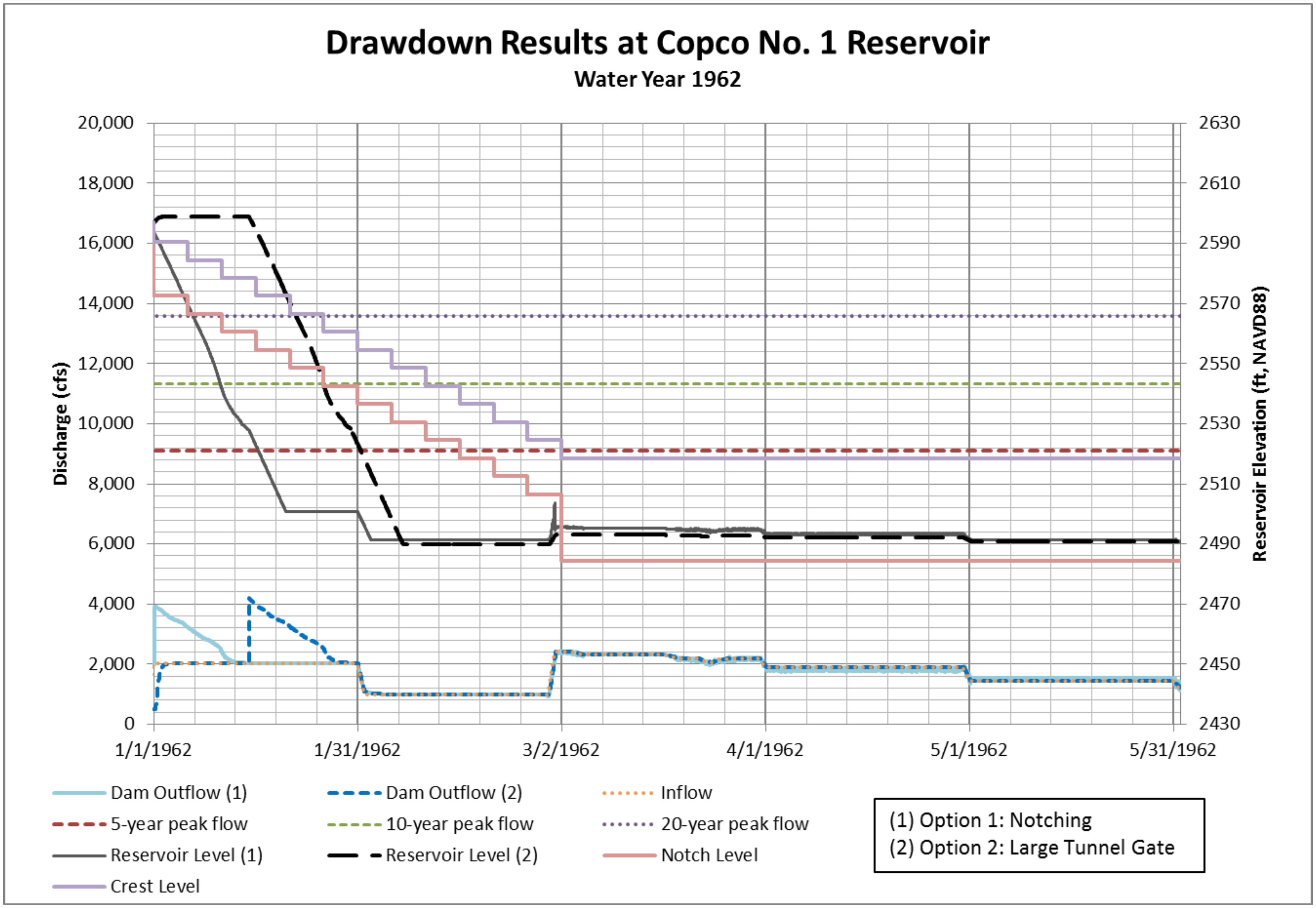

Figure 3-3 **Copco No. 1 Reservoir Drawdown, Water Year 1962**

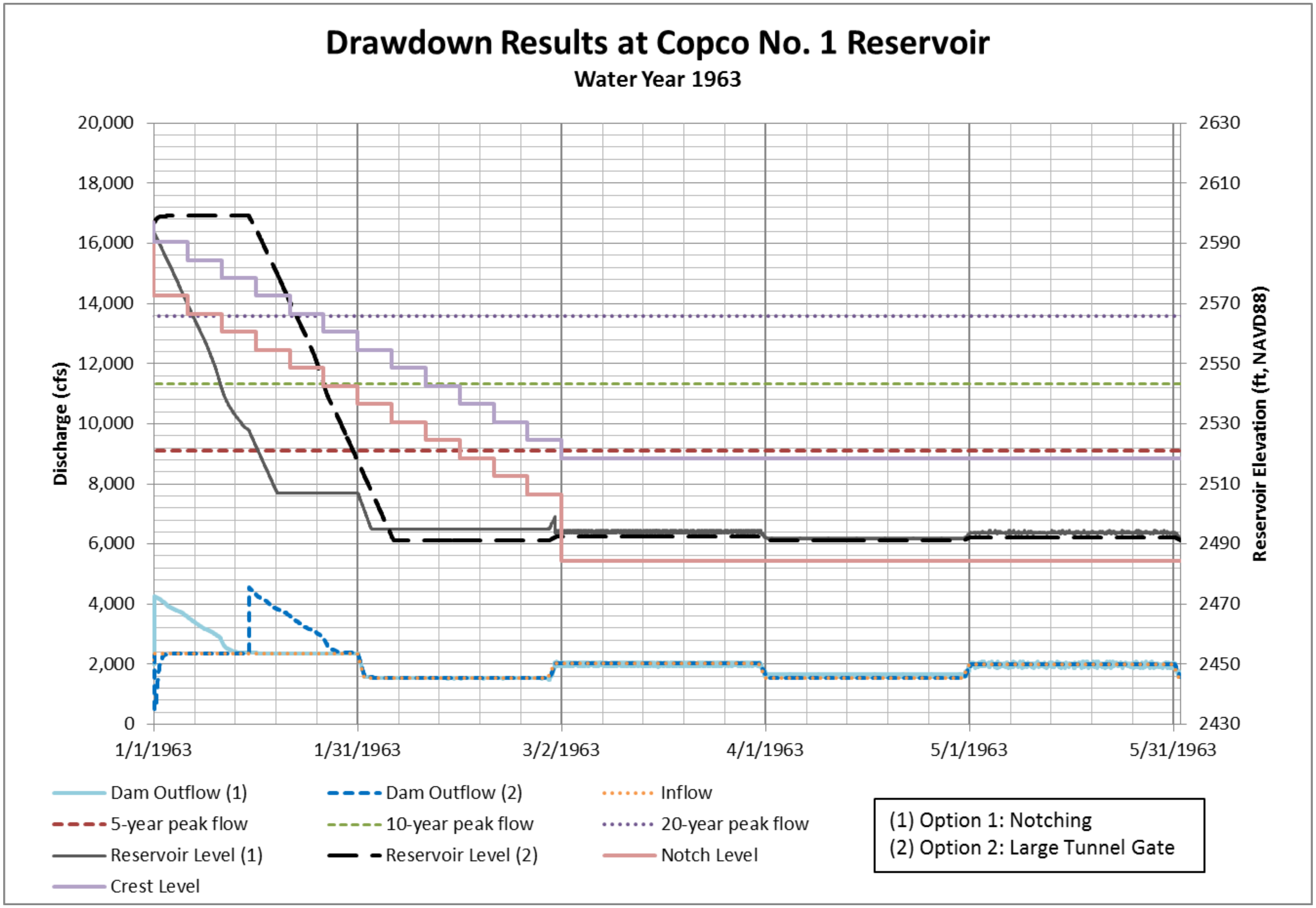

Figure 3-4 Copco No. 1 Reservoir Drawdown, Water Year 1963

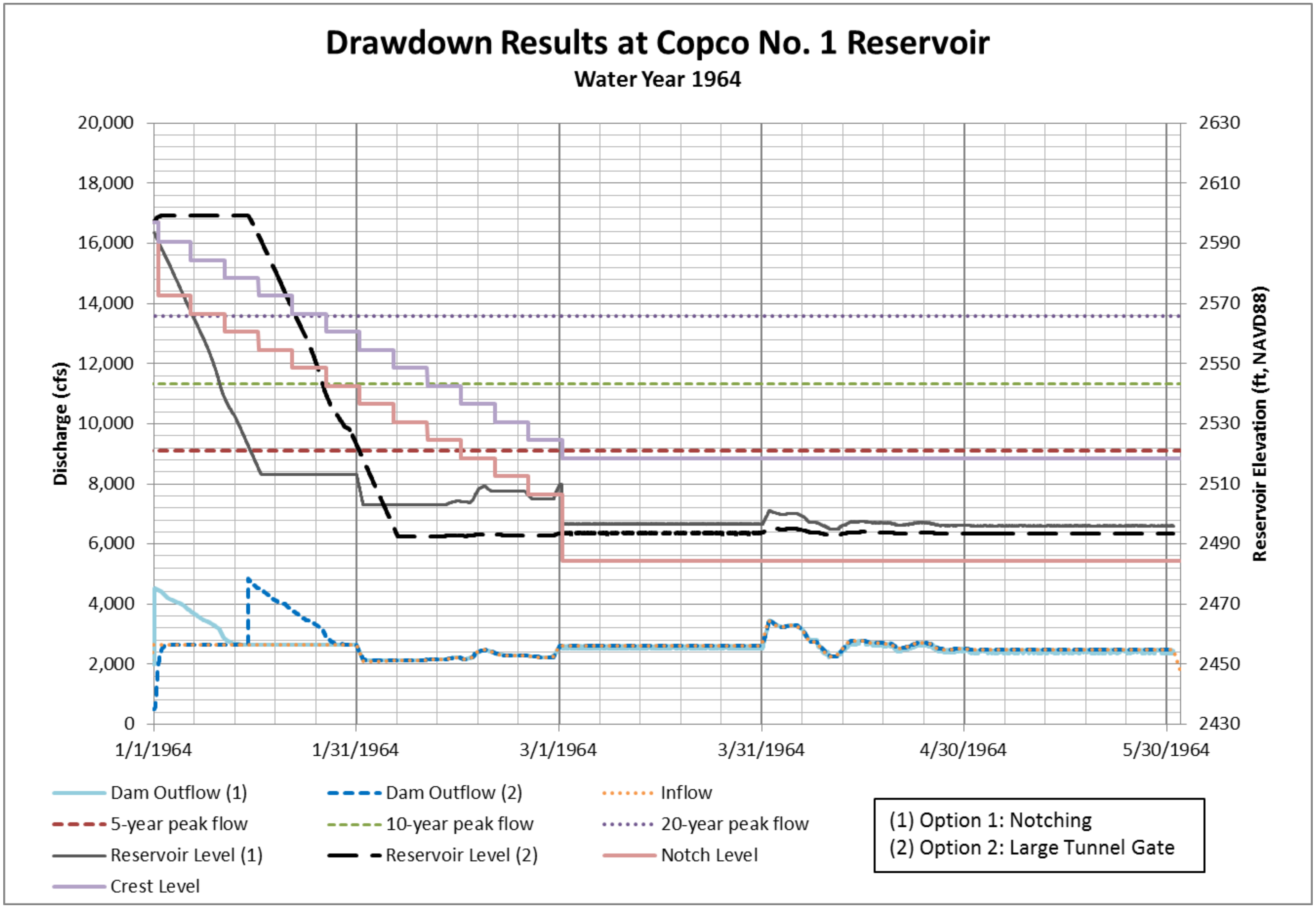

Figure 3-5 Copco No. 1 Reservoir Drawdown, Water Year 1964

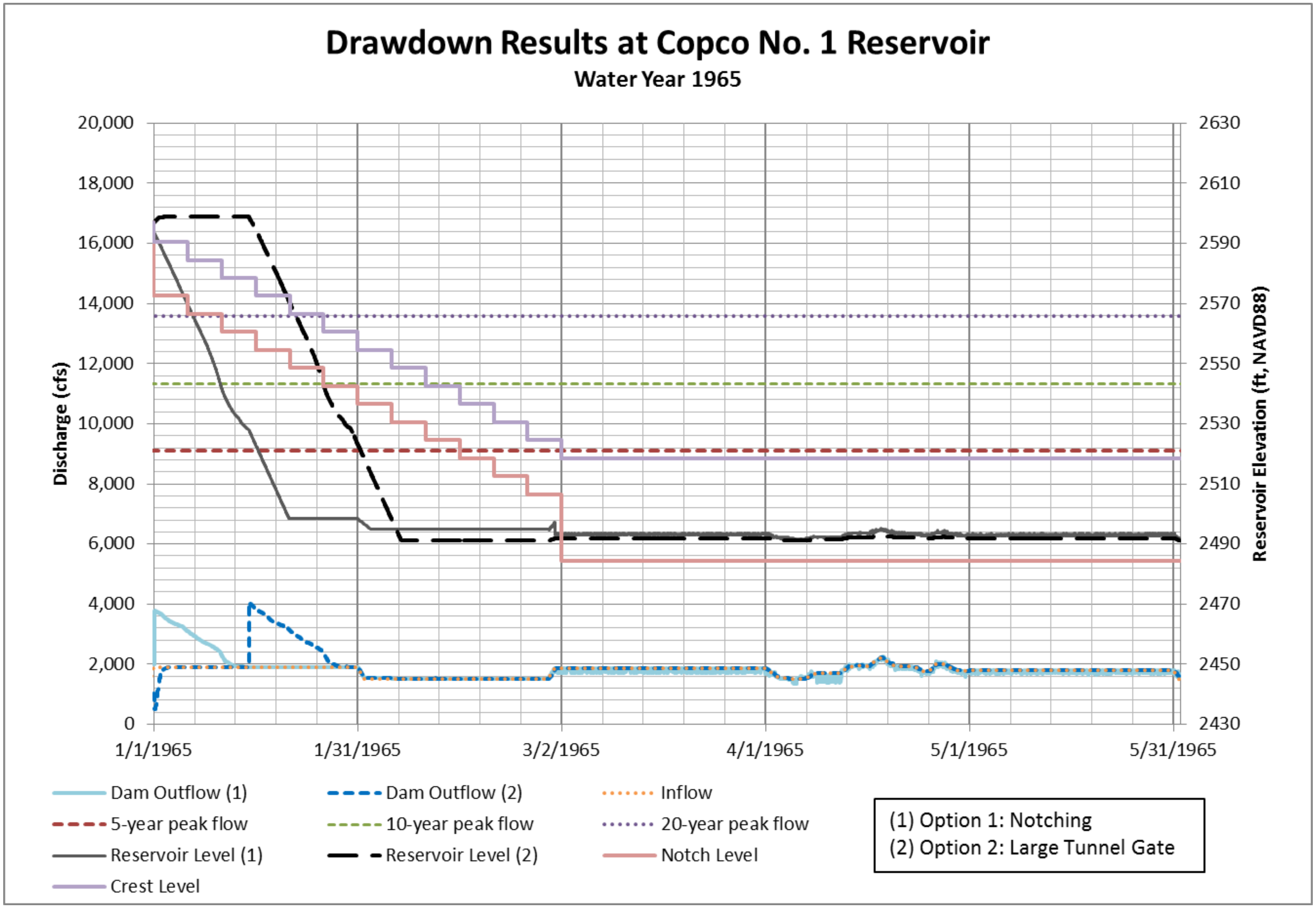

Figure 3-6 Copco No. 1 Reservoir Drawdown, Water Year 1965

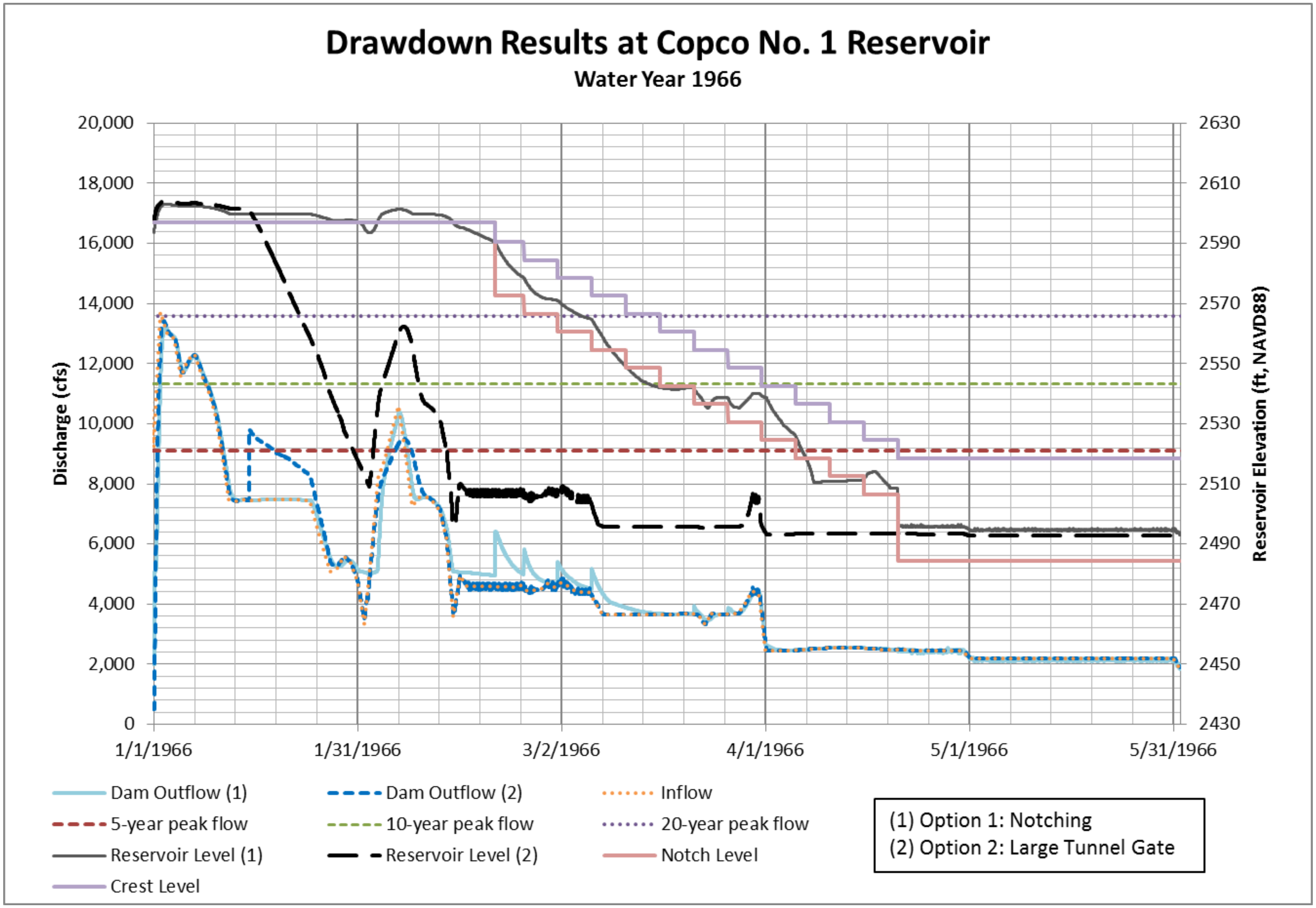

Figure 3-7 **Copco No. 1 Reservoir Drawdown, Water Year 1966**

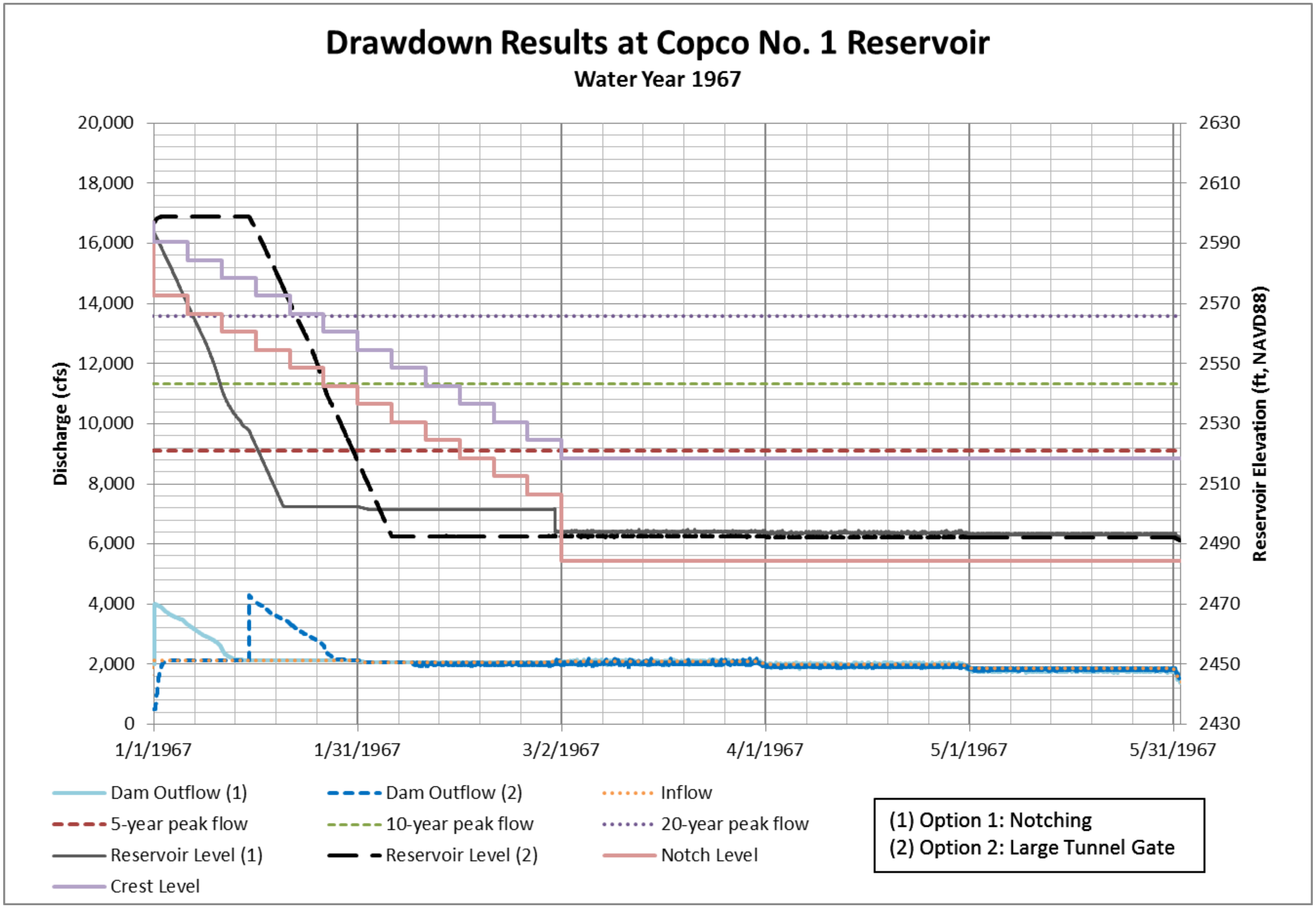

Figure 3-8 Copco No. 1 Reservoir Drawdown, Water Year 1967

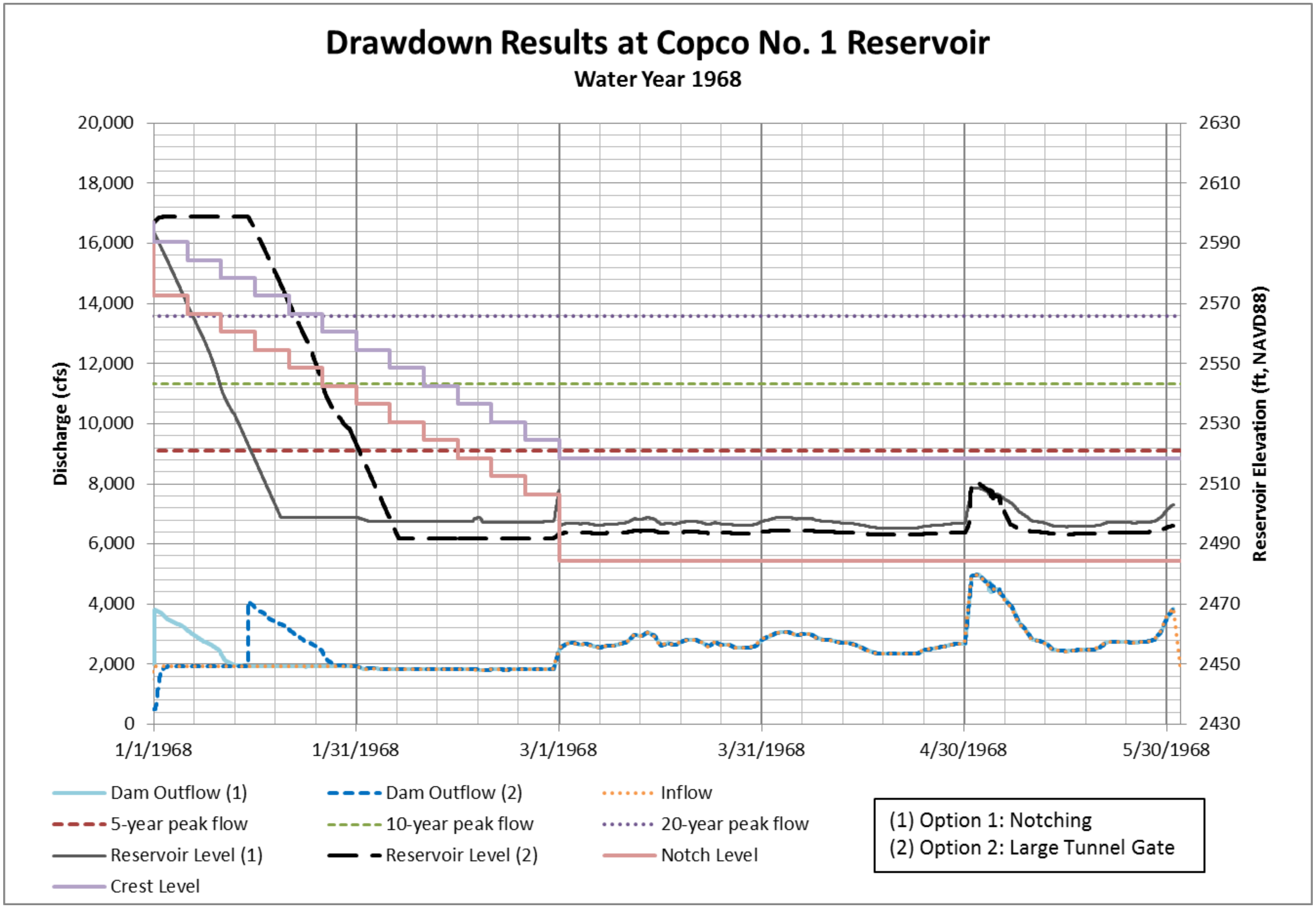

Figure 3-9 Copco No. 1 Reservoir Drawdown, Water Year 1968

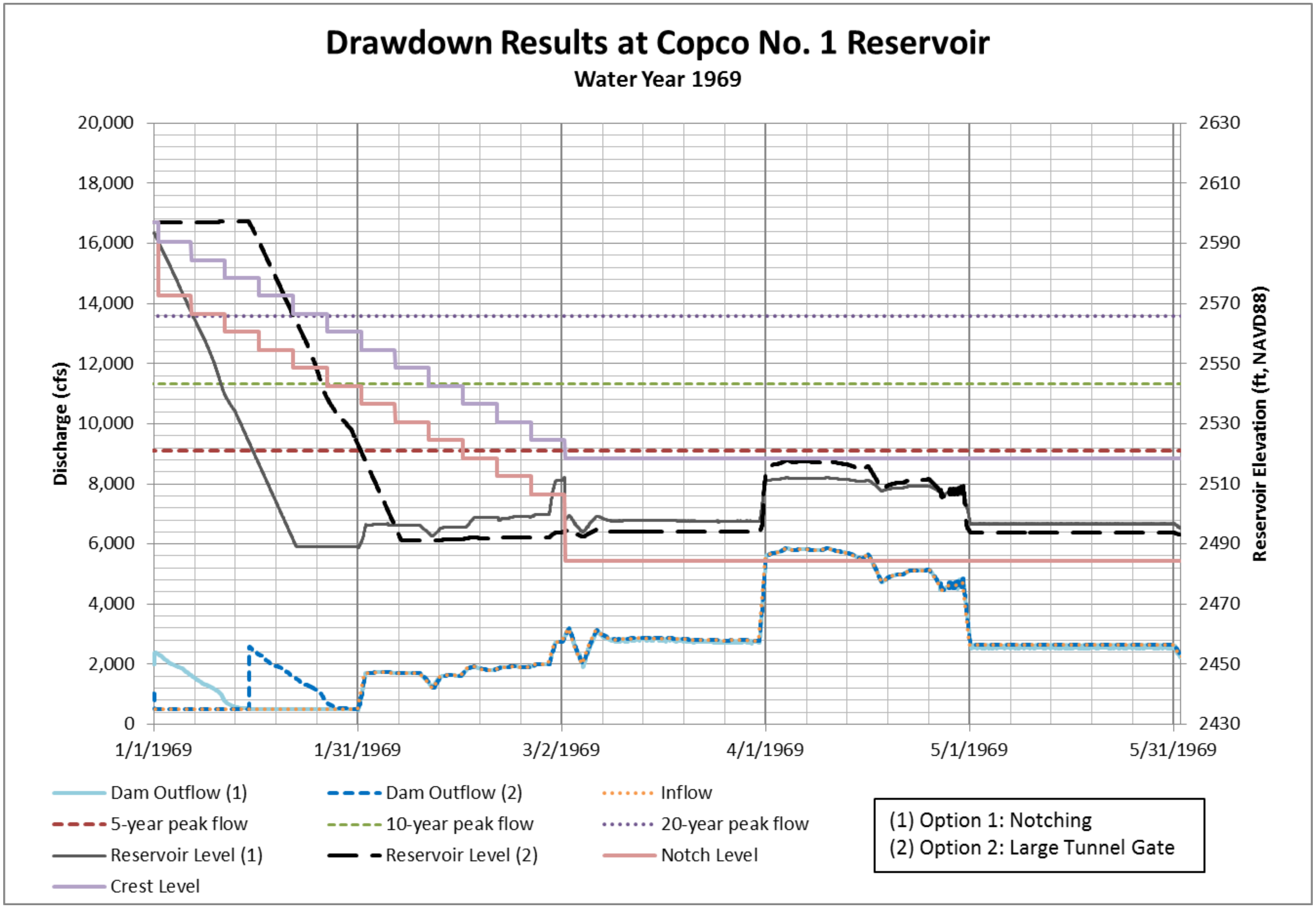

Figure 3-10 Copco No. 1 Reservoir Drawdown, Water Year 1969

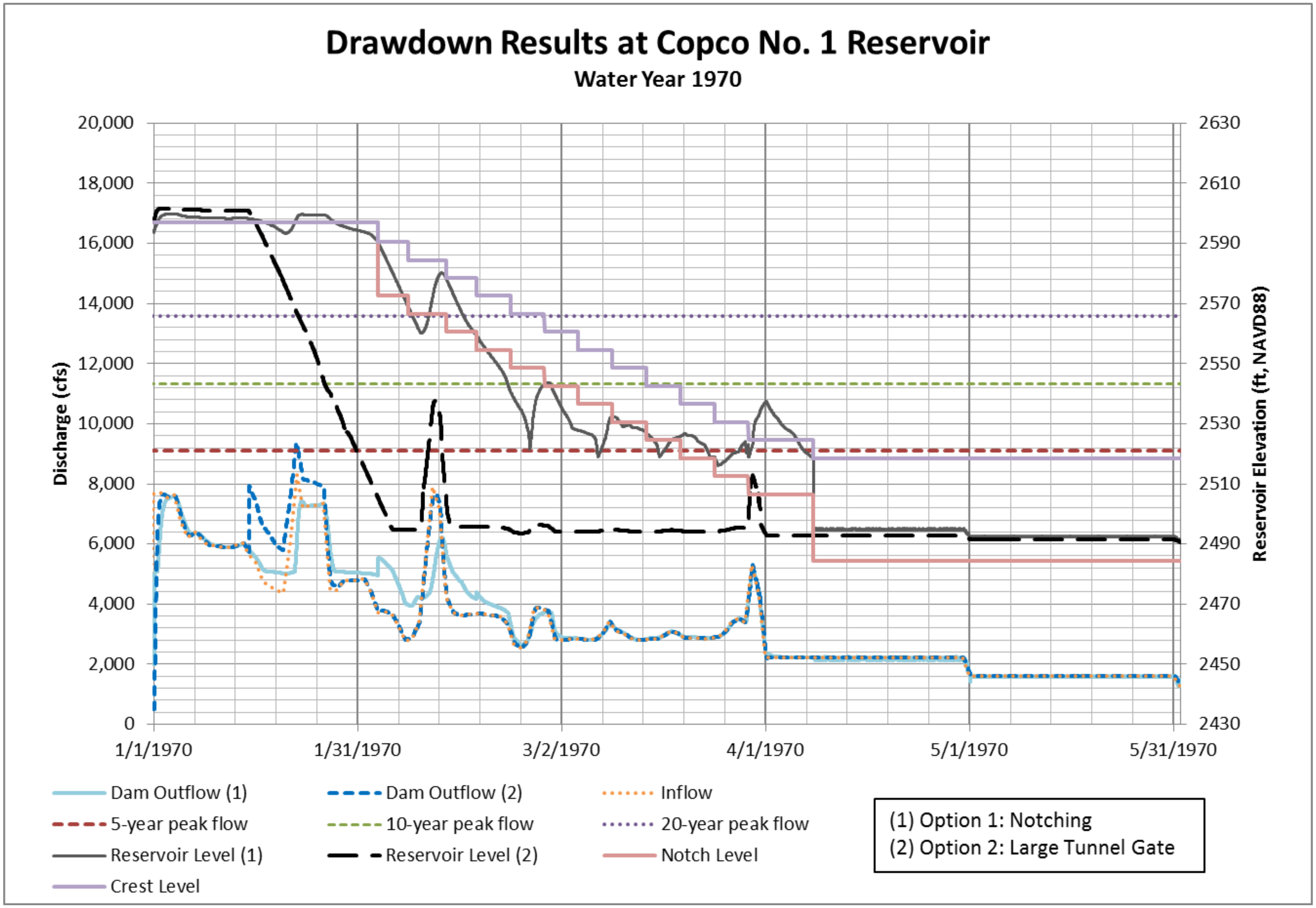

Figure 3-11 Copco No. 1 Reservoir Drawdown, Water Year 1970

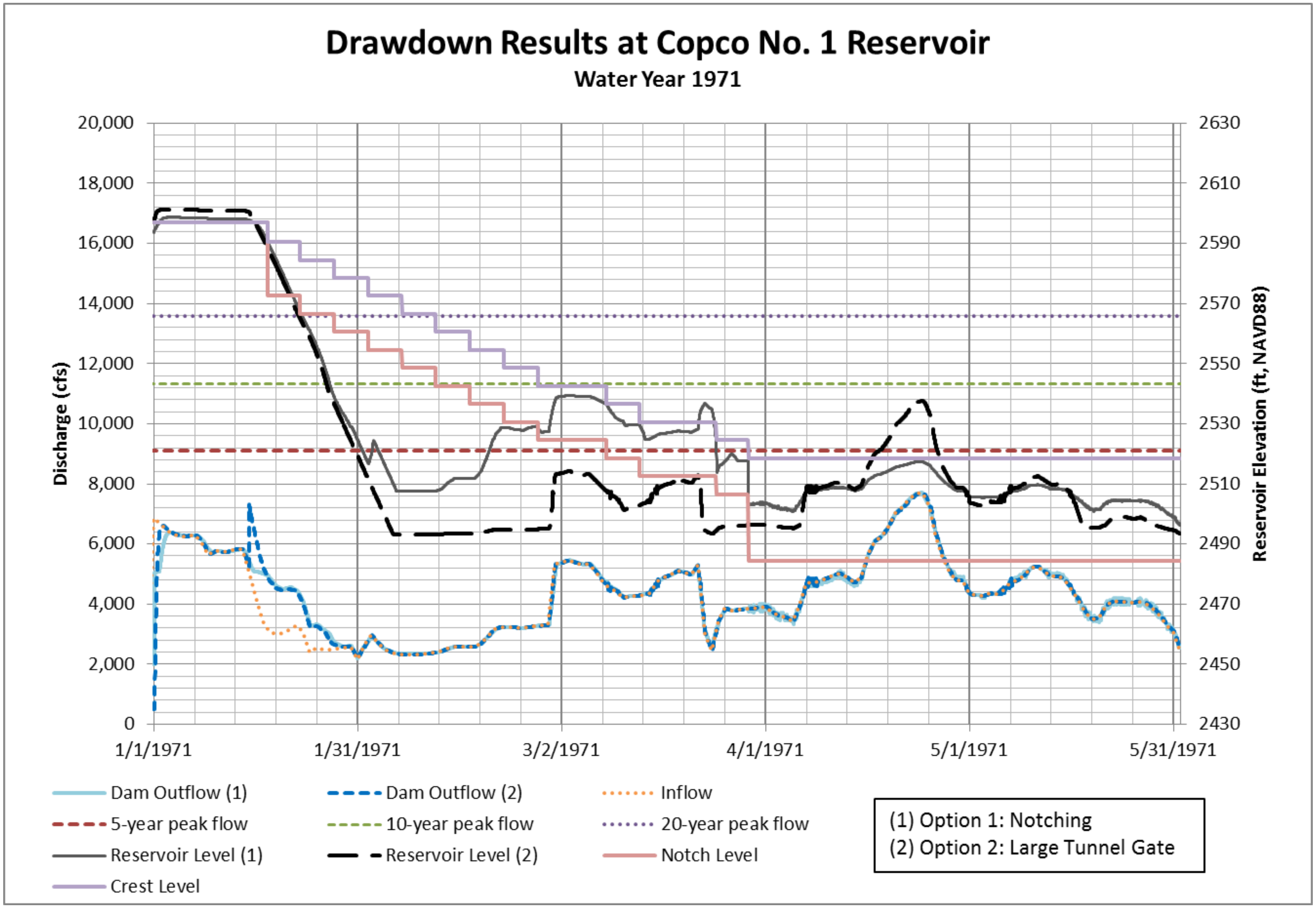

Figure 3-12 Copco No. 1 Reservoir Drawdown, Water Year 1971

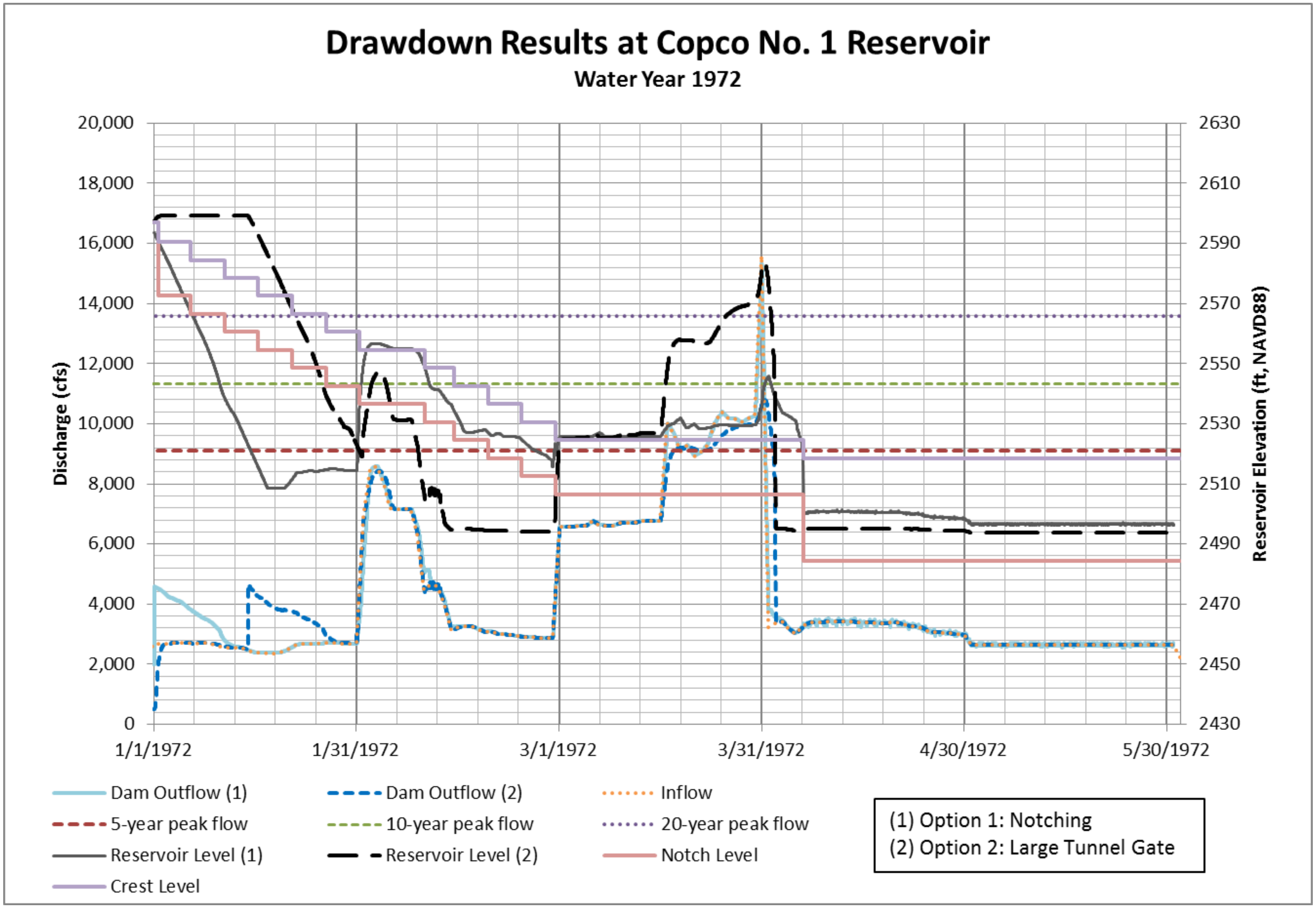

Figure 3-13 Copco No. 1 Reservoir Drawdown, Water Year 1972

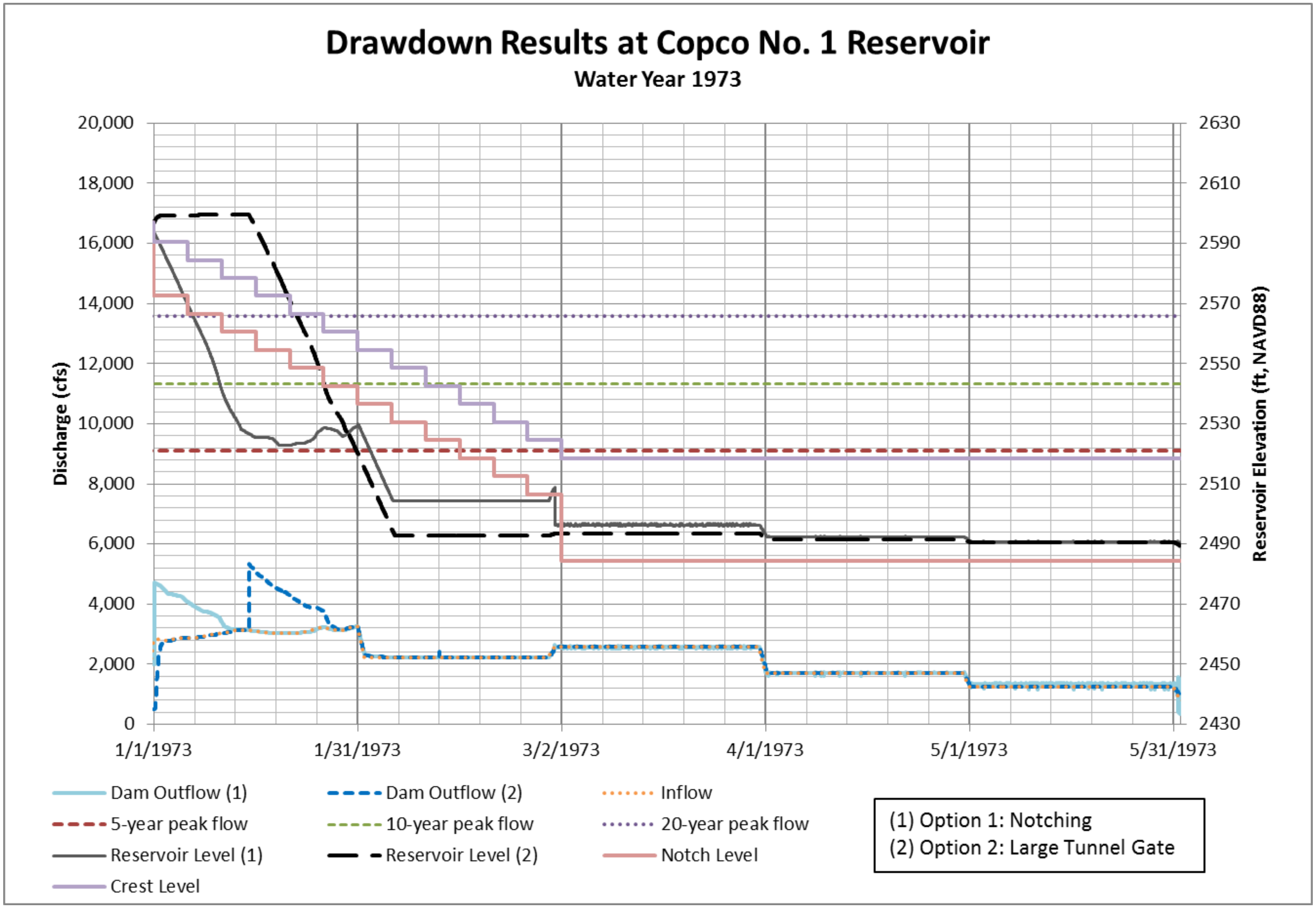

Figure 3-14 Copco No. 1 Reservoir Drawdown, Water Year 1973

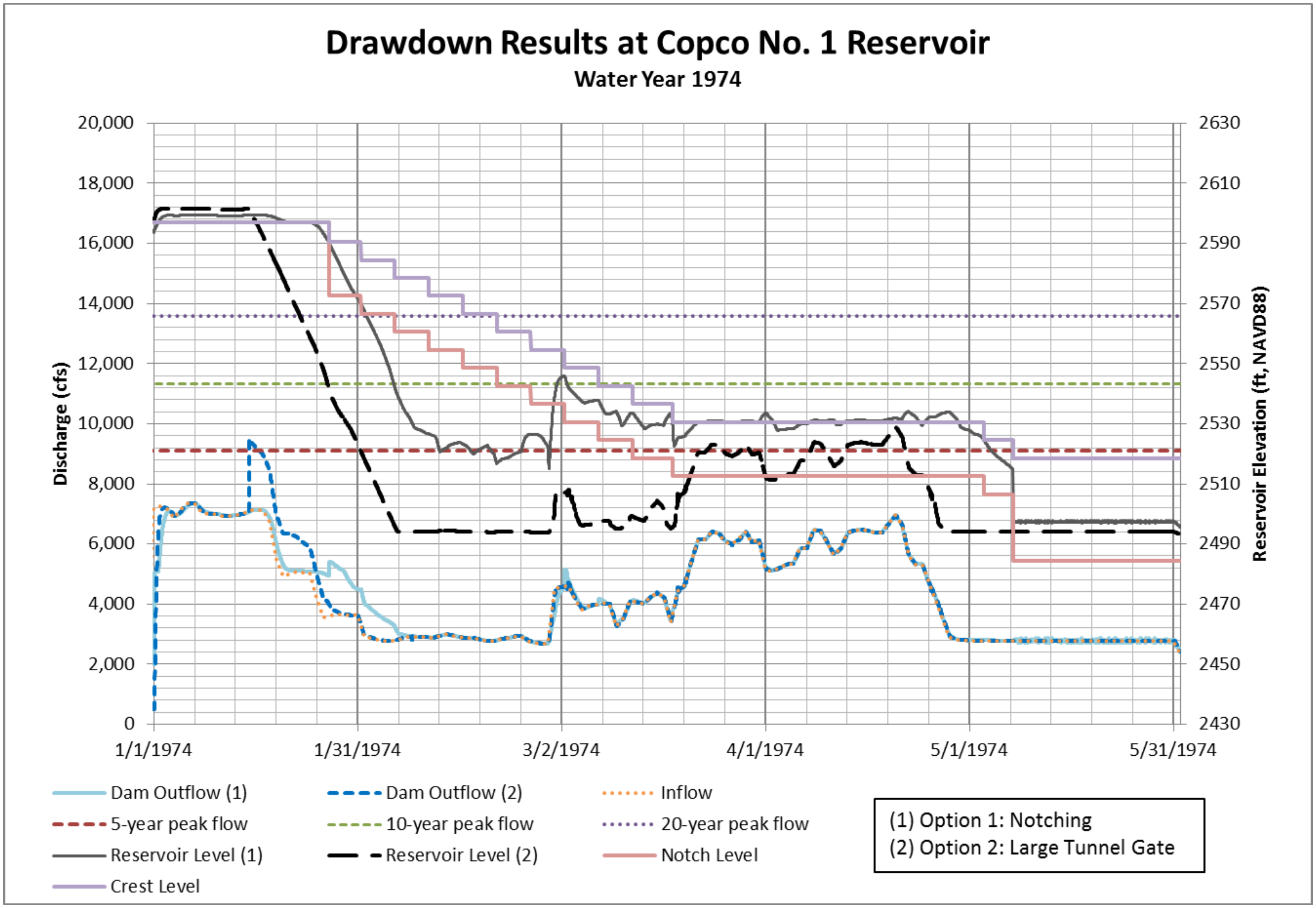

Figure 3-15 Copco No. 1 Reservoir Drawdown, Water Year 1974

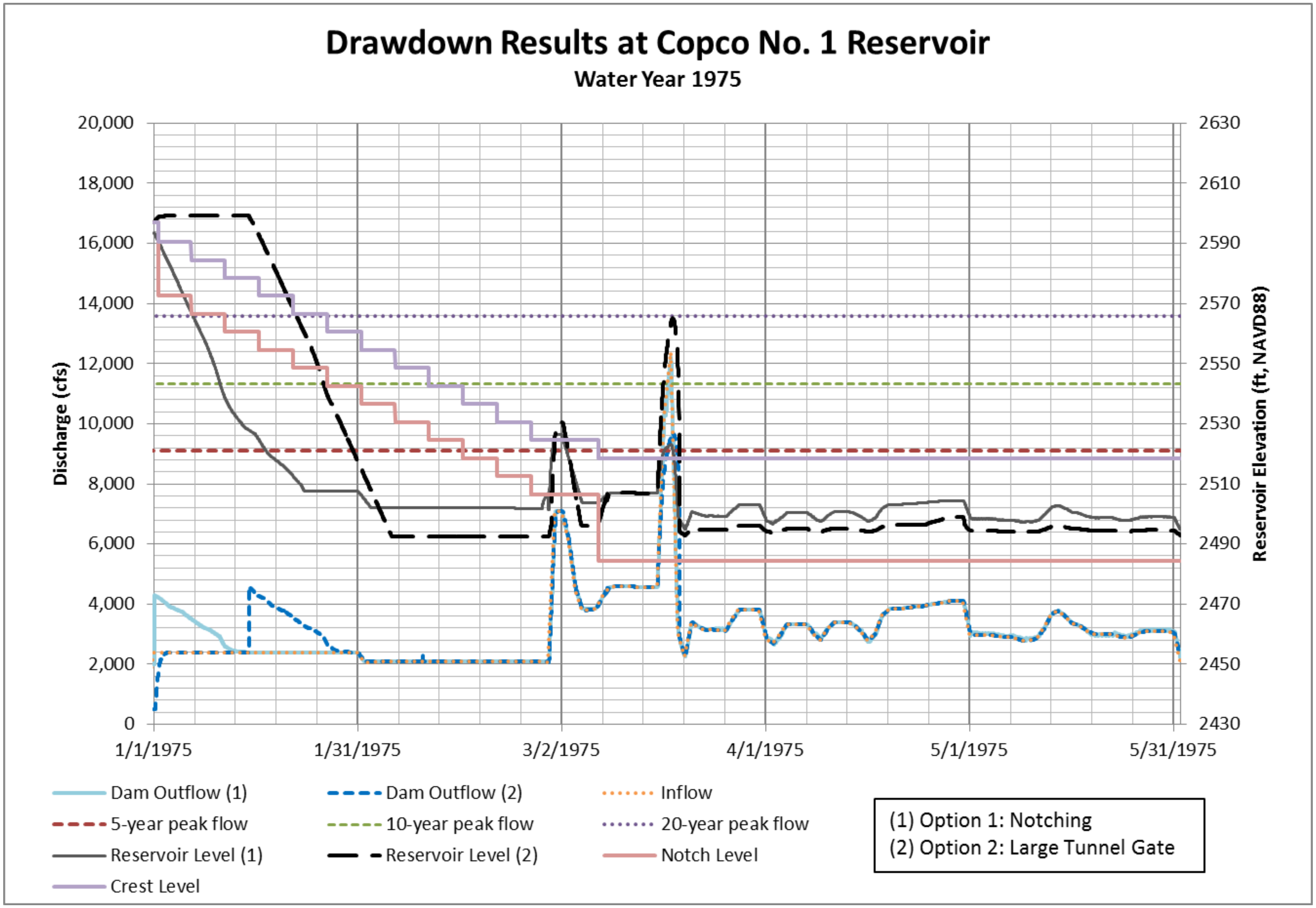

Figure 3-16 Copco No. 1 Reservoir Drawdown, Water Year 1975

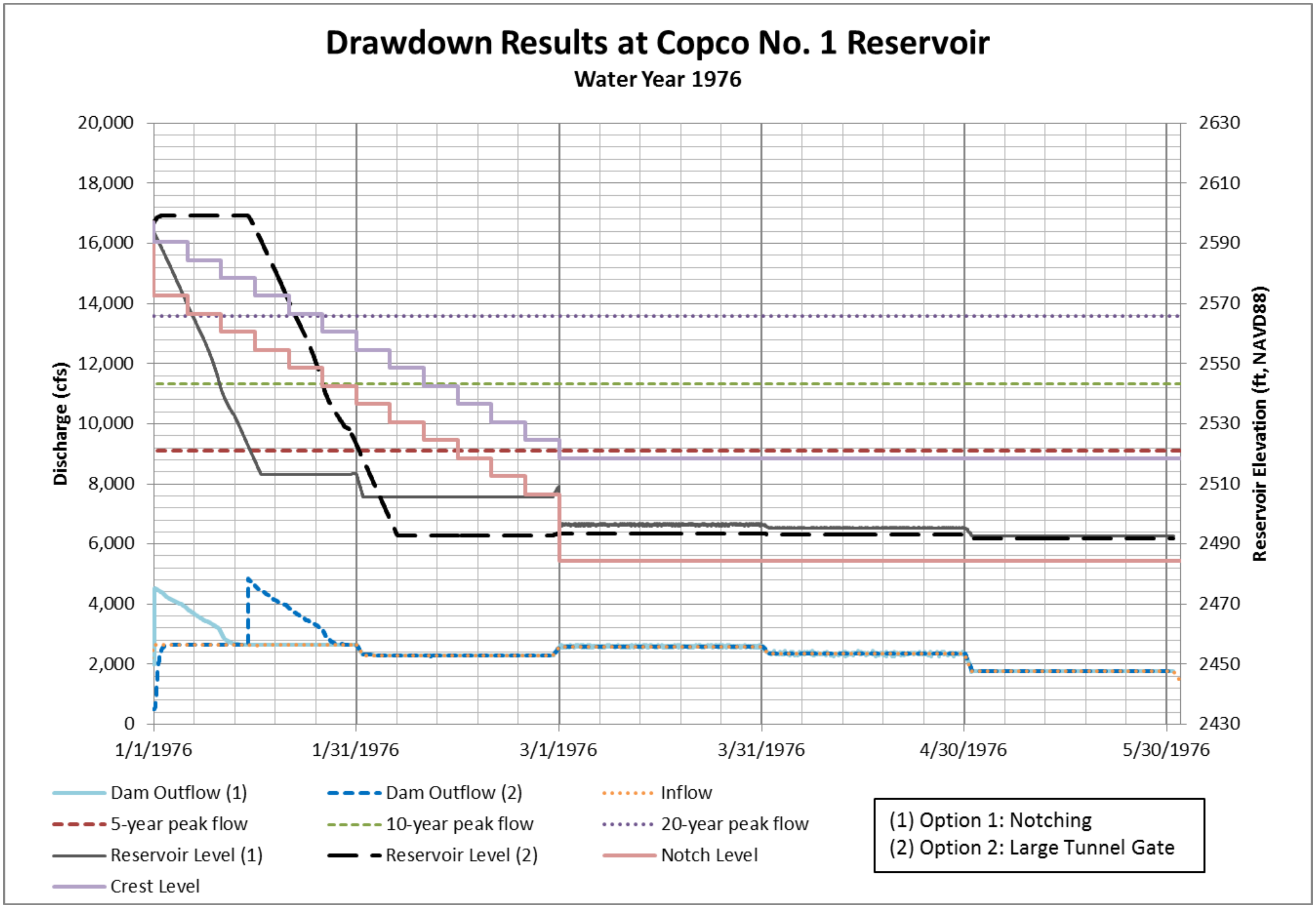

Figure 3-17 Copco No. 1 Reservoir Drawdown, Water Year 1976

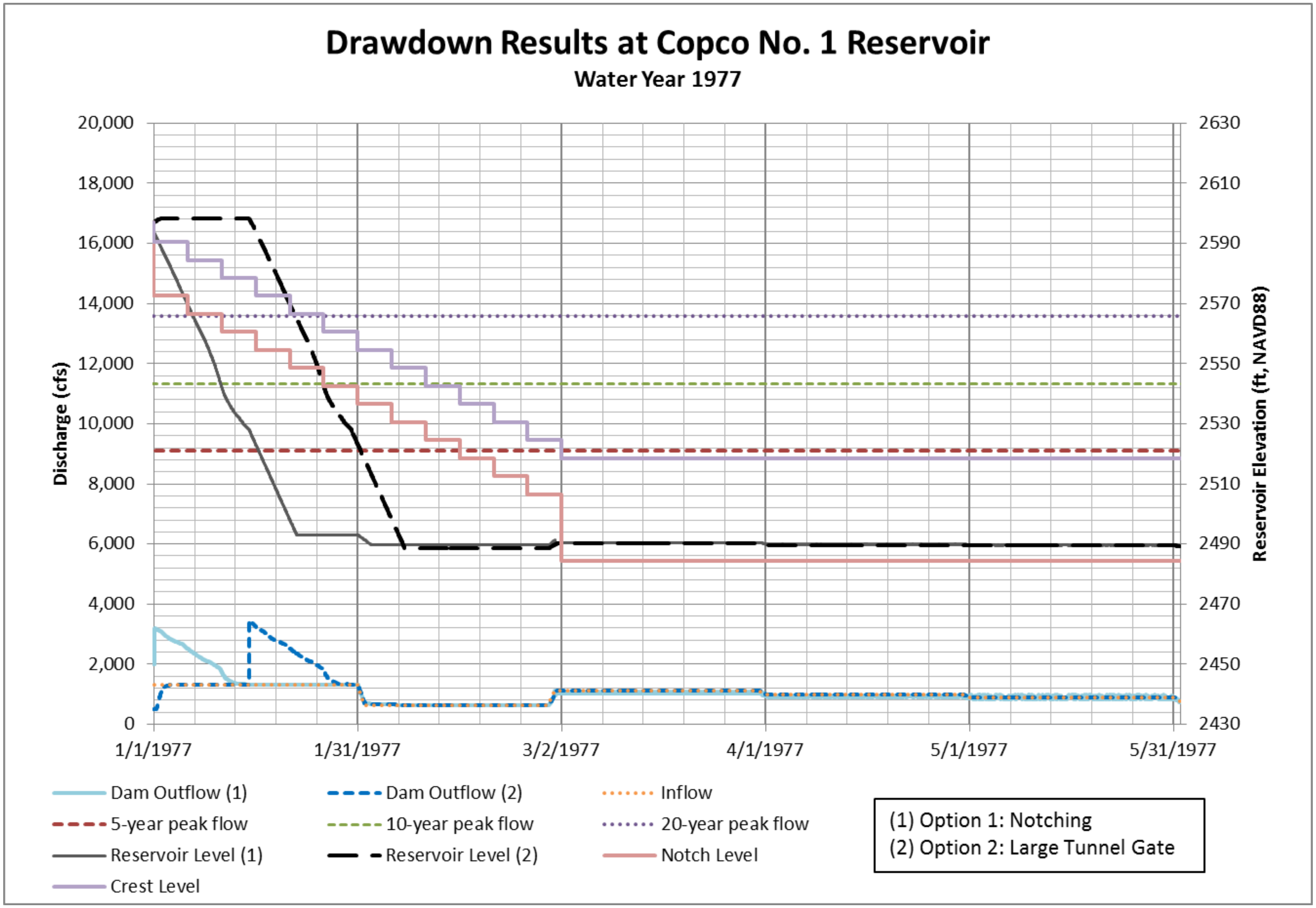

Figure 3-18 Copco No. 1 Reservoir Drawdown, Water Year 1977

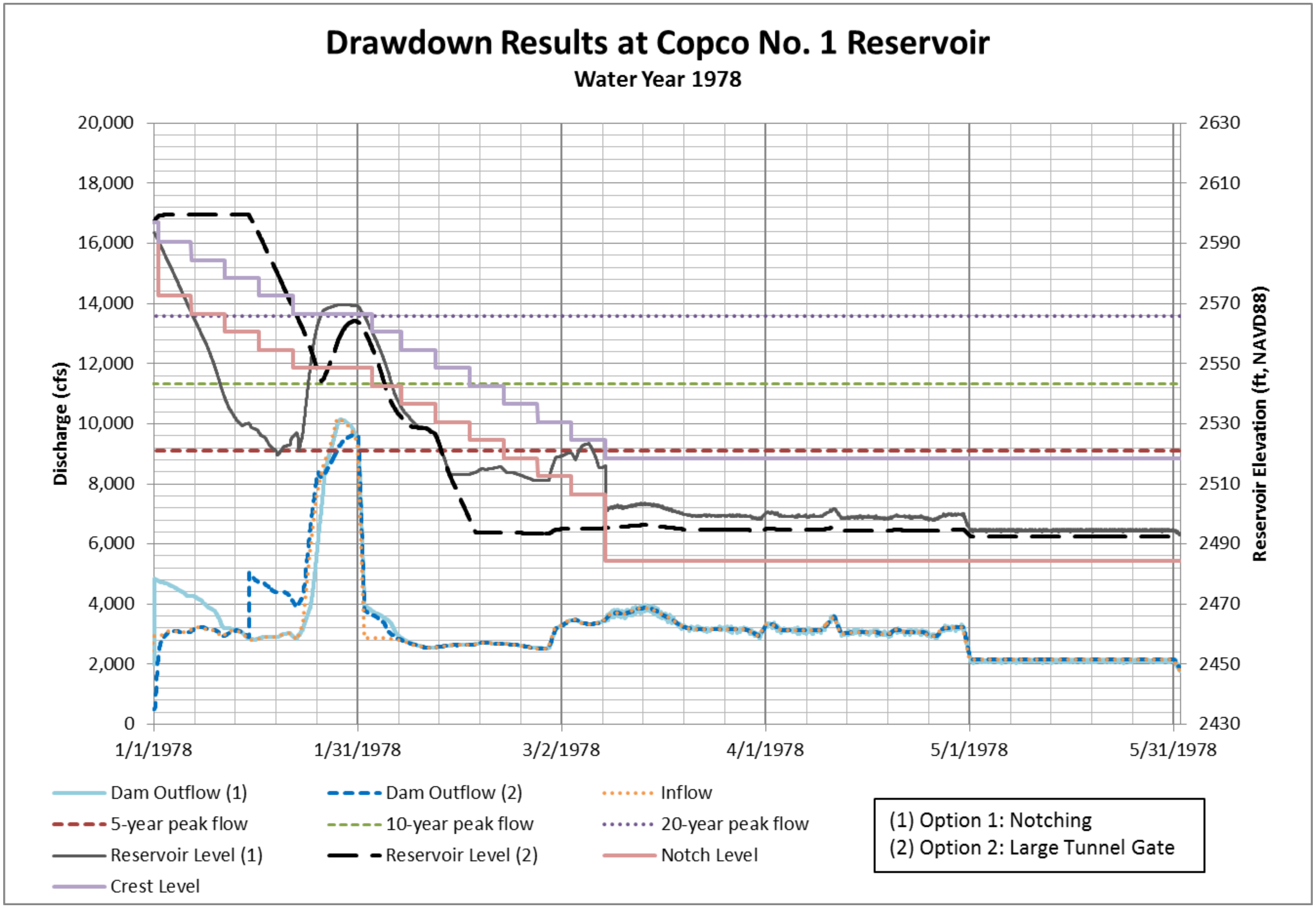

Figure 3-19 Copco No. 1 Reservoir Drawdown, Water Year 1978

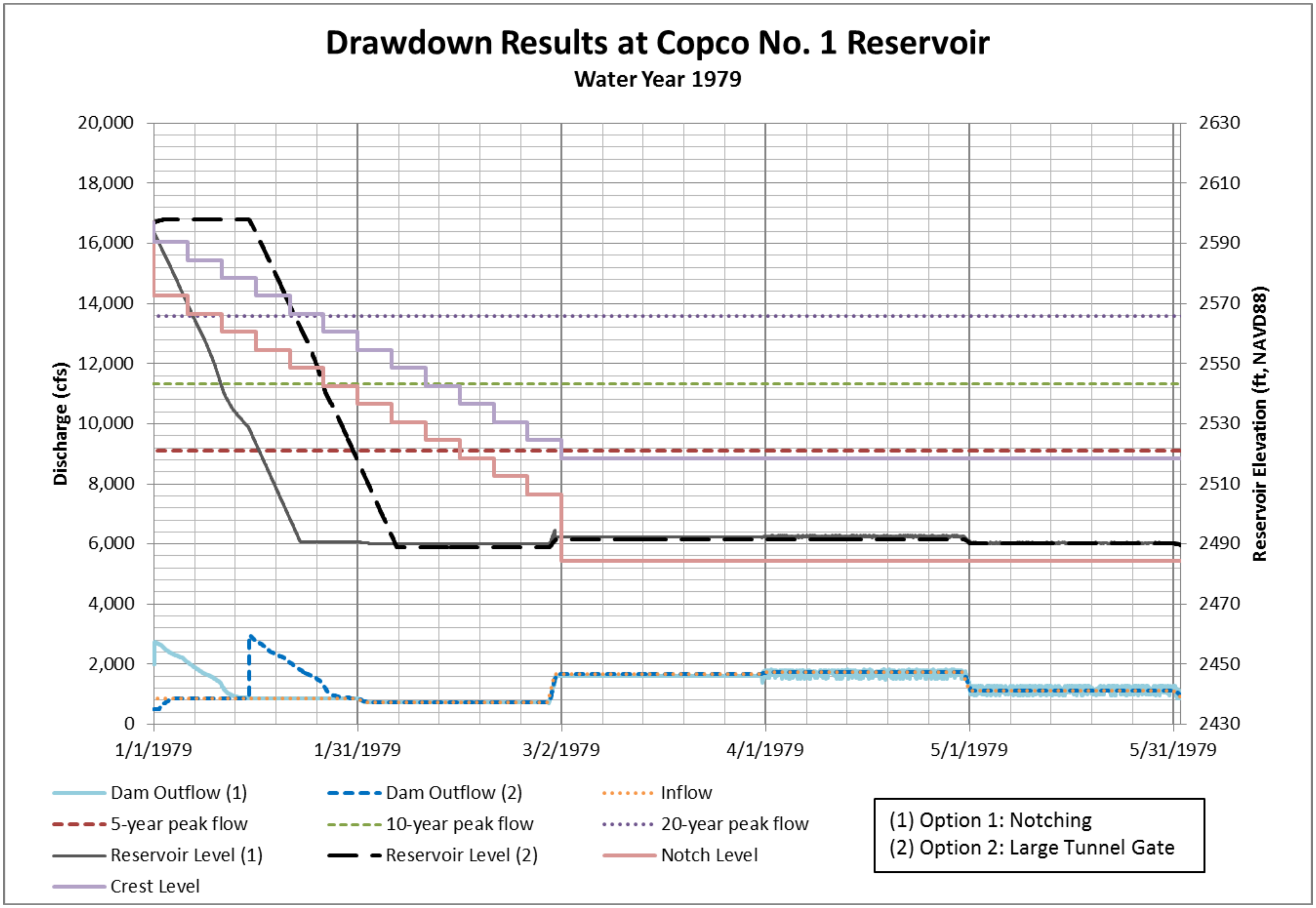

Figure 3-20 Copco No. 1 Reservoir Drawdown, Water Year 1979

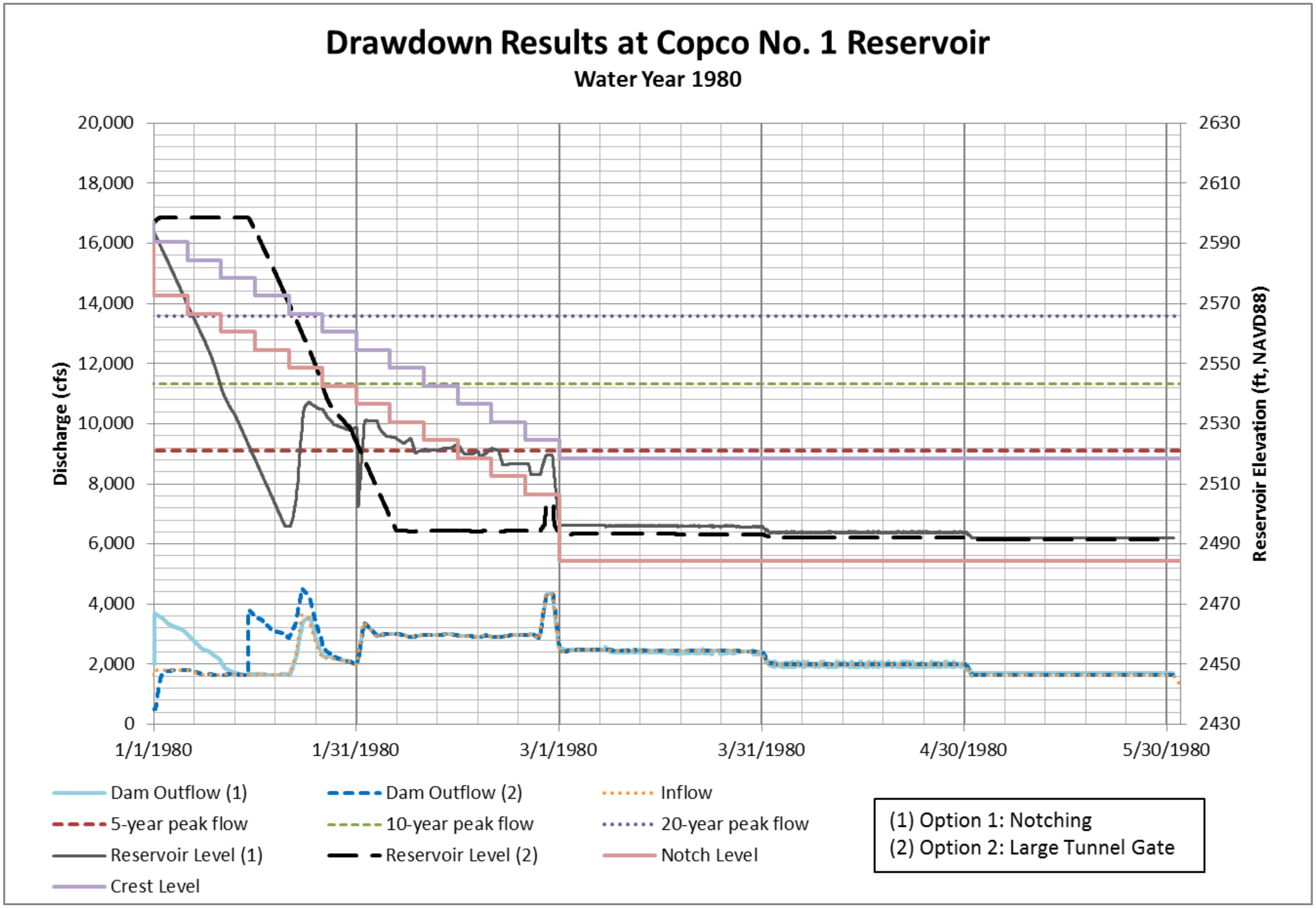

Figure 3-21 Copco No. 1 Reservoir Drawdown, Water Year 1980

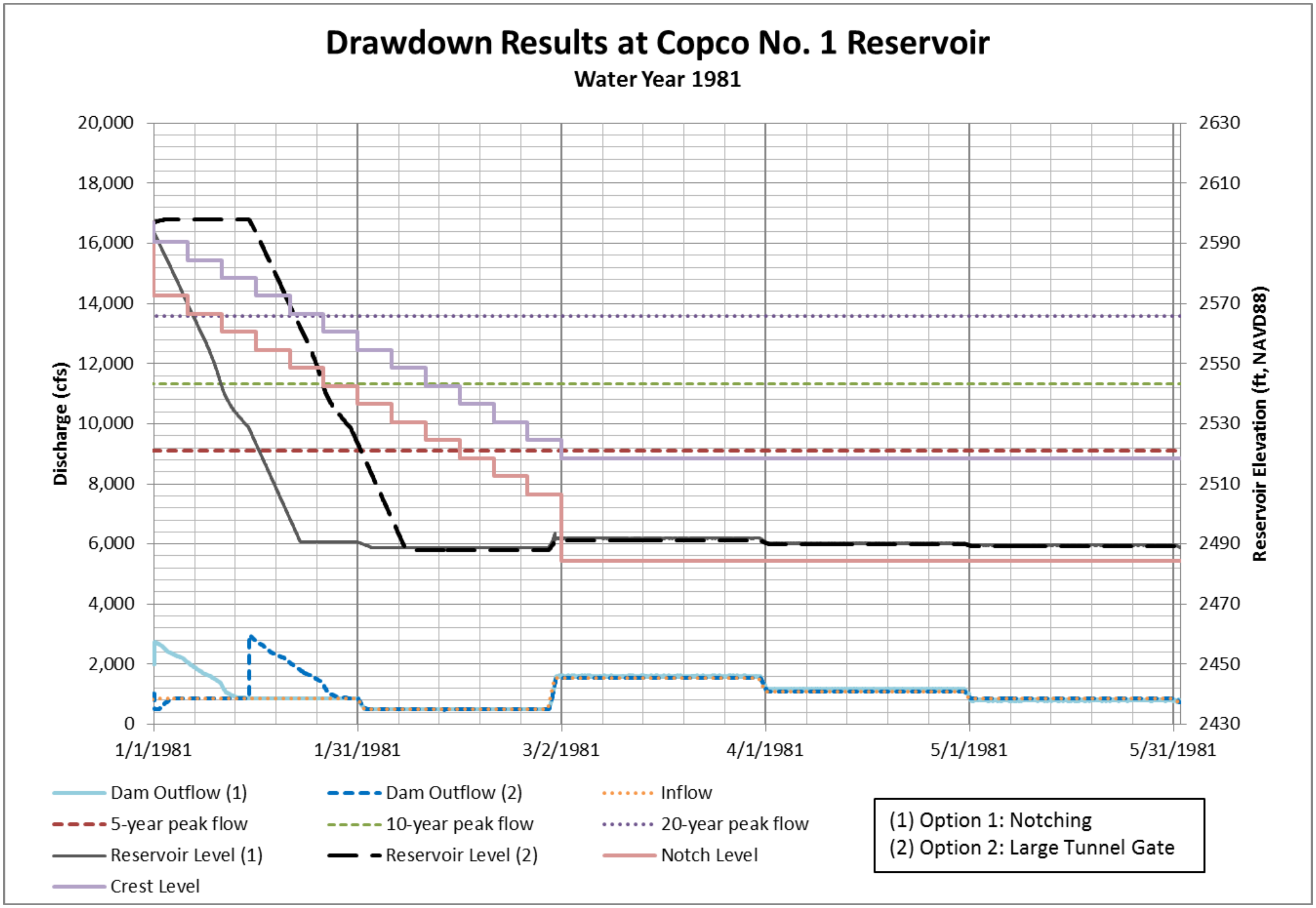

Figure 3-22 Copco No. 1 Reservoir Drawdown, Water Year 1981

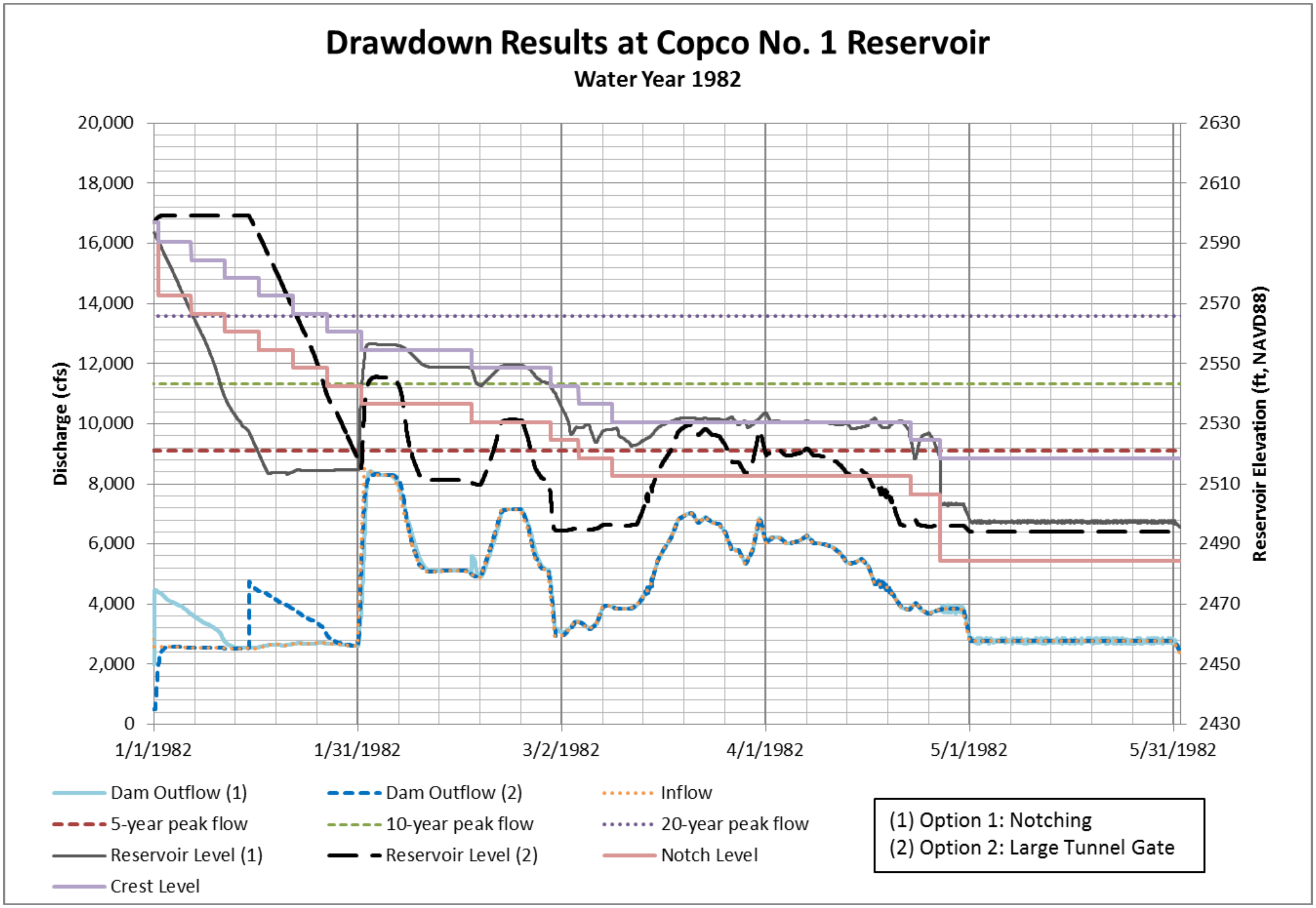

Figure 3-23 Copco No. 1 Reservoir Drawdown, Water Year 1982

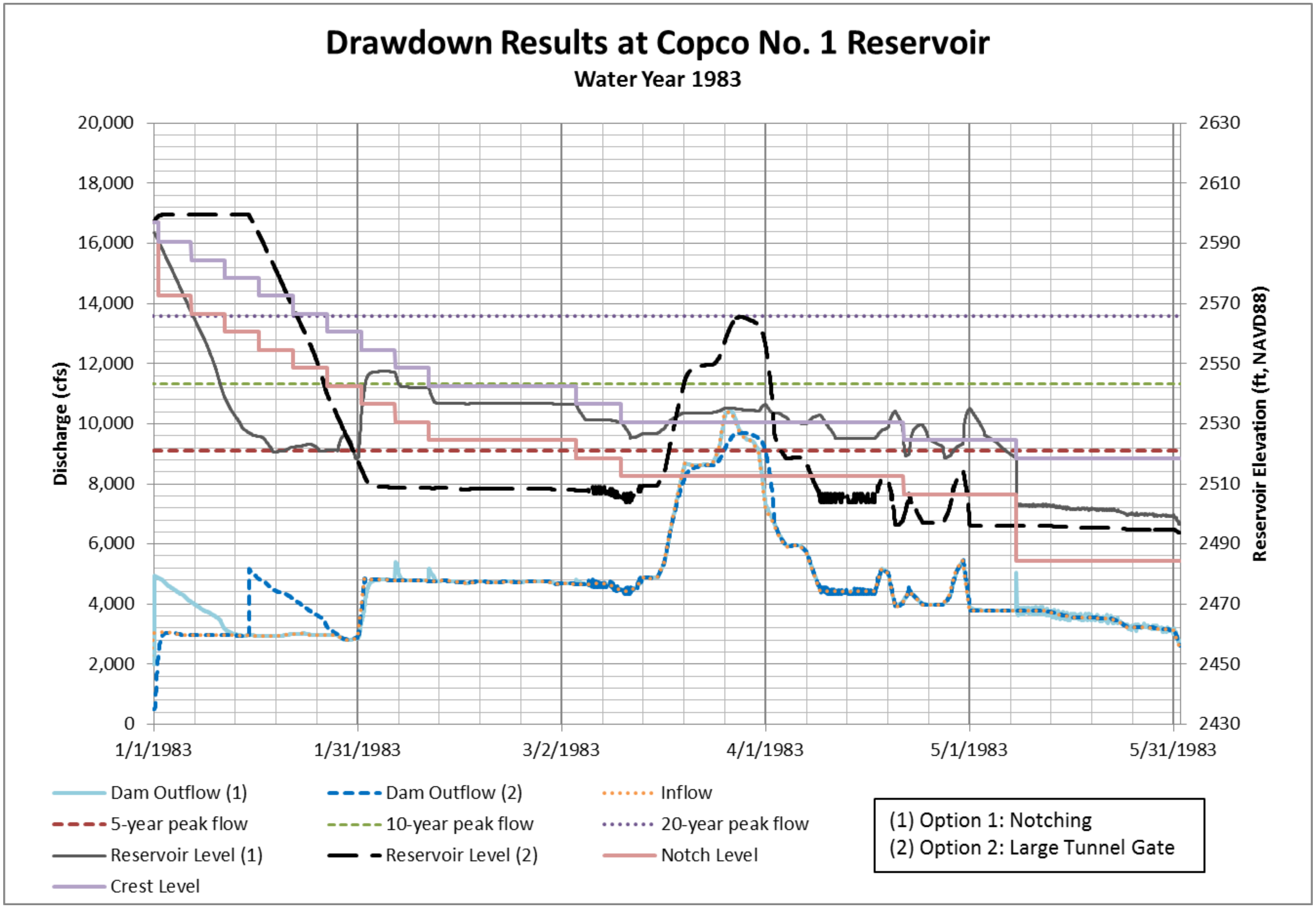

Figure 3-24 Copco No. 1 Reservoir Drawdown, Water Year 1983

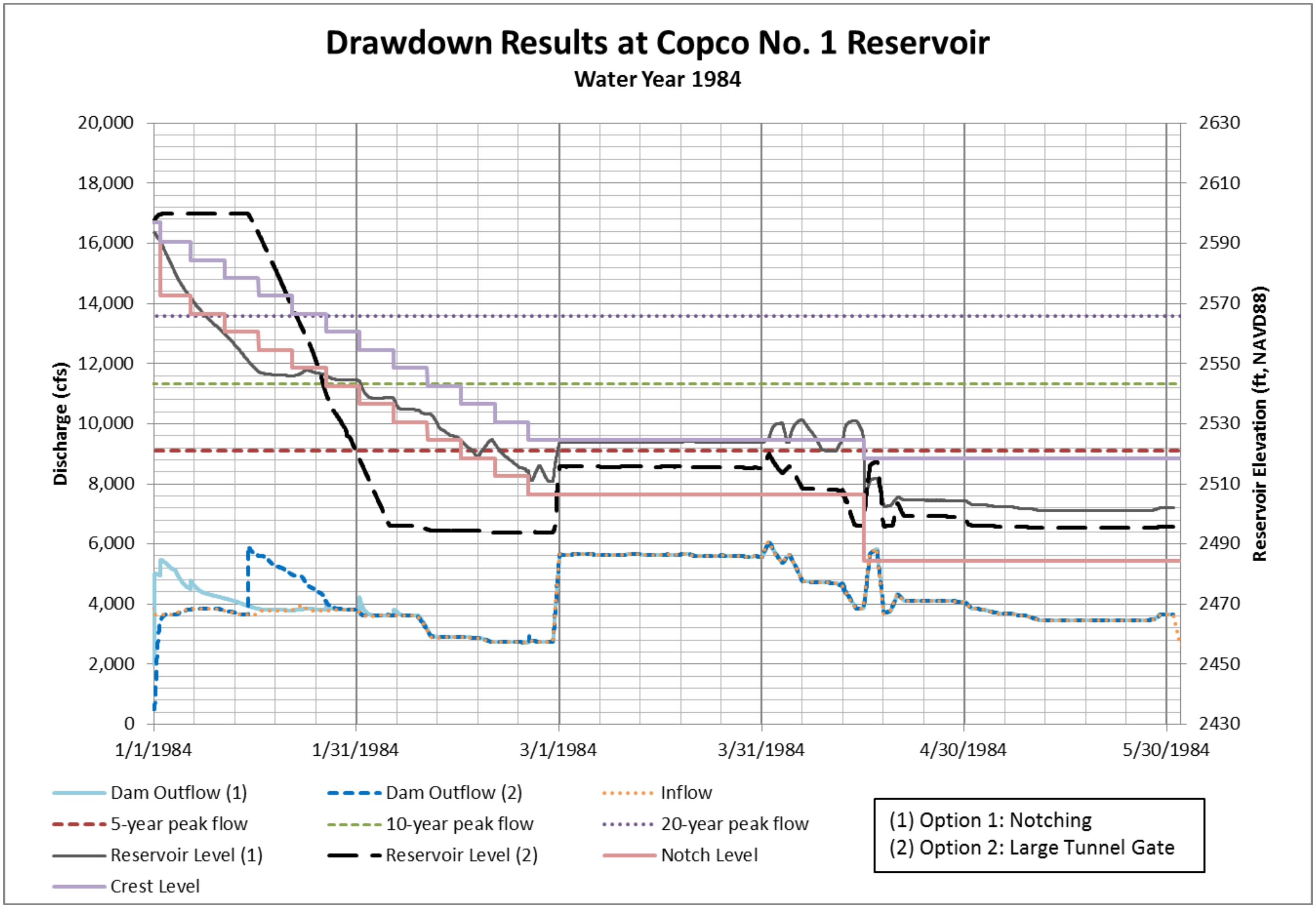

Figure 3-25 Copco No. 1 Reservoir Drawdown, Water Year 1984

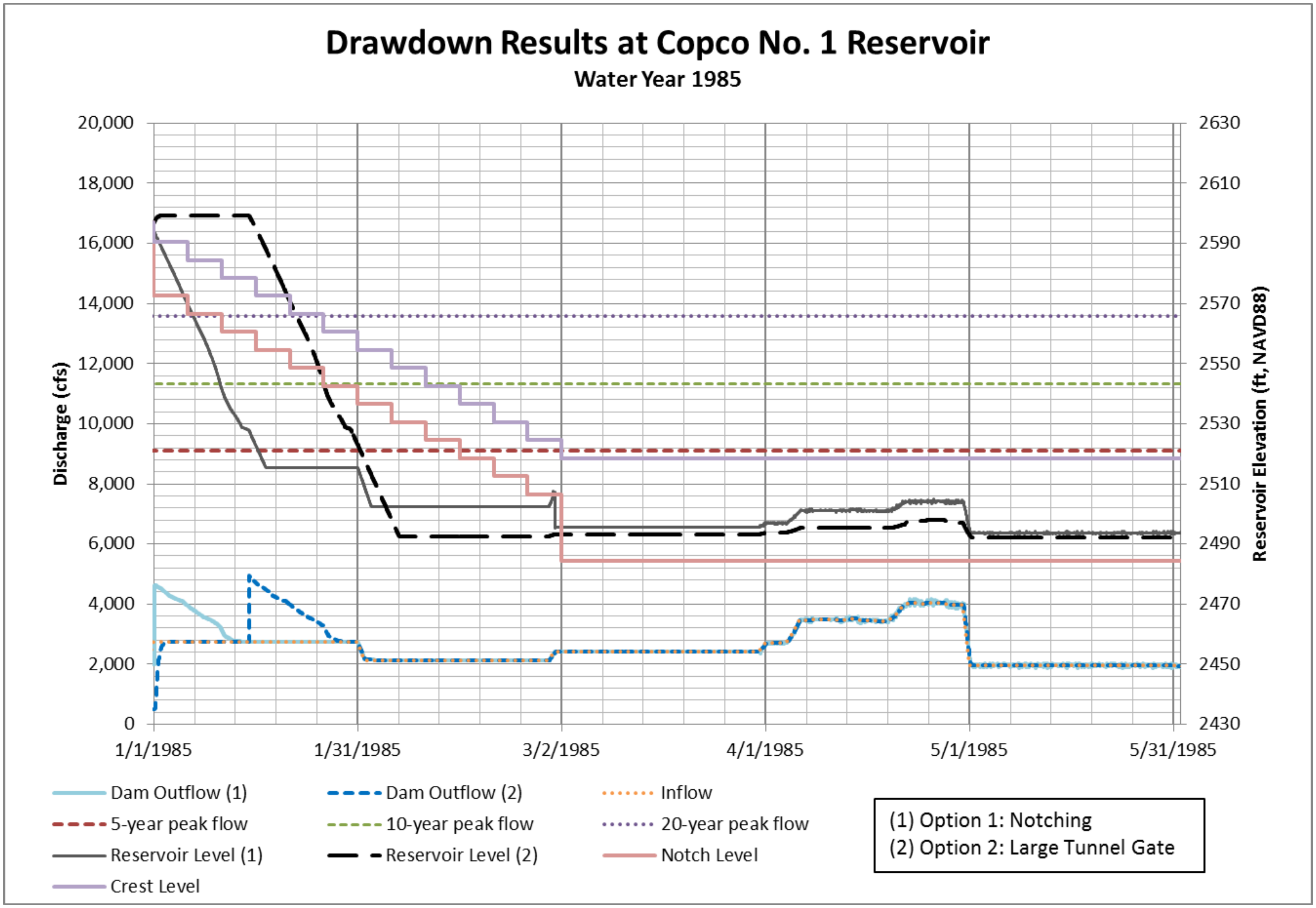

Figure 3-26 Copco No. 1 Reservoir Drawdown, Water Year 1985

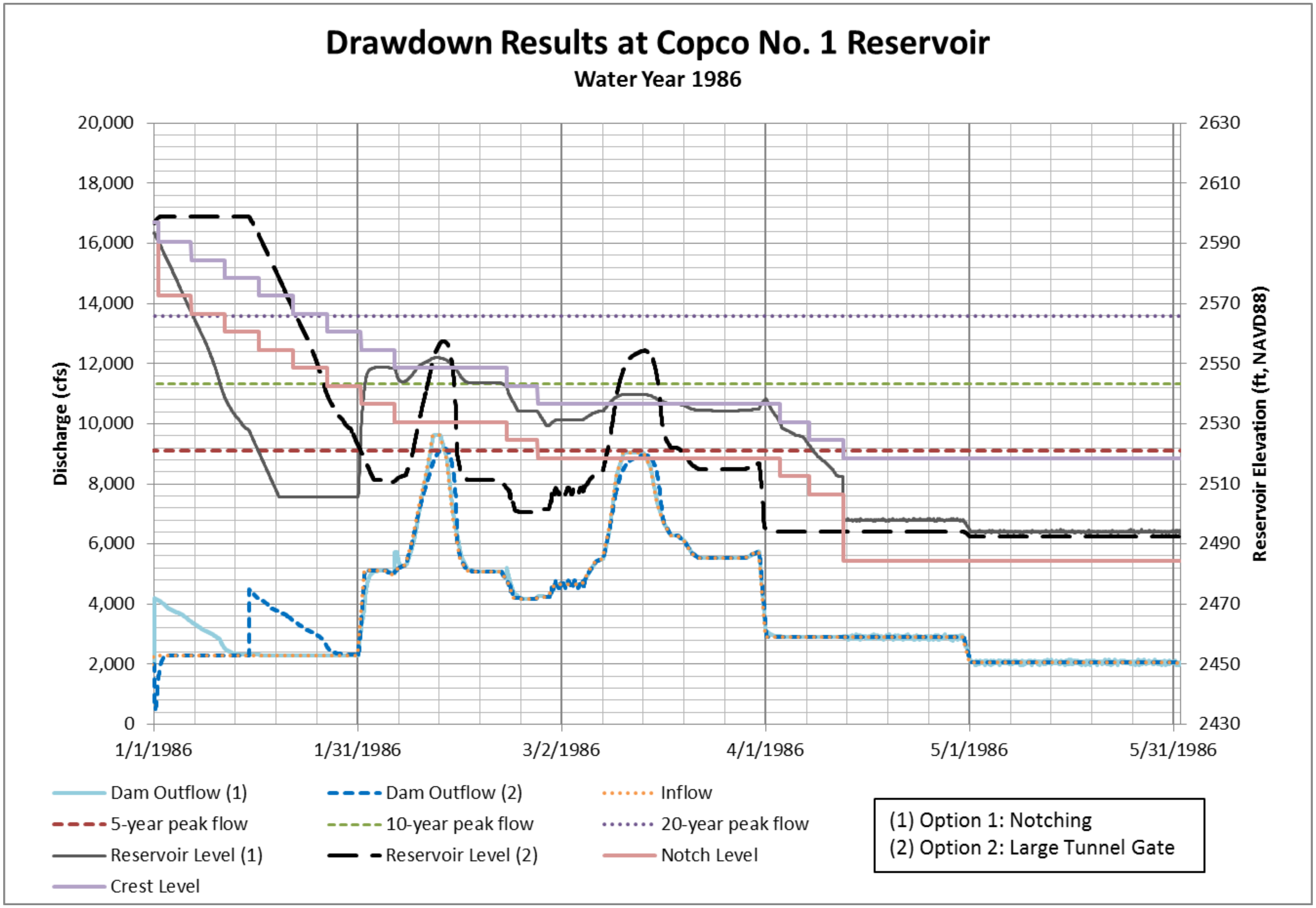

Figure 3-27 Copco No. 1 Reservoir Drawdown, Water Year 1986

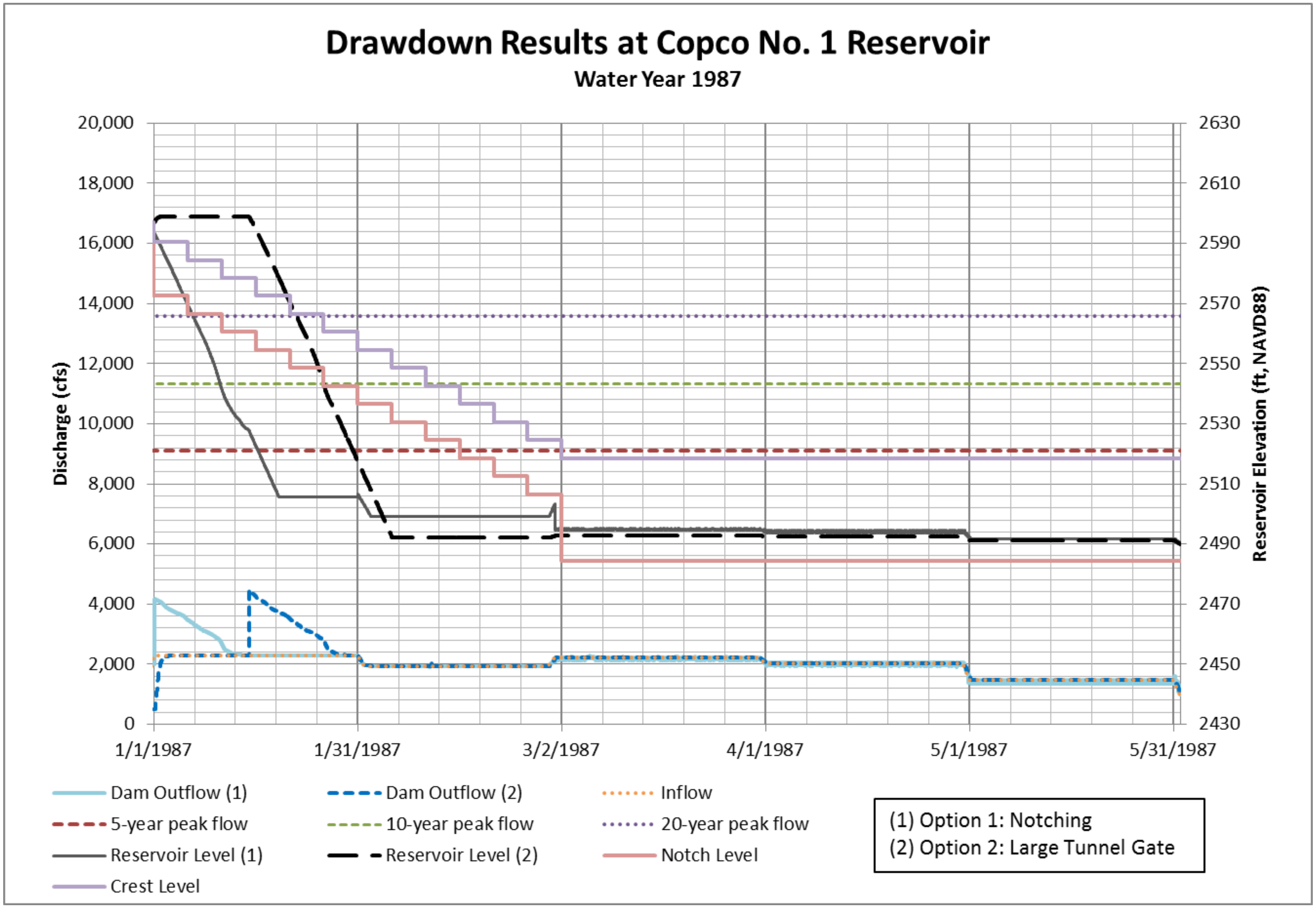

Figure 3-28 Copco No. 1 Reservoir Drawdown, Water Year 1987

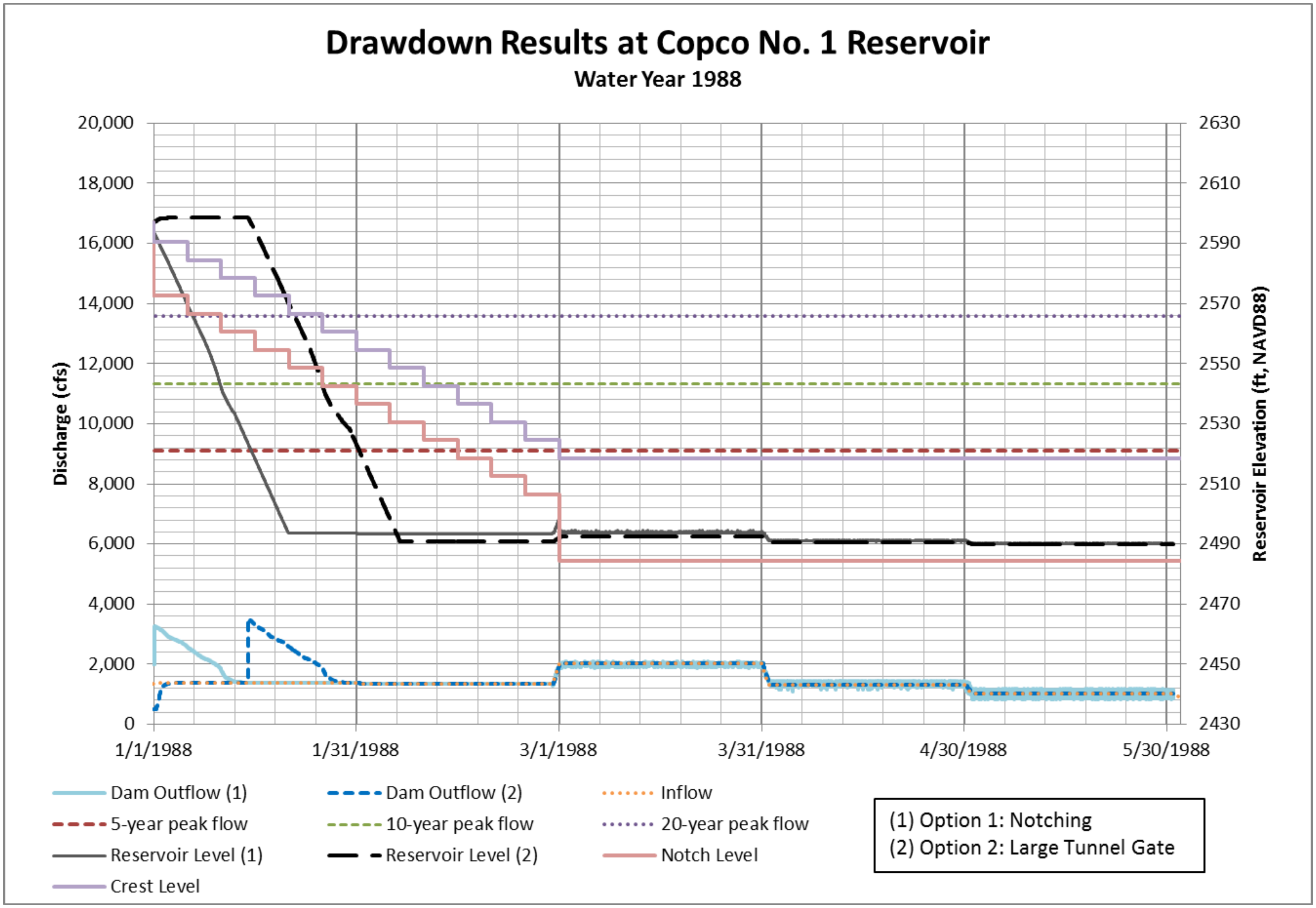

Figure 3-29 Copco No. 1 Reservoir Drawdown, Water Year 1988

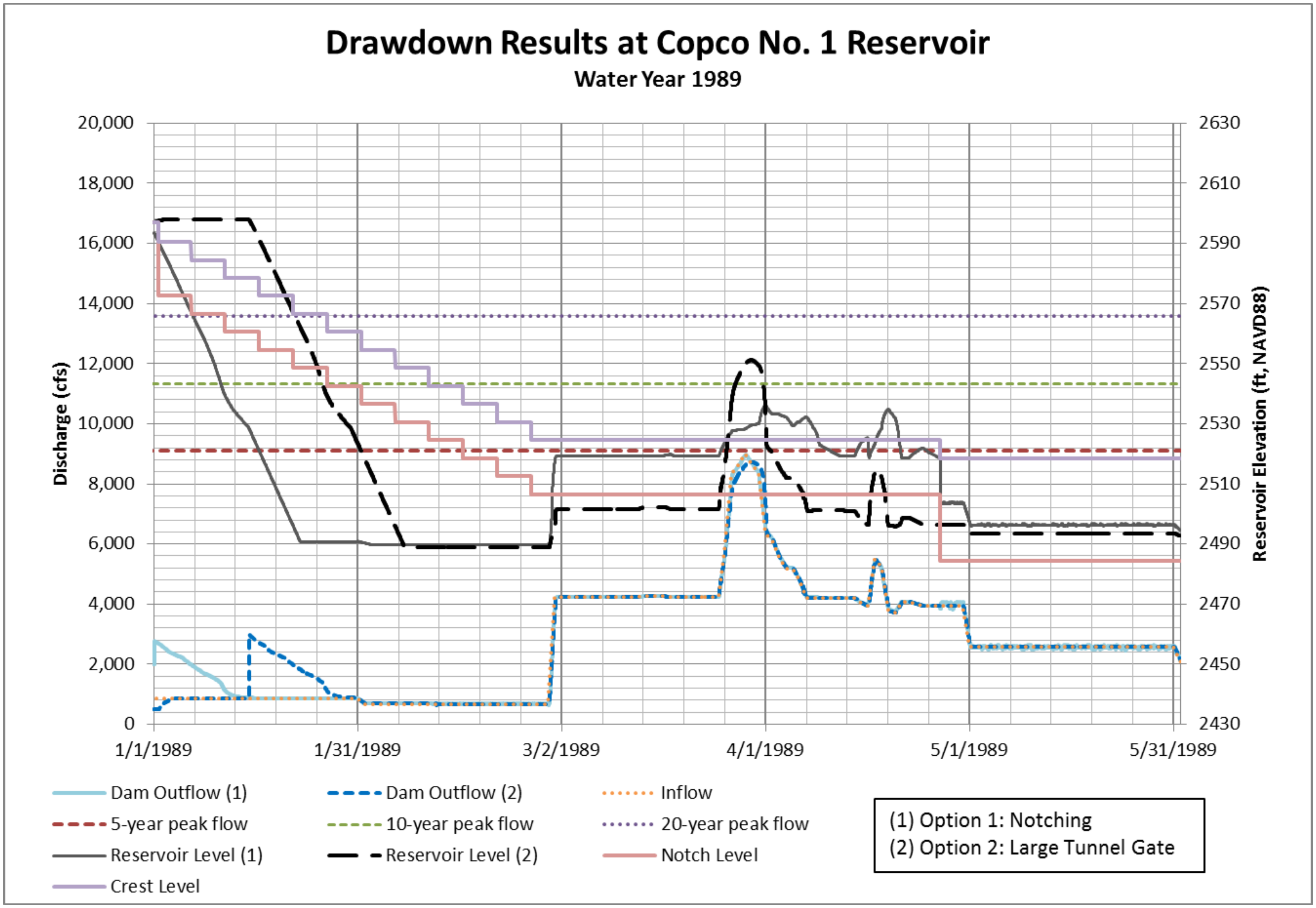

Figure 3-30 Copco No. 1 Reservoir Drawdown, Water Year 1989

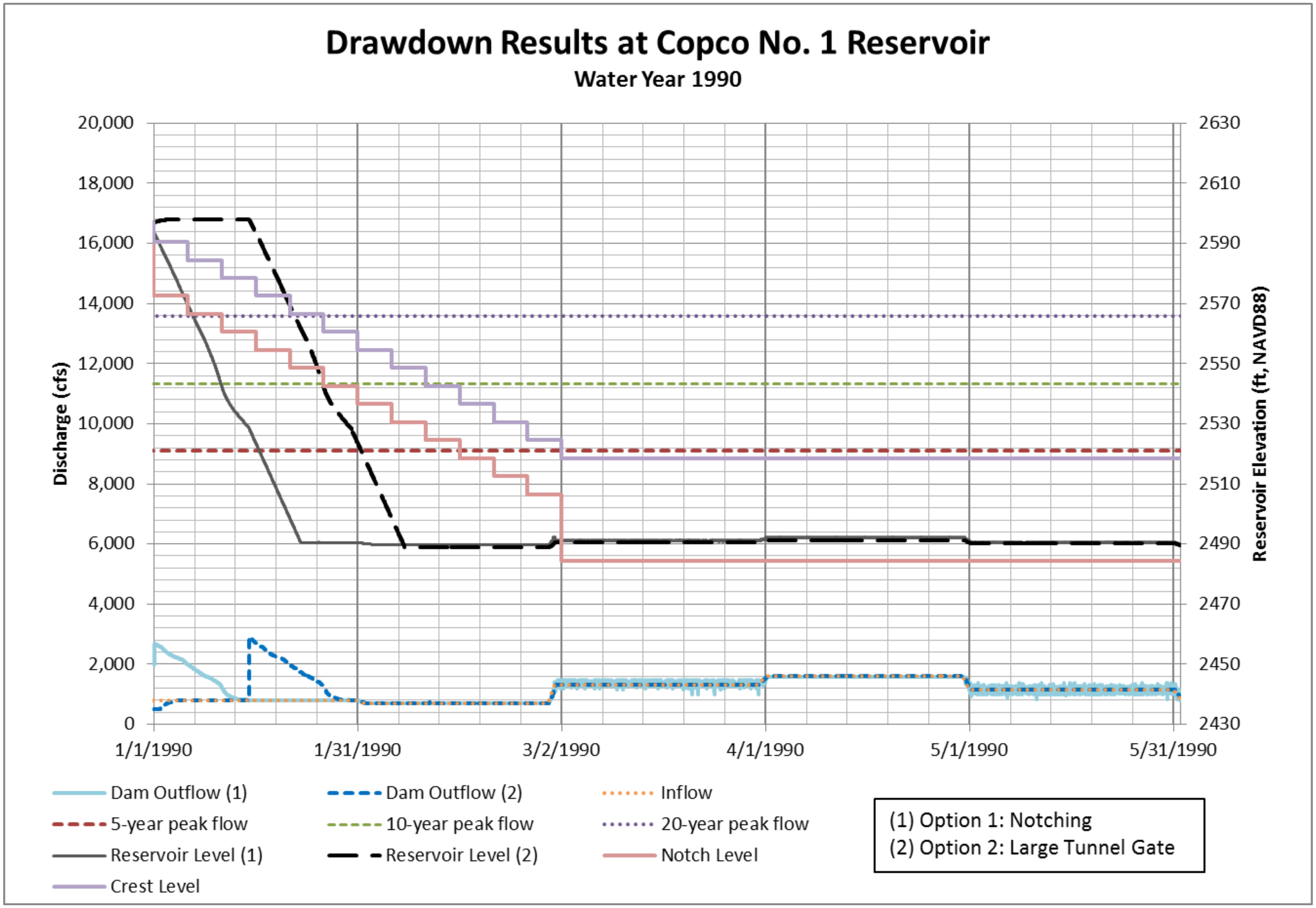

Figure 3-31 Copco No. 1 Reservoir Drawdown, Water Year 1990

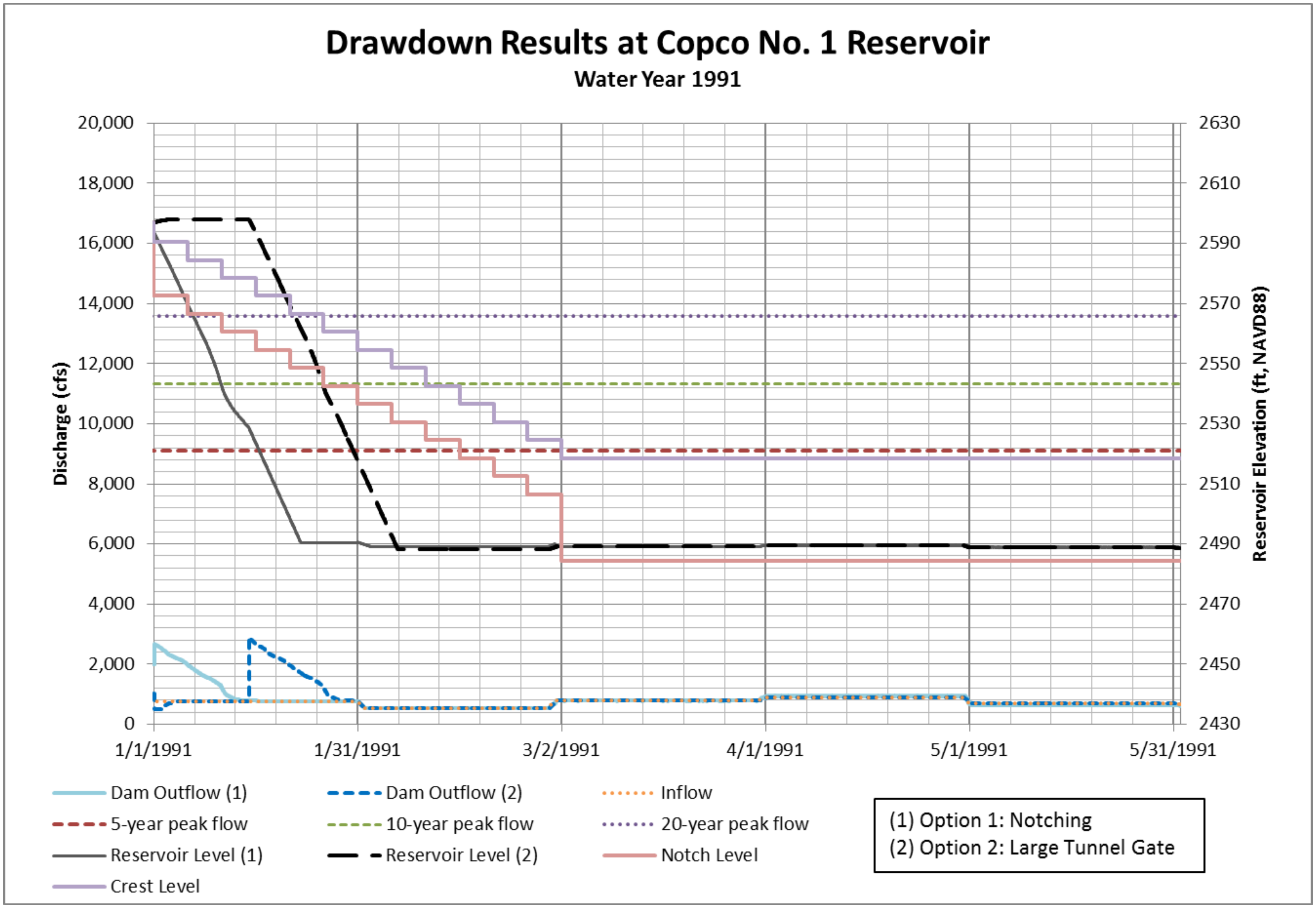

Figure 3-32 Copco No. 1 Reservoir Drawdown, Water Year 1991

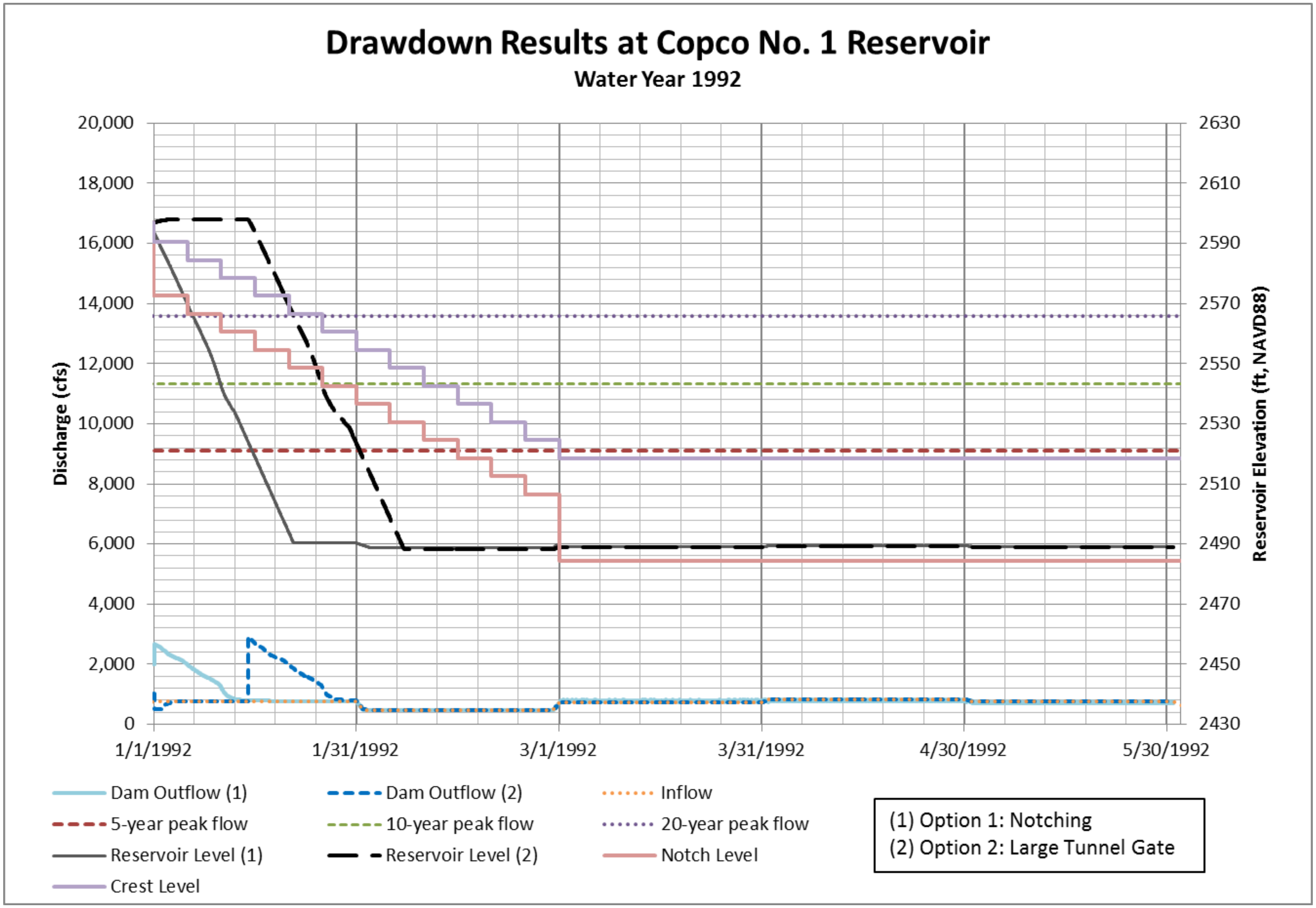

Figure 3-33 Copco No. 1 Reservoir Drawdown, Water Year 1992

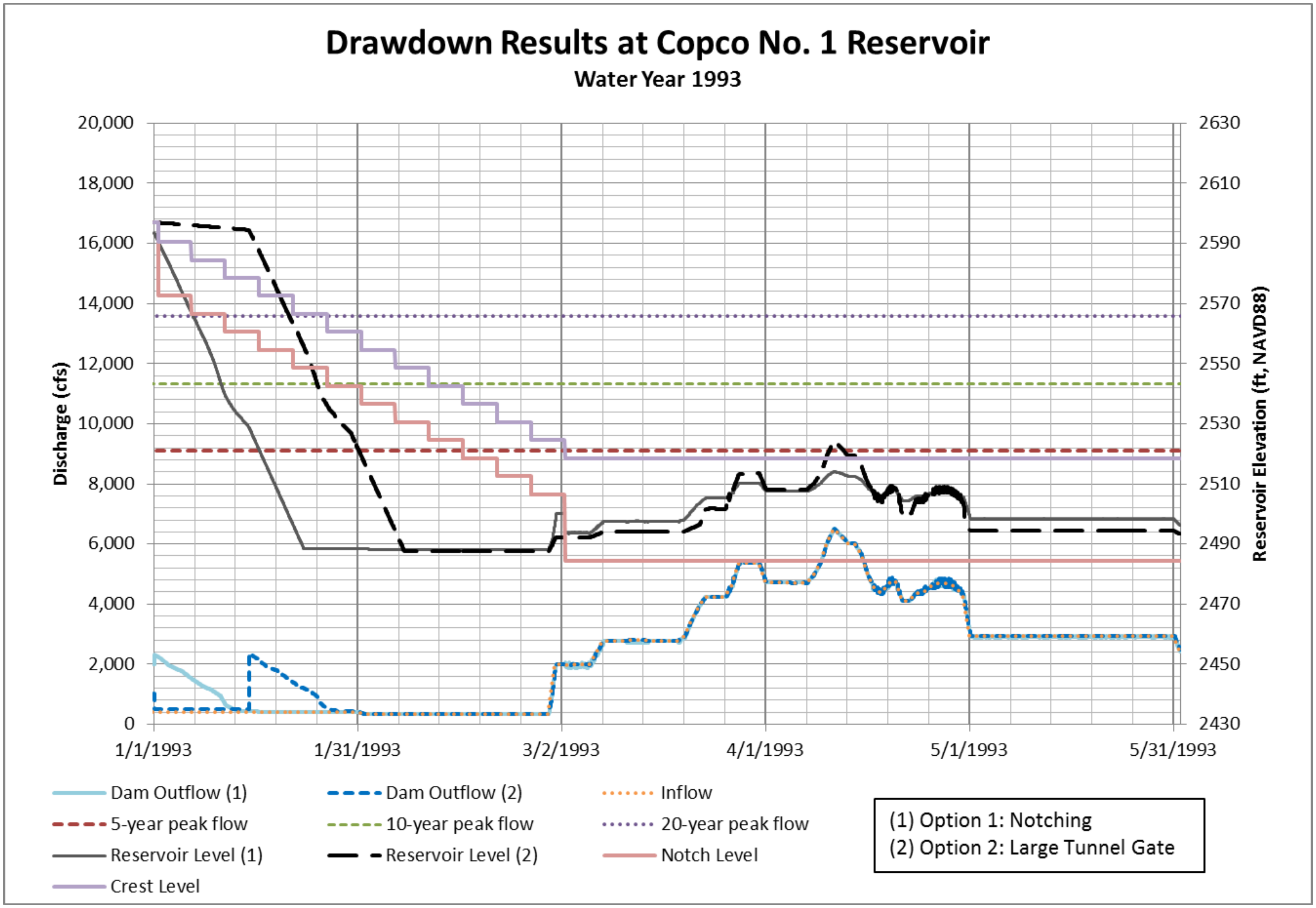

Figure 3-34 Copco No. 1 Reservoir Drawdown, Water Year 1993

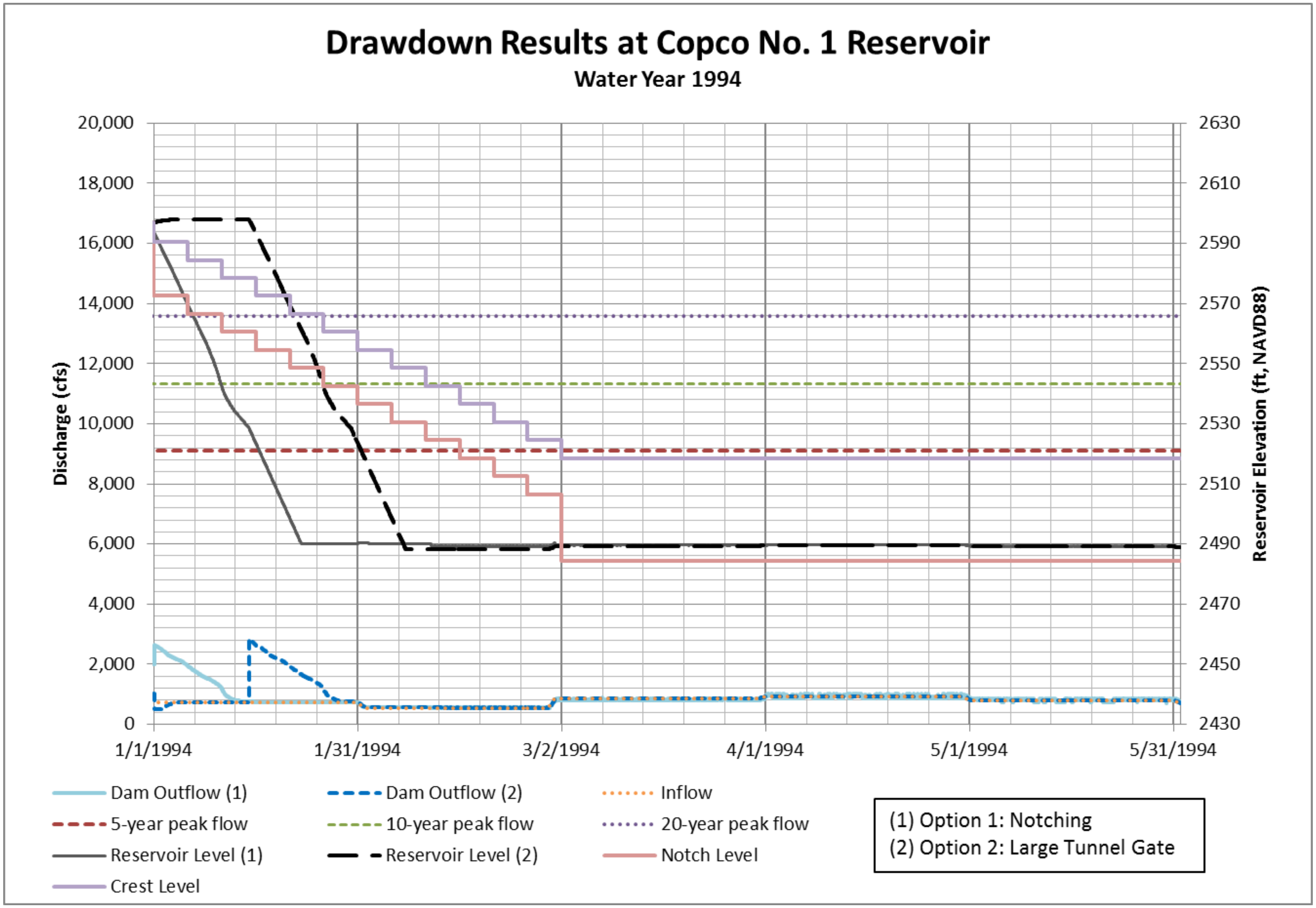

Figure 3-35 Copco No. 1 Reservoir Drawdown, Water Year 1994

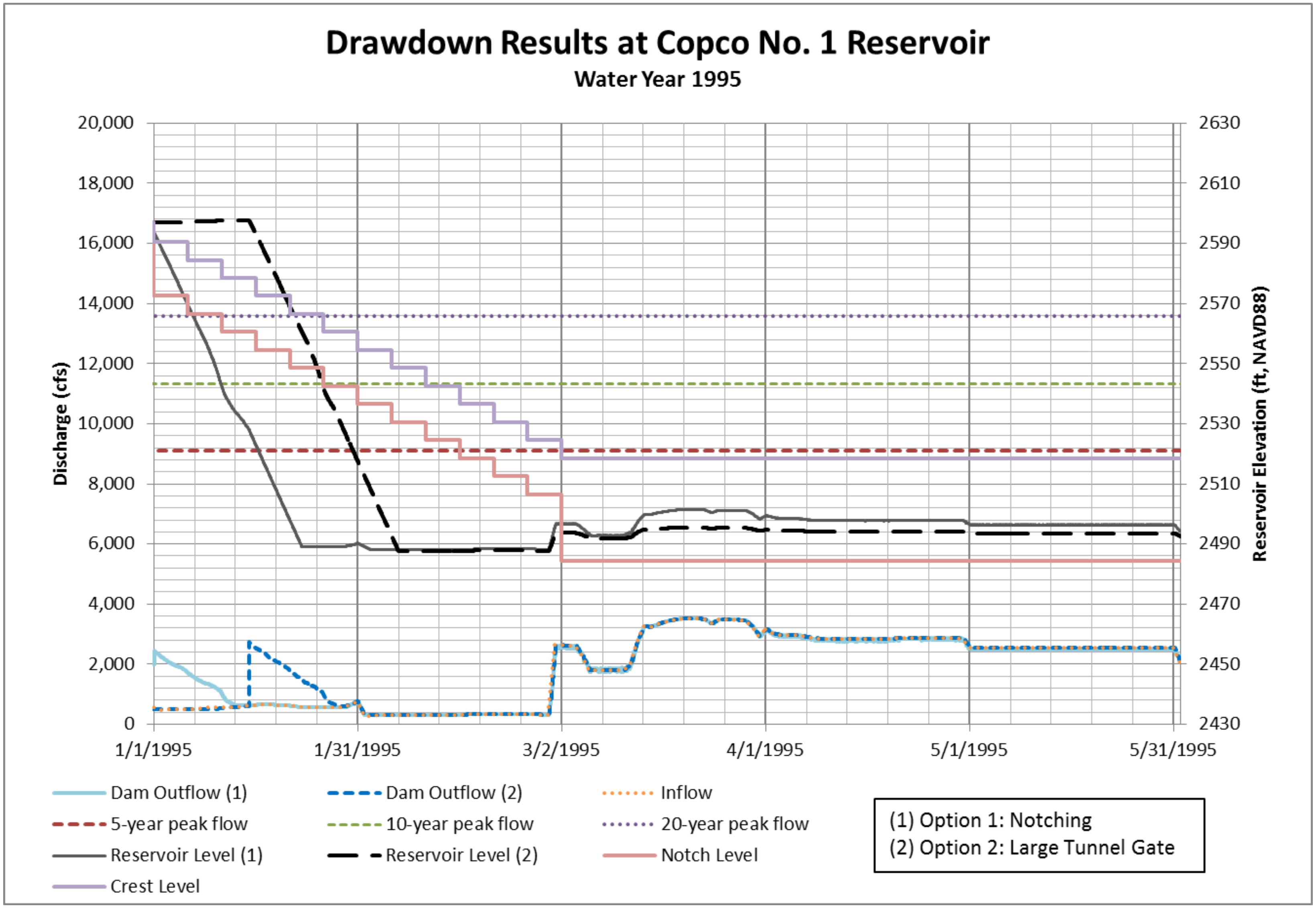

Figure 3-36 Copco No. 1 Reservoir Drawdown, Water Year 1995

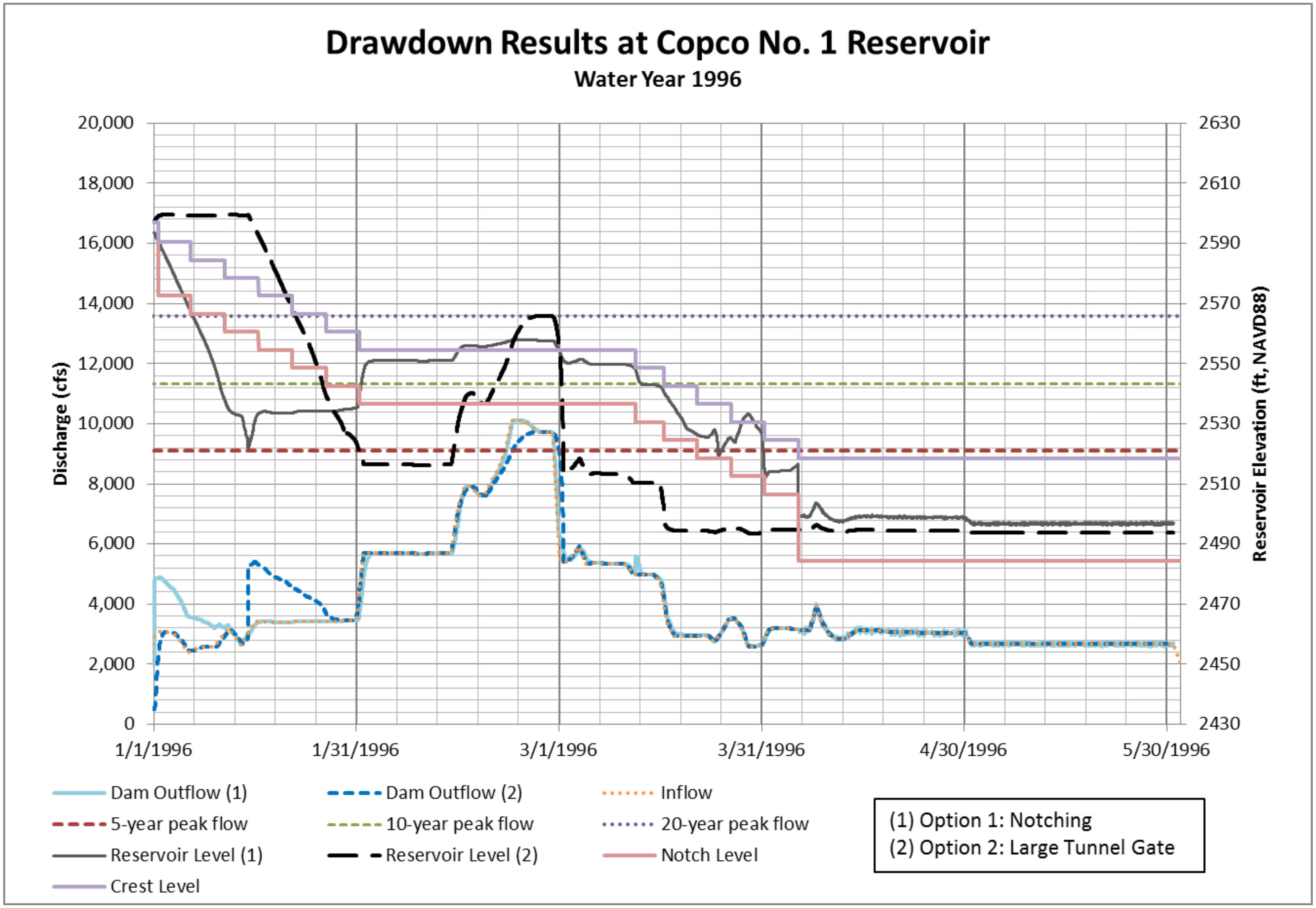

Figure 3-37 Copco No. 1 Reservoir Drawdown, Water Year 1996

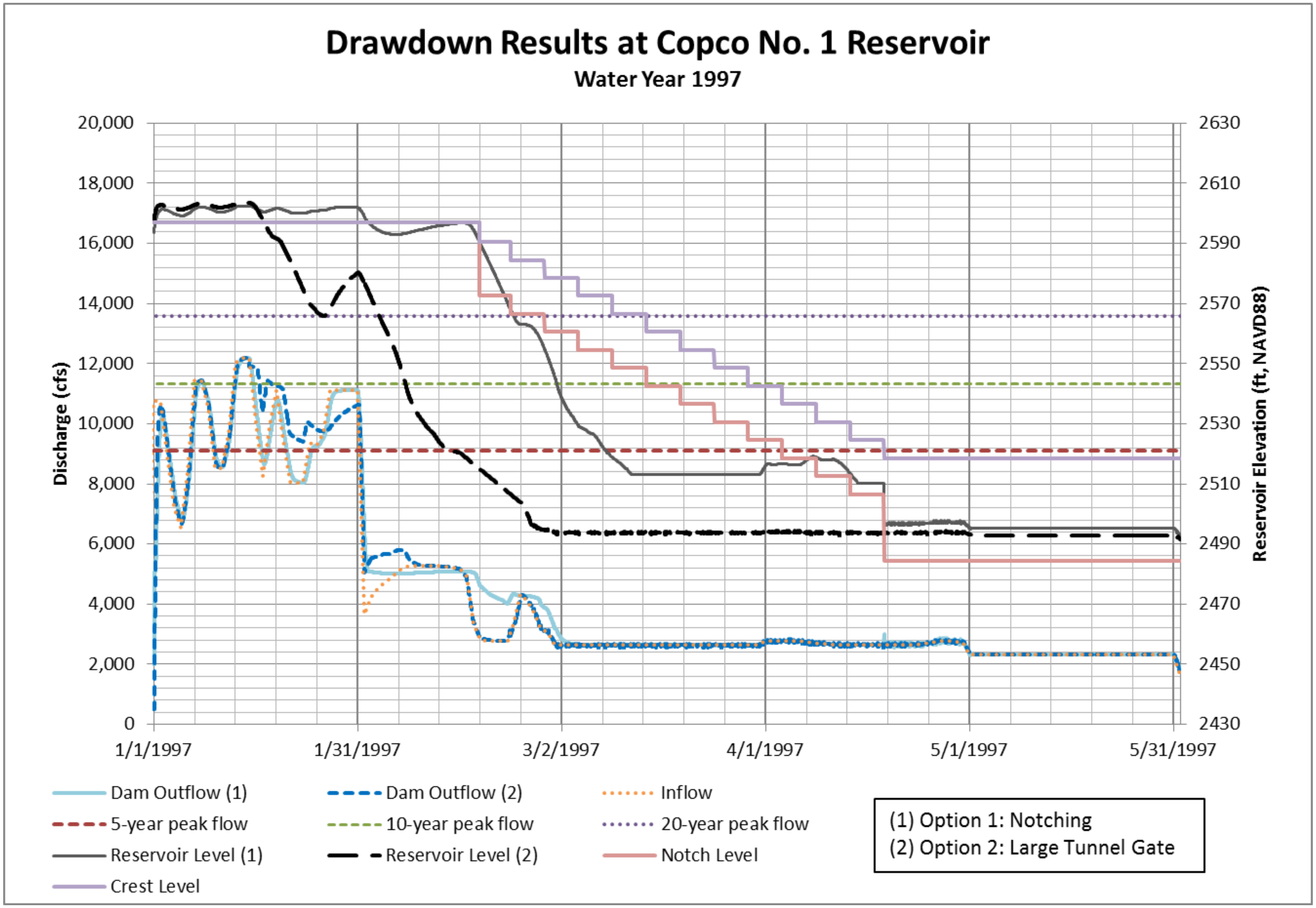

Figure 3-38 Copco No. 1 Reservoir Drawdown, Water Year 1997

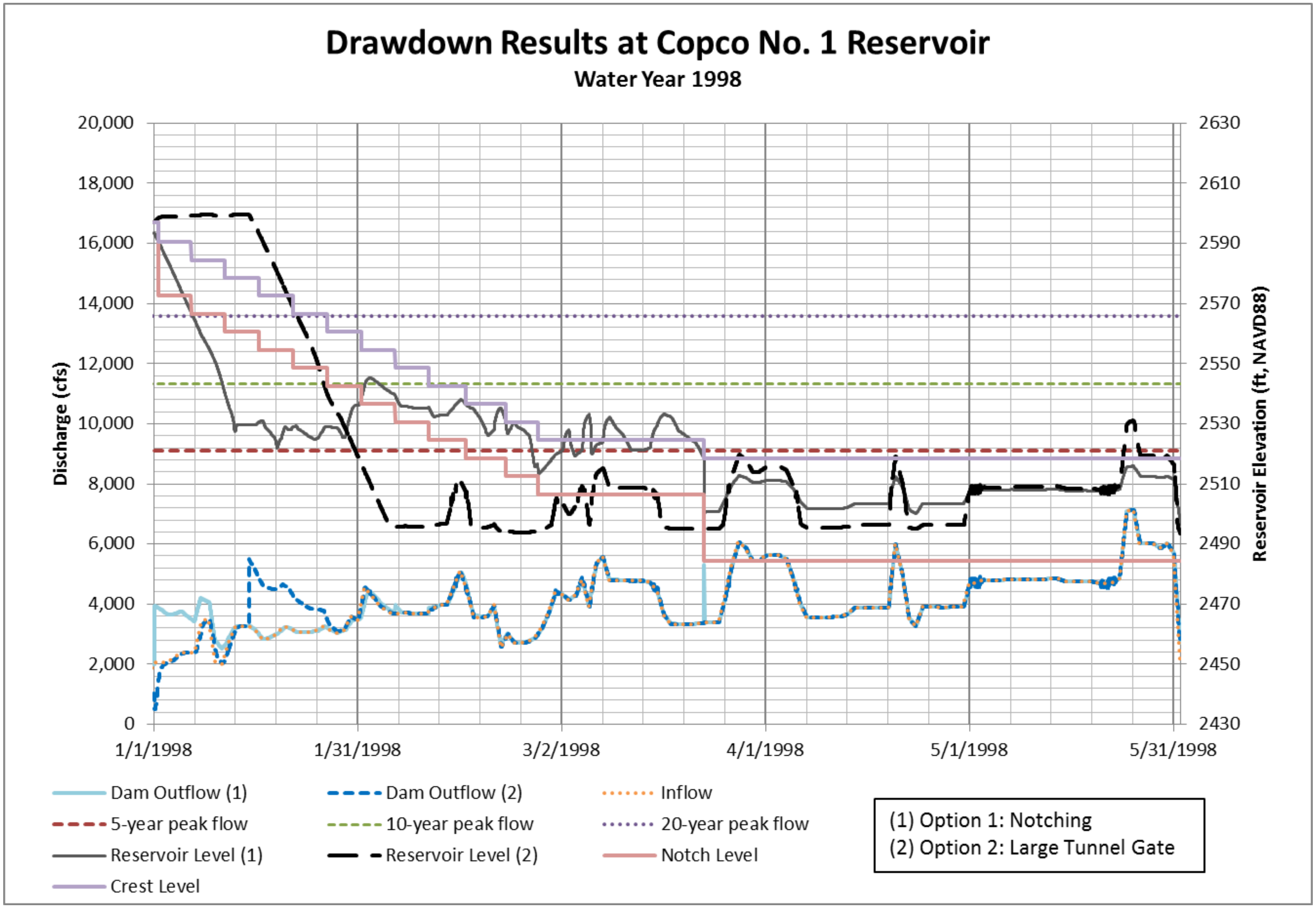

Figure 3-39 Copco No. 1 Reservoir Drawdown, Water Year 1998

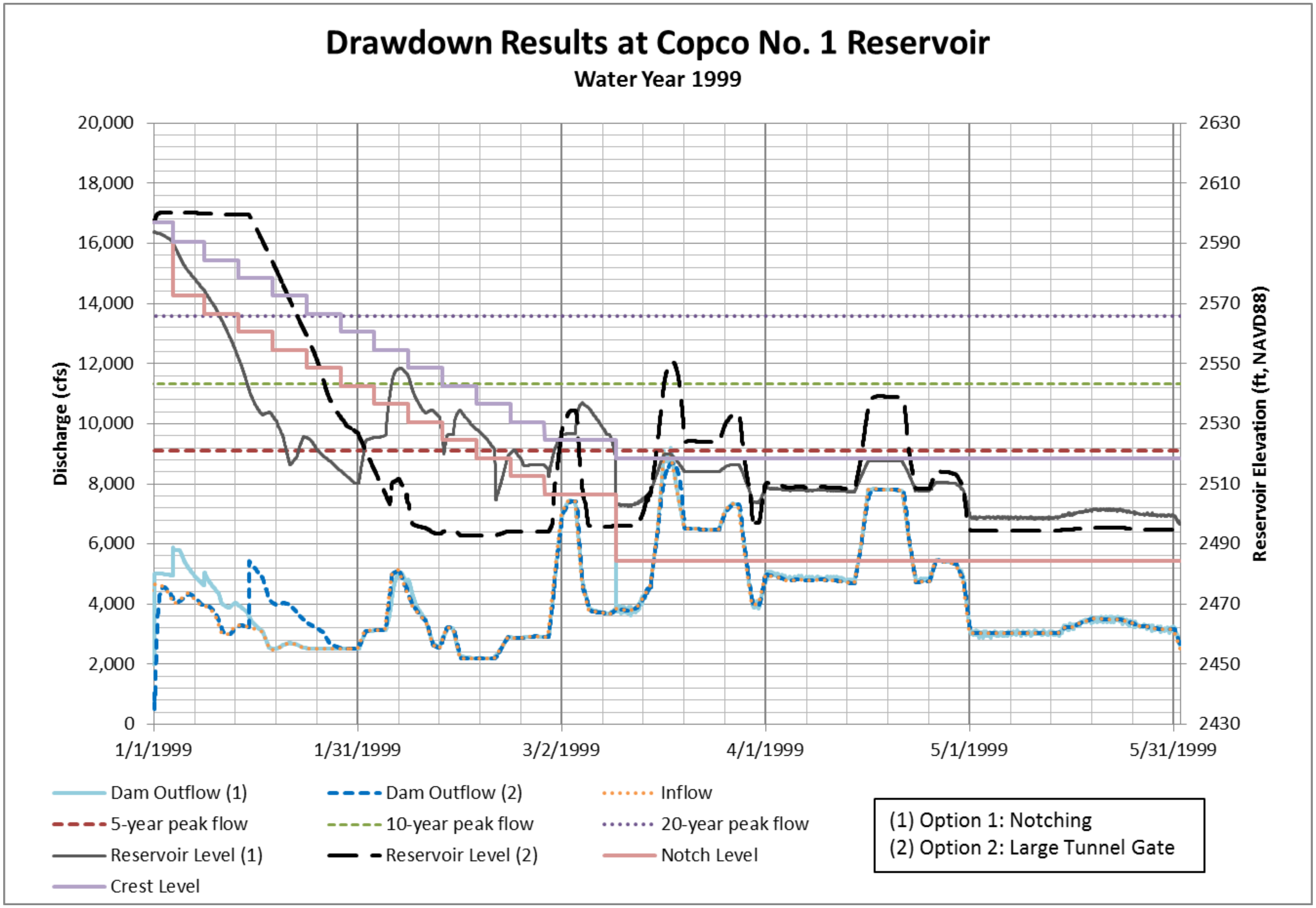

Figure 3-40 Copco No. 1 Reservoir Drawdown, Water Year 1999

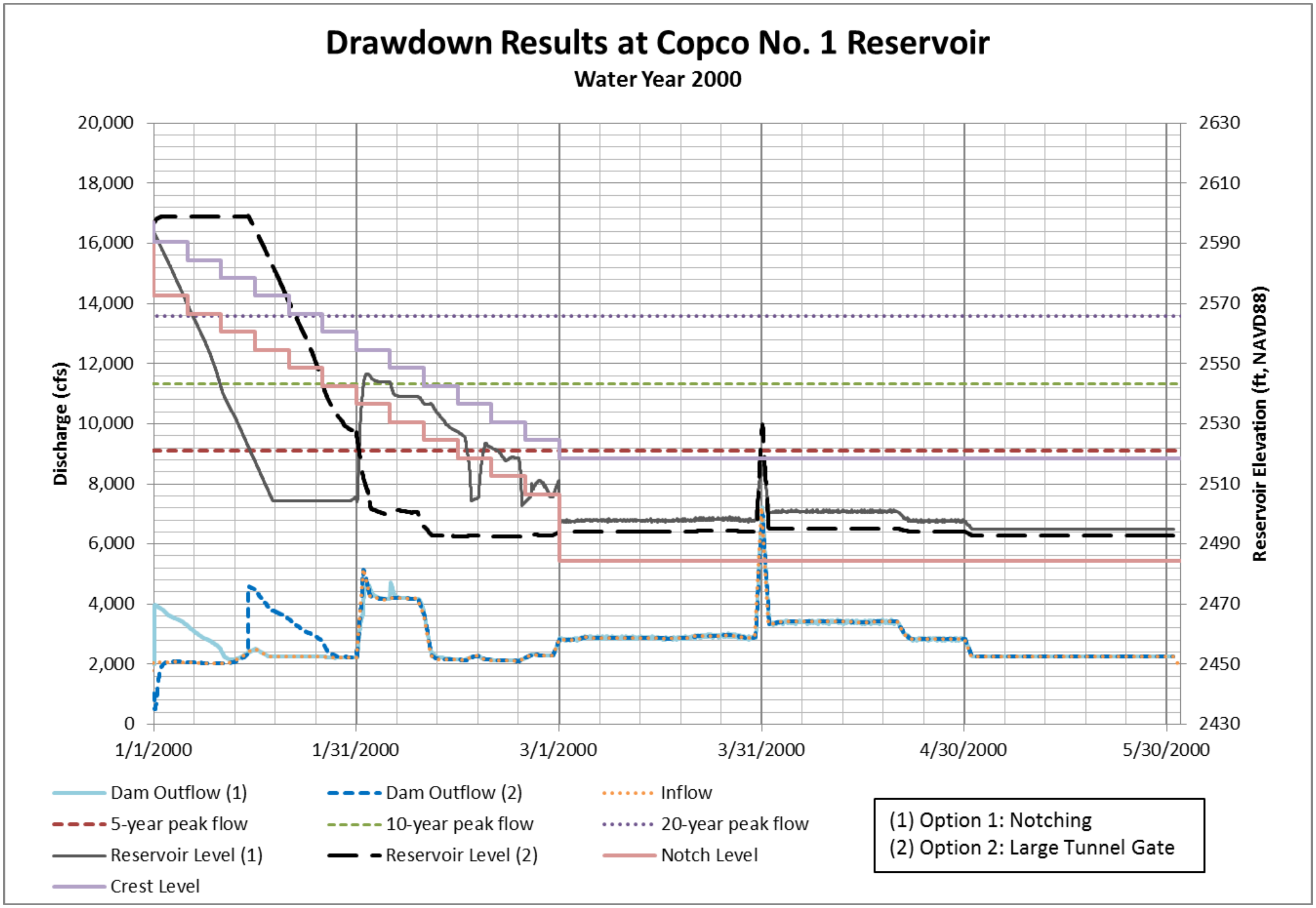

Figure 3-41 Copco No. 1 Reservoir Drawdown, Water Year 2000

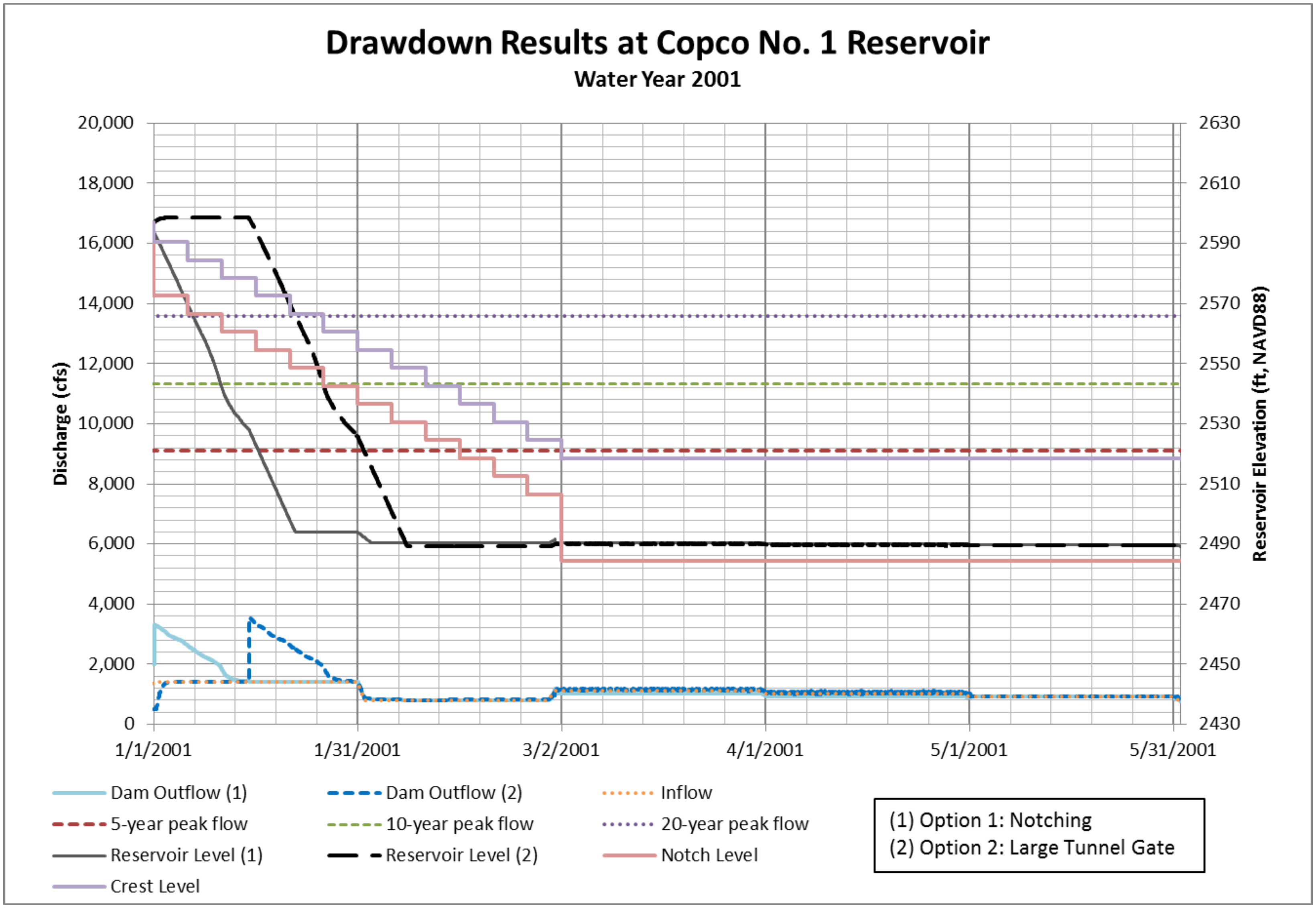

Figure 3-42 Copco No. 1 Reservoir Drawdown, Water Year 2001

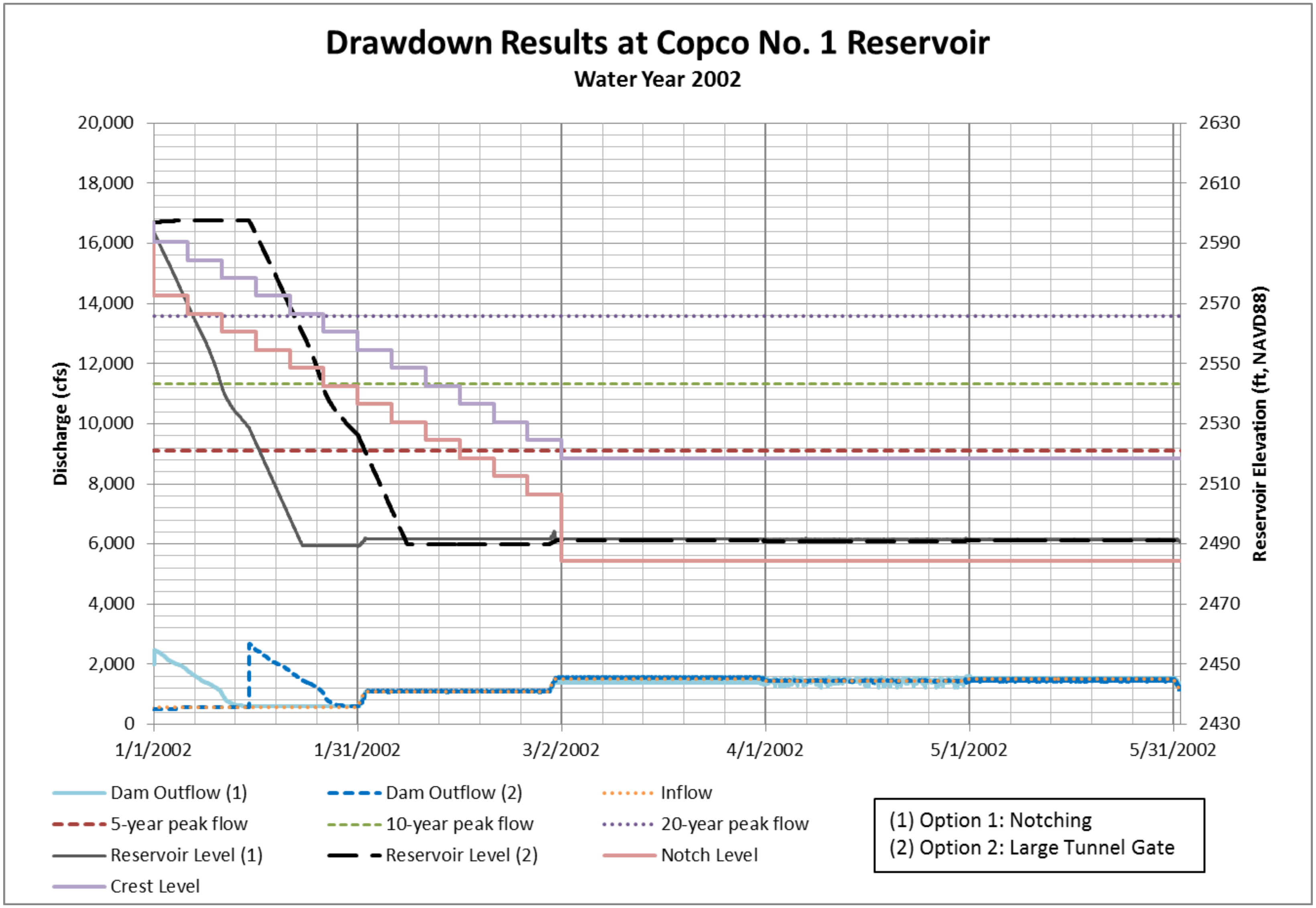

Figure 3-43 Copco No. 1 Reservoir Drawdown, Water Year 2002

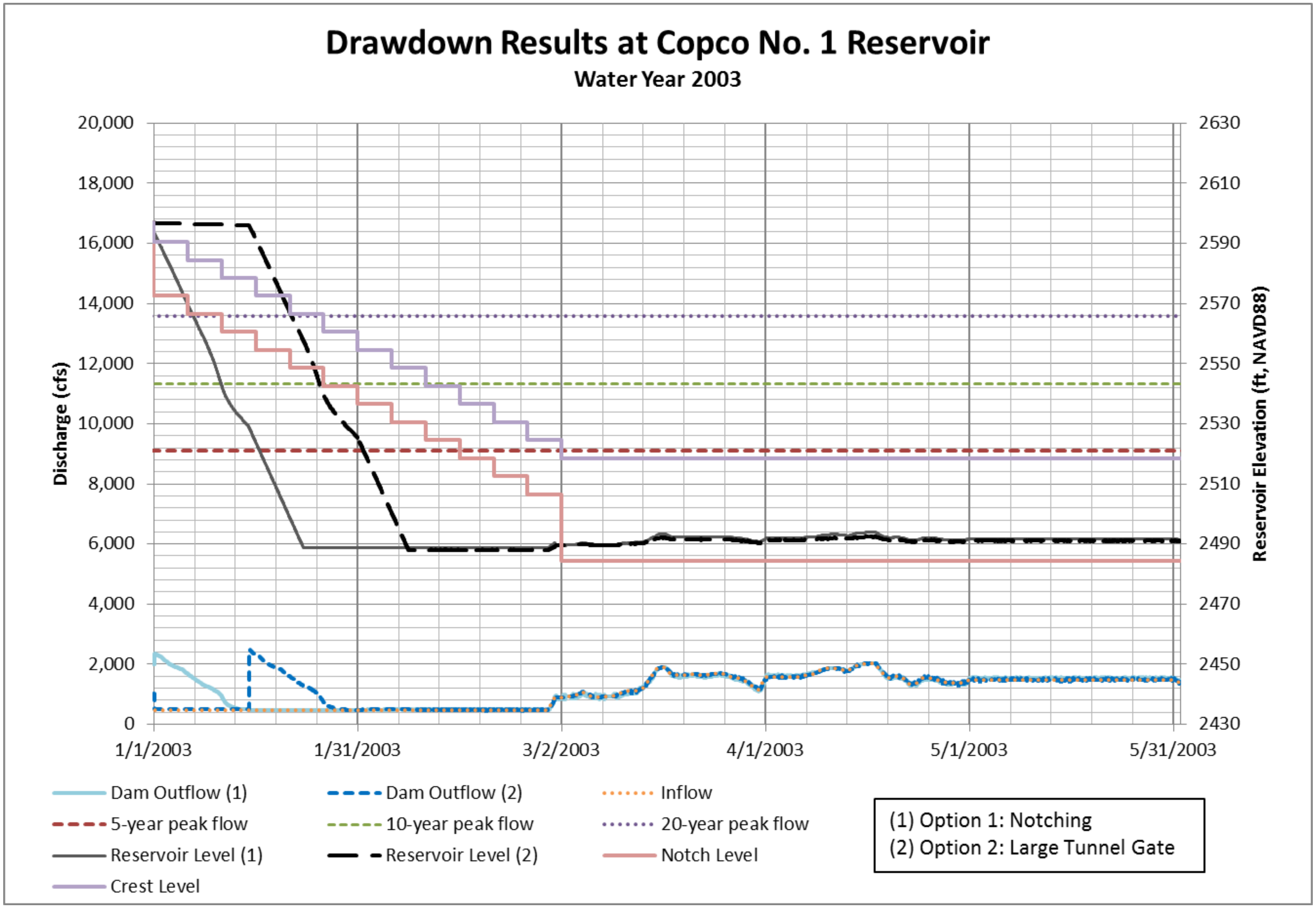

Figure 3-44 Copco No. 1 Reservoir Drawdown, Water Year 2003

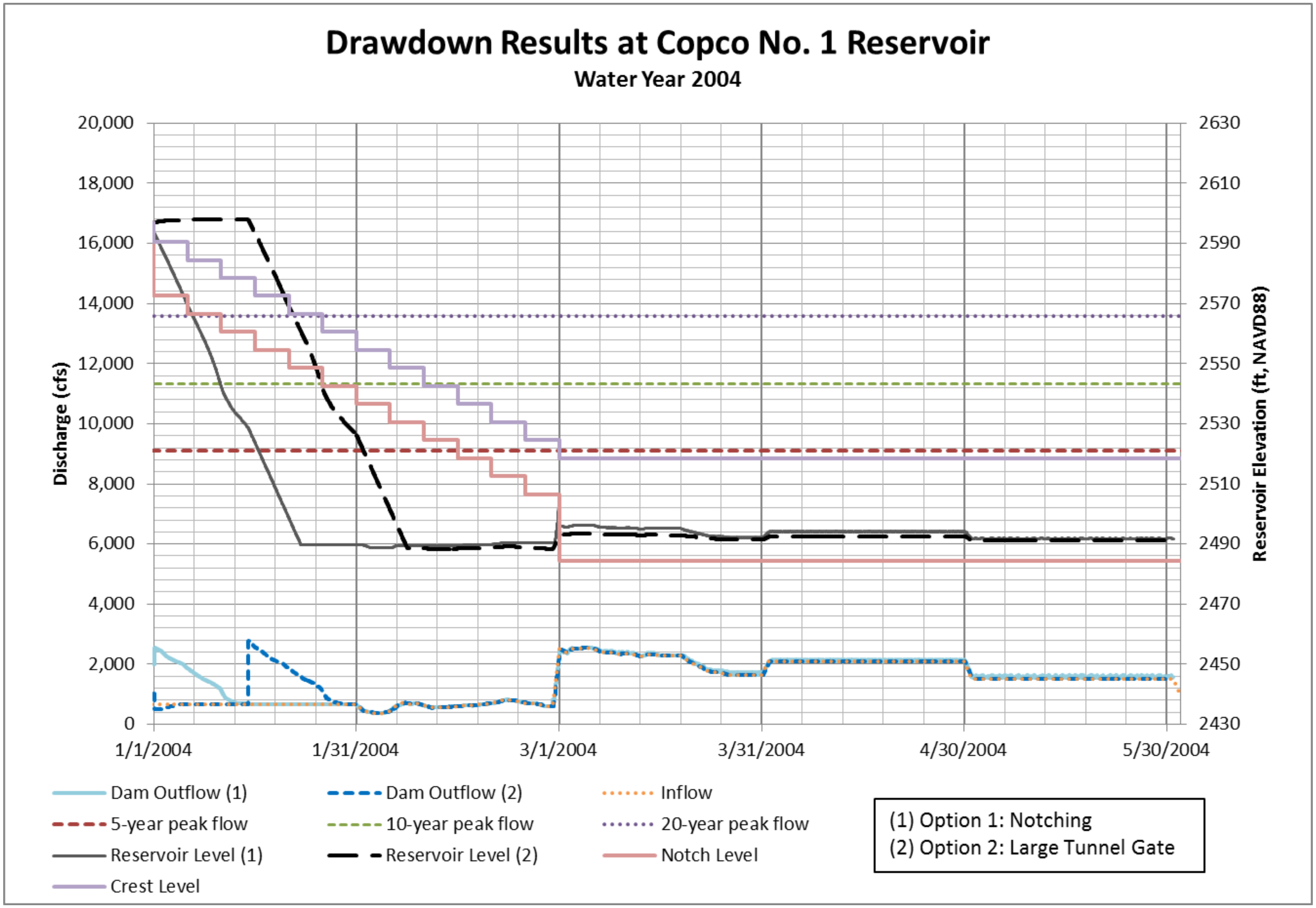

Figure 3-45 Copco No. 1 Reservoir Drawdown, Water Year 2004

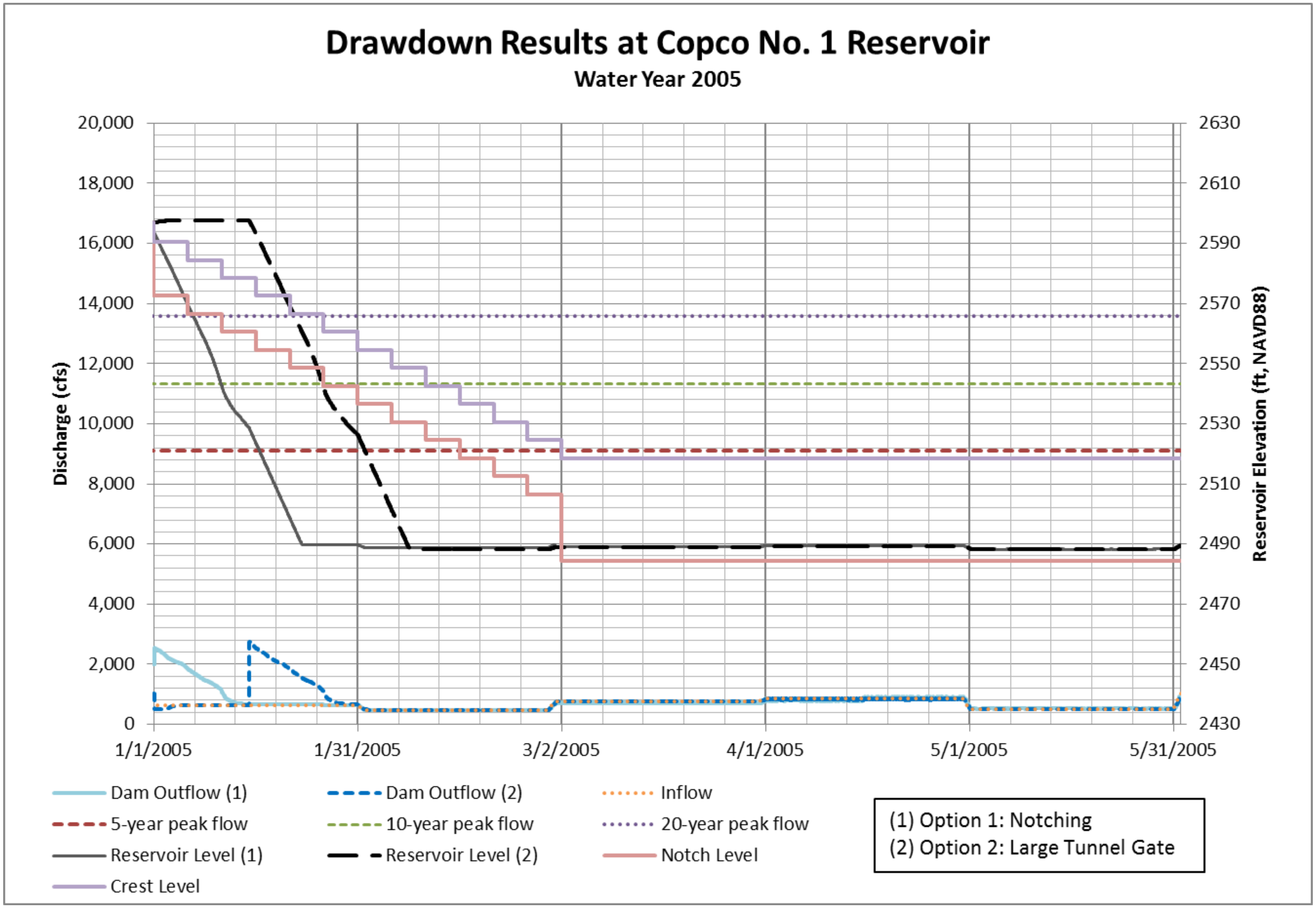

Figure 3-46 Copco No. 1 Reservoir Drawdown, Water Year 2005

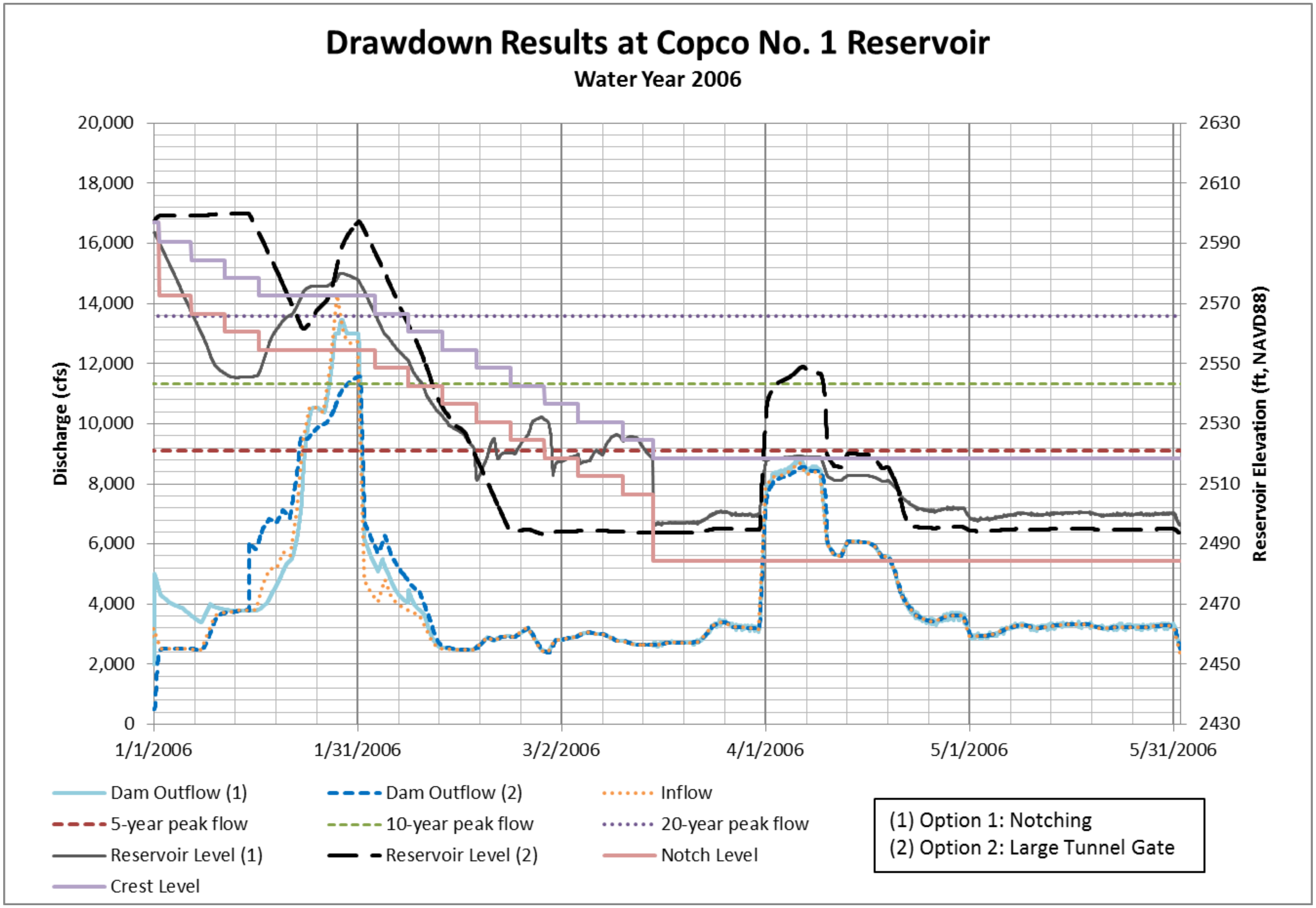

Figure 3-47 Copco No. 1 Reservoir Drawdown, Water Year 2006

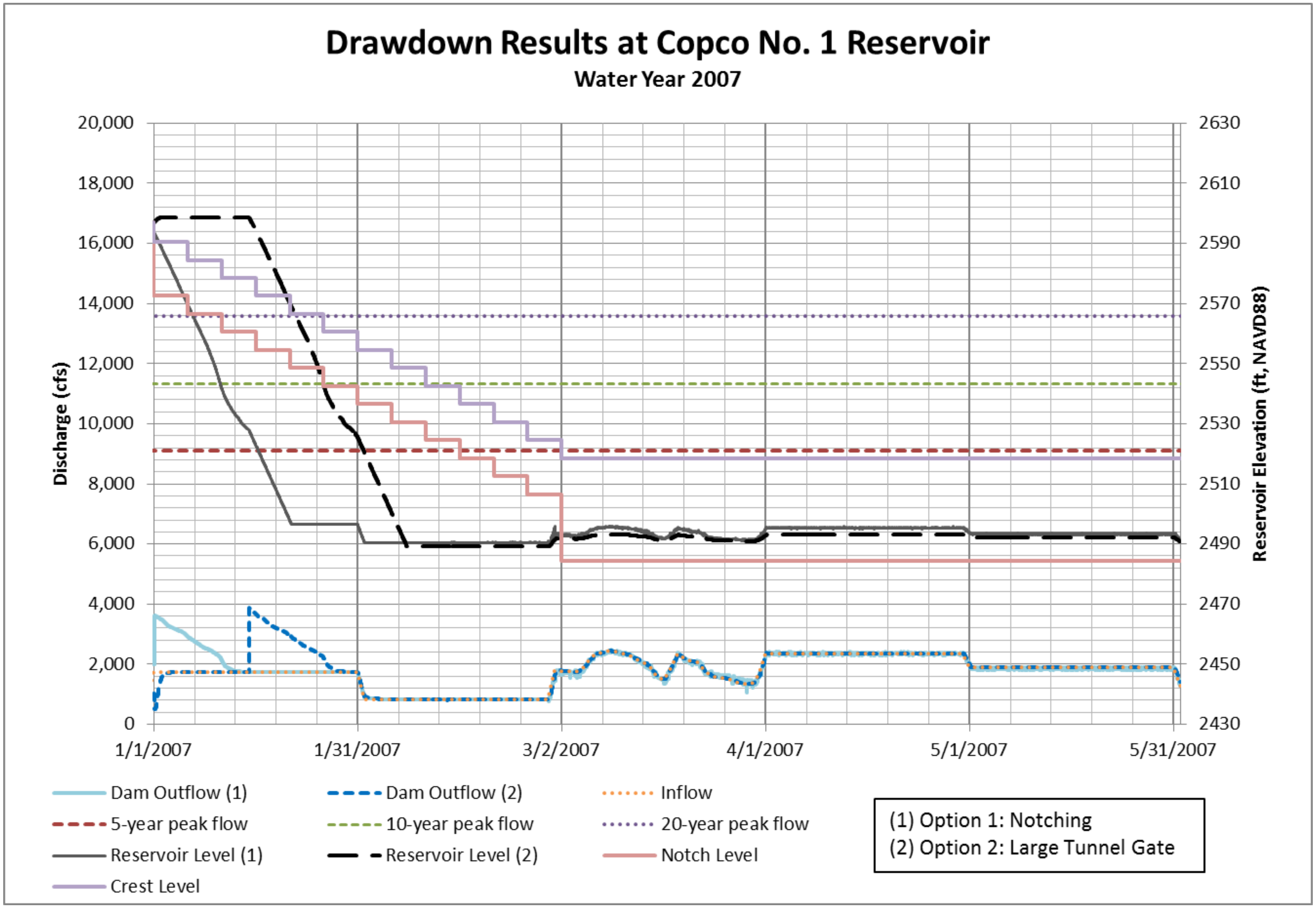

Figure 3-48 Copco No. 1 Reservoir Drawdown, Water Year 2007

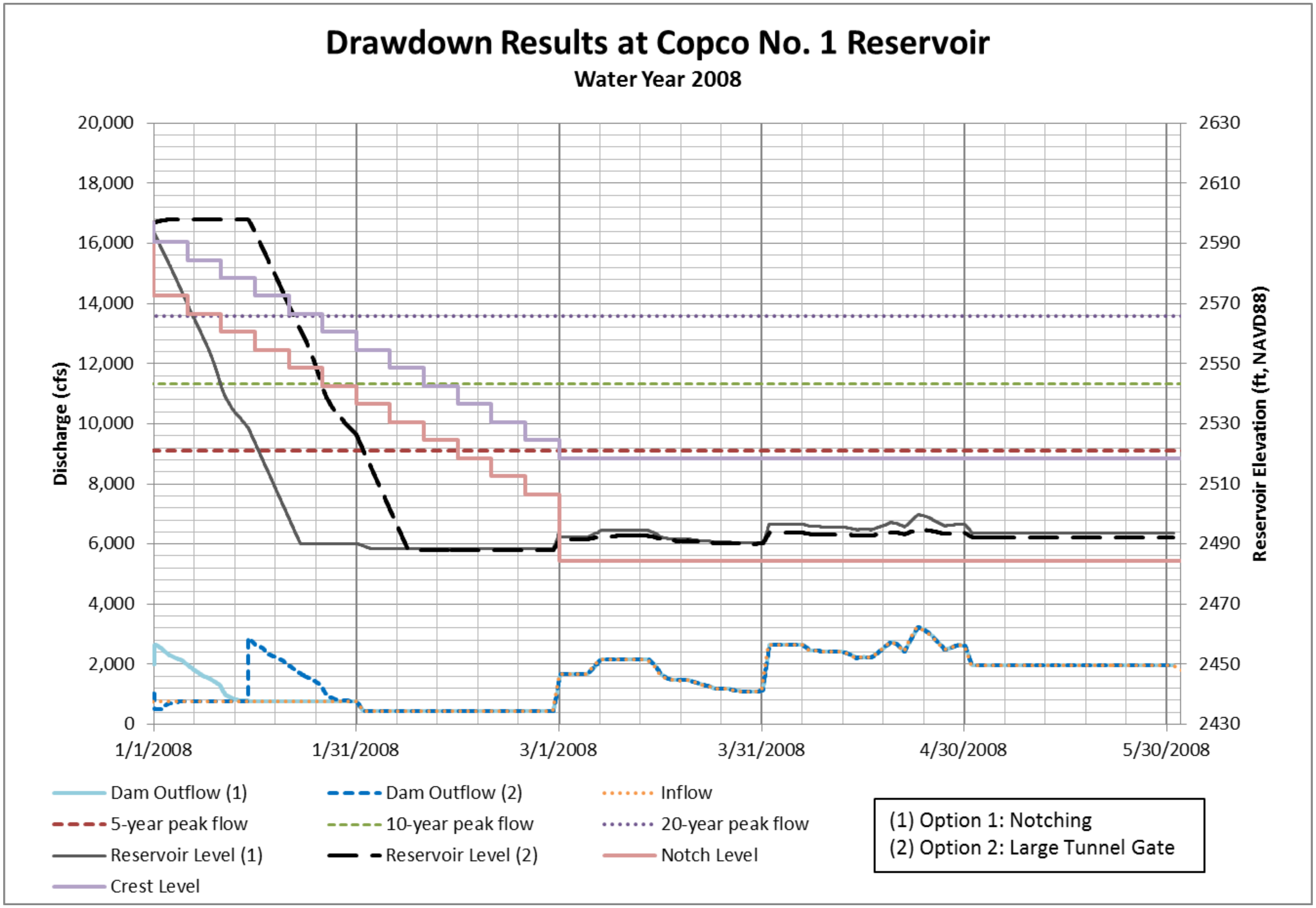

Figure 3-49 Copco No. 1 Reservoir Drawdown, Water Year 2008

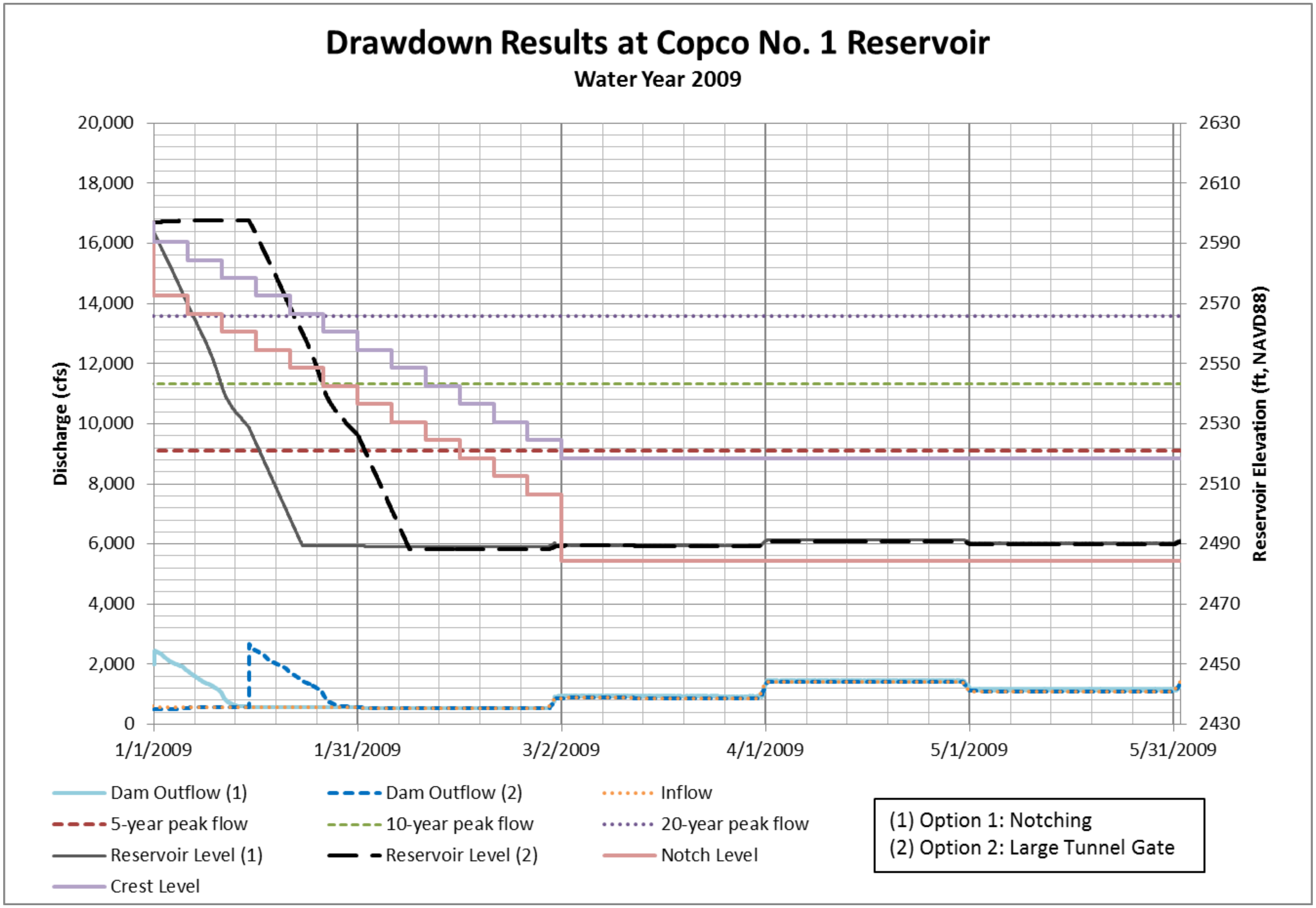

Figure 3-50 Copco No. 1 Reservoir Drawdown, Water Year 2009

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Chapter 4: Iron Gate Reservoir

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4. IRON GATE RESERVOIR

Reservoir drawdown at Iron Gate will begin from normal operating elevation 2331.3 feet on January 1, 2021 by making controlled releases through the modified diversion tunnel. Reservoir drawdown will be limited to a maximum of 5 feet per day to maintain embankment and reservoir rim slope stability. The maximum additional discharge downstream of Iron Gate 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 10,000 cfs. For reference, the 5-year flow event downstream of Iron Gate Dam is 10,900 cfs.

4.1 Results

Figures 4-1 through 4-49 show results for drawdown of Iron Gate Reservoir. Due to their close physical proximity, KRRC modeled the Iron Gate Reservoir drawdown 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. Since KRRC proposes Option 2 for the Project, the remaining results discuss only Option 2.

During representative drier years (for example1973 and 1979), Iron Gate 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 model shows Iron Gate Reservoir almost completely drawn down by March 1, but it partially refilled later in the year when storms occurred. The majority of the accumulated sediment will 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 model shows the reservoir draws down by early March, but the probability of a storm of this magnitude occurring in the drawdown year is low.

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 mainly limited to those periods when flows are below the 10-year flood elevation. KRRC does not anticipate that sediment concentrations resulting from the proposed drawdown procedure and associated hydraulics would differ from those previously estimated (USBR 2012c).

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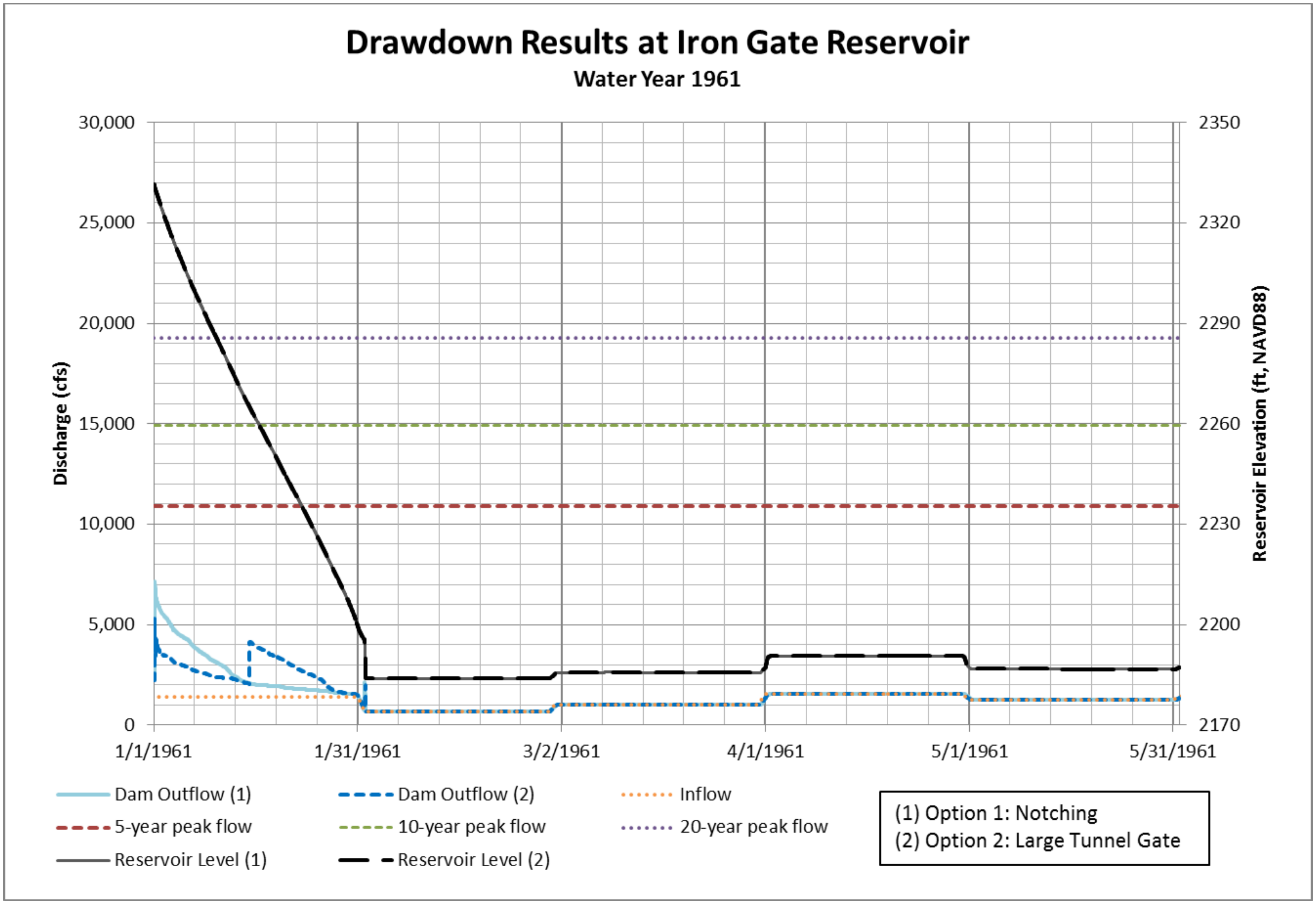

Figure 4-1 Iron Gate Reservoir Drawdown, Water Year 1961

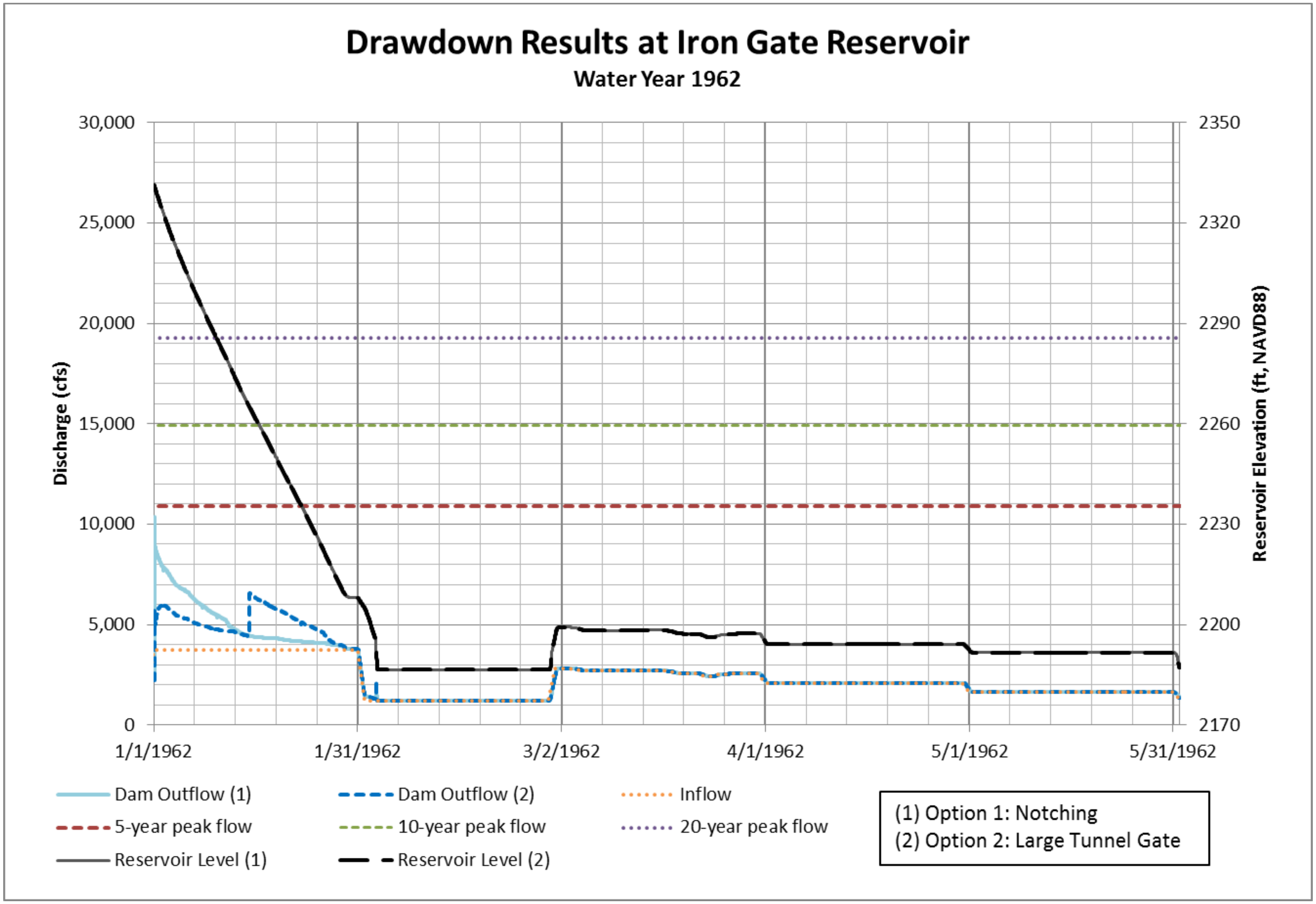

Figure 4-2 **Iron Gate Reservoir Drawdown, Water Year 1962**

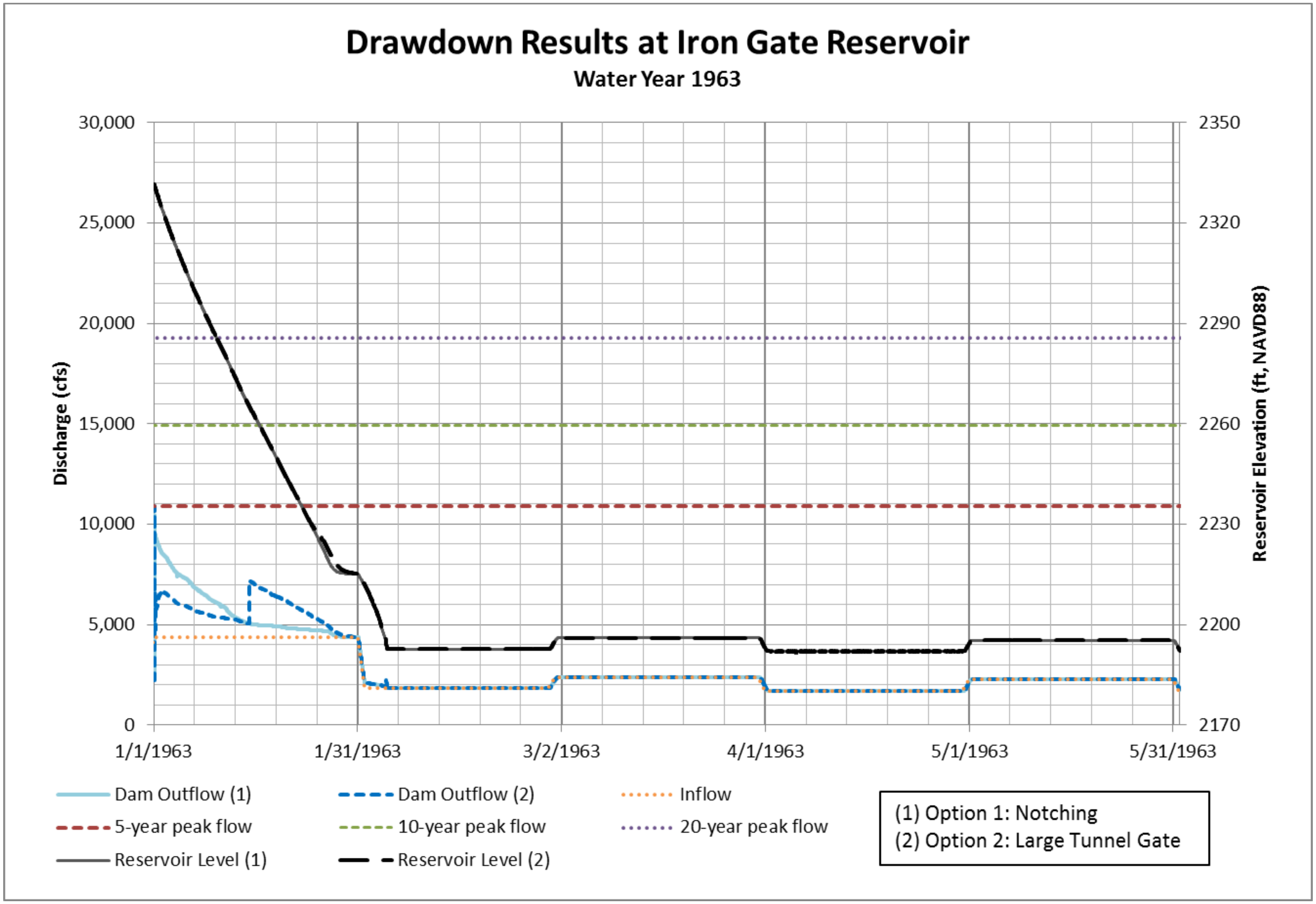

Figure 4-3 Iron Gate Reservoir Drawdown, Water Year 1963

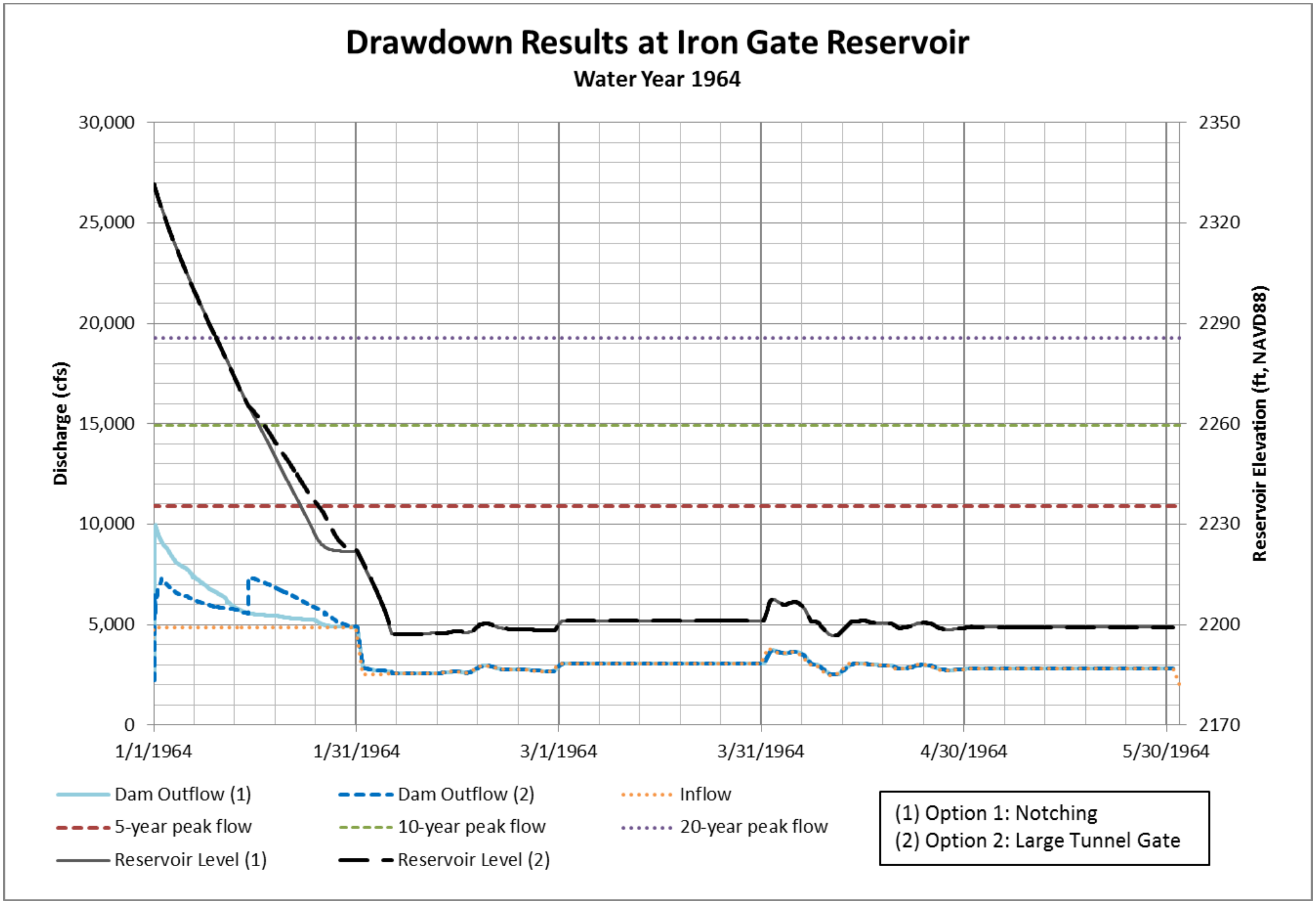

Figure 4-4 **Iron Gate Reservoir Drawdown, Water Year 1964**

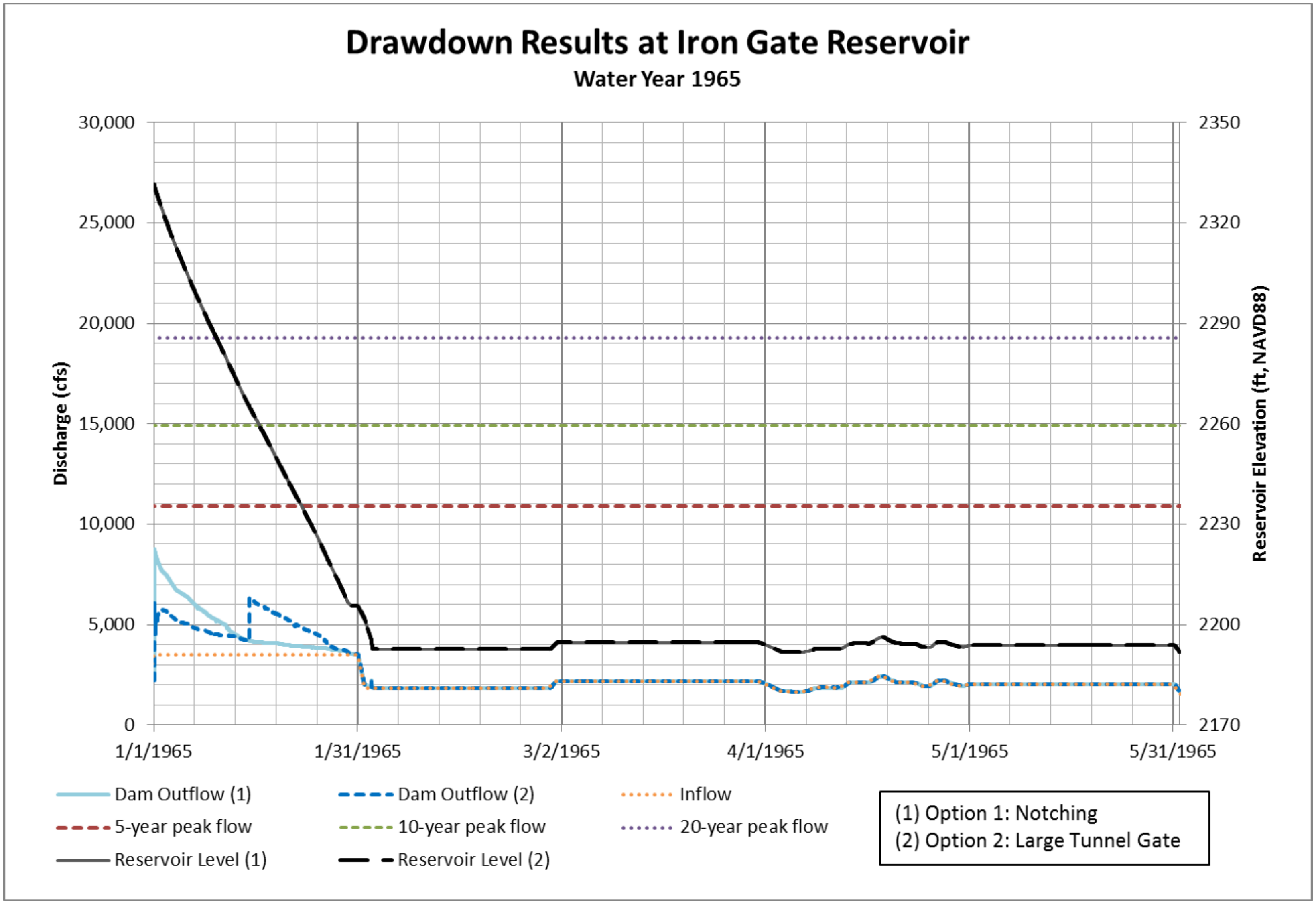

Figure 4-5 Iron Gate Reservoir Drawdown, Water Year 1965

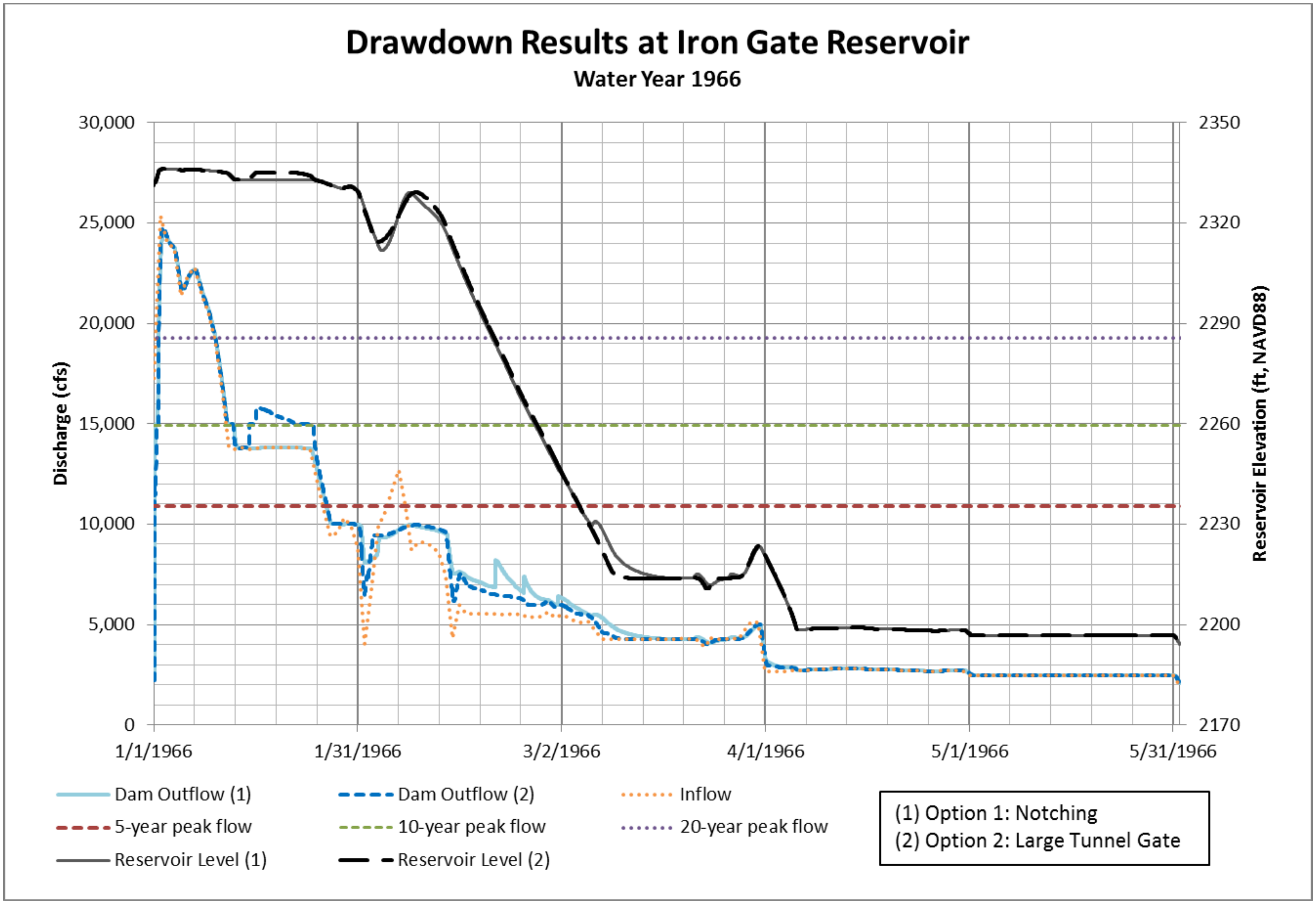

Figure 4-6 Iron Gate Reservoir Drawdown, Water Year 1966

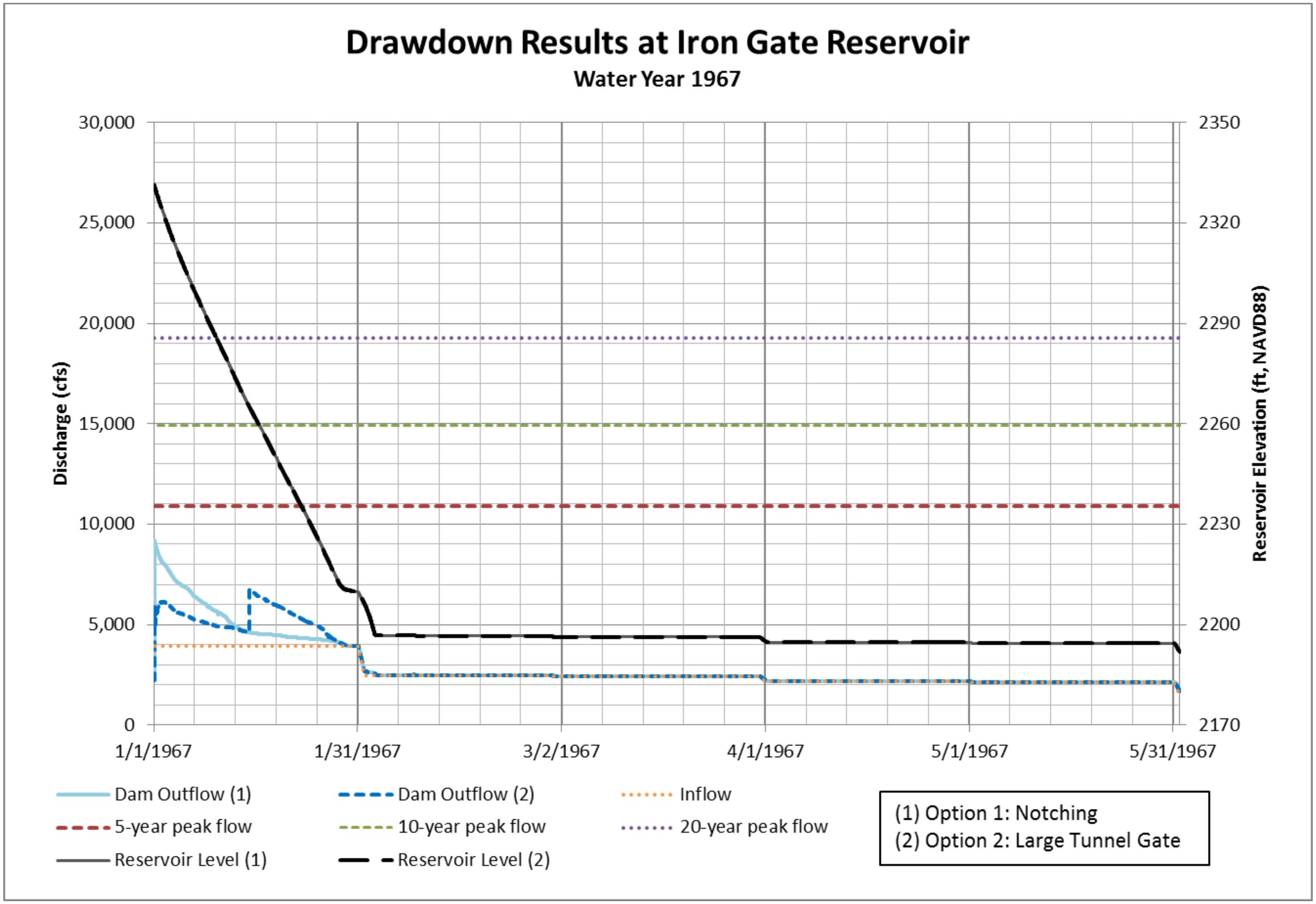

Figure 4-7 Iron Gate Reservoir Drawdown, Water Year 1967

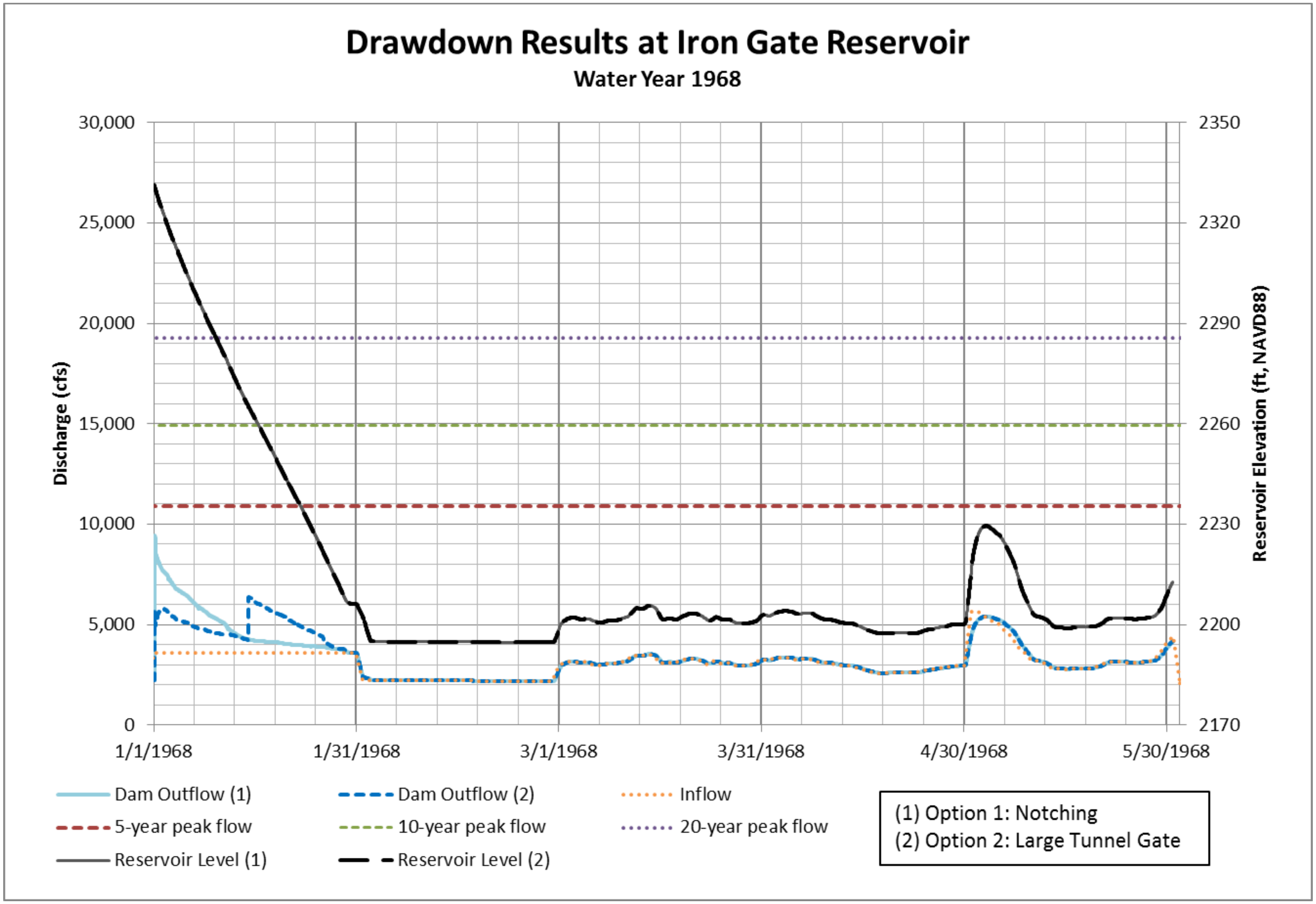

Figure 4-8 Iron Gate Reservoir Drawdown, Water Year 1968

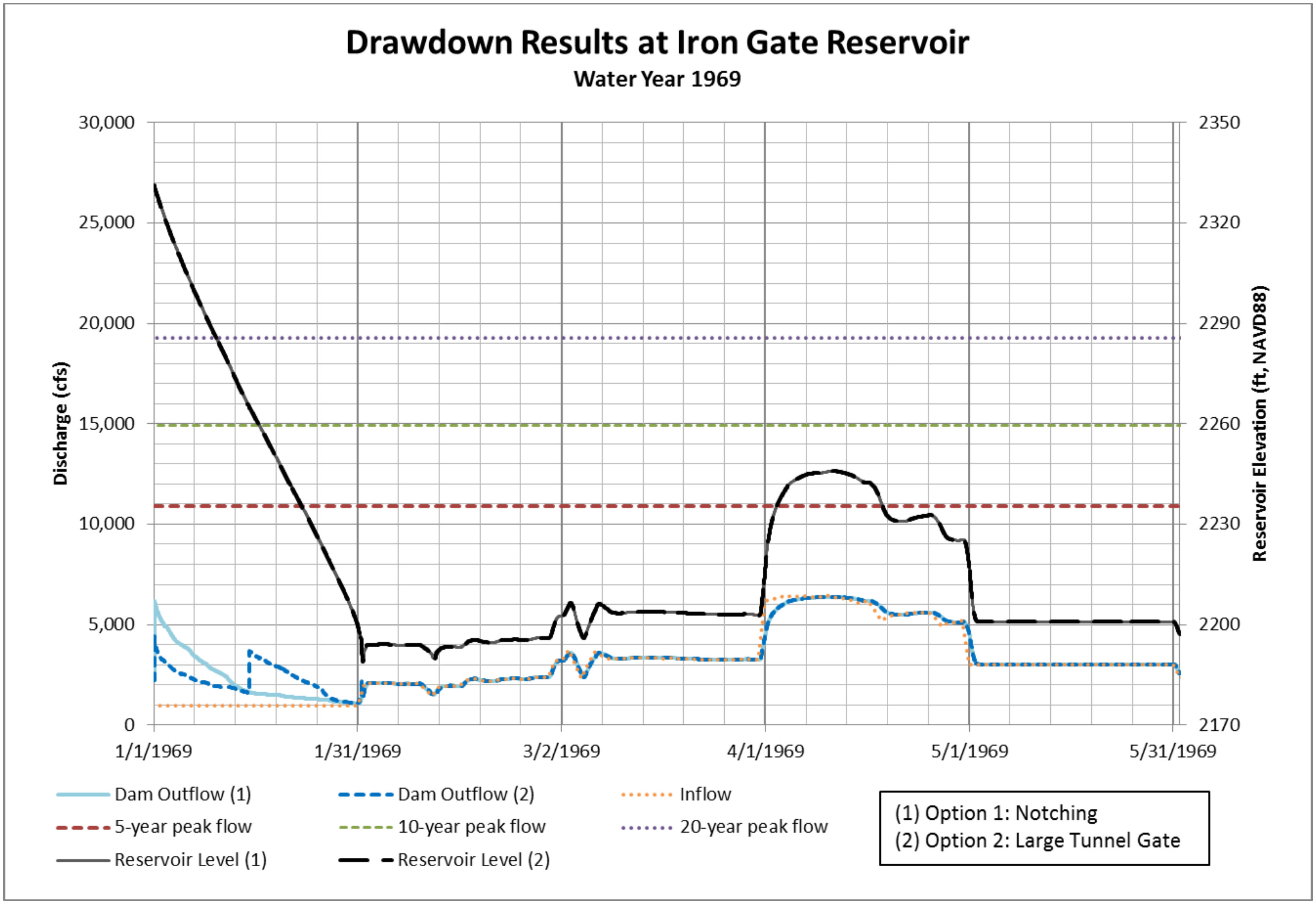

Figure 4-9 Iron Gate Reservoir Drawdown, Water Year 1969

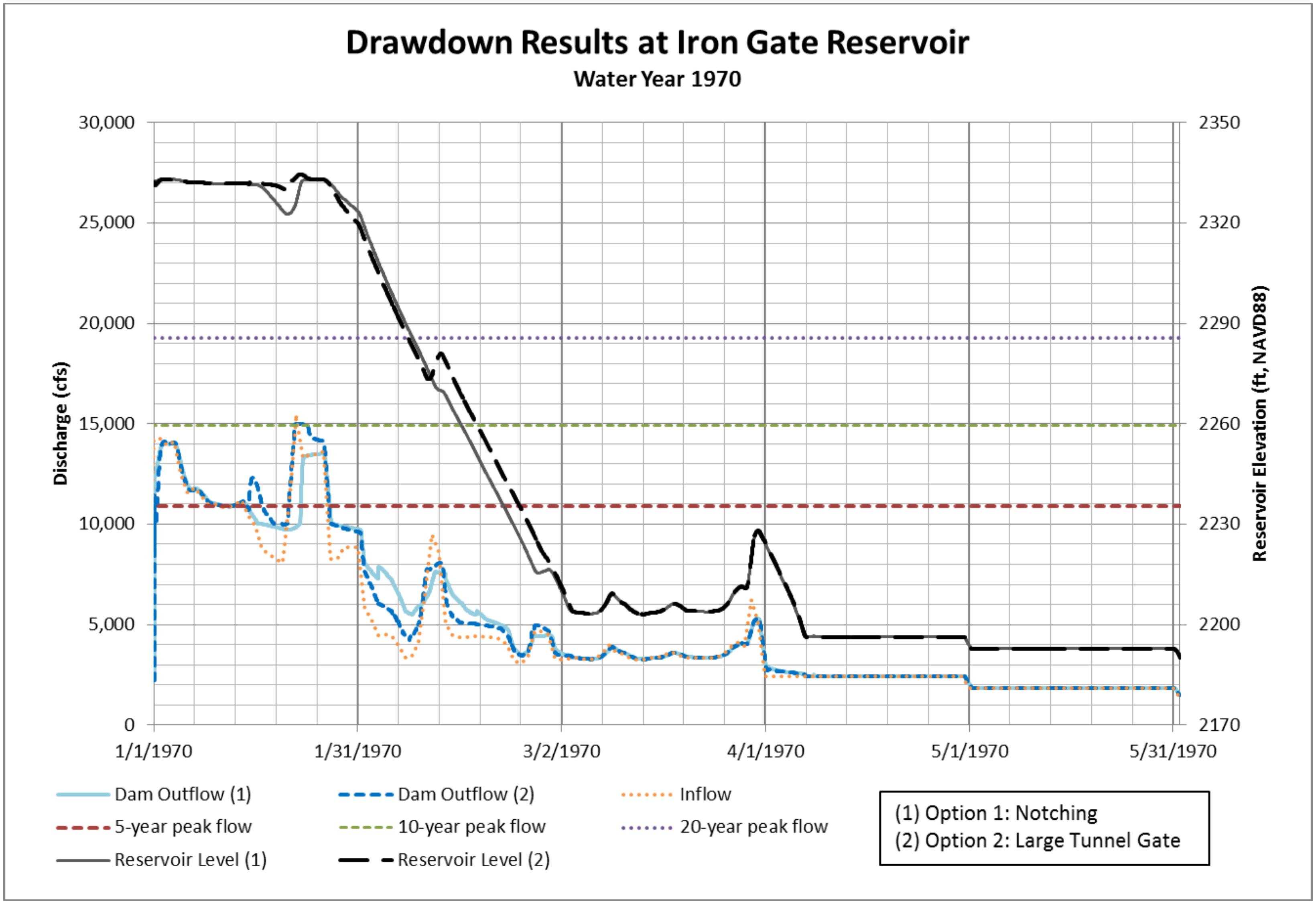

Figure 4-10 Iron Gate Reservoir Drawdown, Water Year 1970

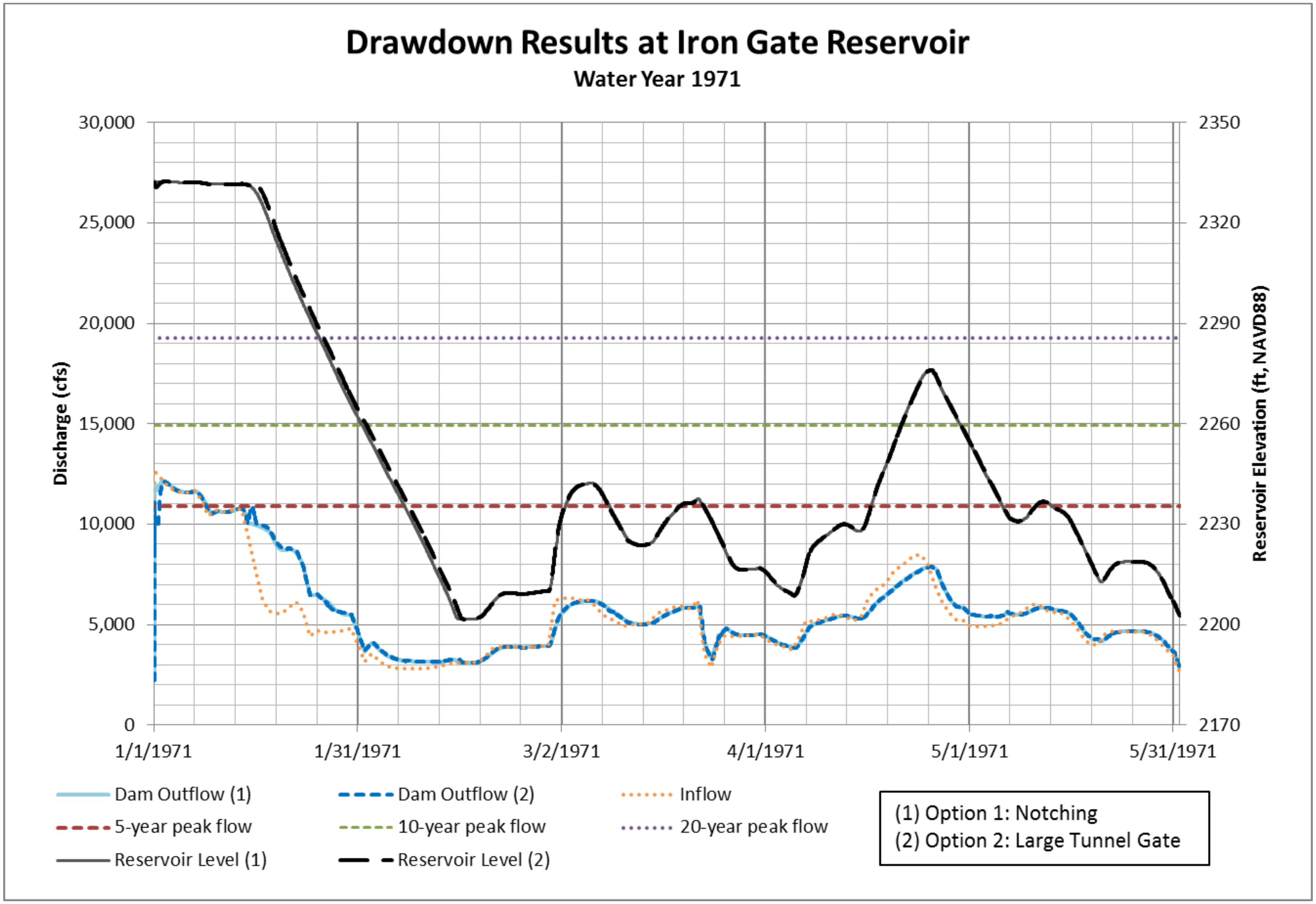

Figure 4-11 Iron Gate Reservoir Drawdown, Water Year 1971

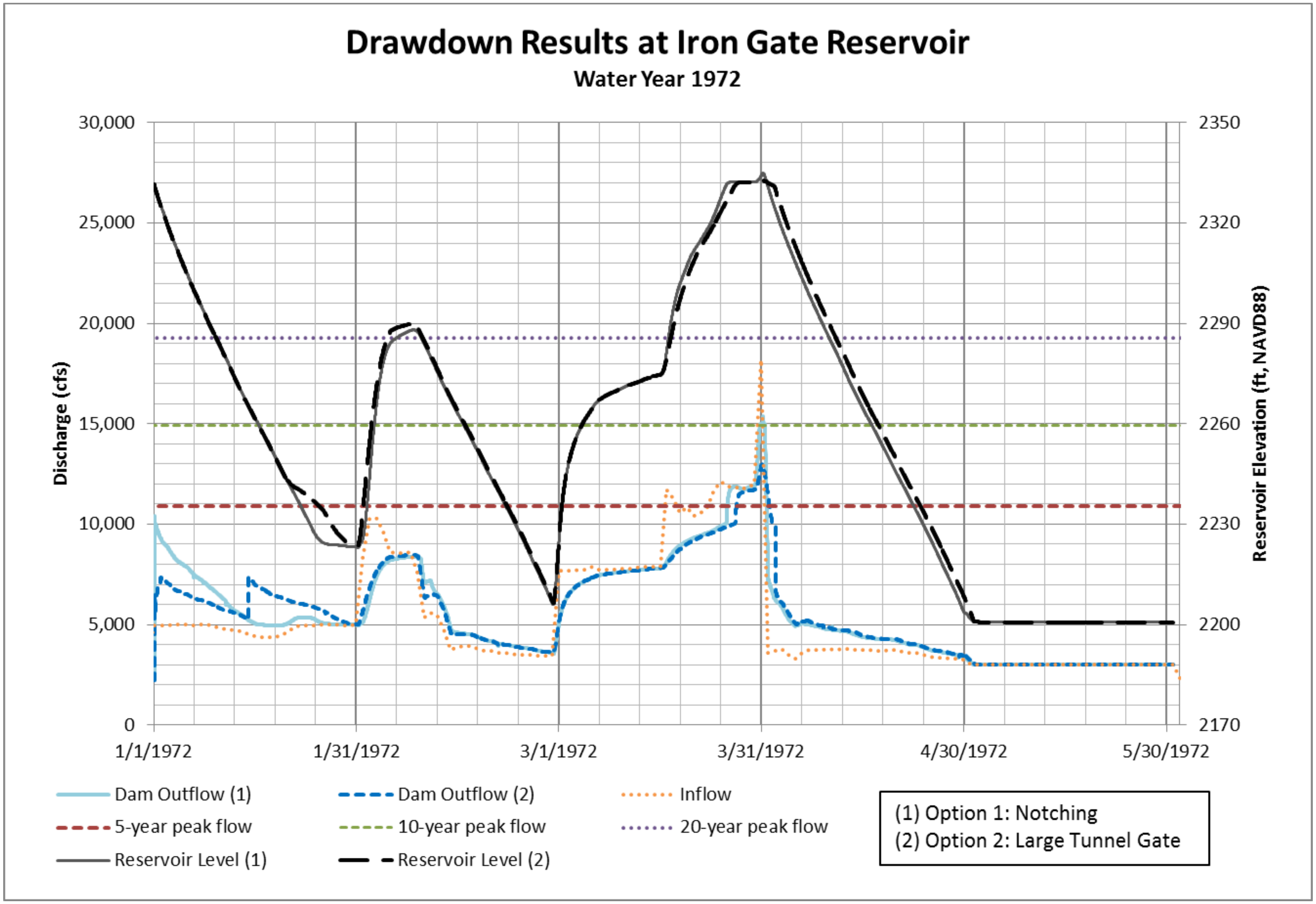

Figure 4-12 **Iron Gate Reservoir Drawdown, Water Year 1972**

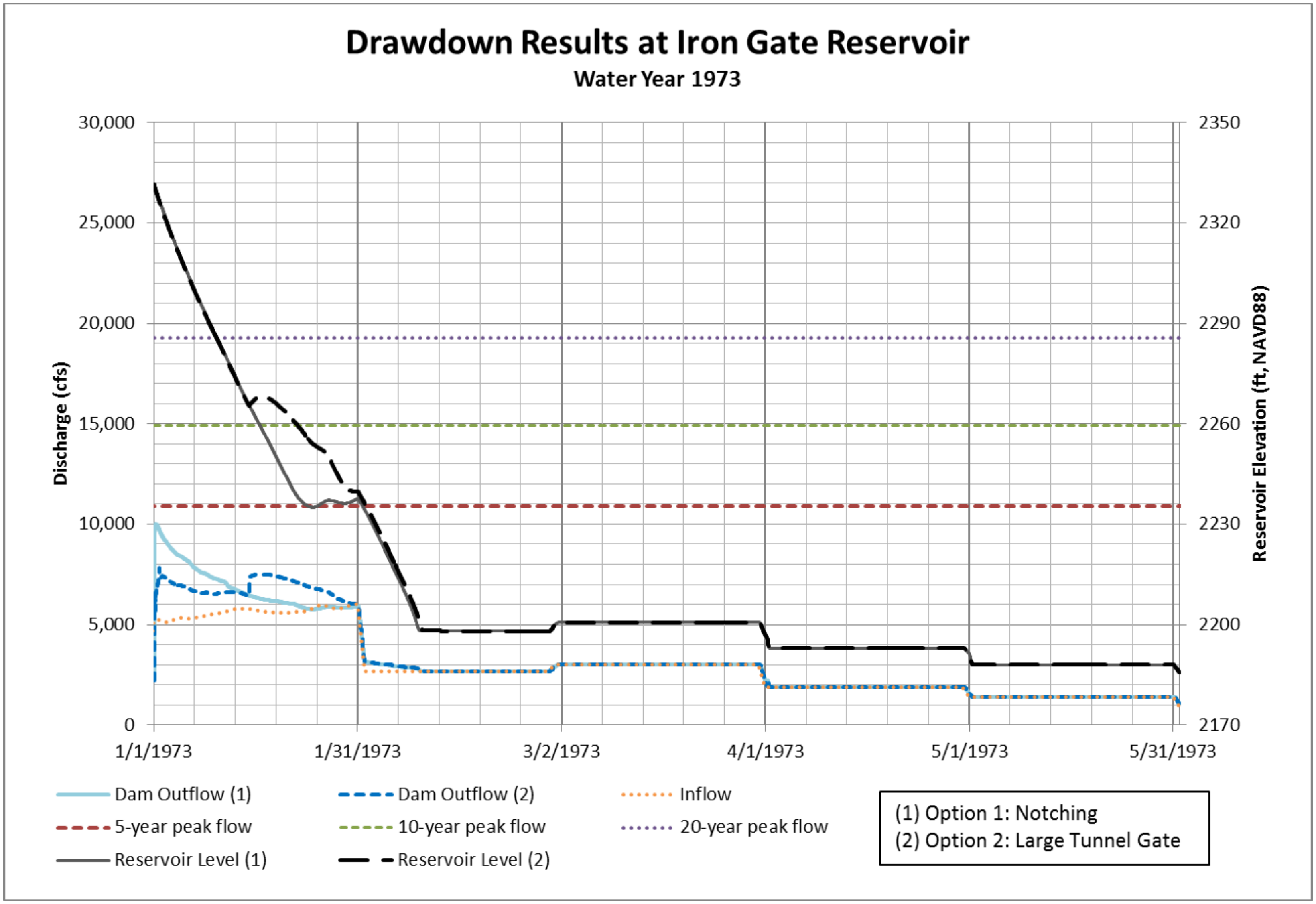

Figure 4-13 **Iron Gate Reservoir Drawdown, Water Year 1973**

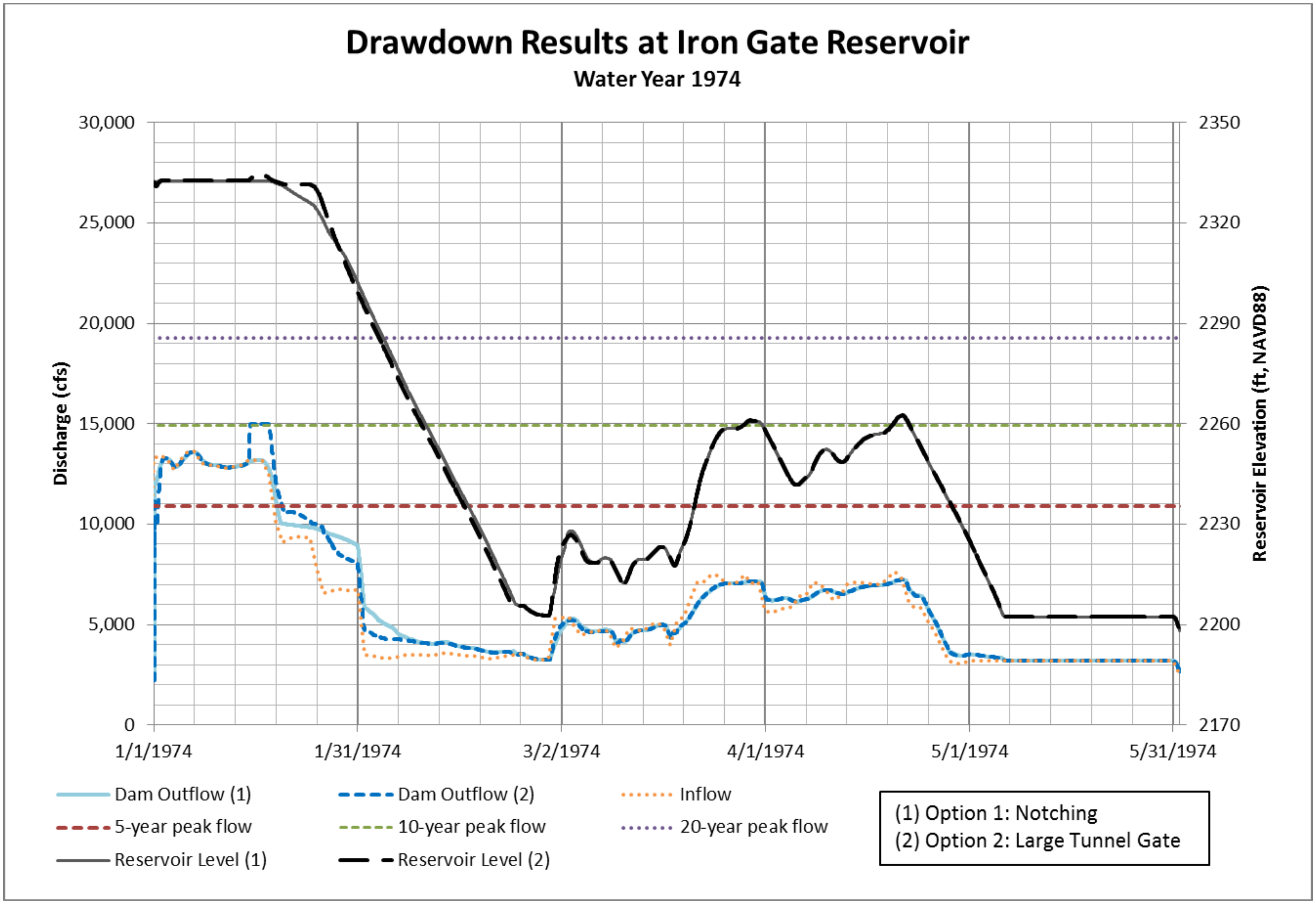

Figure 4-14 Iron Gate Reservoir Drawdown, Water Year 1974

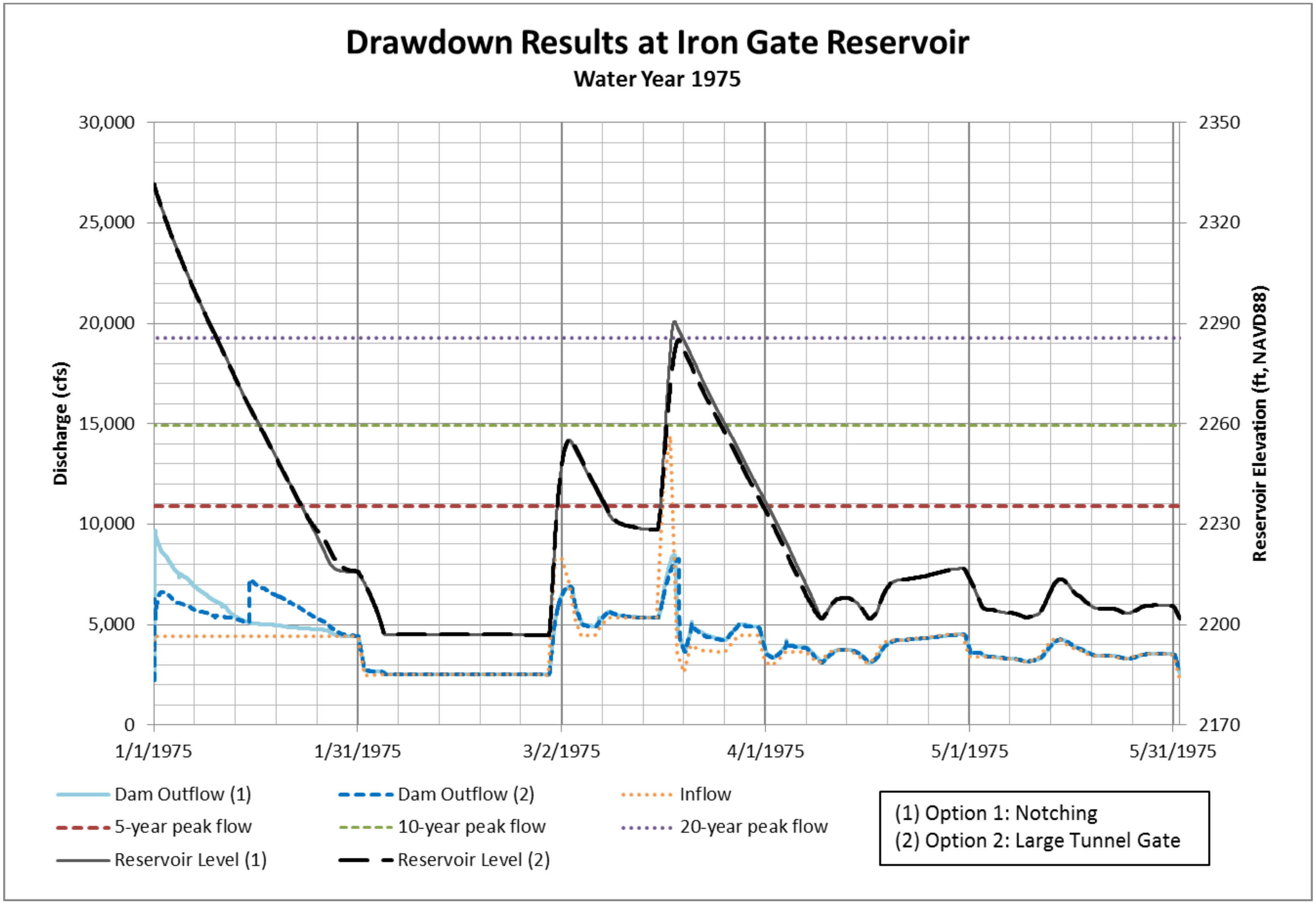

Figure 4-15 Iron Gate Reservoir Drawdown, Water Year 1975

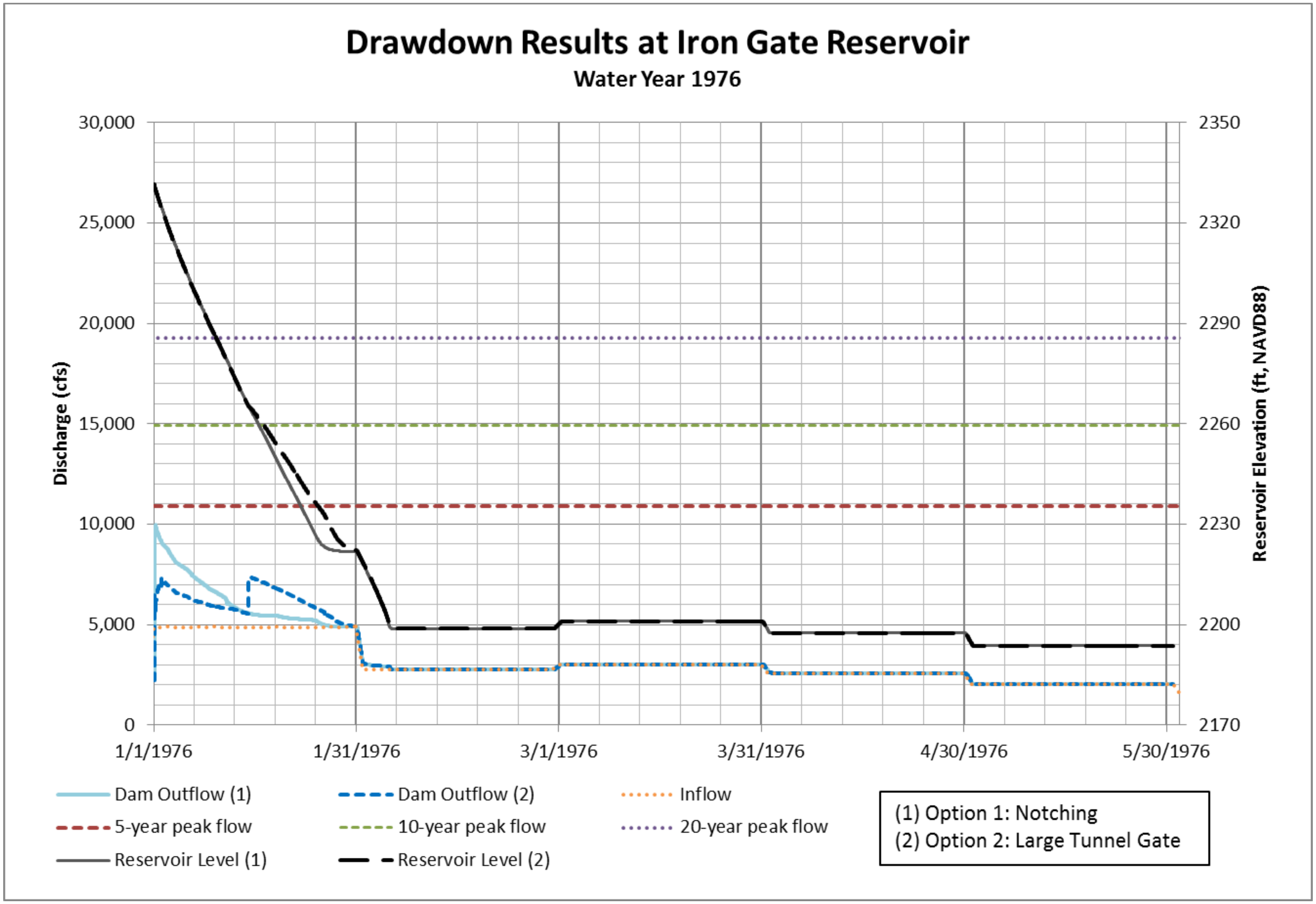

Figure 4-16 Iron Gate Reservoir Drawdown, Water Year 1976

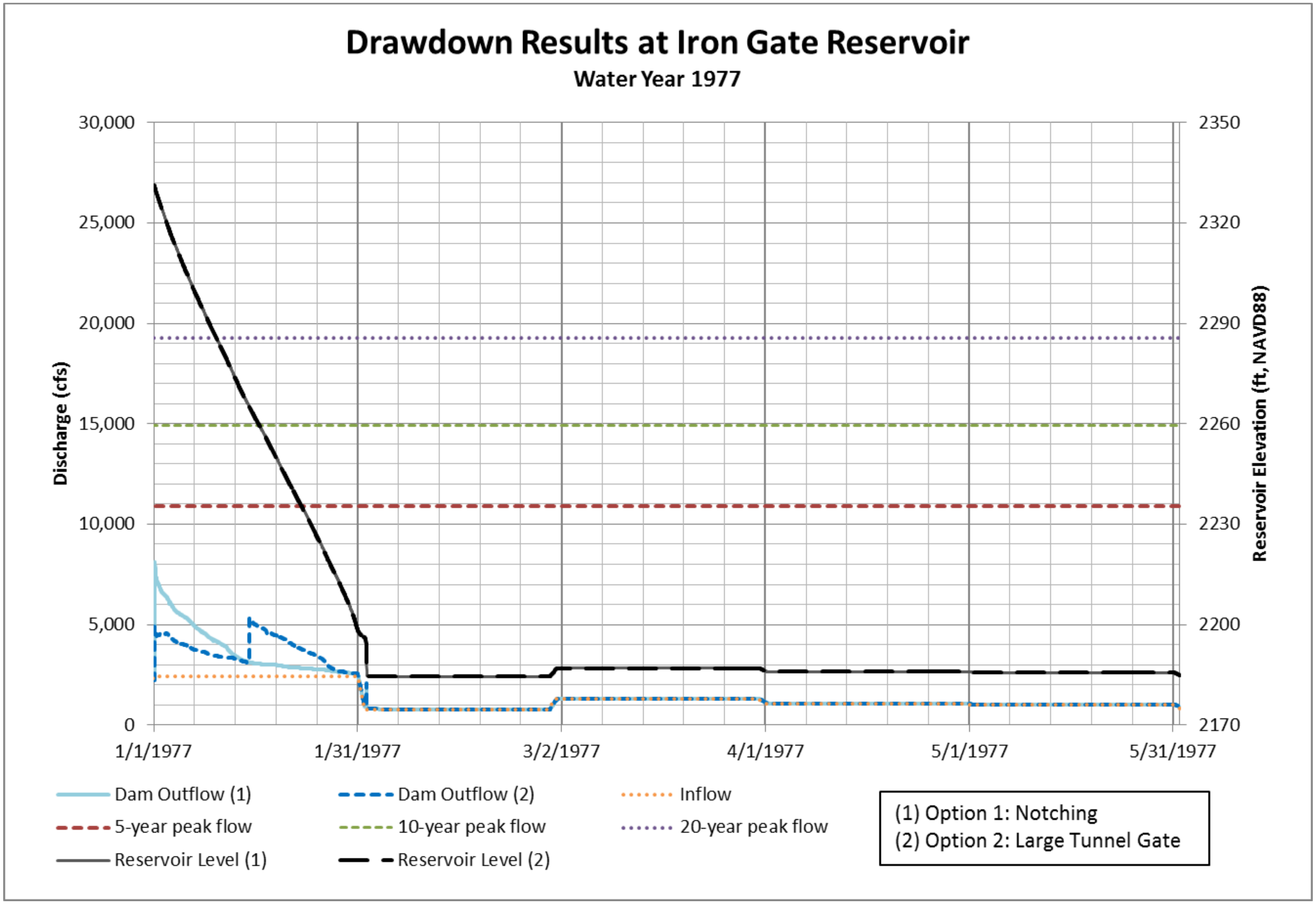

Figure 4-17 Iron Gate Reservoir Drawdown, Water Year 1977

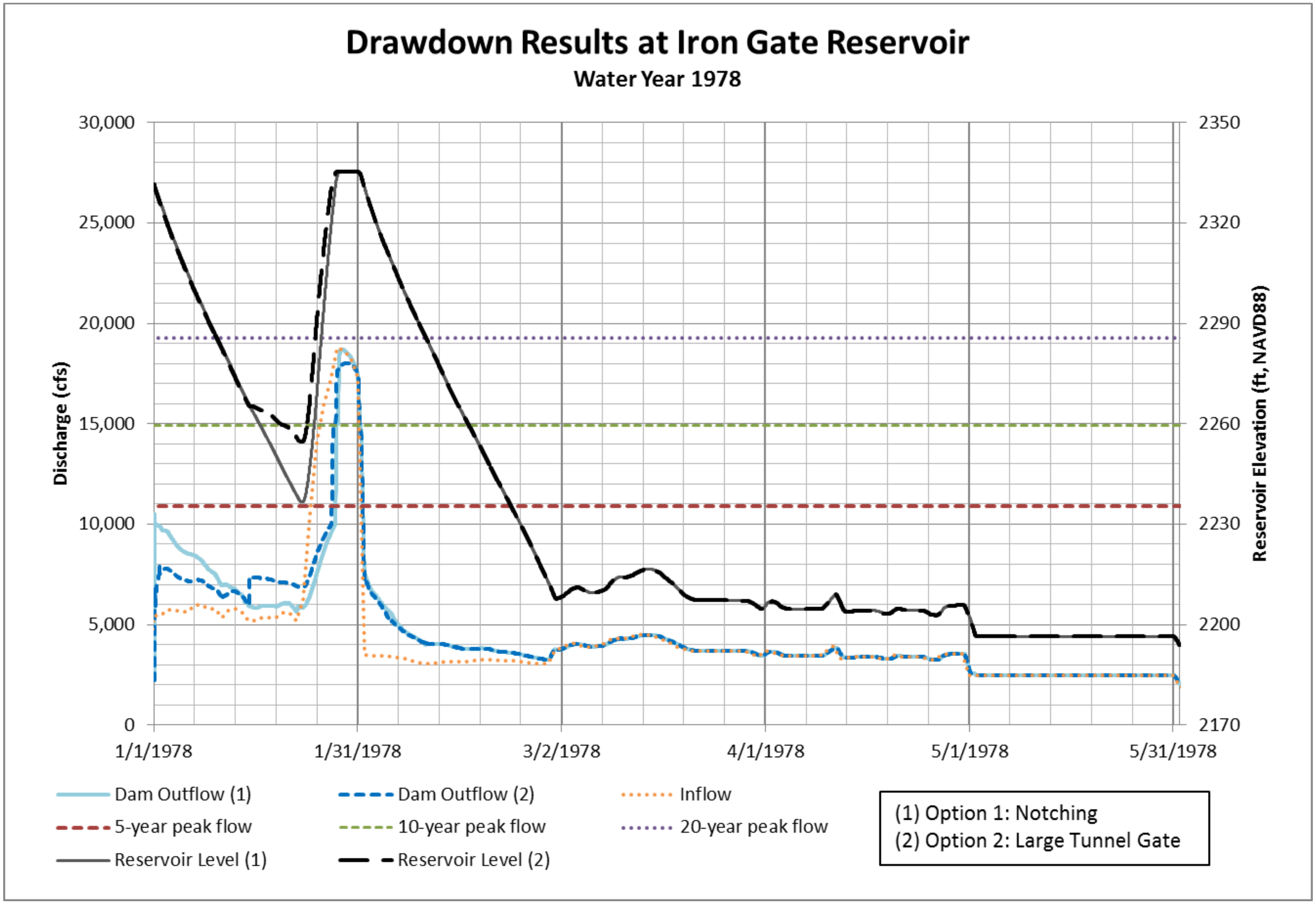

Figure 4-18 Iron Gate Reservoir Drawdown, Water Year 1978

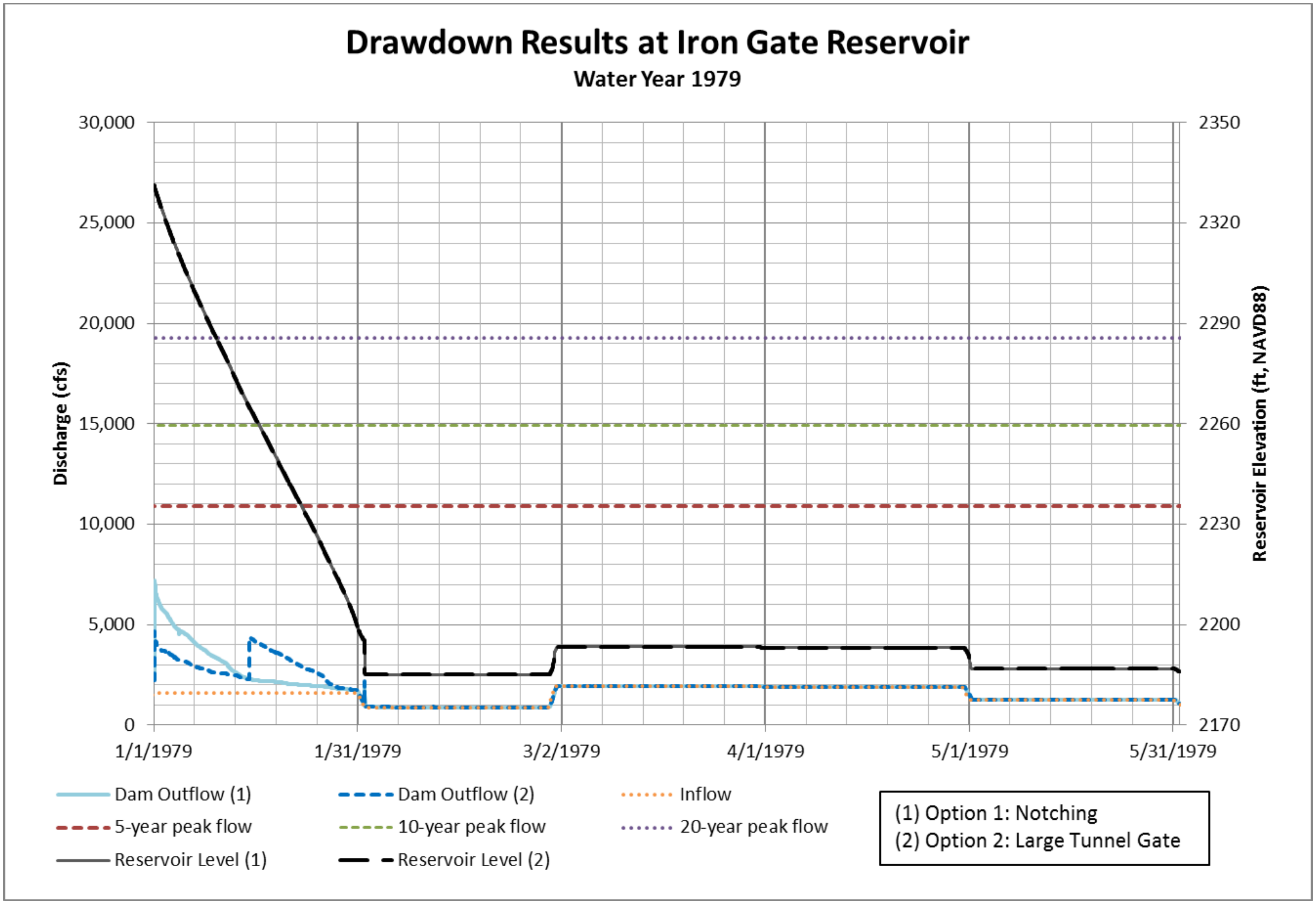

Figure 4-19 Iron Gate Reservoir Drawdown, Water Year 1979

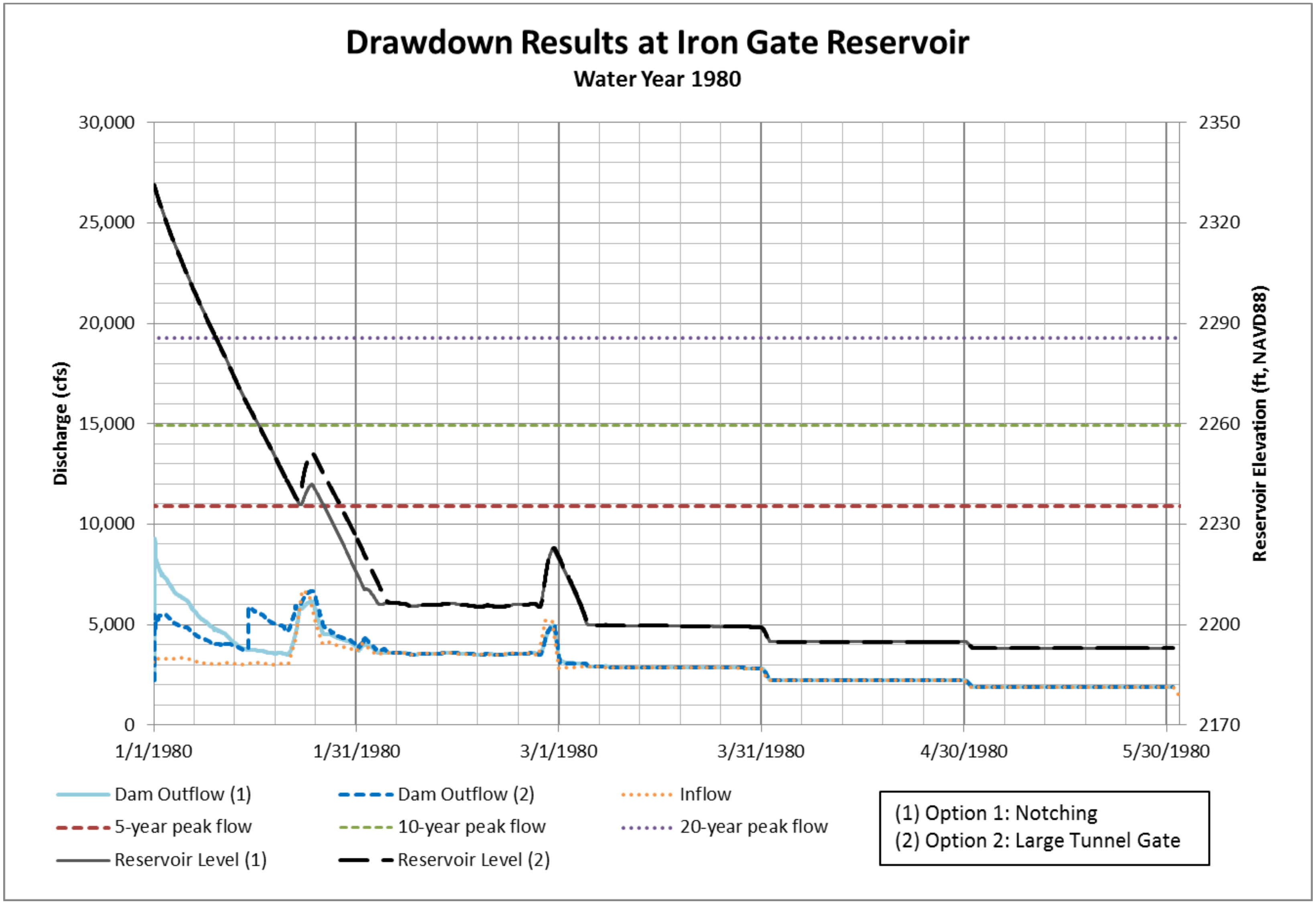

Figure 4-20 **Iron Gate Reservoir Drawdown, Water Year 1980**

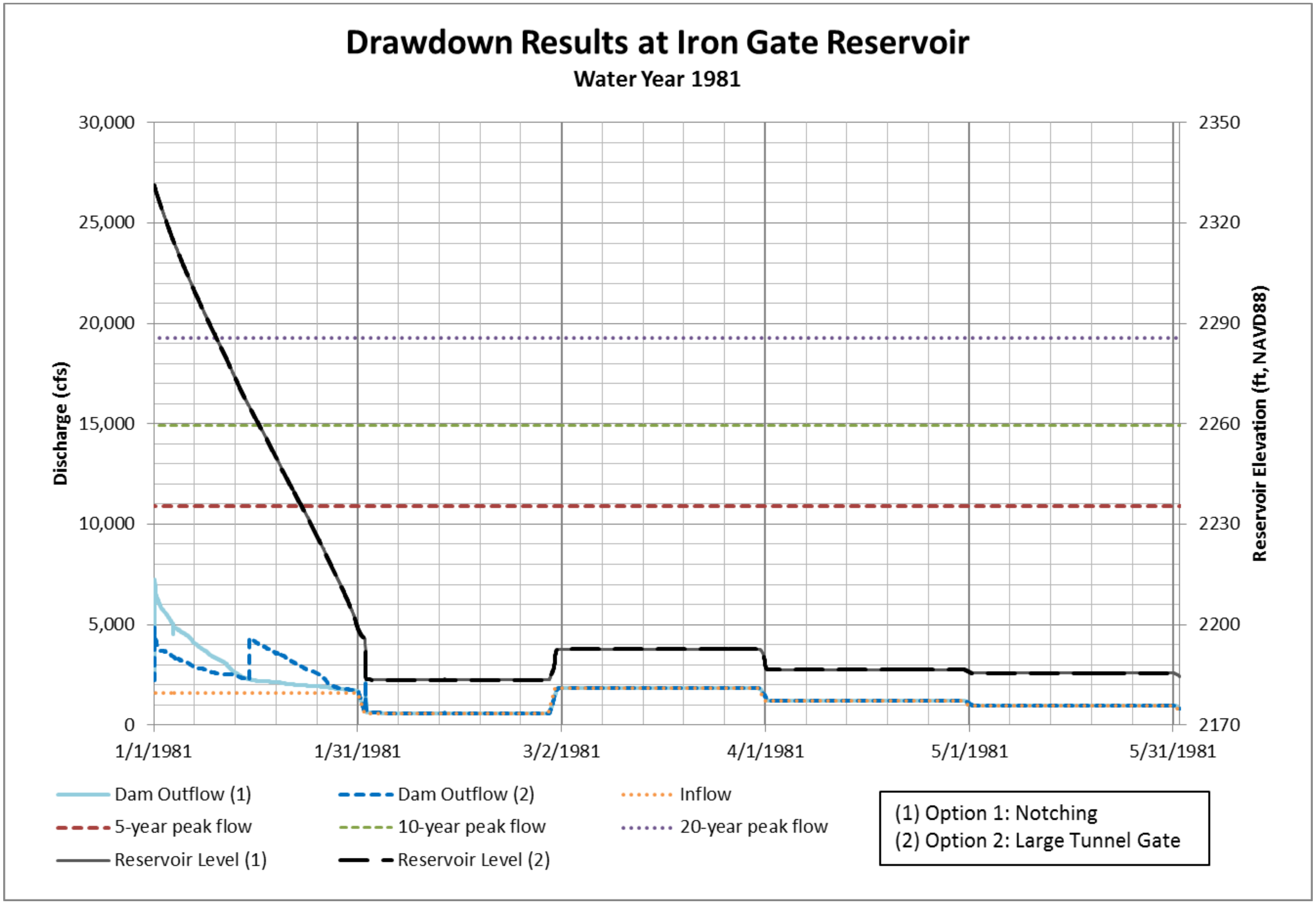

Figure 4-21 Iron Gate Reservoir Drawdown, Water Year 1981

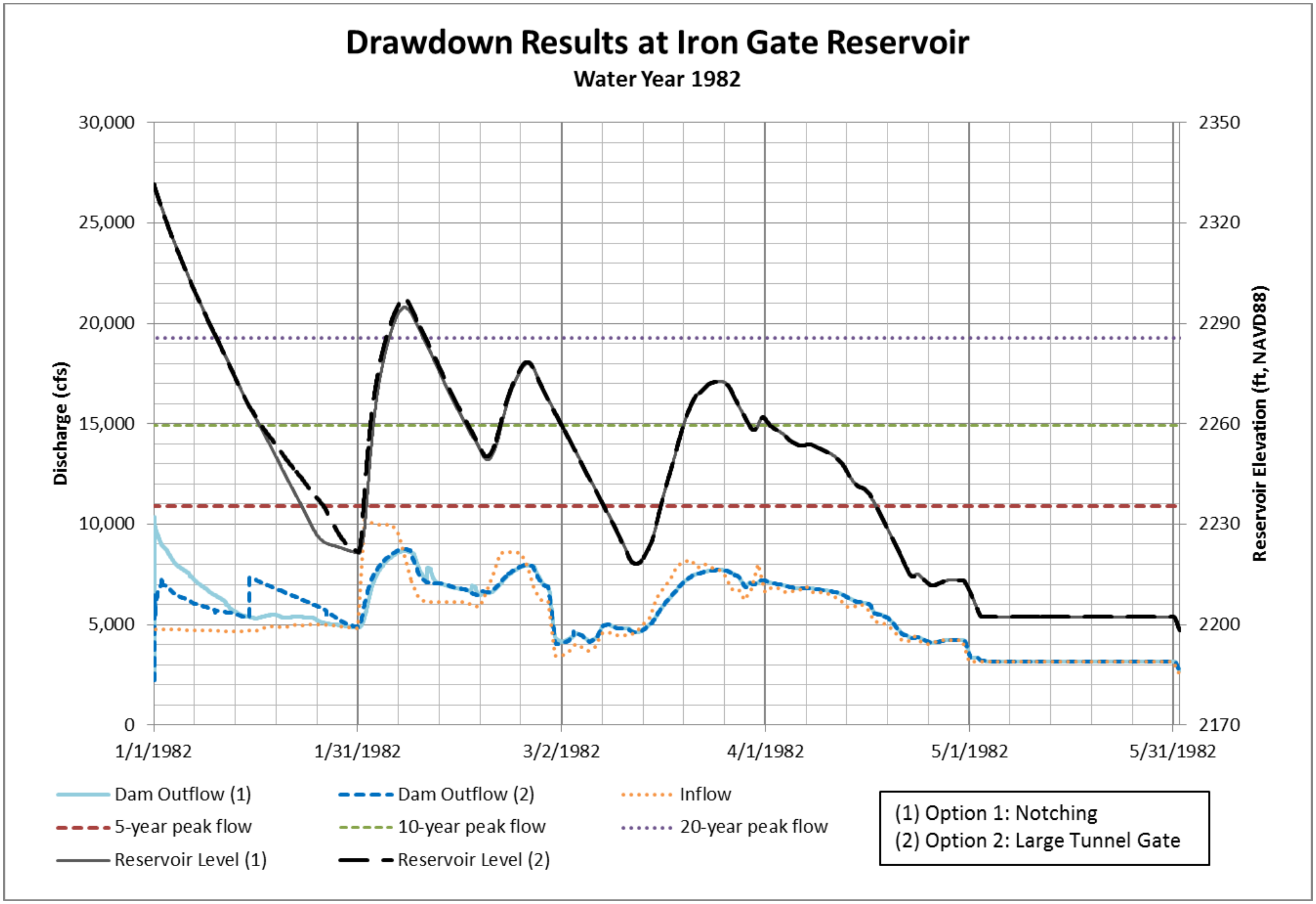

Figure 4-22 Iron Gate Reservoir Drawdown, Water Year 1982

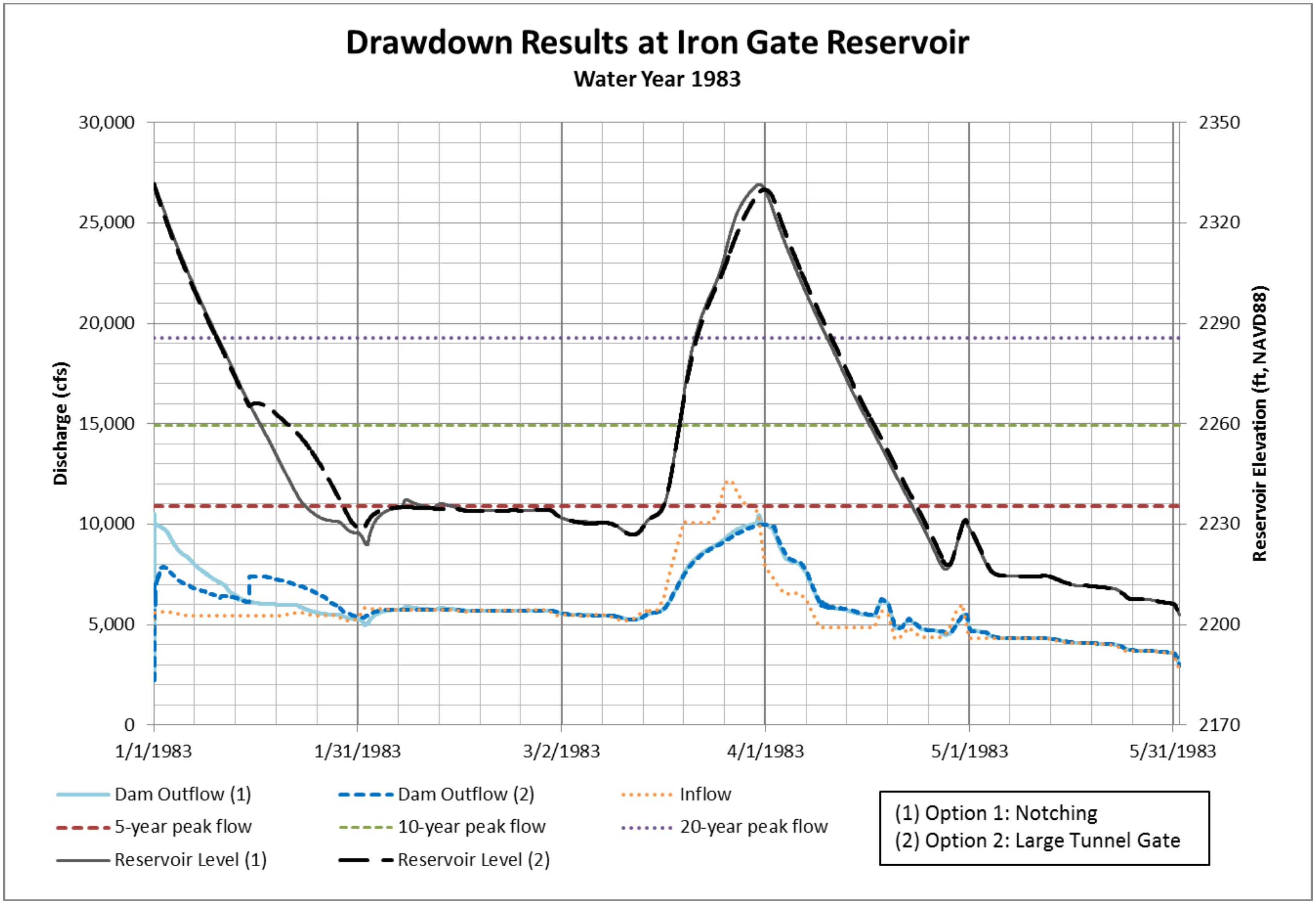

Figure 4-23 Iron Gate Reservoir Drawdown, Water Year 1983

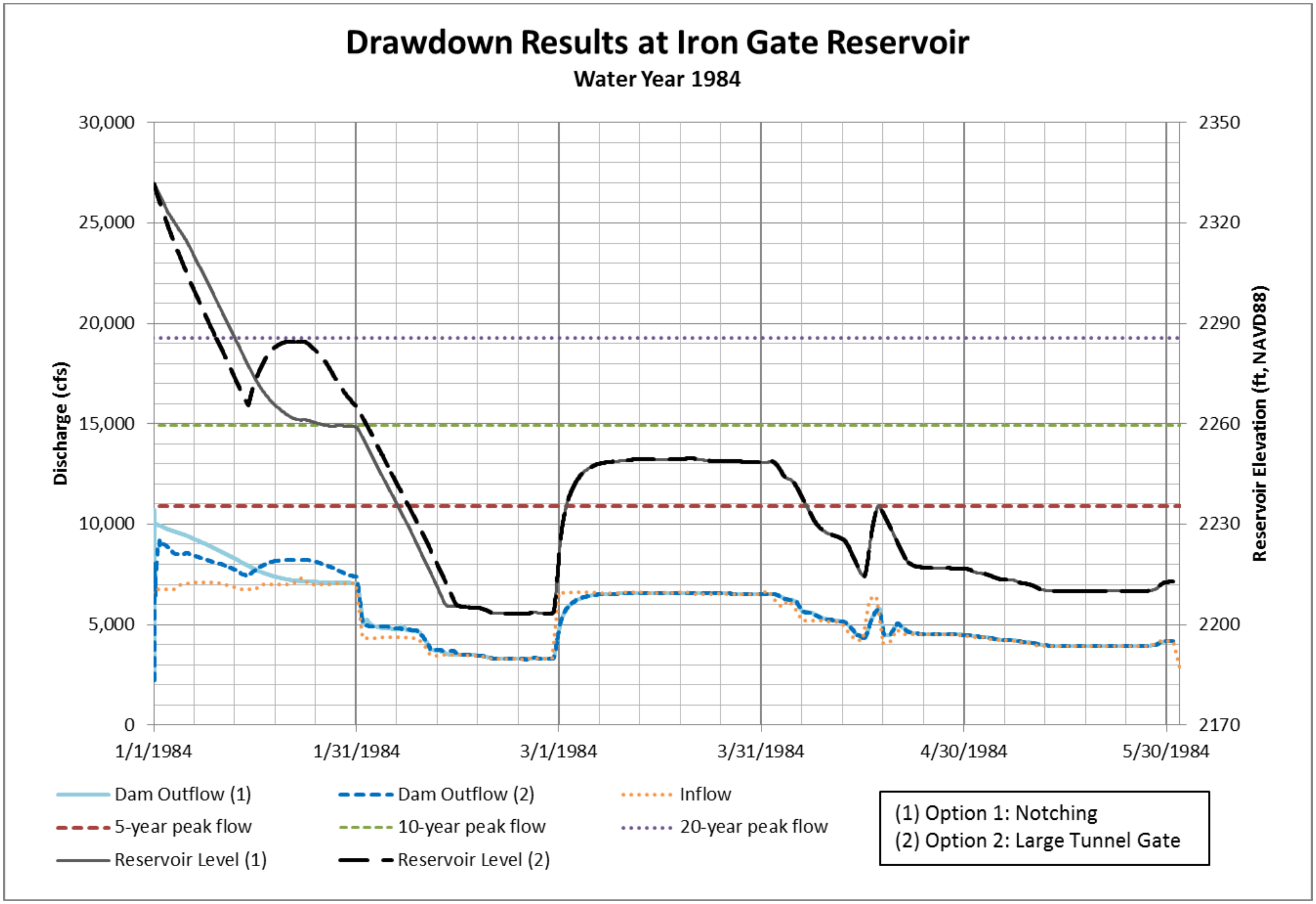

Figure 4-24 Iron Gate Reservoir Drawdown, Water Year 1984

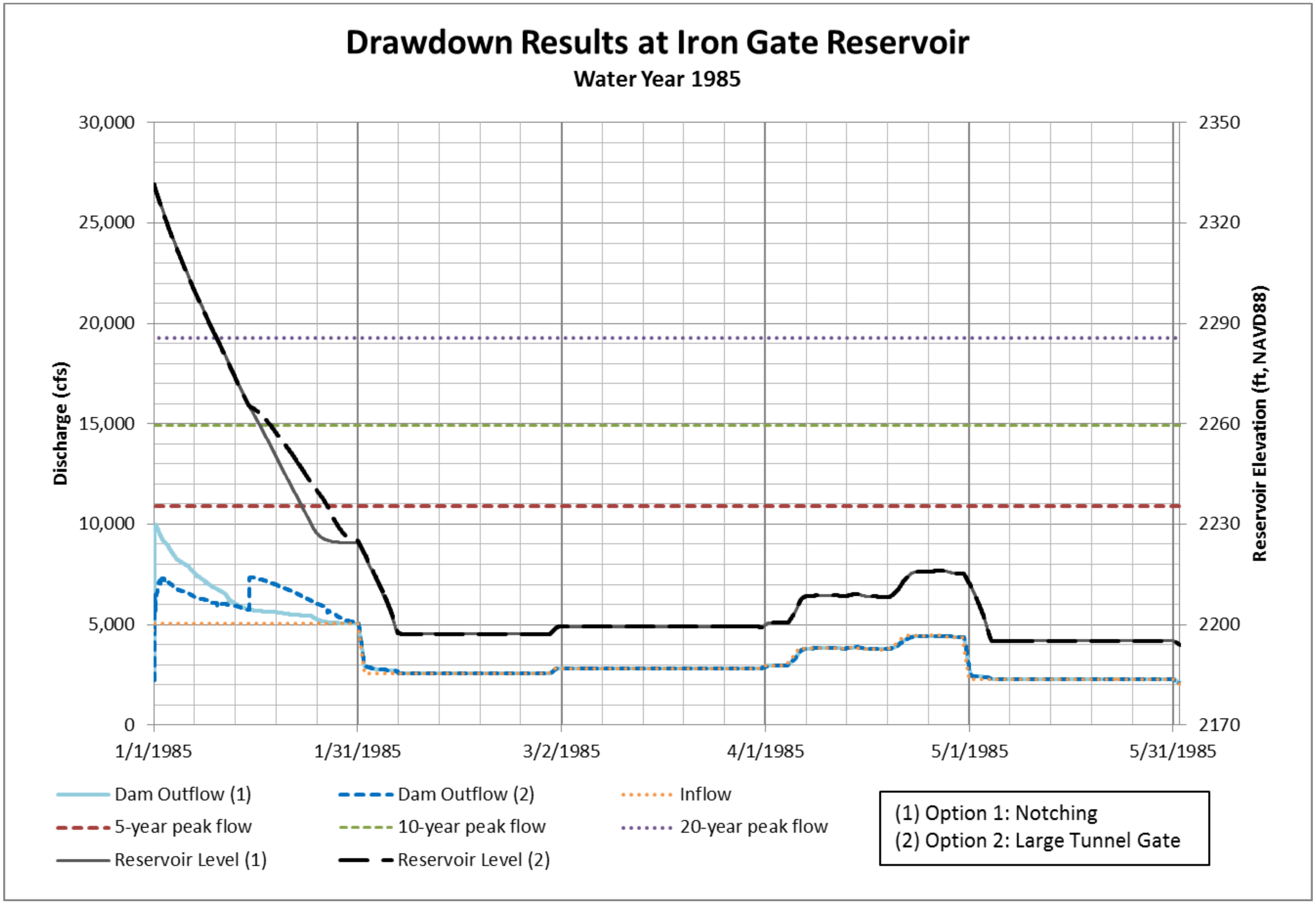

Figure 4-25 Iron Gate Reservoir Drawdown, Water Year 1985

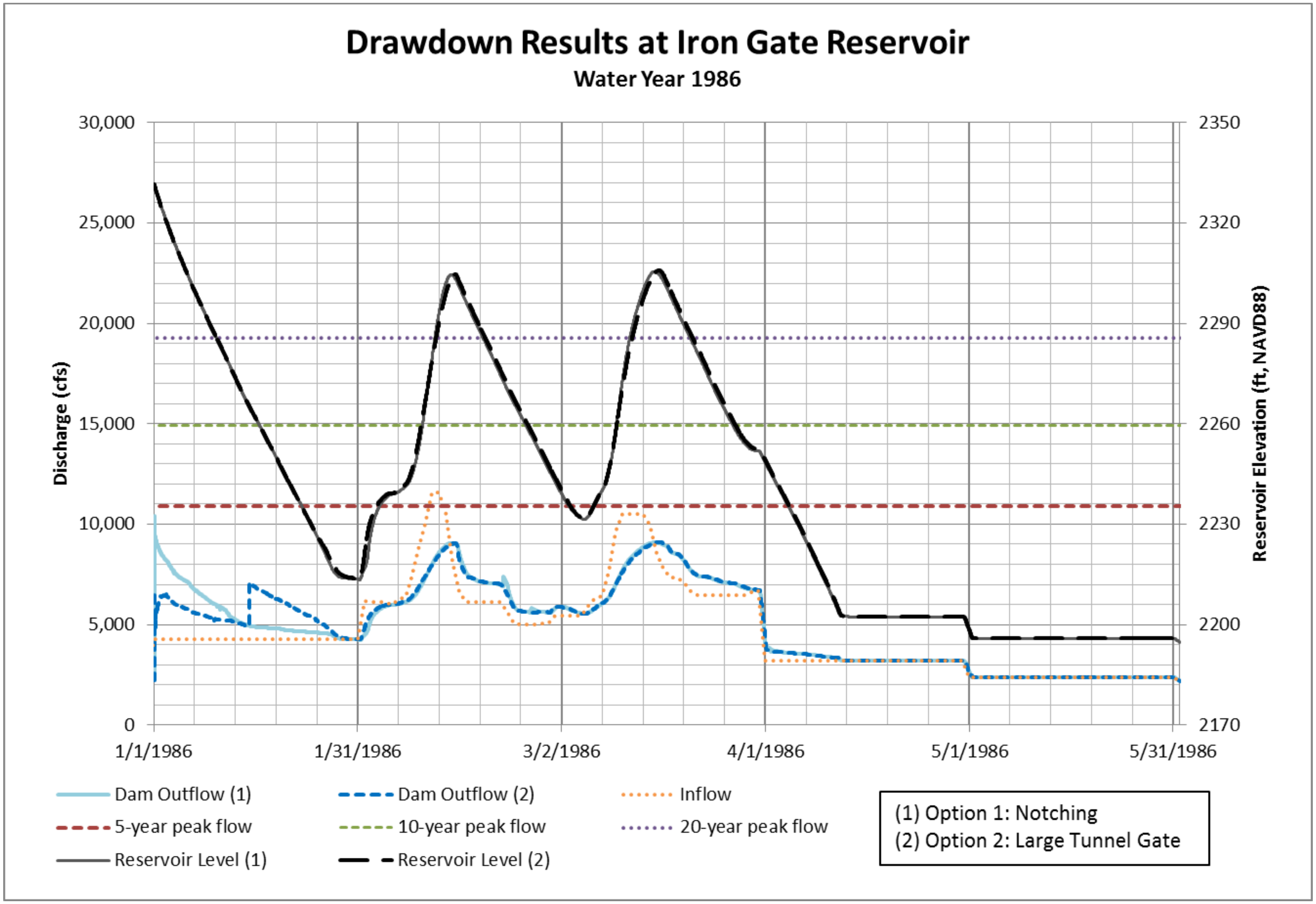

Figure 4-26 Iron Gate Reservoir Drawdown, Water Year 1986

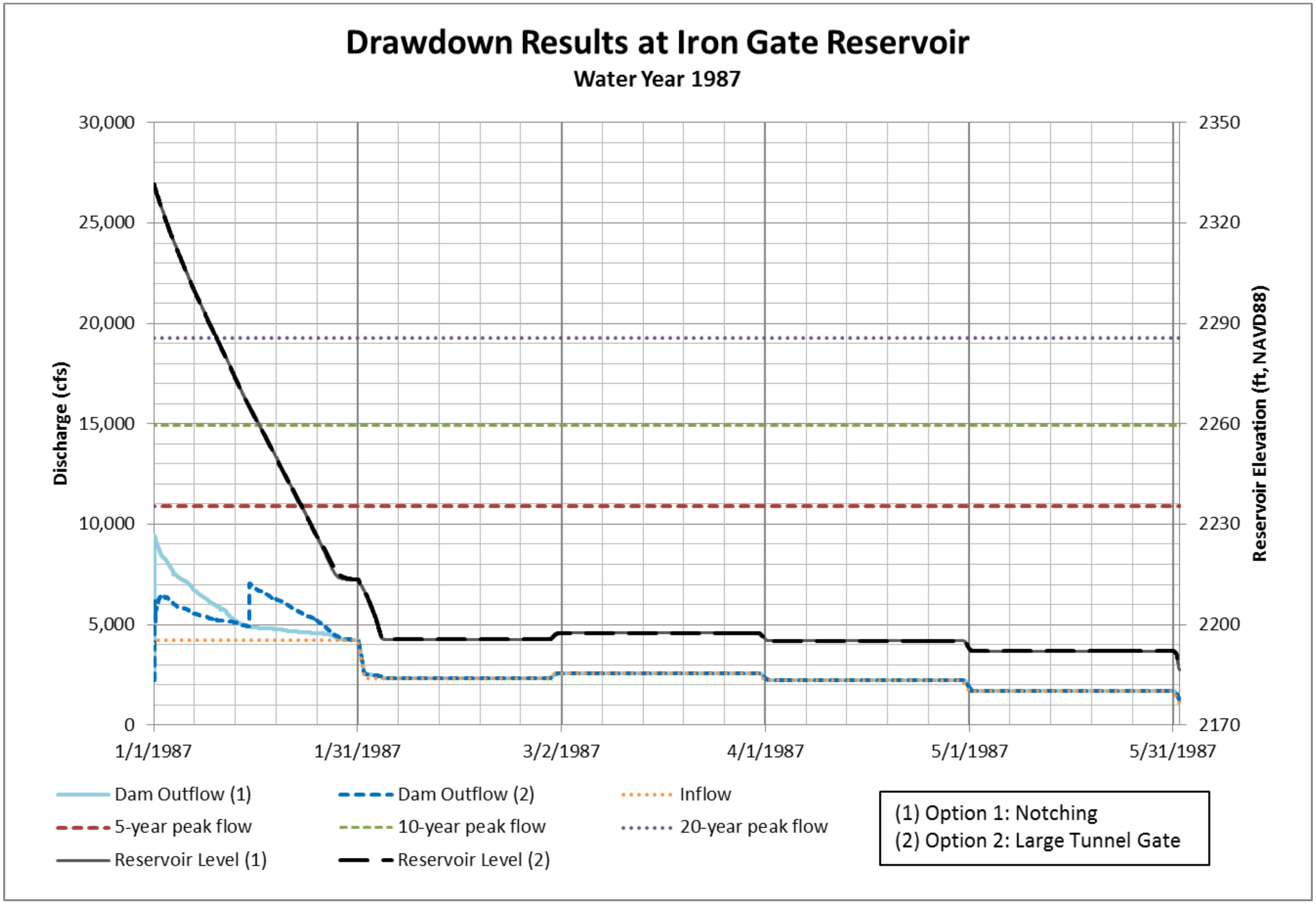

Figure 4-27 Iron Gate Reservoir Drawdown, Water Year 1987

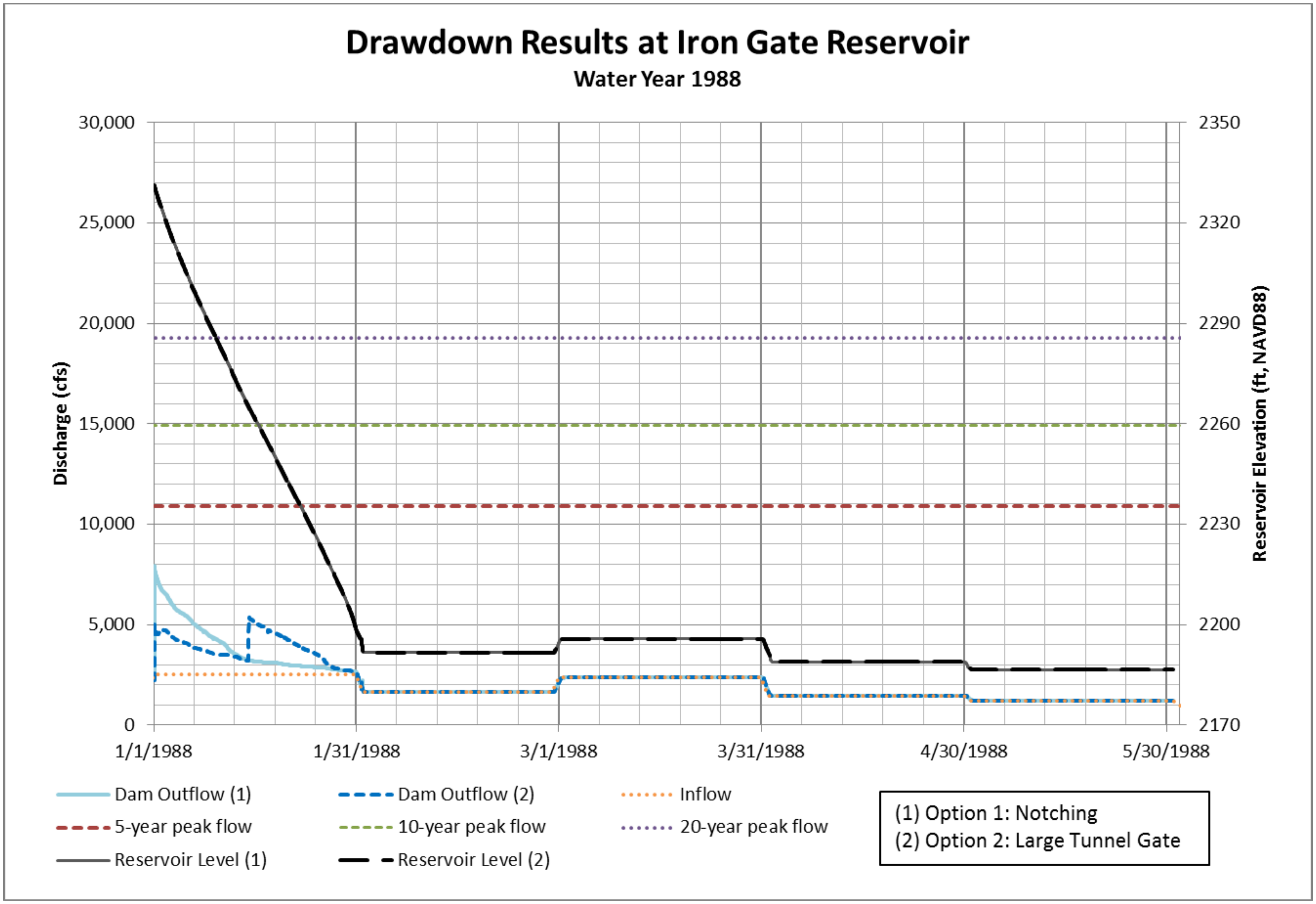

Figure 4-28 Iron Gate Reservoir Drawdown, Water Year 1988

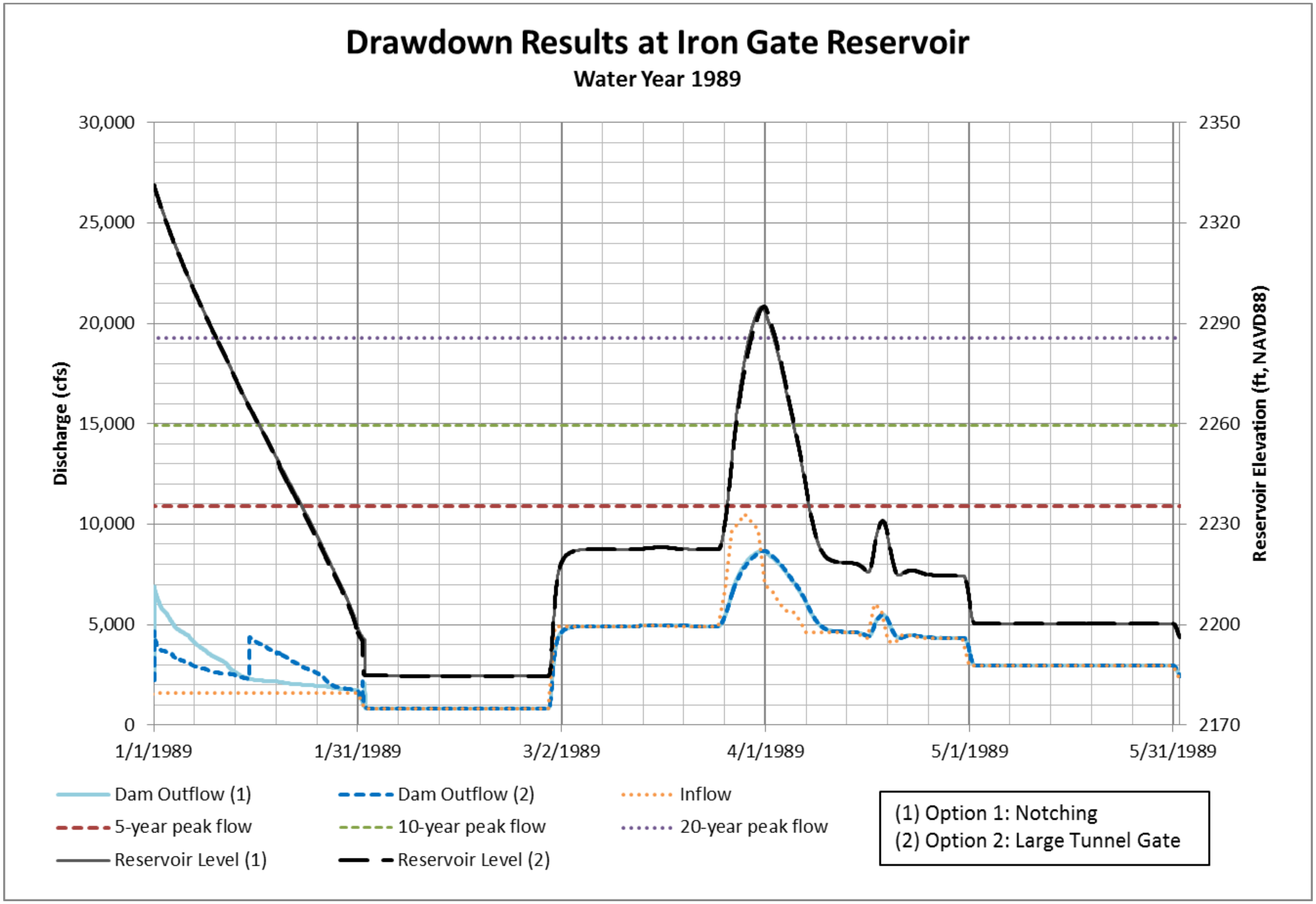

Figure 4-29 Iron Gate Reservoir Drawdown, Water Year 1989

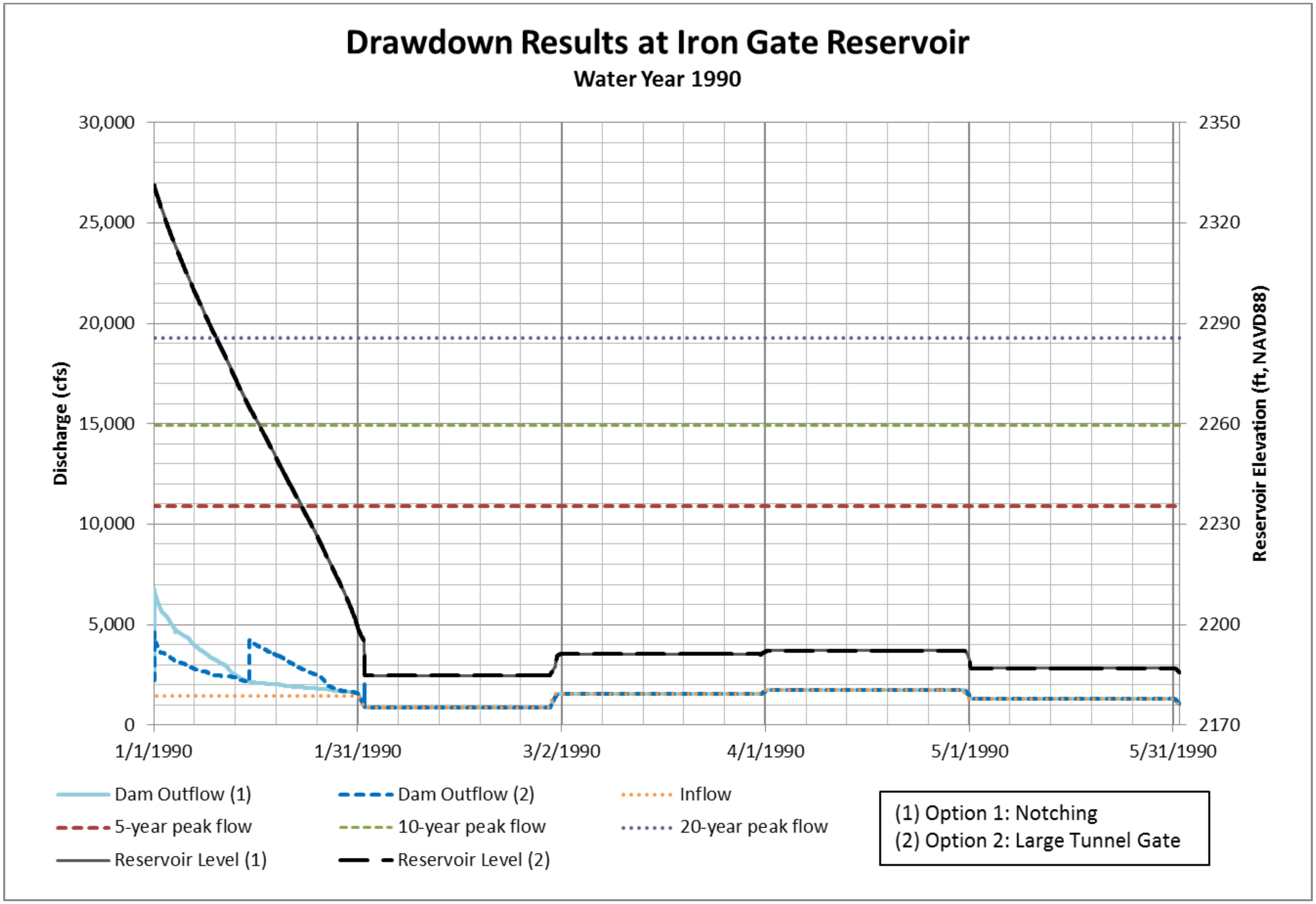

Figure 4-30 Iron Gate Reservoir Drawdown, Water Year 1990

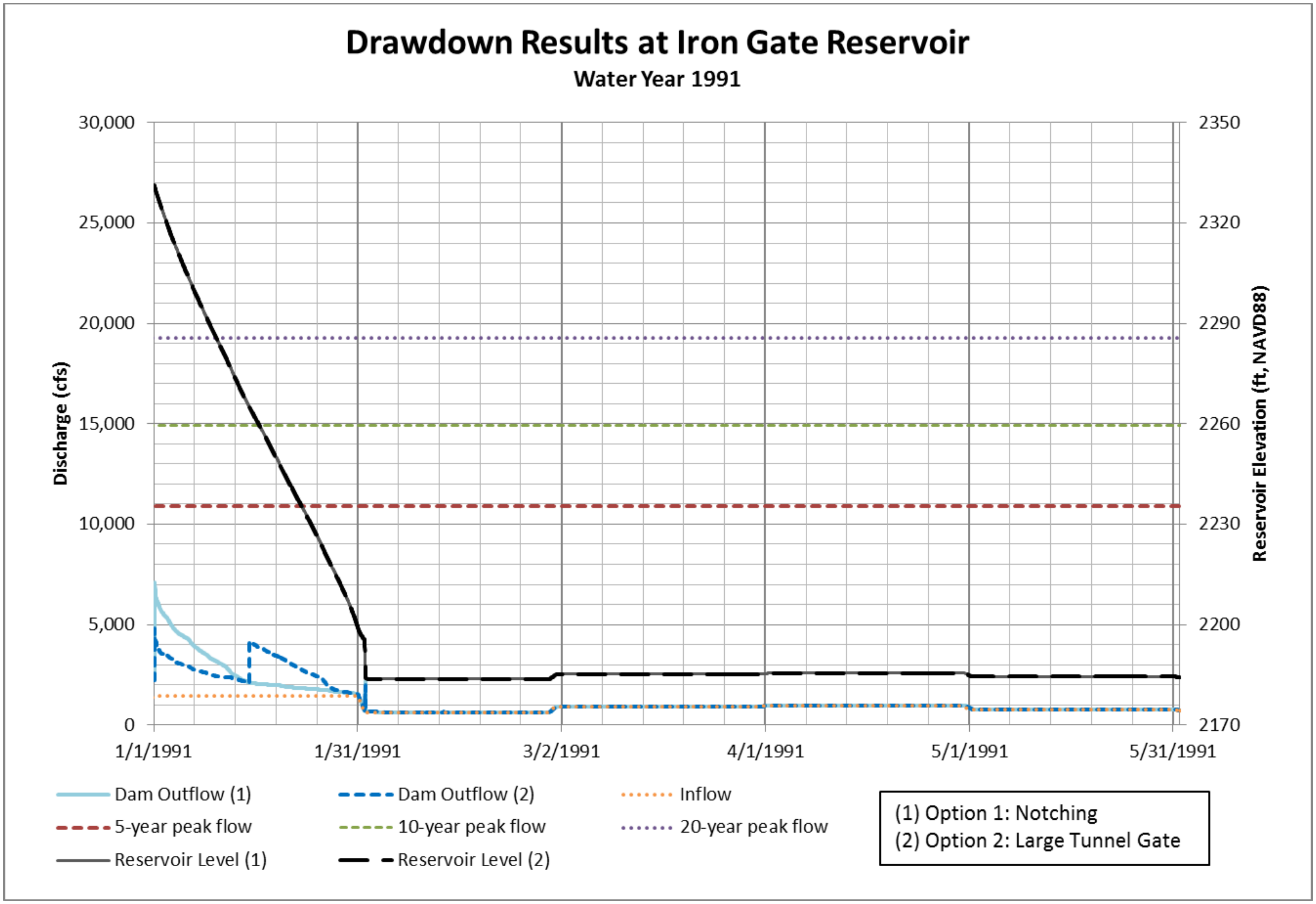

Figure 4-31 Iron Gate Reservoir Drawdown, Water Year 1991

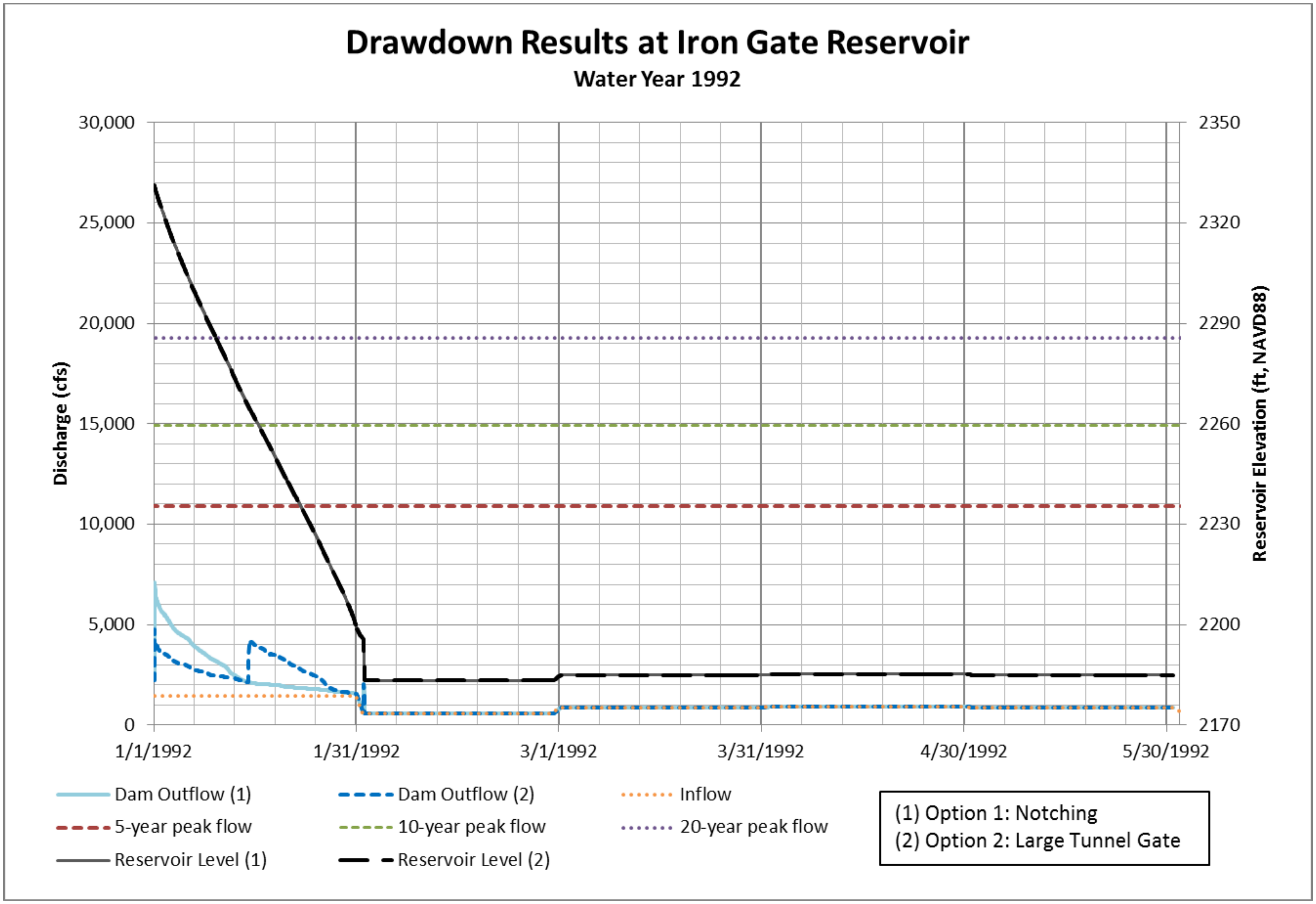

Figure 4-32 Iron Gate Reservoir Drawdown, Water Year 1992

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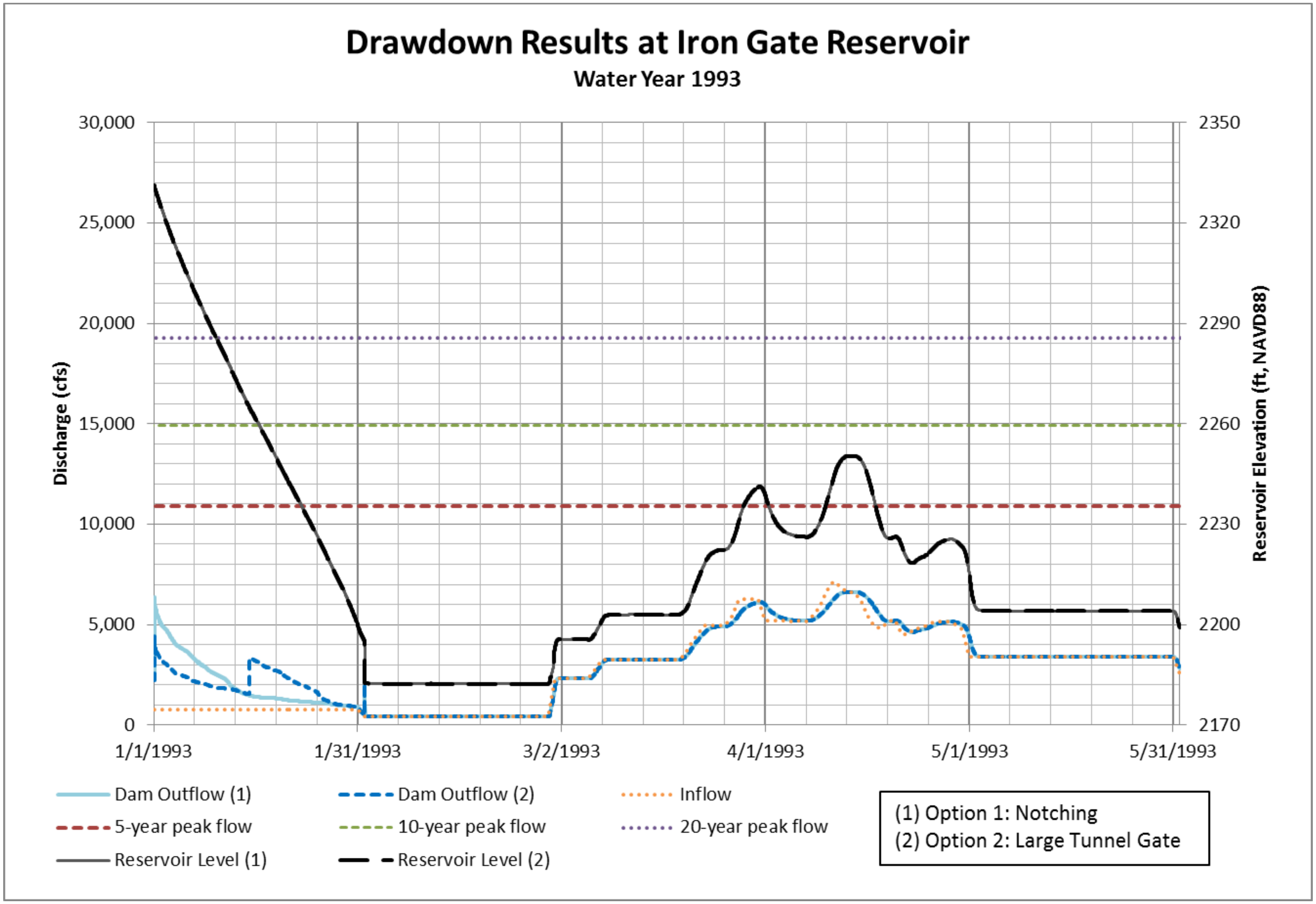

Figure 4-33 Iron Gate Reservoir Drawdown, Water Year 1993

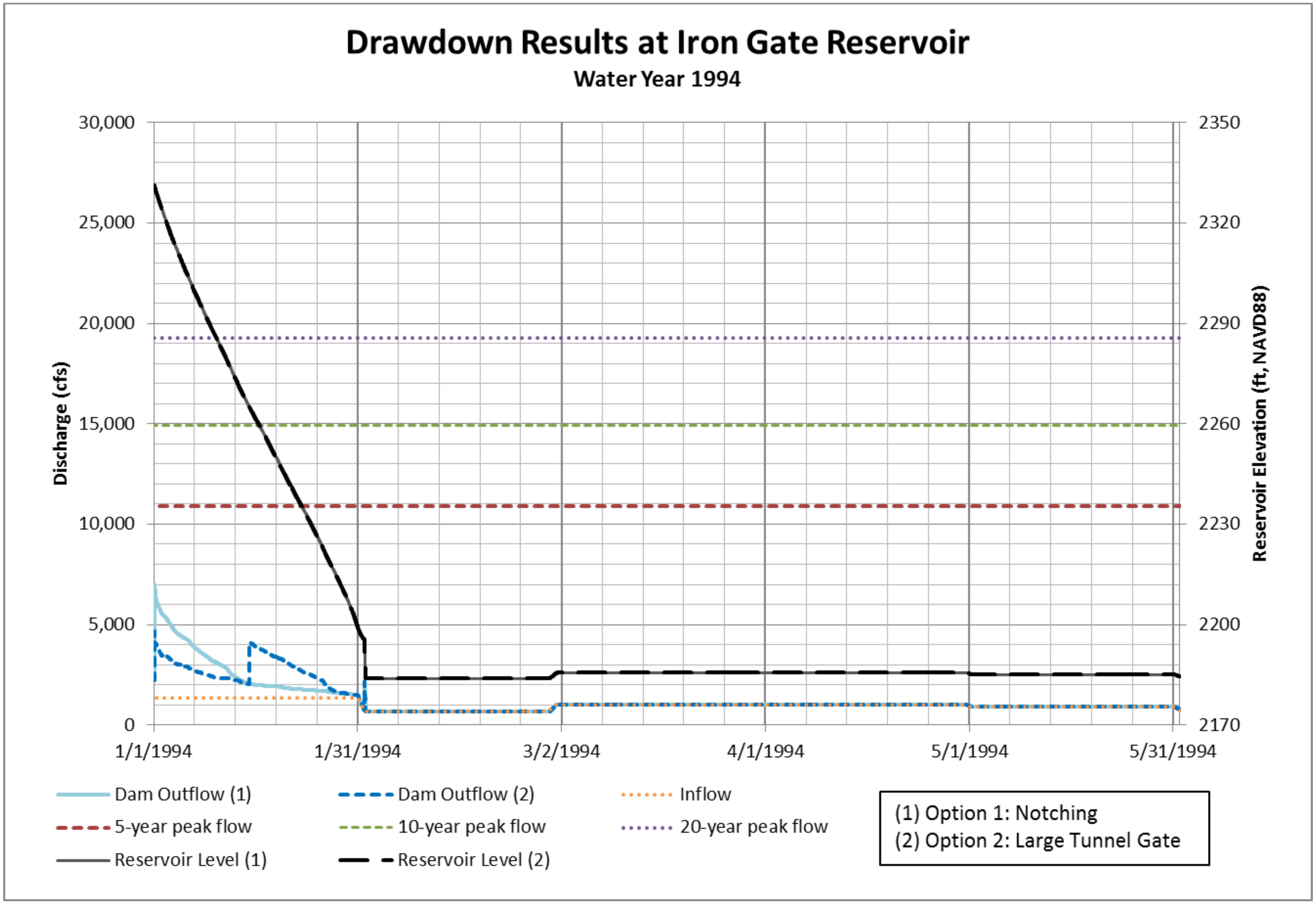

Figure 4-34 Iron Gate Reservoir Drawdown, Water Year 1994

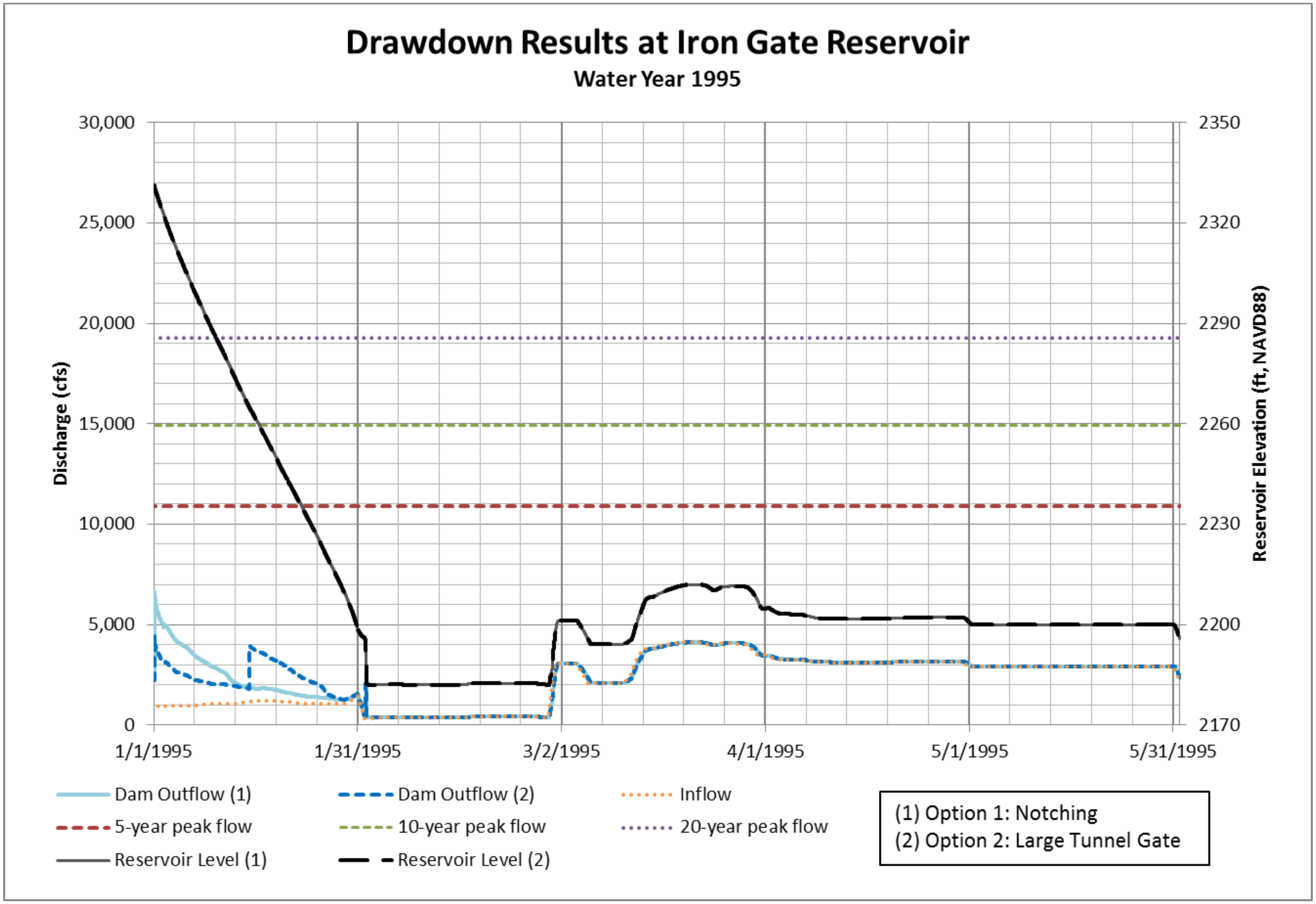

Figure 4-35 Iron Gate Reservoir Drawdown, Water Year 1995

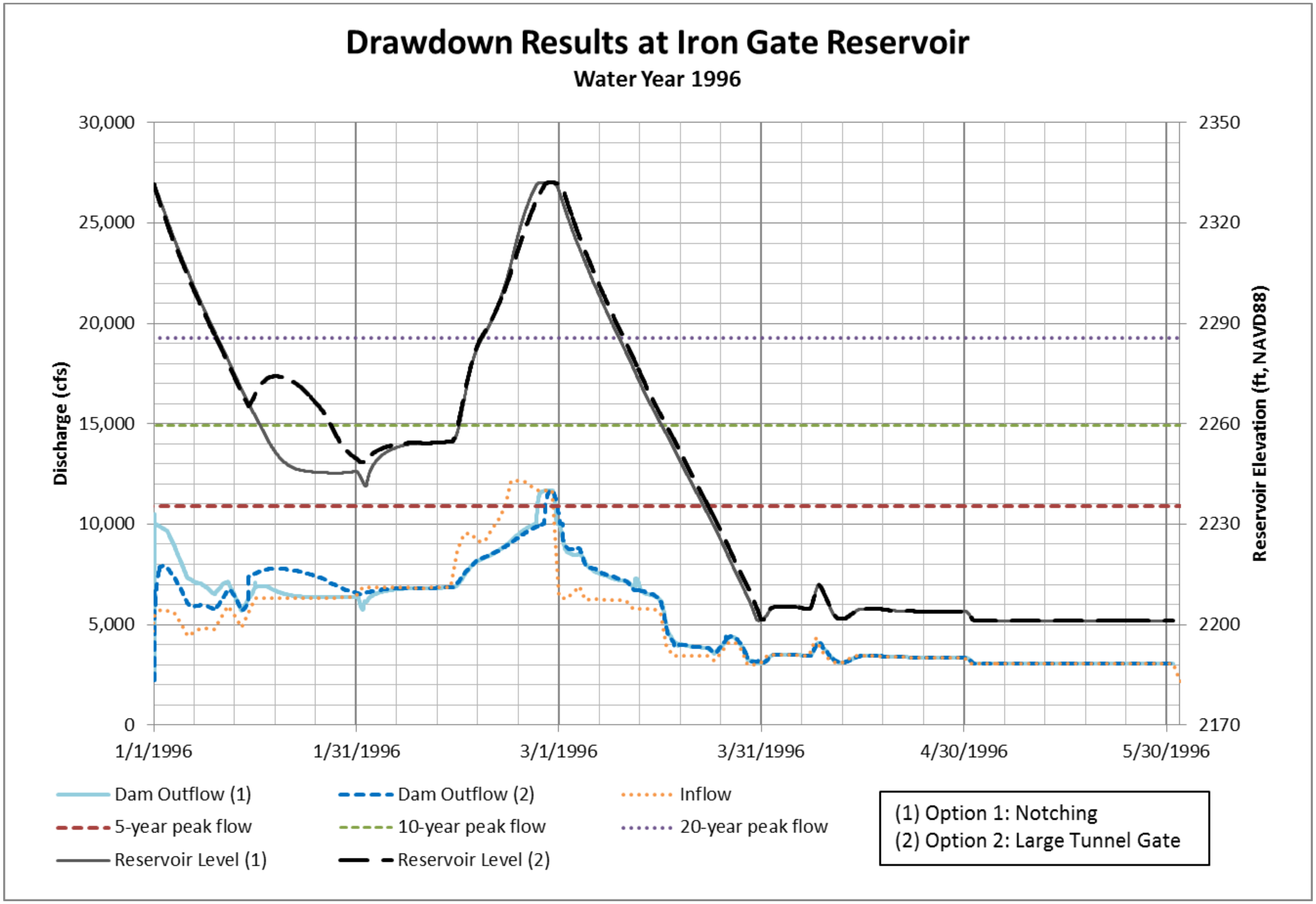

Figure 4-36 Iron Gate Reservoir Drawdown, Water Year 1996

KLAMATH RIVER RENEWAL CORPORATION

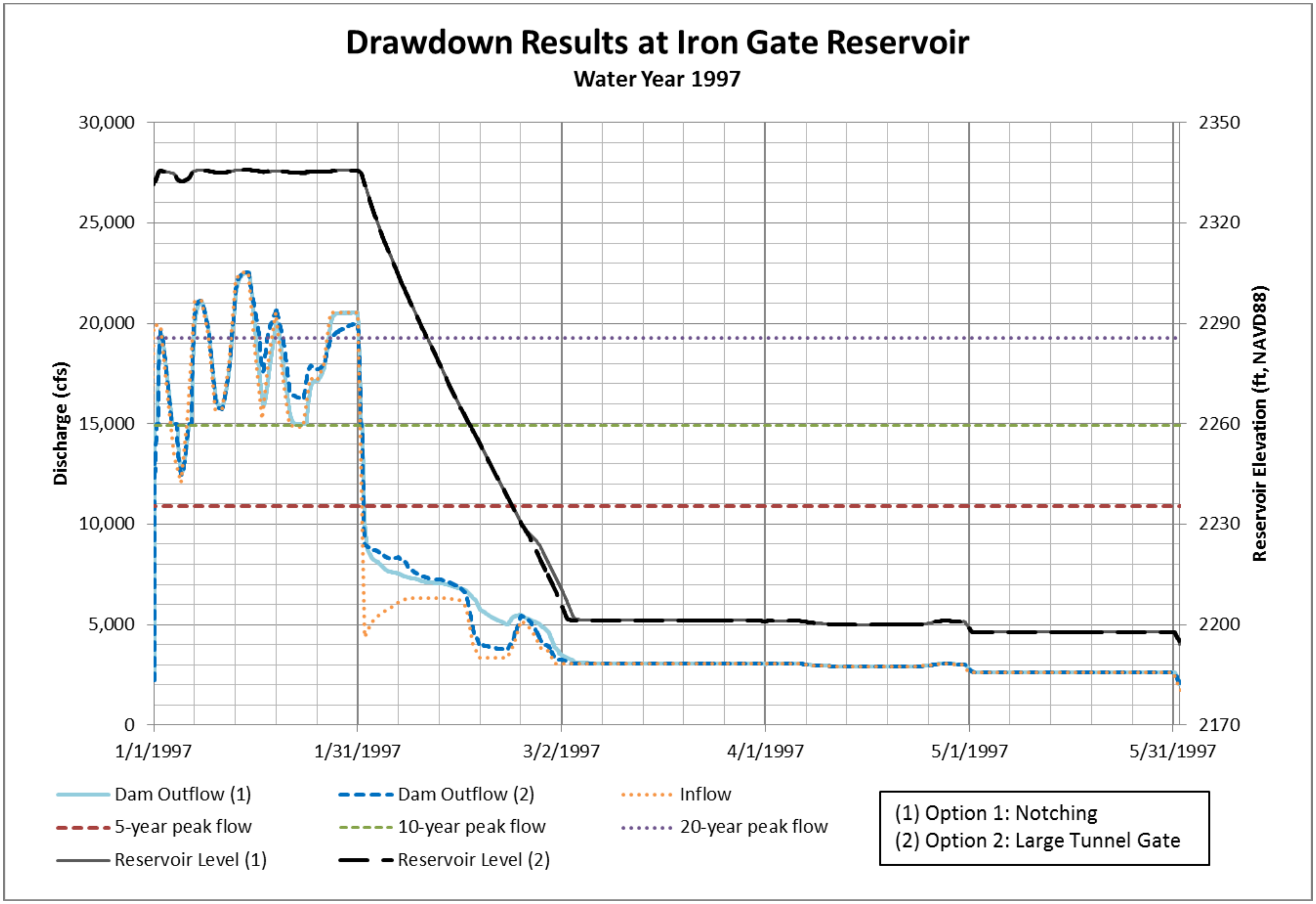

Figure 4-37 Iron Gate Reservoir Drawdown, Water Year 1997

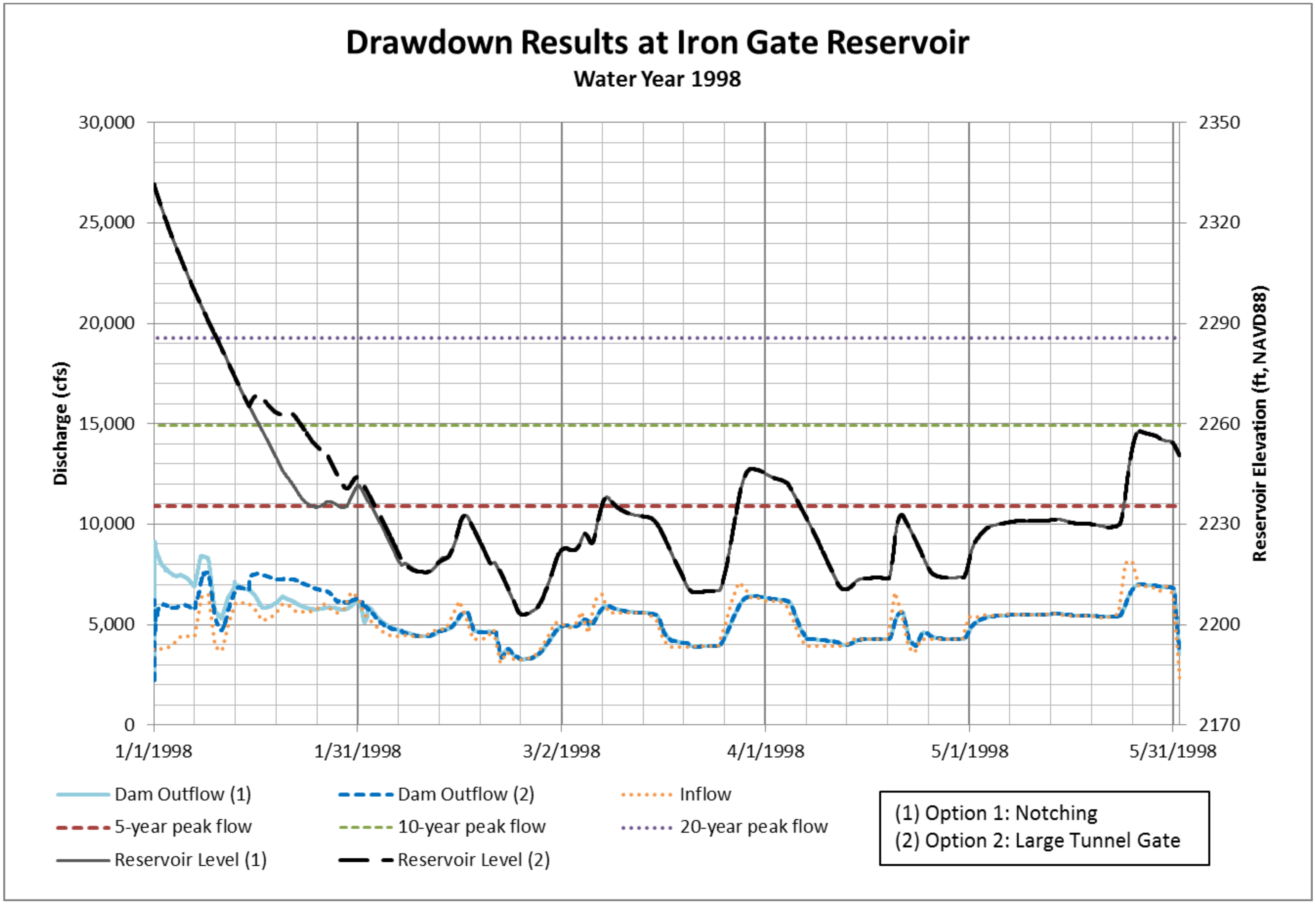

Figure 4-38 Iron Gate Reservoir Drawdown, Water Year 1998

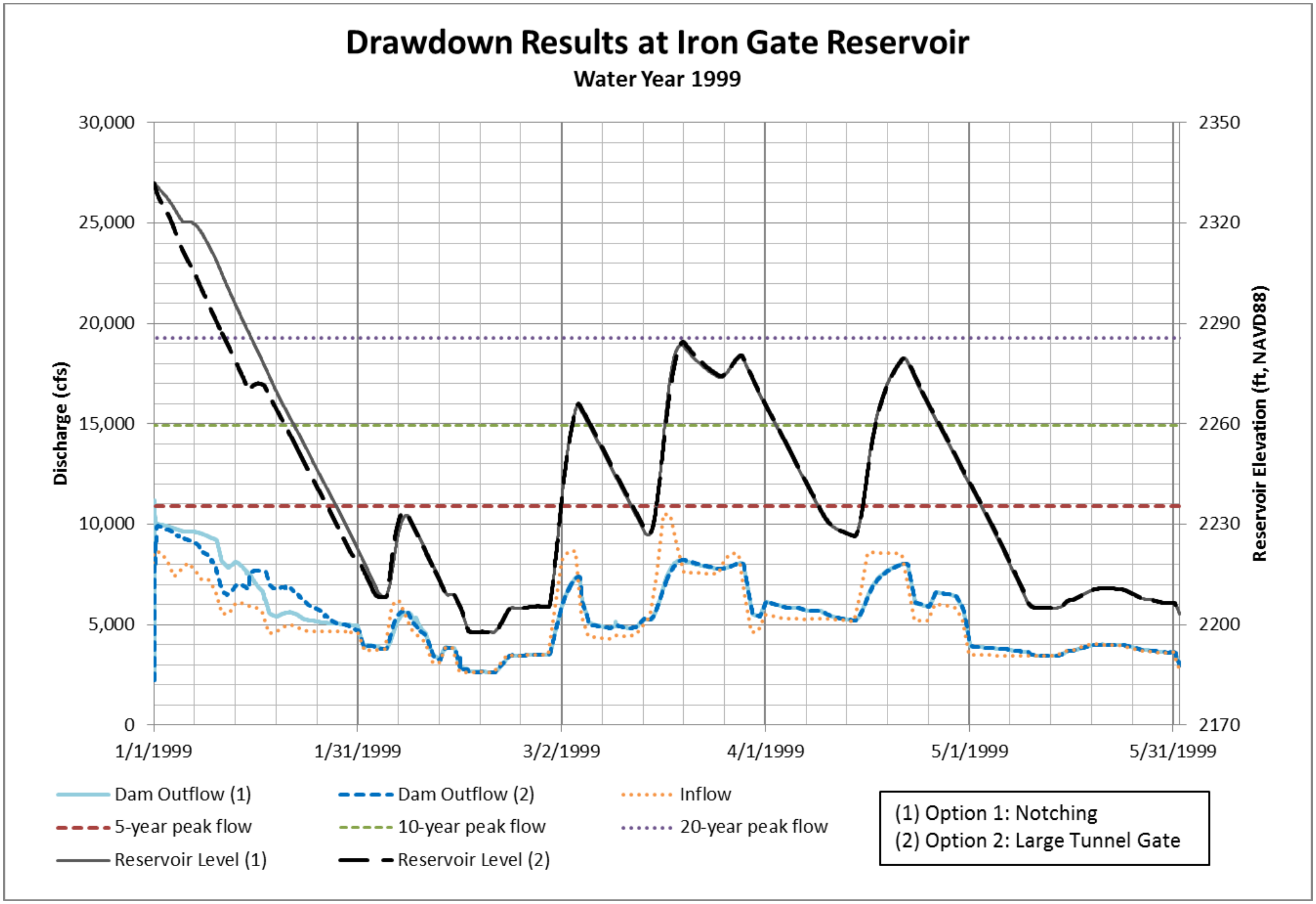

Figure 4-39 Iron Gate Reservoir Drawdown, Water Year 1999

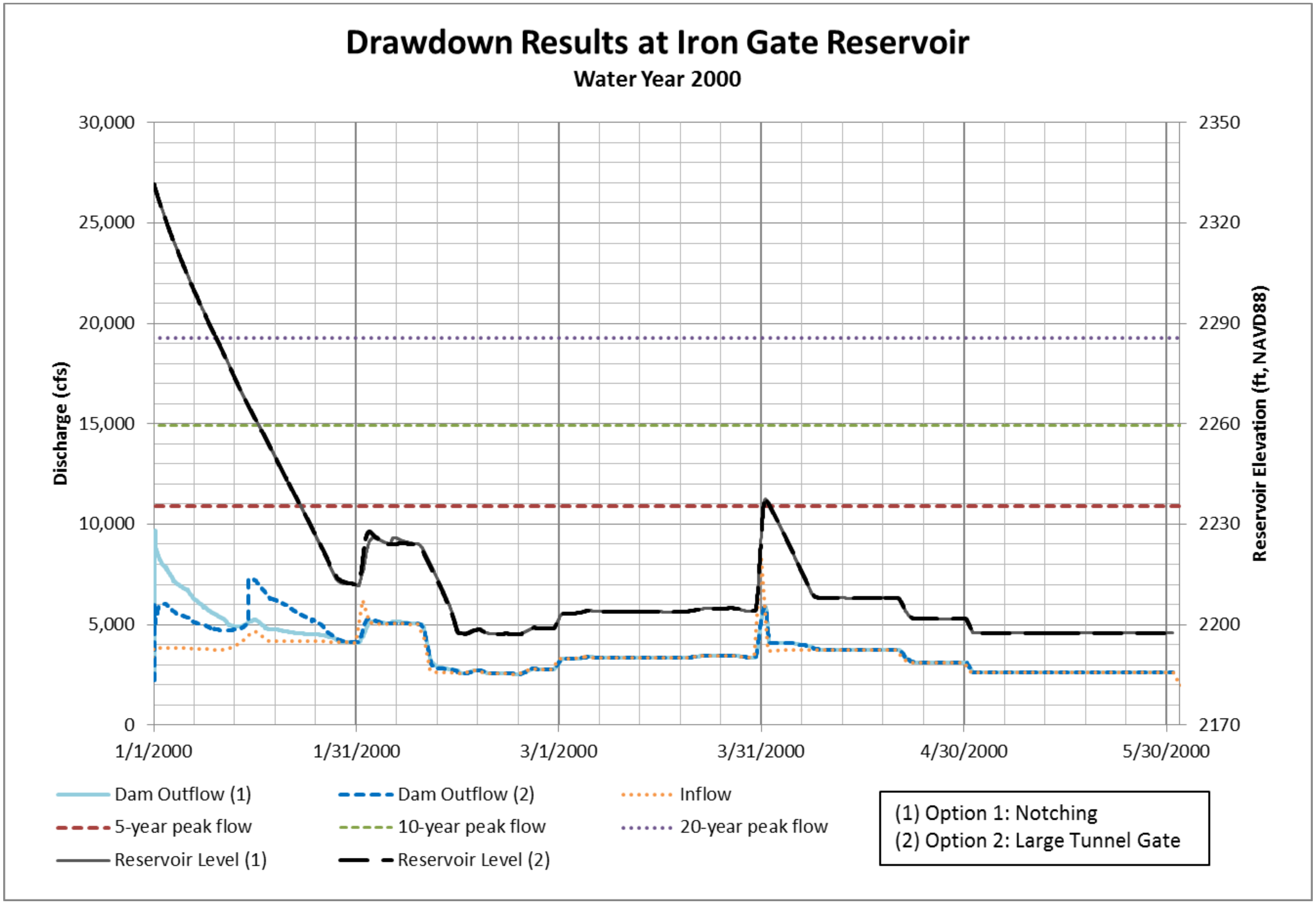

Figure 4-40 Iron Gate Reservoir Drawdown, Water Year 2000

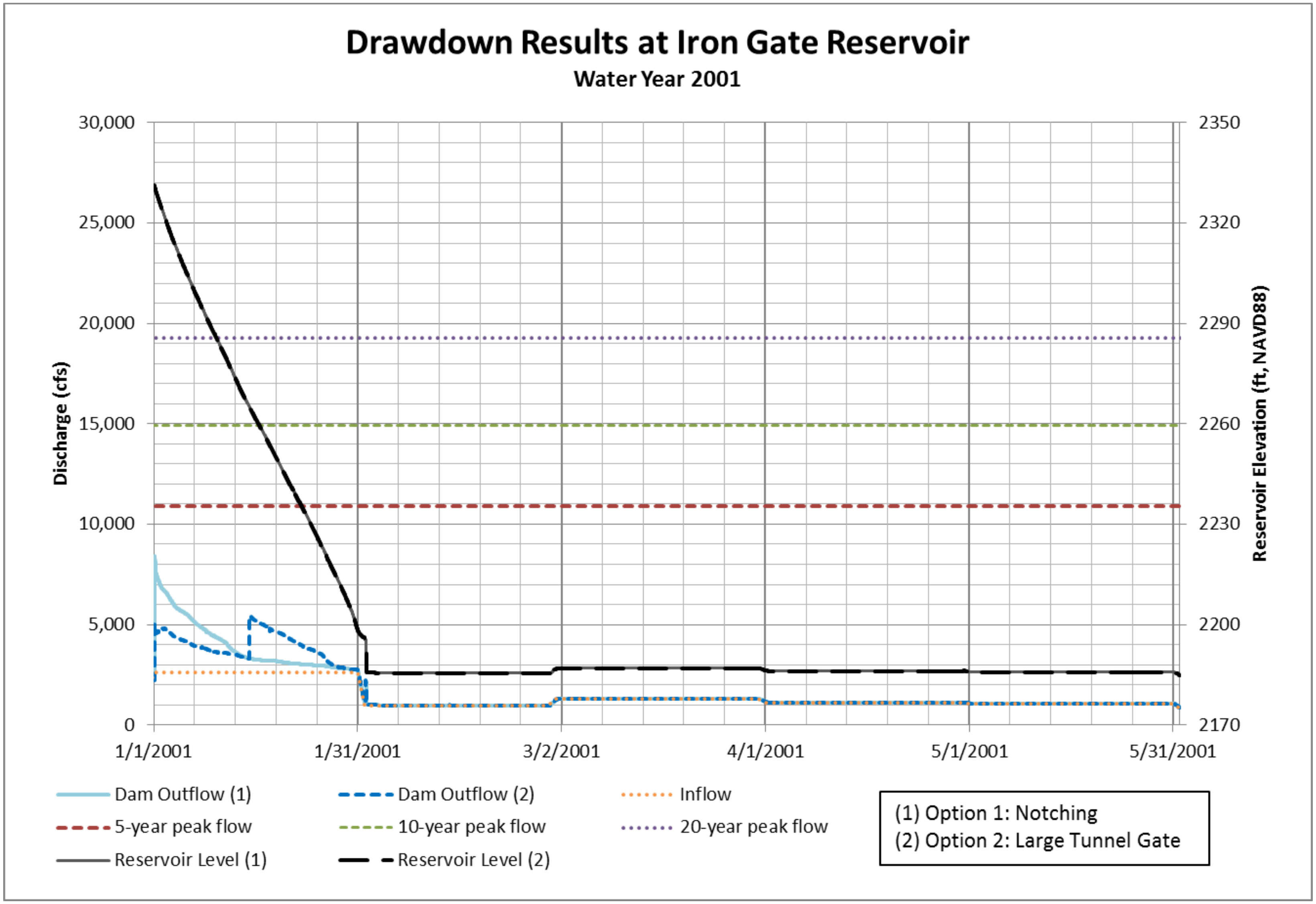

Figure 4-41 **Iron Gate Reservoir Drawdown, Water Year 2001**

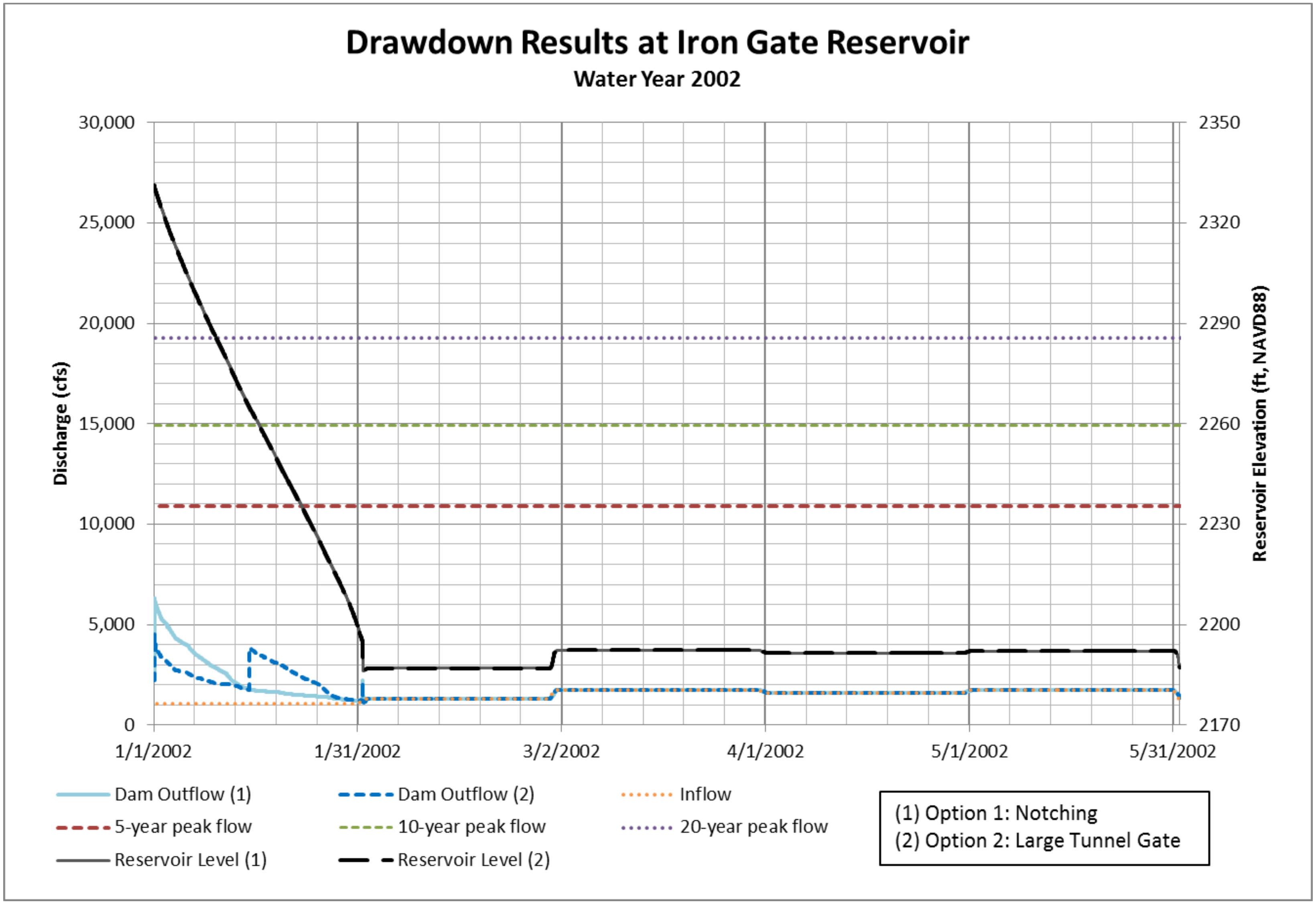

Figure 4-42 Iron Gate Reservoir Drawdown, Water Year 2002

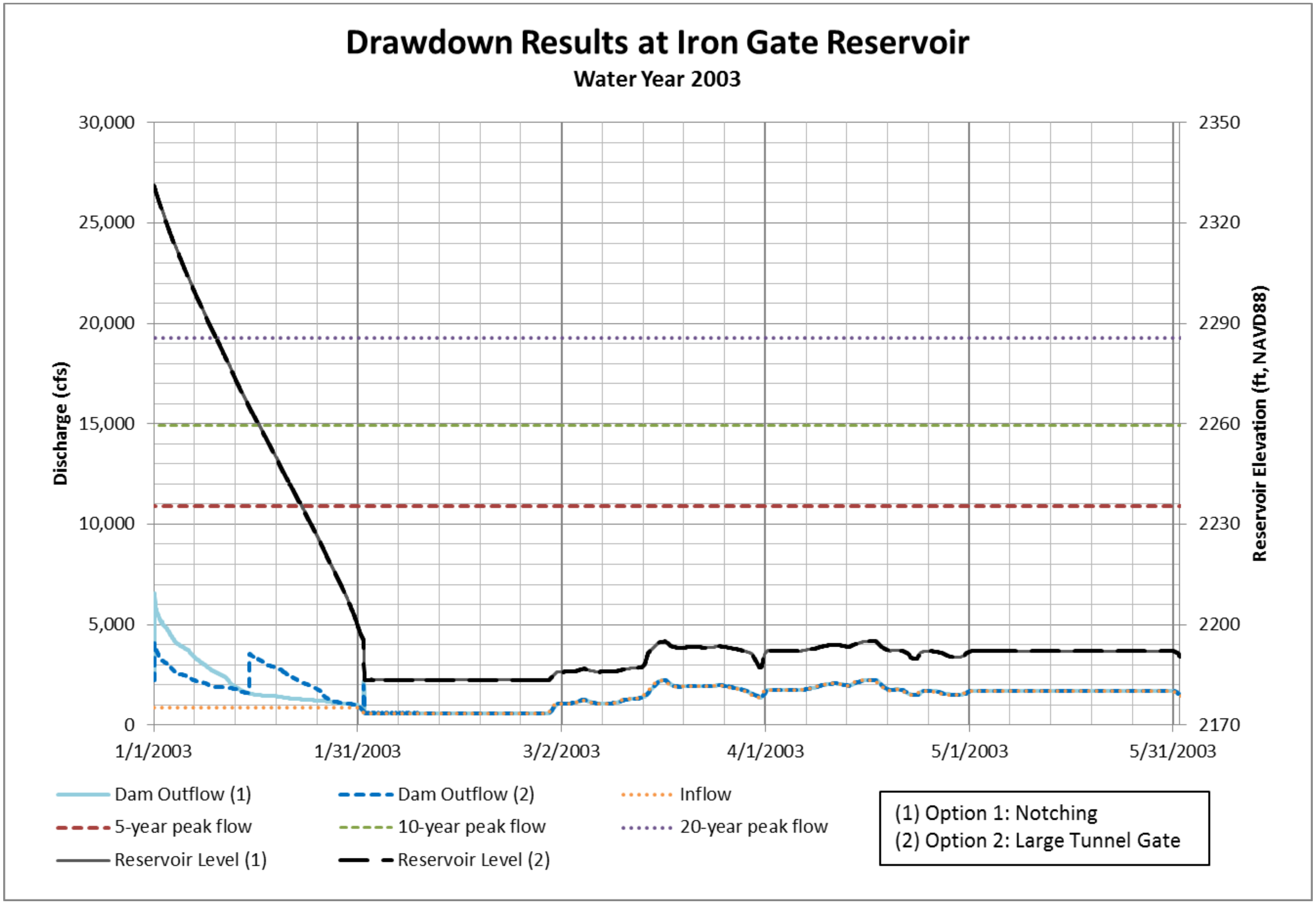

Figure 4-43 Iron Gate Reservoir Drawdown, Water Year 2003

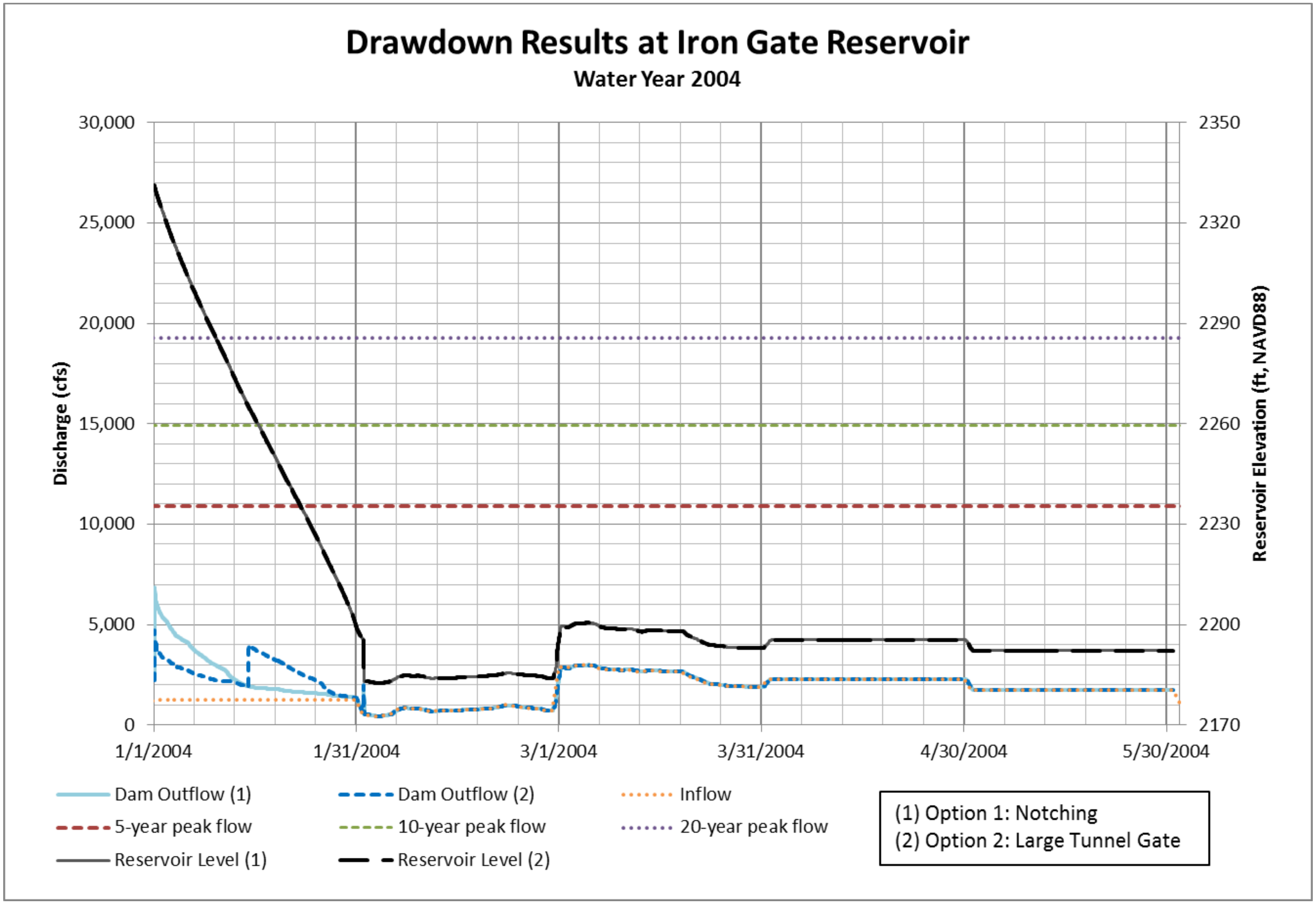

Figure 4-44 Iron Gate Reservoir Drawdown, Water Year 2004

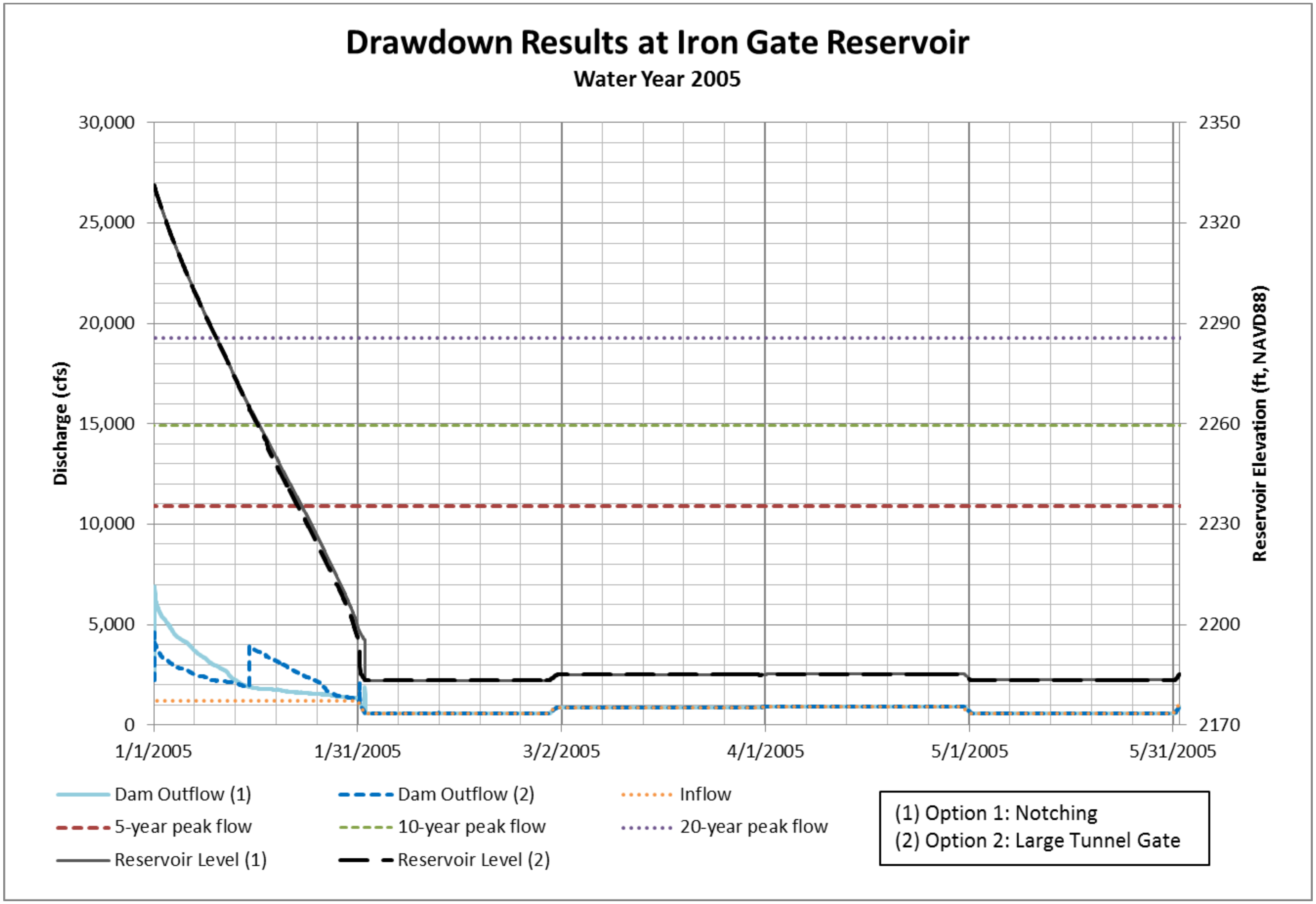

Figure 4-45 Iron Gate Reservoir Drawdown, Water Year 2005

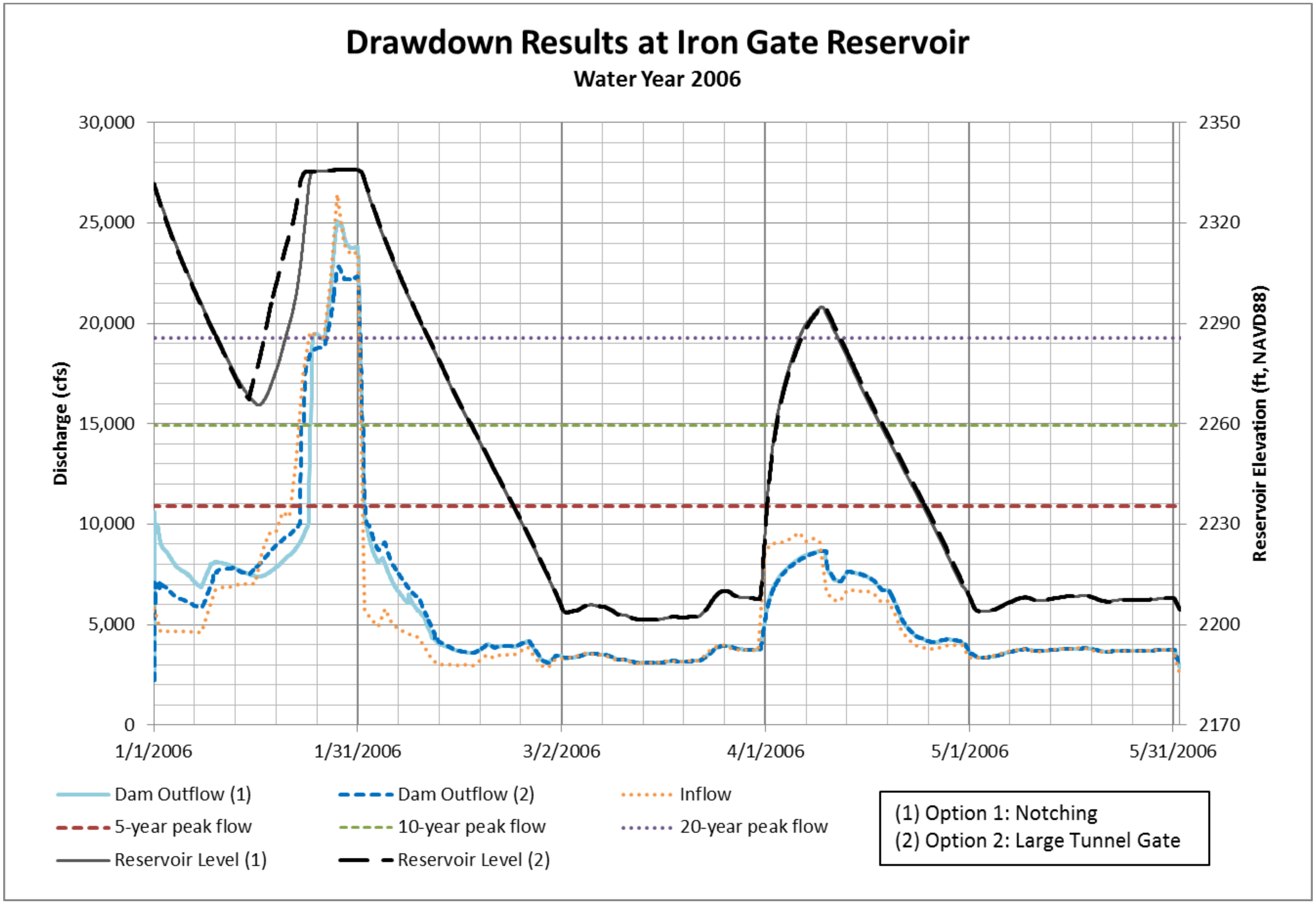

Figure 4-46 Iron Gate Reservoir Drawdown, Water Year 2006

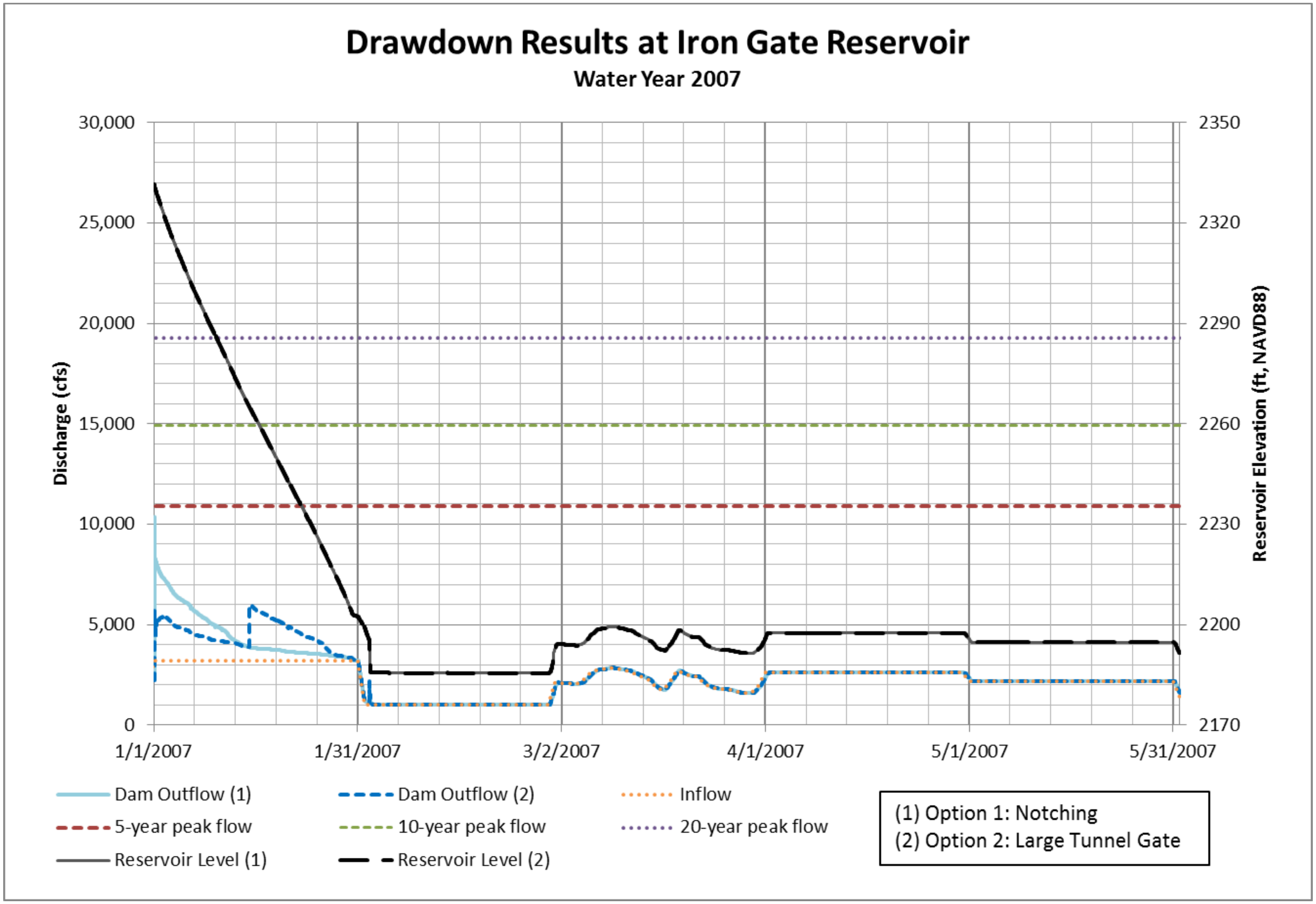

Figure 4-47 Iron Gate Reservoir Drawdown, Water Year 2007

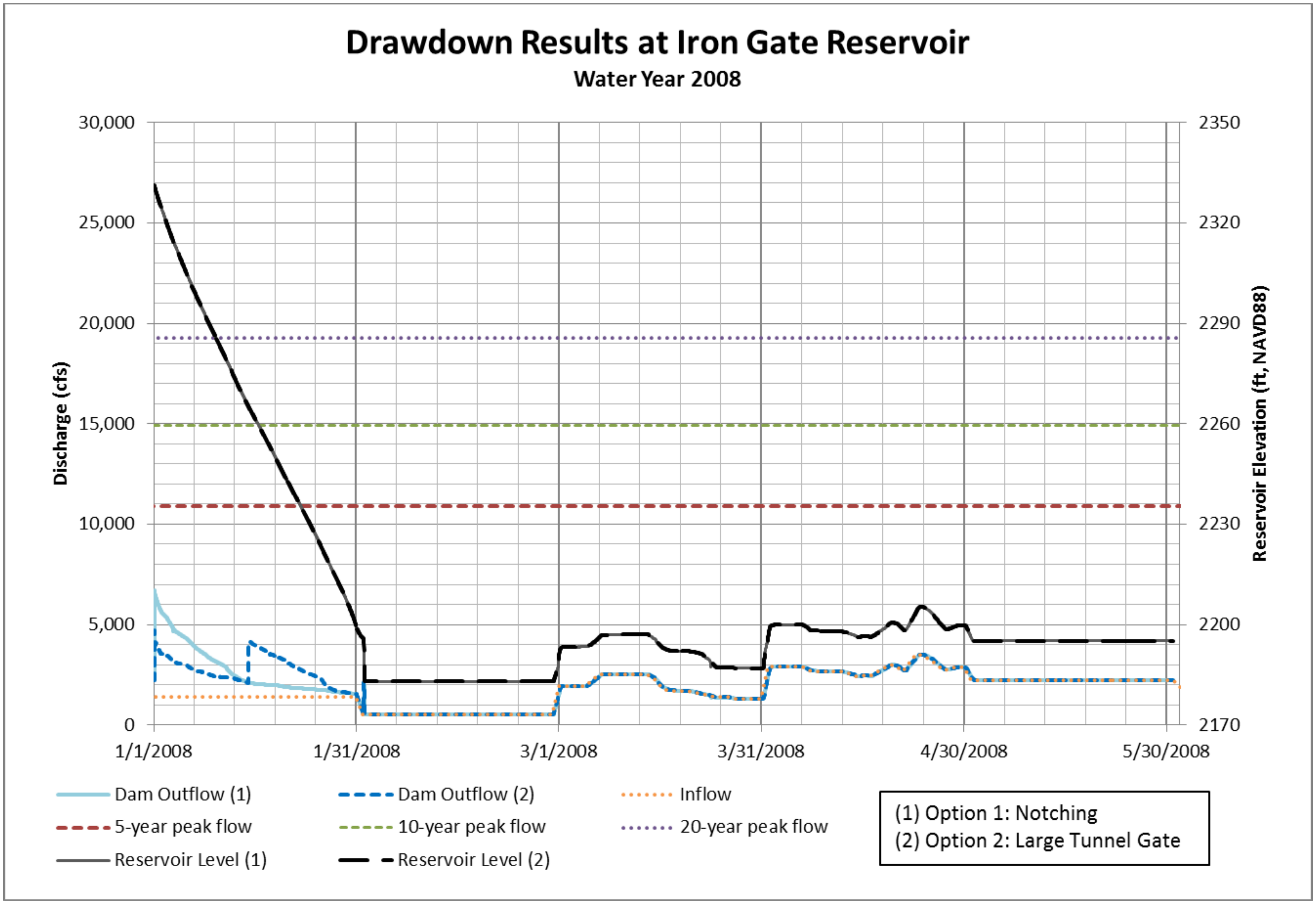

Figure 4-48 Iron Gate Reservoir Drawdown, Water Year 2008

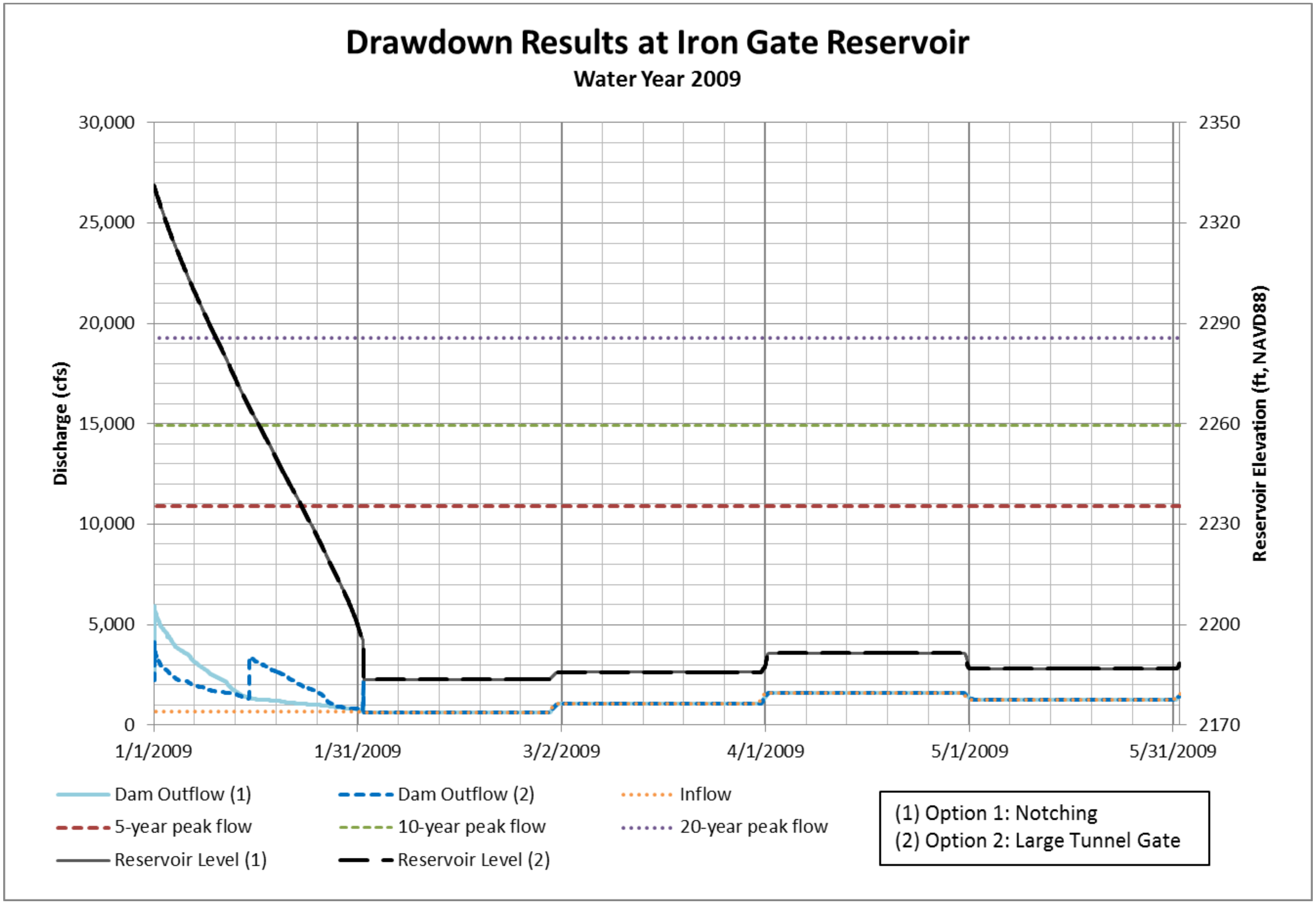

Figure 4-49 Iron Gate Reservoir Drawdown, Water Year 2009

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Chapter 5: Flood Frequency Analysis

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5. FLOOD FREQUENCY ANALYSIS

Figures 5-1 and 5-2 show the linear correlation between flows measured at the USGS gauges at J.C. Boyle and Copco as compared to the measured flows at Keno. KRRC used these relationships to extend the historical record of flows at J.C. Boyle and Copco prior to performing the flood frequency analysis. Figures 5-3, 5-4, and 5-5 show the results of the flood frequency analysis at J.C. Boyle, Copco, and Iron Gate, respectively.

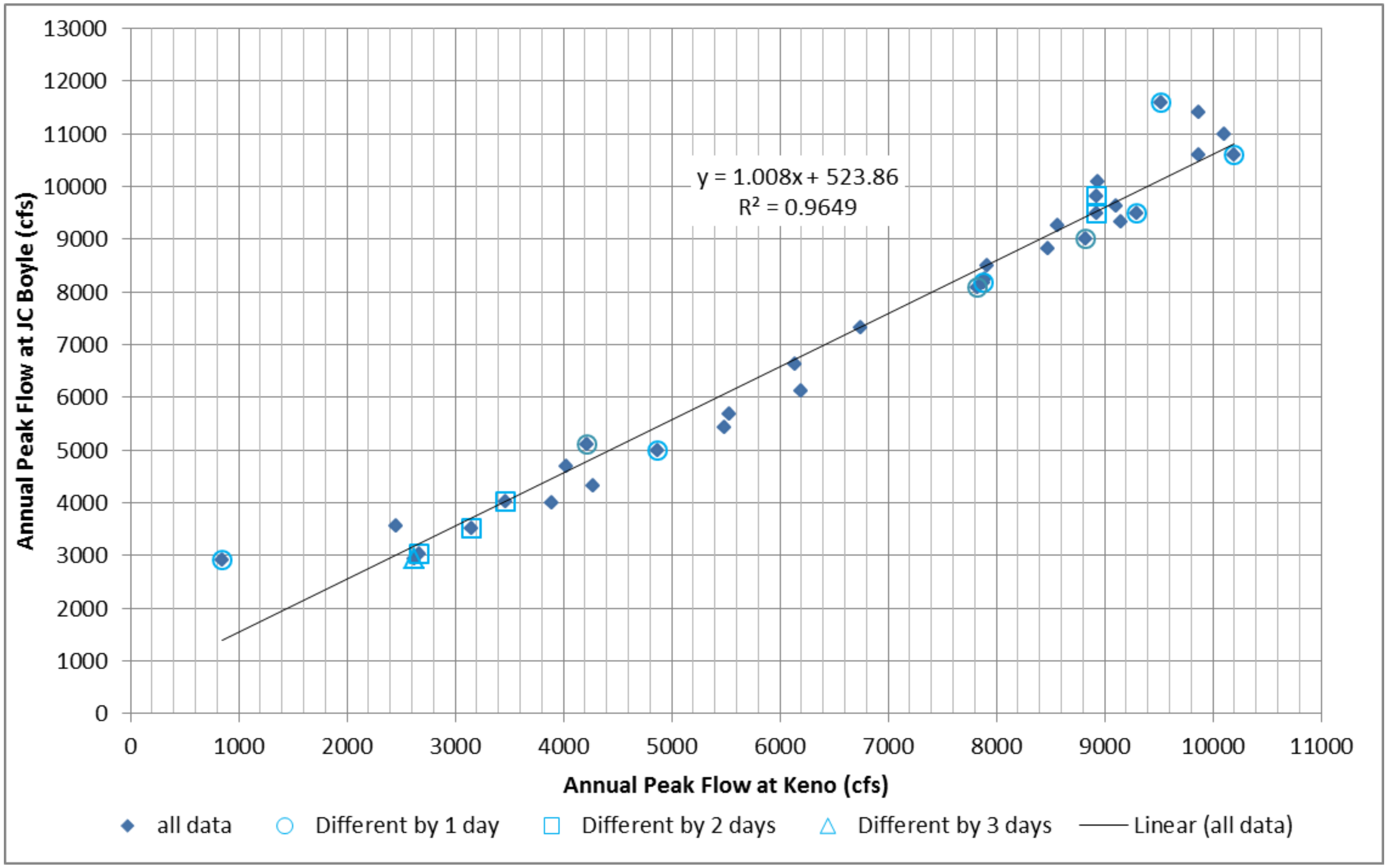

Figure 5-1 Linear Correlation between Flows at J.C. Boyle versus Flows at Keno

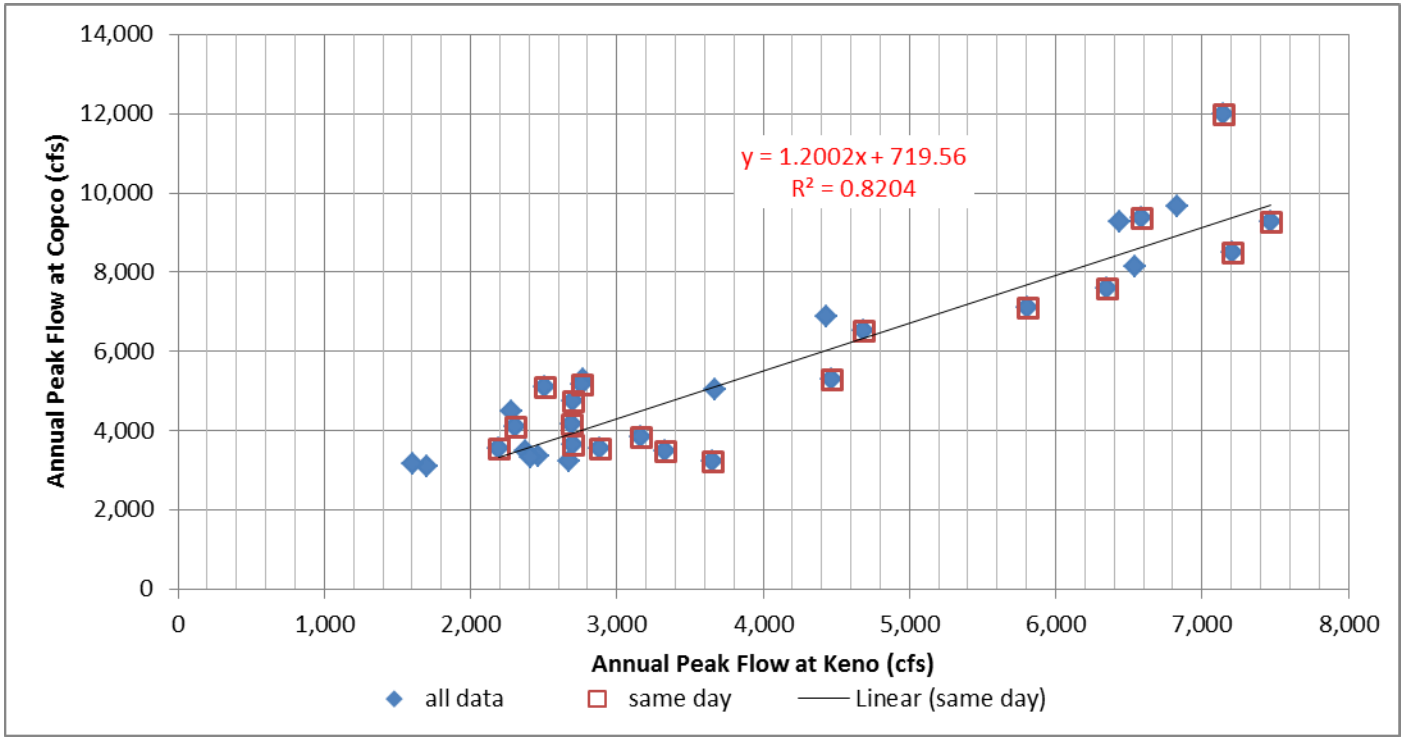

Figure 5-2 Linear Correlation between Flows at Copco versus Flows at Keno

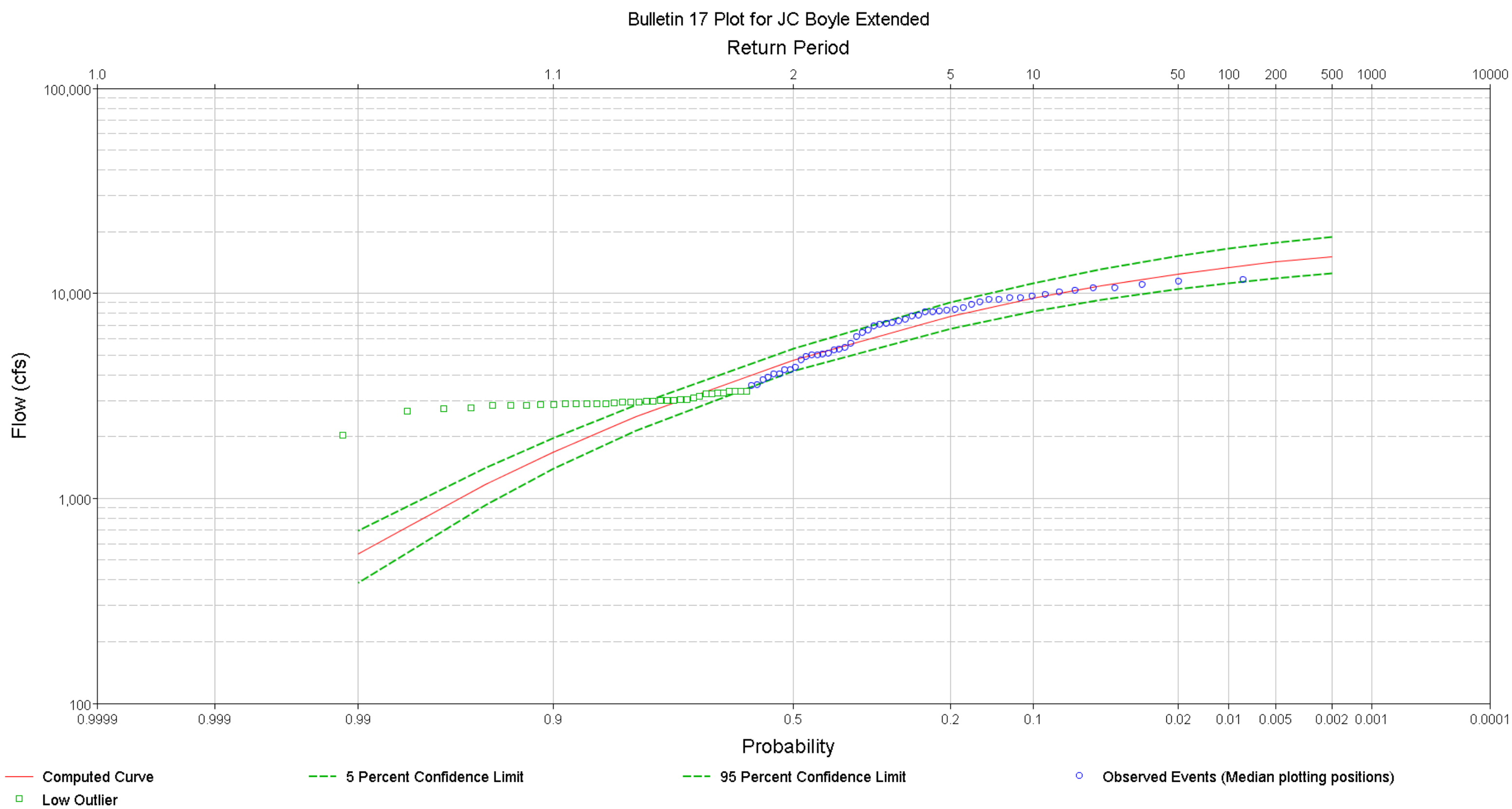

Figure 5-3 Flood Frequency Curve, J.C. Boyle

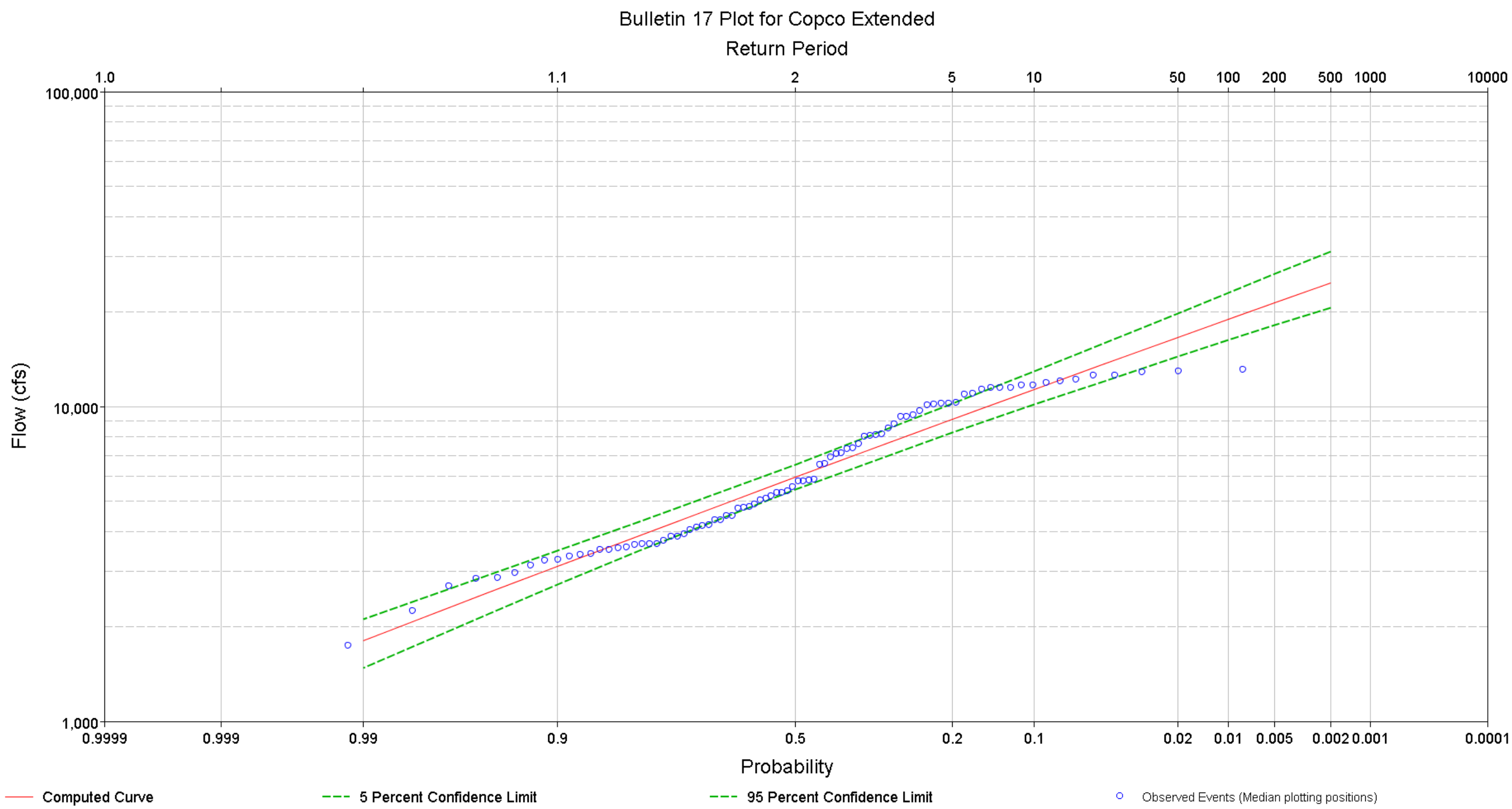

Figure 5-4 Flood Frequency Curve, Copco 1

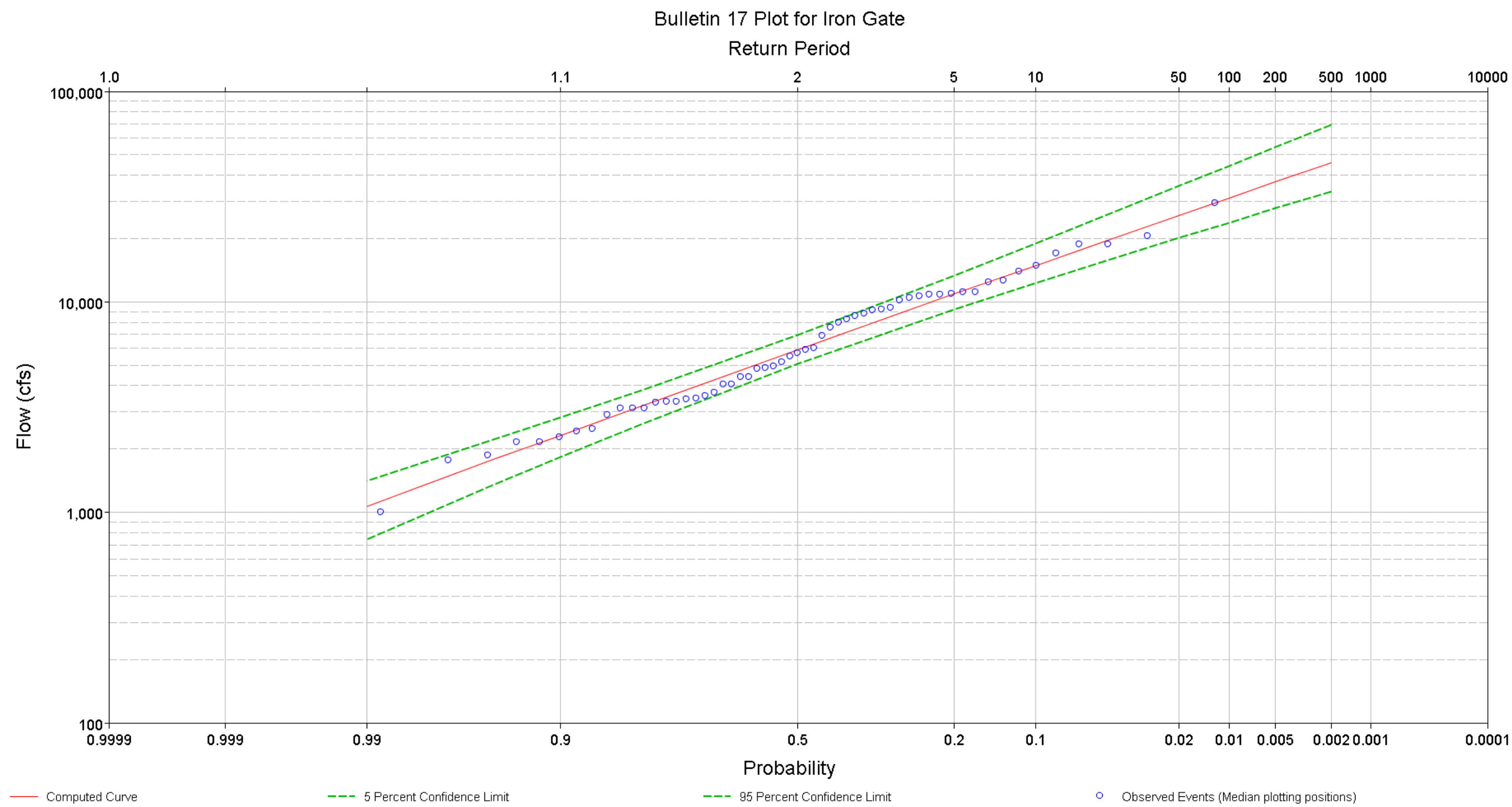

Figure 5-5 Flood Frequency Curve, Iron Gate

Appendix G Copco Foundation Removal

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AECOM
300 Lakeside Drive, Suite 400, Oakland, CA 94612
USA
aecom.com

Project name:
Klamath River Renewal Project

Project ref:
60537920

From:
Phillip Mineart, Shannon Leonard

Date:
June 20, 2018

To: Klamath River Renewal Coporation

CC:

Technical Memorandum

Subject: Definite Plan for the Lower Klamath Project
Analysis of Copco No. 1 Foundation Removal

1.0 Introduction

During construction of Copco No. 1 Dam, approximately 100 feet of alluvium was removed below channel grade and backfilled with concrete. 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.

2.0 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 of the main body of the Definite Plan, 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 (discussed in Section 4 of the Definite Plan) 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.

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 2012) provides a figure (Figure 5-18 in USBR 2012) 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 1 below lists the values estimated from that figure.

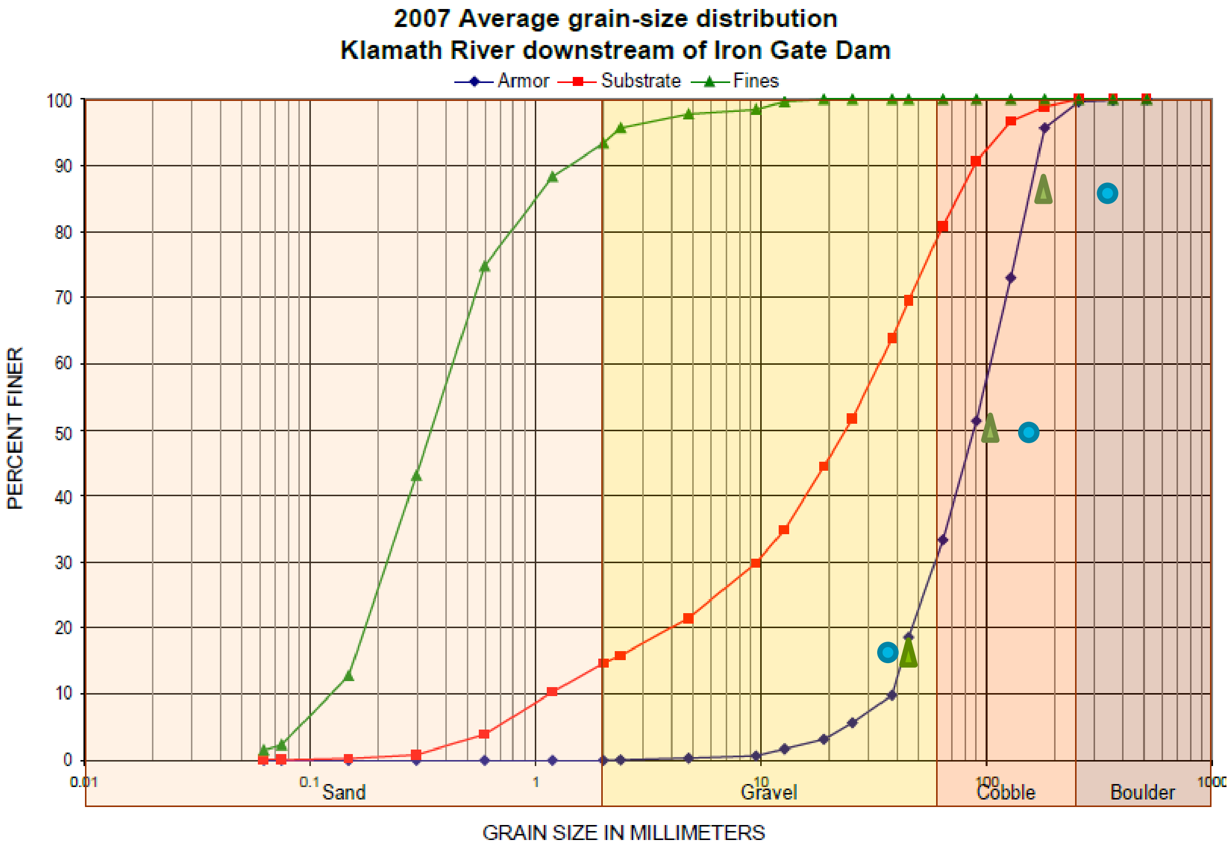
Table 1. Particle Size Data near Copco Dams

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 2012); 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.

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.

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[1]. The USBR data and the Holmquist-Johnson and Milhous distributions are plotted together in Figure 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.



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

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

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:

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

Where:

τ_0 = boundary (bed) shear stress
γ = 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:

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

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.
τ_{ci} = critical shear stress for particle i

τ_0 = bed shear stress

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

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

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 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.

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.

3.0 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:

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

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:

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

Where:

- y = flow depth
- S_e = energy slope
- Δs_g = relative submerged density of bed-material sediment □ 1.65
- U_* = shear velocity
- ν = 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.

4.0 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.

5.0 References

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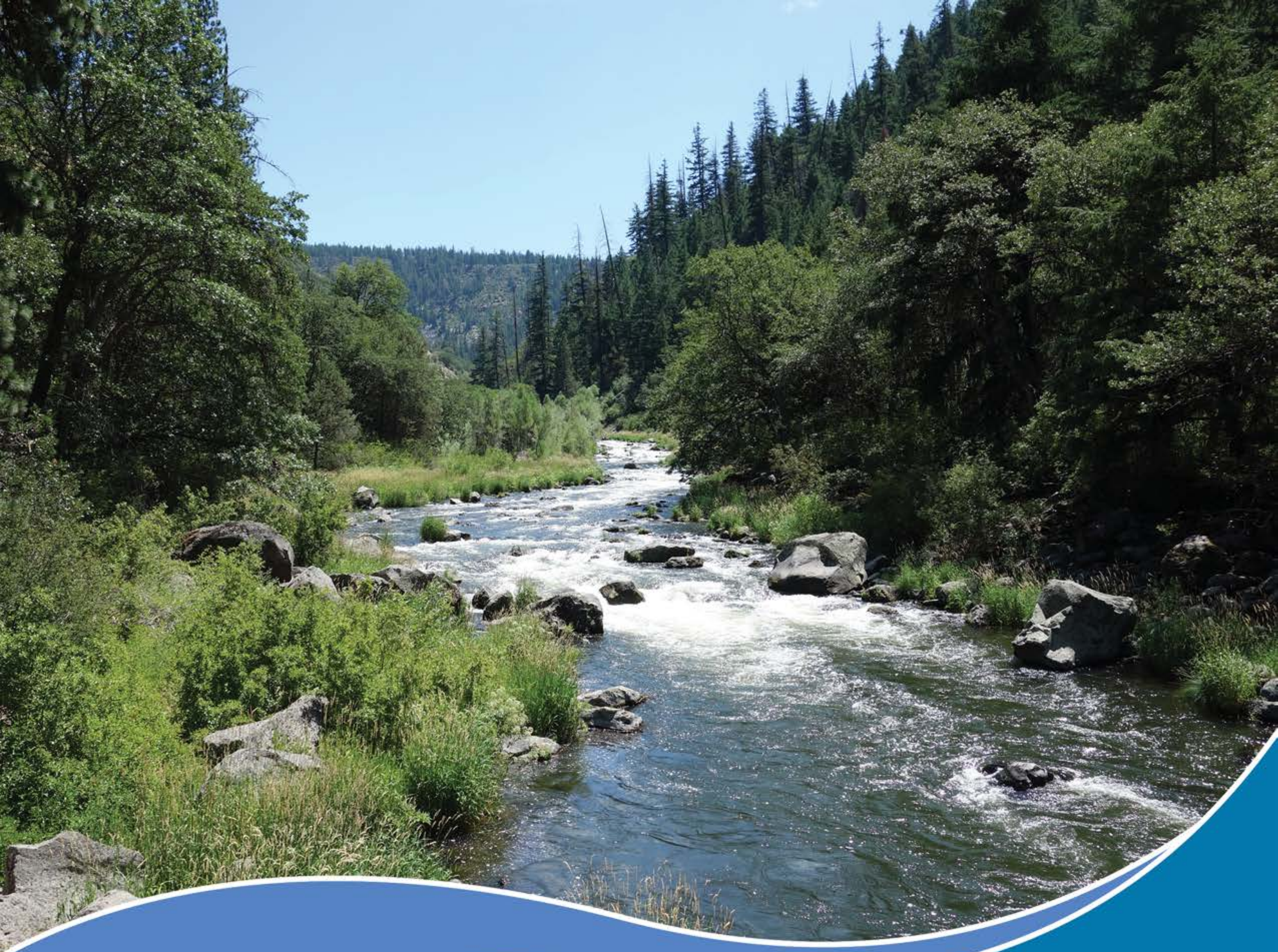

Definite Plan for the Lower Klamath Project

Appendix H – Reservoir Area Management Plan

KLAMATH RIVER RENEWAL CORPORATION

June 2018

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KLAMATH RIVER RENEWAL CORPORATION

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Acronyms and Abbreviations

1D	one-dimensional
2D	two-dimensional
BLM	Bureau of Land Management
Cal IPC	California Invasive Plant Council
CDFW	California Department of Fish and Wildlife
cm	centimeters
CY	cubic yards

EIS/R	Environmental Impact Statement/Report
FERC	Federal Energy Regulatory Commission
ft	foot/feet
ft^3	cubic foot
GIS	geographic information system
GPS	global positioning system
H:V	horizontal to vertical ratio
IEV	invasive exotic vegetation
IPM	Integrated Pest Management
KBMP	Klamath Basin Monitoring Program
KHSA	Klamath Hydroelectric Settlement Agreement
kPa	kilopascals
KRRC	Klamath River Renewal Corporation
KRWG	Klamath Restoration Work Group
lbf/ft^2	pound-force/square foot
lbf/in^2	pound-force/square Inch
lbs	pounds
LW	large wood
NMFS	National Marine Fisheries Services
ODFW	Oregon Department of Fish and Wildlife
O.C.	On center
Pa	Pascals
PLS	pure live seed
PNA	plant nutrient availability
Q100	100-year
Q2	2-year
RM	river miles
RWQCB	Regional Water Quality Control Board
RWZ	Rocky wake zone
SDOR	Secretarial Determination of Record
USBR	US Bureau of Reclamation
USDA	US Department of Agriculture
USGS	U.S. Geological Survey

Chapter 1: Introduction and Purpose

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1. INTRODUCTION AND PURPOSE

The Klamath Hydroelectric Settlement Agreement (KHSA) signed in 2010 and updated in 2016 establishes the framework to decommission and remove four dams (Iron Gate, Copco No. 1, Copco No. 2, and J.C. Boyle) on the Klamath River as shown on Figure 1-1. Upon approval by the Federal Energy Regulatory Commission (FERC) of a license transfer application filed by PacifiCorp and the Klamath River Renewal Corporation (KRRC), and further approval by the FERC of a surrender application filed by KRRC, the dams, power generation facilities, water intake structures, canals, pipelines, and ancillary building will be removed (the Project) by the KRRC as licensee. As the Project is implemented, the 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.

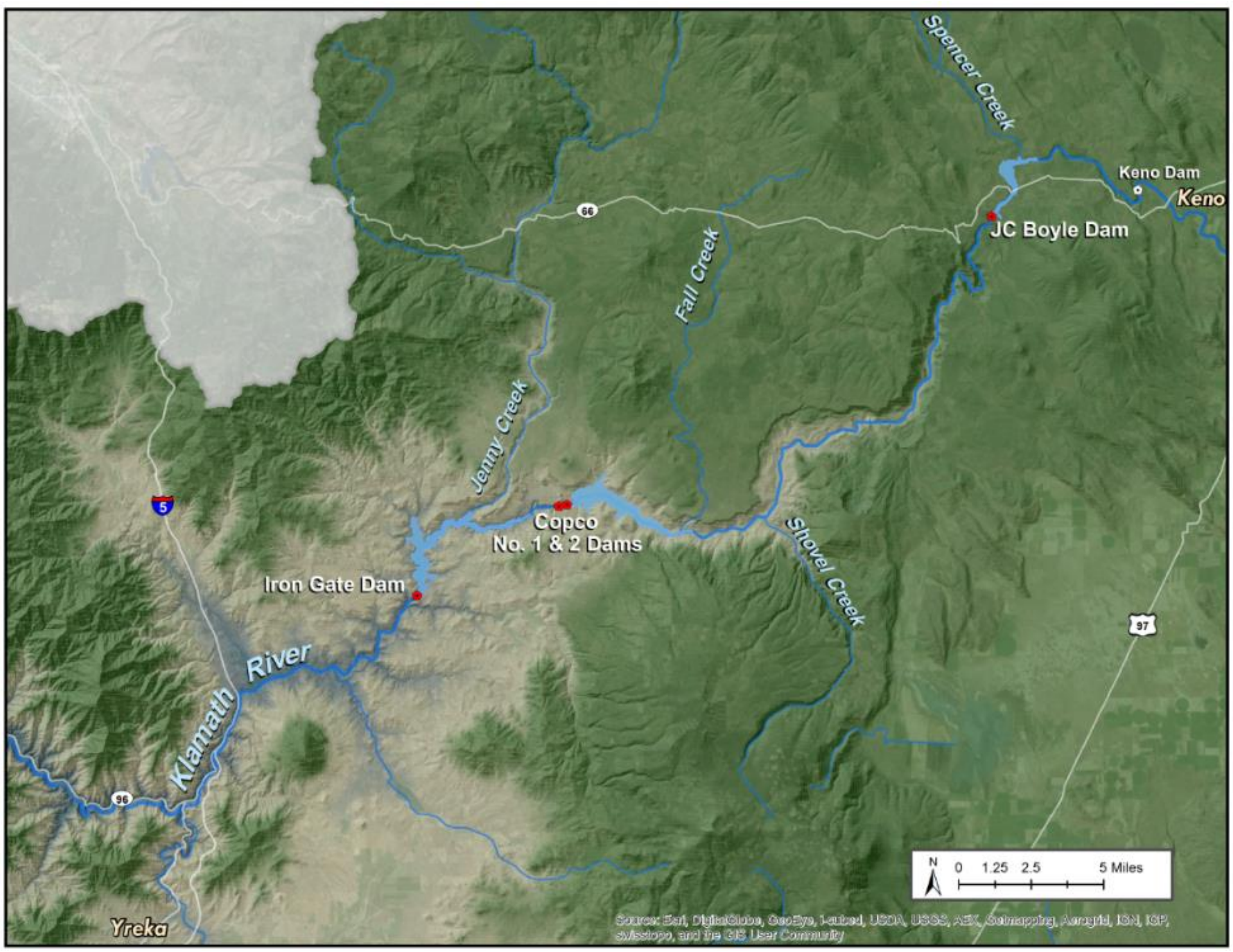

Figure 1-1 Vicinity map showing locations of Klamath River dams

As part of the 2012 Environmental Impact Statement/Report (EIS/R) and 2013 Secretarial Determination of Record (SDOR), a Reservoir Area Management Plan (USBR, 2011c) (the 2011 Plan) was developed by the Bureau of Reclamation (USBR) with assistance from the National Marine Fisheries Services (NMFS), Bureau of Land Management (BLM) and the EIS/R project team. The 2011 Plan describes anticipated conditions in the reservoir areas after removal of the four dams based on hydraulic modeling, sediment characteristics, and reservoir drawdown scenarios.

The 2011 Plan was developed primarily with the intent to minimize invasive vegetation and stabilize remaining reservoir sediments to reduce the likelihood of future sediment releases. Numerous dam removals and reservoir restoration projects have been completed since the 2011 Plan with valuable lessons learned. Likewise, additional testing has been performed with the reservoir sediments and current restoration techniques that can be incorporated into the Project to improve reservoir restoration success. Hence, this Reservoir Area Management Plan (RAMP) incorporates current restoration practices and techniques. The primary purposes of updating the 2011 Plan through this RAMP is threefold:

1. Update the goals and objectives to better match current stakeholder and regulatory requirements;
2. Include current knowledge base and lessons learned from other dam removal and restoration projects; and
3. Include details and information that were not fully developed in the 2011 Plan.

The remainder of this report follows the outline below:

1. Project goals and objectives;
2. Historical and existing conditions in the reservoir areas;
3. Anticipated reservoir conditions after dam removal;
4. Reservoir area restoration; and
5. Monitoring and adaptive management.

Chapter 2: Reservoir Area Management Goals and Objectives

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2. RESERVOIR AREA MANAGEMENT GOALS AND OBJECTIVES

KRRC convened a working group of, regulatory, tribal, and consulting professionals, the Klamath Restoration Work Group (KRWG) to provide expert knowledge and recommendations for updating the 2011 Plan. The KRRC Technical Representative led the KRWG. KRRC held two workshops in 2017 and a consensus recommendation was to update the goals and objectives based on current knowledge of restoration and experience from recent dam removal and restoration plans. Table 2-1 provides a summary of goals and objectives of this RMAP.

Table 2-1 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 IEV 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 likely evolution of reservoirs post-removal and responses 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 potential.
			Perform revegetation pilot tests for native seed mixes.
			Identify reference physical and ecological conditions in tributaries.

Period	Goal	Objective	Restoration Activity
	Maximize reservoir area restoration for ecological uplift.	Develop comprehensive restoration plan for post-removal reservoir conditions.	Actively promote erosion of reservoir deposits during drawdown, use available techniques such as barge mounted hydraulic monitors or boats.
			Modify and enhance site specific restoration actions based on site conditions after drawdown.
			Identify culturally significant areas that are off limits to disturbance.
			Develop final engineering plans for implementation.
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.	Prepare and amend sediment based on pilot test plot results.
	Evaluate active restoration options (post-removal) for habitat development.	Determine locations amenable to site specific restoration actions.	Install irrigation system.
			Hydroseed sediment by planting zones.
			Install pole cuttings, acorns, and container plants.
	Stabilize remaining reservoir sediments.	Initiate native plant revegetation.	Conduct field monitoring of mainstem/tributaries, fix non-natural barriers.
			Include criteria for IEV removal during revegetation implementation.
			Bi-weekly inspections of revegetation areas to verify IEV compliance.
			Actively promote erosion of reservoir deposits during drawdown, use available techniques such as barge mounted hydraulic monitors or boats.
	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 IEV.	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.
	Implement process-based river and tributary restoration actions where applicable.	Increase quantity and quality of in-stream and off-channel habitat for aquatic species.	Construct in-stream habitat features based on engineered designs that are appropriate for the system.
			Construct off-channel wetlands, side channels, and alcoves where appropriate.
			Enhance mid-channel gravel bars.

Period	Goal	Objective	Restoration Activity
	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.
	Monitor and maintain restoration features.	Ensure habitat restoration features are functioning as planned.	Field based monitoring throughout reservoir areas where restoration features were installed.
	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.

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Chapter 3: Historical and Existing Conditions

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3. HISTORICAL AND CURRENT CONDITIONS

Conditions at the J.C. Boyle, Copco No. 1, and Iron Gate reservoirs were well documented prior to construction of the dams. Topographic surveys were conducted prior to dam construction and there are photos of pre-dam conditions and the 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. The Copco No. 2 reservoir area is relatively small and is not discussed in this updated plan as it will readily transition back to pre-dam conditions without active restoration.

3.1 J.C. Boyle

KRRC subdivides discussion of the J.C. Boyle Reservoir into two reaches 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 (U.S. Geological Survey [USGS] river miles [RM] 230 to 231) and the Upstream Reach runs from the Highway 66 bridge to the upstream extent of the J.C. Boyle Reservoir (RM 231 to 233) (Figure 3-1).

3.1.1 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 (Figure 3-1). The narrow valley contained limited space for sediment storage, and accordingly there are no mapped historical geomorphic features (USBR, 2011c). 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-sized (e.g., Figure 3-2 and Figure 3-3). Rapids that were likely bedrock-controlled are visible upstream of RM 230 and downstream of the Highway 66 bridge (Figure 3-2). At RM 230, an unnamed tributary enters from river left, and the historical valley widens (Figure 3-1). The narrow width of the 2-year and 100-year flood extents demonstrates the confined nature of the Canyon Reach (Figure 3-1). 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 (LW) 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.

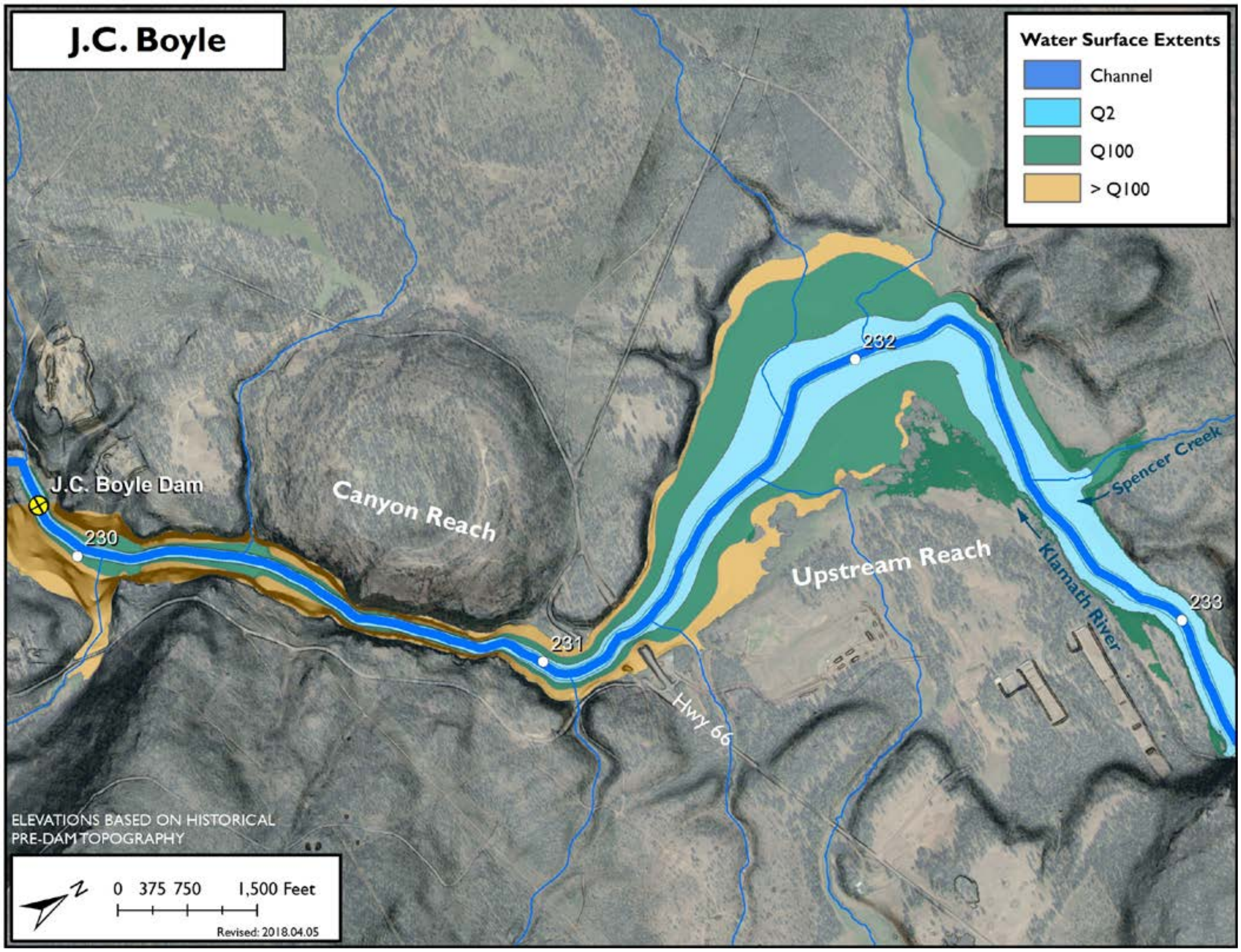


Figure 3-1 Slopeshades of bare earth LiDAR overlaid with aerial imagery and historical topography of J.C. Boyle Reservoir area with flood inundation boundaries for the 2-year (Q2) and 100-year (Q100) floods. Reach designations and river miles are noted.

The Upstream Reach occupies a wide, low relief area as the river abruptly exits the steep, narrow bedrock canyon upstream of RM 233 (Figure 3-1). Bedrock control is visible on river right approximately 1,000 feet (ft) upstream of RM 232 where the Klamath River abruptly turns south, but otherwise the pre-dam 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 (USBR, 2011c). A nearly 1 mile wide alluvial fan and terrace was mapped on river-right around RM 232 and 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 233 and was associated with a mapped floodplain and alluvial fan (USBR, 2011c). The Klamath River actively modified its channel as suggested by the extensive mapped floodplains and the vegetated and unvegetated bars, including a large semi-vegetated, mid-channel bar upstream of the Highway 66 Bridge (Figure 3-2). Most of the current reservoir was shallowly inundated during high flows (Figure 3-1) as a result of the low floodplain gradient and the small bank heights of the historical river. 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 LW was visible in the active channel. Wetland conditions were likely supported in Spencer Creek, which had a multi-threaded distributary character in its lower sections.

Highway 66 bridge crosses the Klamath River in current location. Flow is top to bottom. Dam location is out of frame to the bottom left.

Figure 3-2 Aerial photo of J.C. Boyle Reservoir area (1952) prior to dam construction

3.1.2 Current Conditions

Current conditions in the J.C. Boyle Reservoir vary considerably between the two reaches. The reservoir is narrow with low sinuosity in the Canyon Reach with reservoir water depths increasing from approximately 10 ft at the Highway 66 bridge to maximum values around 35 ft at the unnamed tributary junction 1,000 ft upstream from the dam. In the Upstream Reach, water depths are near zero for all but the historical channel footprint where depths are typically 10 to 15 ft with maximum values of 20 ft 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 (USBR, 2011c). Most of the sediment volume is stored in the Canyon Reach, where sediment thicknesses increase from 0 to 2 ft at the Highway 66 Bridge to maximum values of 20 ft near the dam (USBR, 2011c). 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 ft thick except for a 1,000 ft section around RM 231.75 where thicknesses of 8 to 10 ft filled the local low topography. Little to no reservoir sediment is stored outside of the historical channel in the Upstream Reach. As expected, the Upstream Reach sediment is coarser than downstream and is approximately 55% sand, 25% silt, and 20% clay on average (USBR, 2011c). In the Upstream Reach, the reservoir sediments are underlain by a 0 to 2 ft thick layer of coarser Quaternary alluvial gravel and sand, which is in turn underlain by fine-grained, but resistant, weathered Tertiary volcanics (USBR, 2010). Intact organic fragments (e.g., roots, twigs, bark, and wood) were only found at the pre-reservoir contact in three of the cores (USBR, 2010). The accumulated in-situ reservoir sediment in both reaches has high moisture content over 100% with low cohesion, low strength, and high erodibility (USBR, 2011c). The measured friction angle for the reservoir sediments from a sediment core near the dam site is approximately 30 degrees.

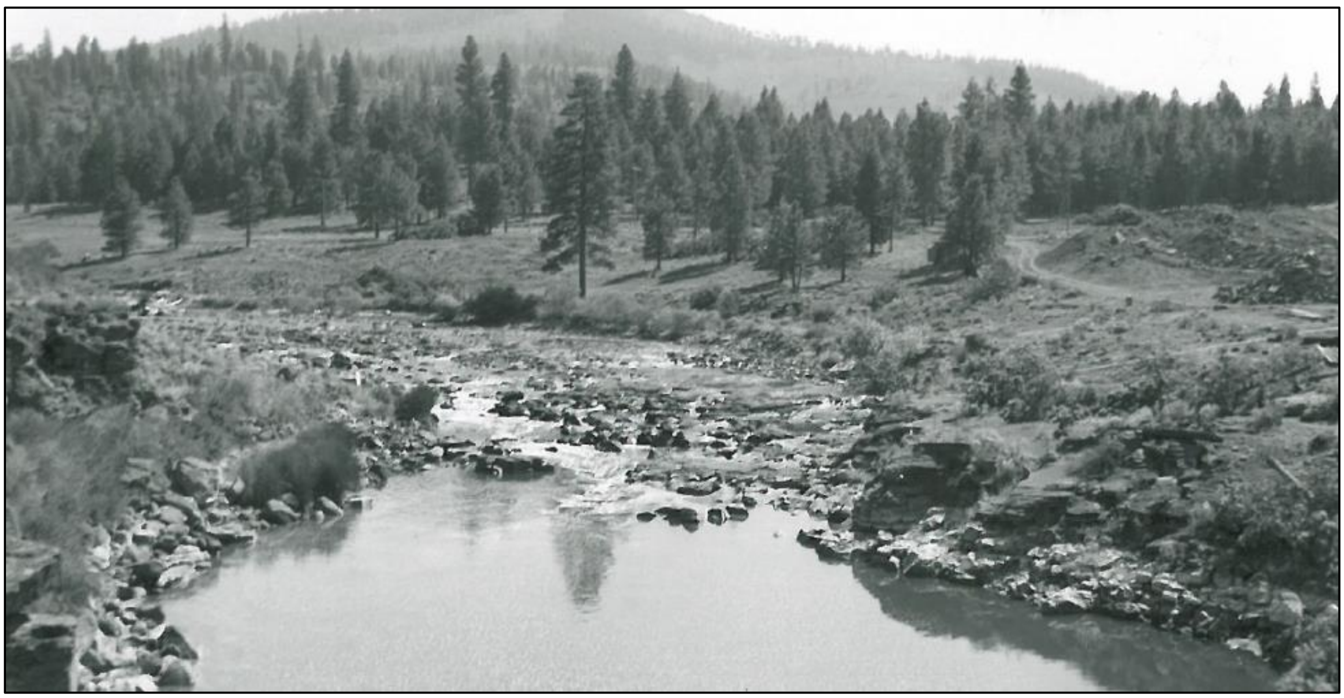


Figure 3-3 View looking upstream at location where J.C. Boyle Dam was constructed in 1957 with view of historical vegetation and geomorphology

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 at the mouths of the Upstream Reach tributaries, notably Spencer Creek. The wide, shallow reservoir margins of the Upstream Reach experience seasonal fluctuations in water level. Assorted native grasses were observed, primarily along the river right bank of the Upstream Reach reservoir (USBR, 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.

At J.C. Boyle, average daily minimum temperatures are below freezing from November until May, and average daily maximum temperatures are over 80 deg. F. in July and August (Figure 3-4). Ice often forms on the reservoir during winter. Extreme warm temperatures do not typically exceed 100 deg. F. Precipitation is greatest during the winter months. Average monthly precipitation amounts in July and August, when temperatures are hottest, are 0.34 and 0.45, respectively.

3.2 Copco No. 1

KRRC subdivides discussion of the Copco No. 1 Reservoir into two reaches 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 historical Deer Creek confluence at RM 205, and the Upstream Reach extends from RM 205 to the upstream extent of the reservoir near RM 208 (Figure 3-5).

3.2.1 Historical Conditions

Historically, the Klamath River within the Copco No. 1 was a sinuous, bedrock meandering river inset within lithified fluvio-lacustrine bedrock. The channel was single-threaded except where flow was split by bedrock islands at RM 202, 203, and 204 (Figure 3-5). The historical valley bottom was relatively wide 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 the result of aggradation caused by the damming of the ancestral Klamath River by the Copco basalt, a 140,000 year old lava flow (Hammond, 1983). The dam was built into this volcanic unit, which continues to constrict the Klamath River and form the canyon walls downstream of RM 202. These lava flows created an ancestral lake approximately 130 ft deep at its maximum (35 to 40 ft above modern lake level) that occupied approximately 5 miles of the Copco valley upstream of RM 202. Tens of feet of diatomite, which is a porous and friable biochemical sedimentary rock formed from the lithification of silica diatom shell accumulations, was deposited while the lava dam was intact to create a relatively flat ancestral lake bed in a similar footprint to the current reservoir. Diatomite is similar to chalk, but is formed from silica, rather than carbonate, and is typically coarser grained in the silt to sand size class (0.01 to 0.2 mm).

The Klamath River incised into the ancestral lake bed after the lava dam was breached and formed the bedrock meandering valley visible in the historical pre-dam topography. This pre-dam topography was characterized by the flat ancestral lake bed, which is perched up to 50 ft above the historical channel, and asymmetric channel-valley cross-sections, which comprise steep to vertical diatomite banks on the outsides of bend and more gradual alluvium-draped slip-off slopes on the insides of the meanders, morphology which is indicative of vertical and lateral erosion proceeding in tandem (e.g., RM 202.5 in Figure 3-5). The diatomite, which is fine-grained but resistant to erosion and capable of supporting vertical slopes where it is exposed on the outsides of bends, likely underlies much of the historical valley floor with maximum thicknesses (measured from tops of bluffs to ancestral valley floor) on the order of 10–100 ft in the downstream-most reaches. Diatomite bluffs ten or more feet in height were present on the outsides of meander bends upstream until at least RM 205 (Figure 3-5, Figure 3-6). The grade of the historical Klamath River in the reservoir area appeared to be controlled by bedrock outcrops, likely the Copco basalt, at the narrow entrance to Ward's Canyon, several hundred feet upstream of the Copco No. 1 Dam location (Figure 3-7).

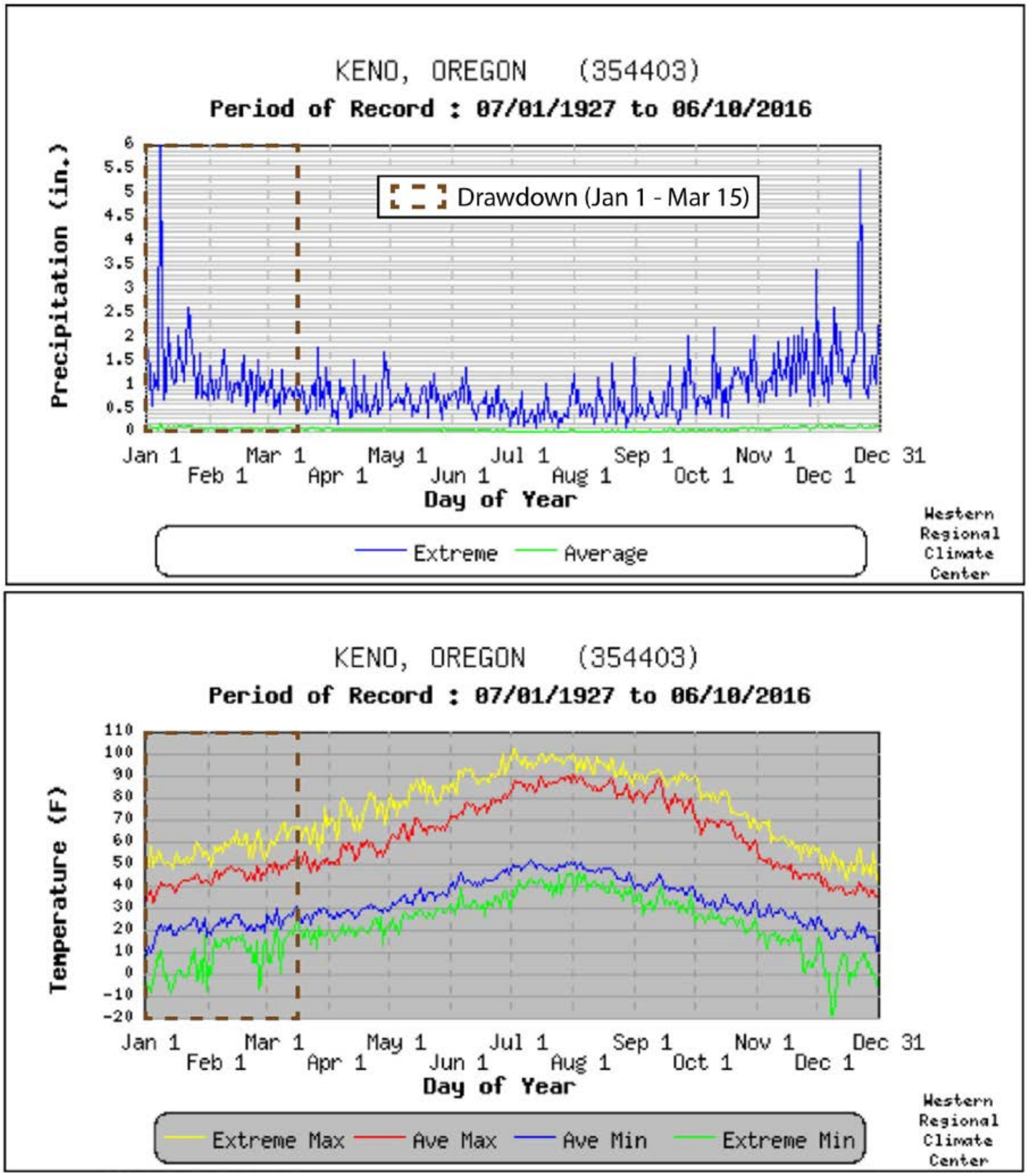


Figure 3-4 Daily temperature (top) and precipitation (bottom) data from nearby Keno, Oregon weather station. Data from Western Regional Climate Center.

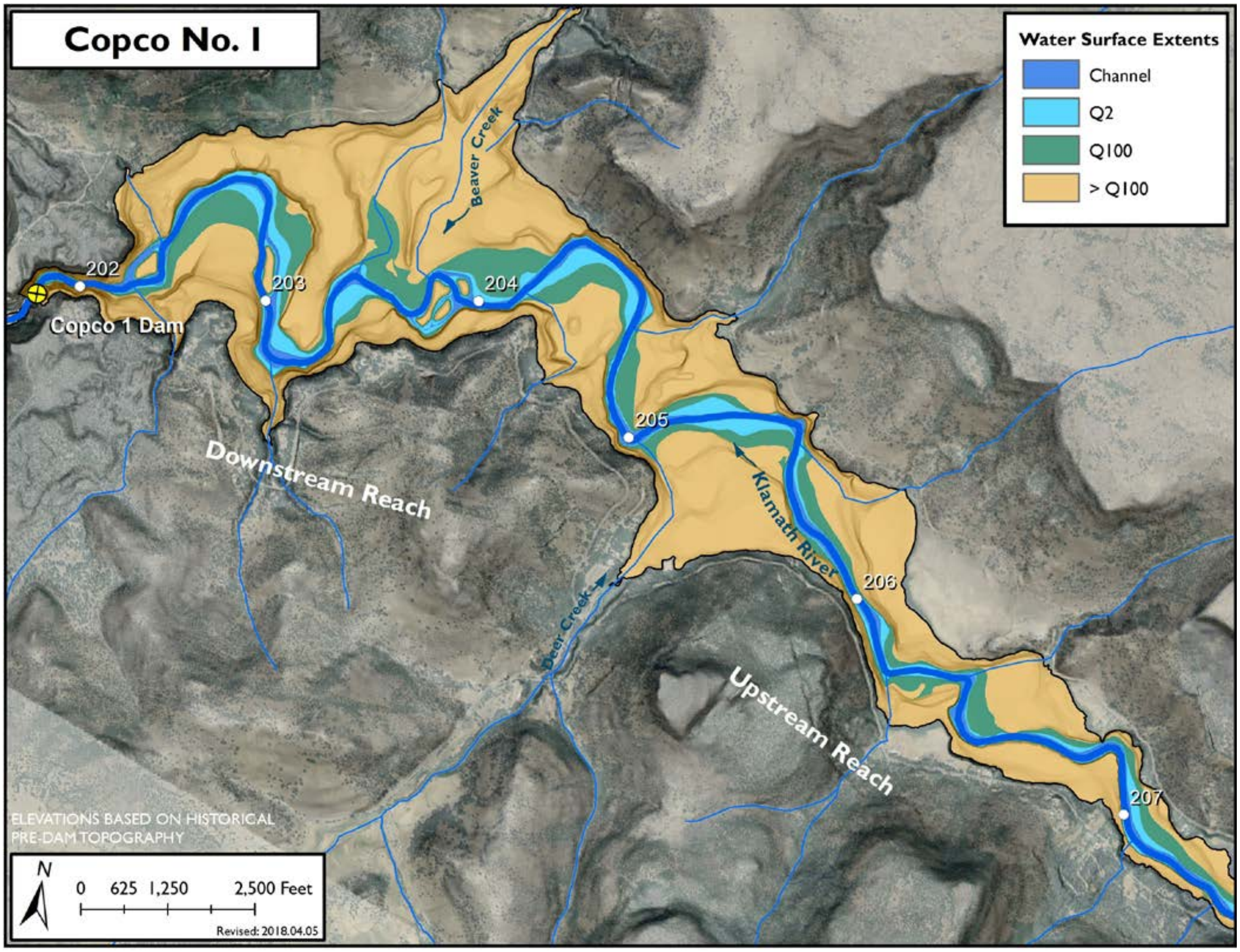
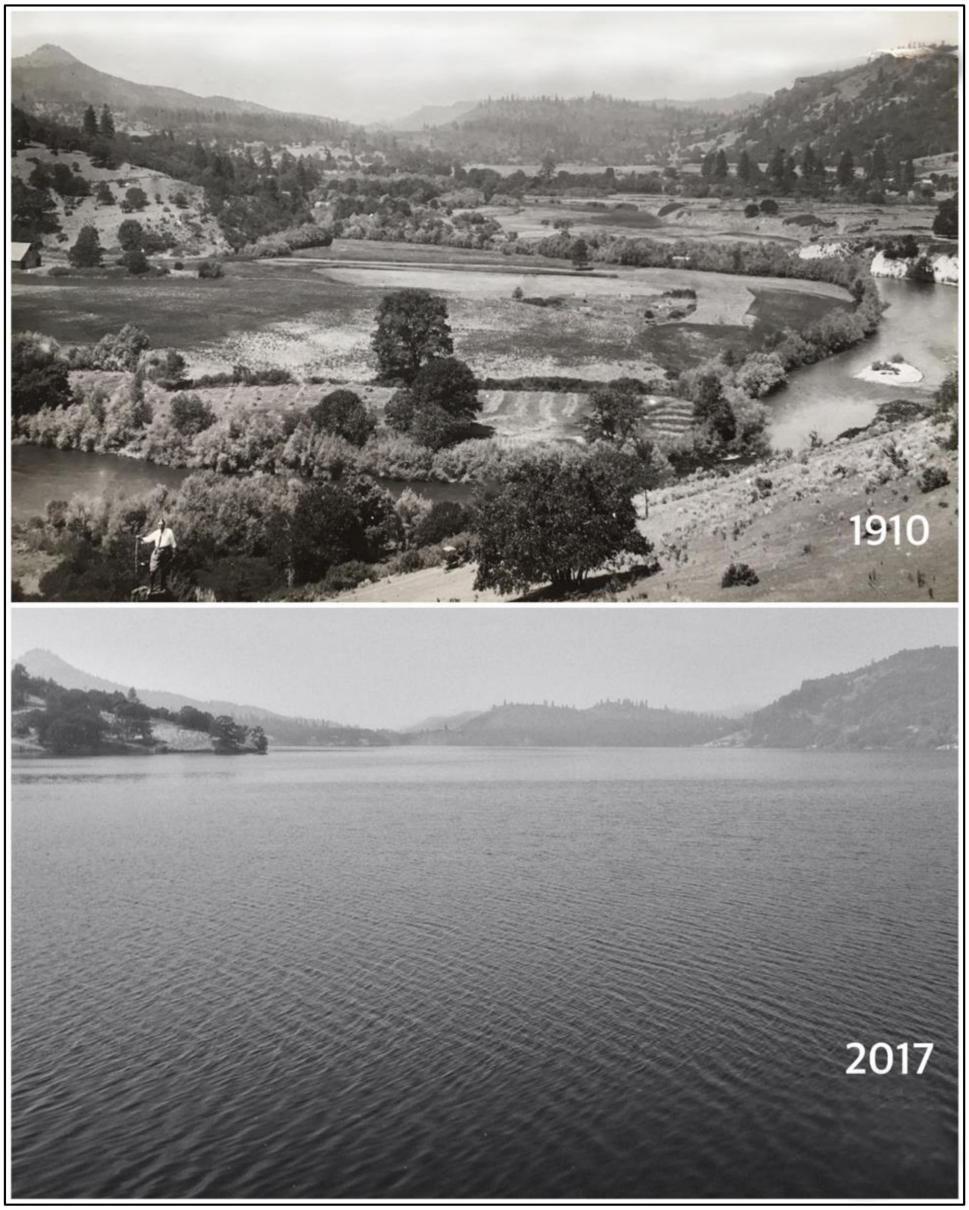


Figure 3-5 Slopeshades of bare earth LiDAR overlaid with aerial imagery and historical topography of Copco Reservoir area with flood inundation boundaries for the 2-year (Q2) and 100-year (Q100) floods.

The historical channel was actively inundating and modifying its narrow floodplain and eroding its diatomite banks as evidenced by the mapped flood inundation boundaries and the presence of a large cut-off meander loop of the mainstem Klamath River occupied by historical Beaver Creek at the time of dam construction (Figure 3-5). Swales, side channels, remnant meanders, and additional floodplain complexity are noted on the 1906 topographic map (Figure 3-8) and visible in the bathymetry (Figure 3-9). However, the large areal extent of the reservoir that is not inundated by the Q100 demonstrates the degree of valley confinement in the reach (Figure 3-5). The degree of alluviation in the historical channel is uncertain. Sand and trace gravel deposits were observed in several of the cores (USBR, 2010), and the channel was eroding diatomite to actively meander, which implies abrasion by sediment tools (Sklar and Dietrich, 2004). Point bars are not noted in historical photos or descriptions, and it is not clear if the vegetated mid-channel island (RM 204.5) visible at the right side of Figure 3-6 is composed of alluvium, diatomite, or a combination.



1910 is prior to dam construction (top photo) showing existing vegetation and land use in the reservoir area. Bedrock/valley fill is exposed in the right bank. 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 3-6 Historical photo of Copco Lake area, 1910 and 2017

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 3-6) and marked on the survey maps (Figure 3-8). 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.

Figure 3-7 1910 photo looking downstream into Wards Canyon prior to dam construction. Bedrock grade control is visible in the center of the photo.

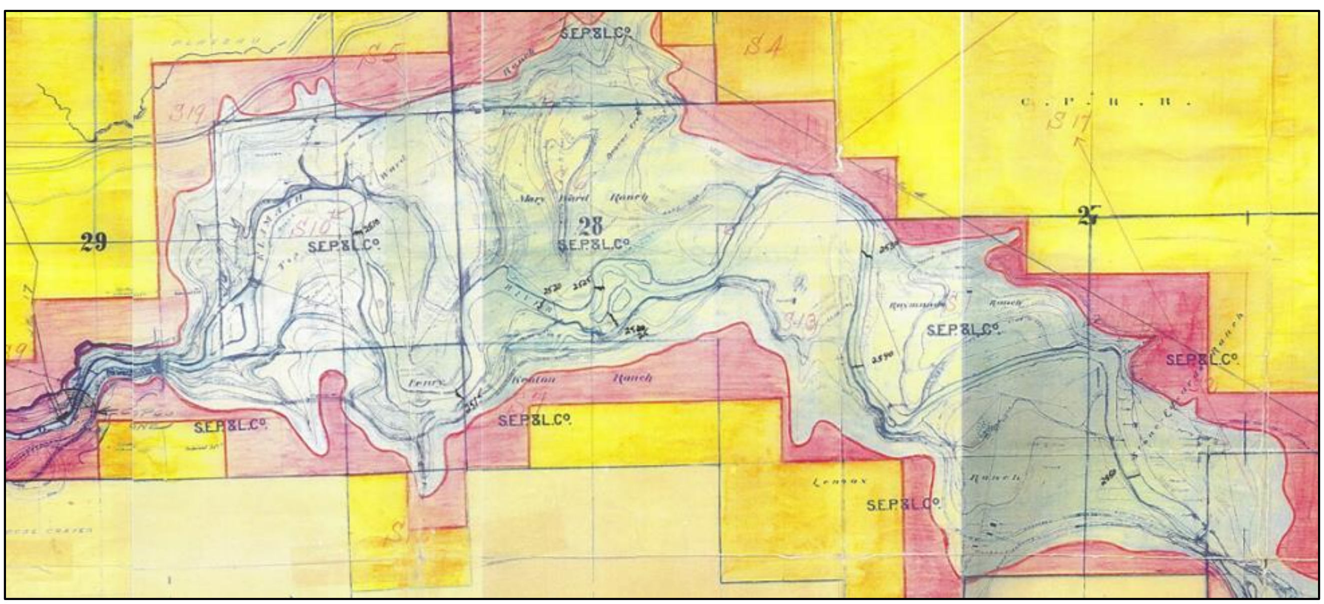


Figure 3-8 Topographic survey and field notes from 1906 survey of Copco Lake area.

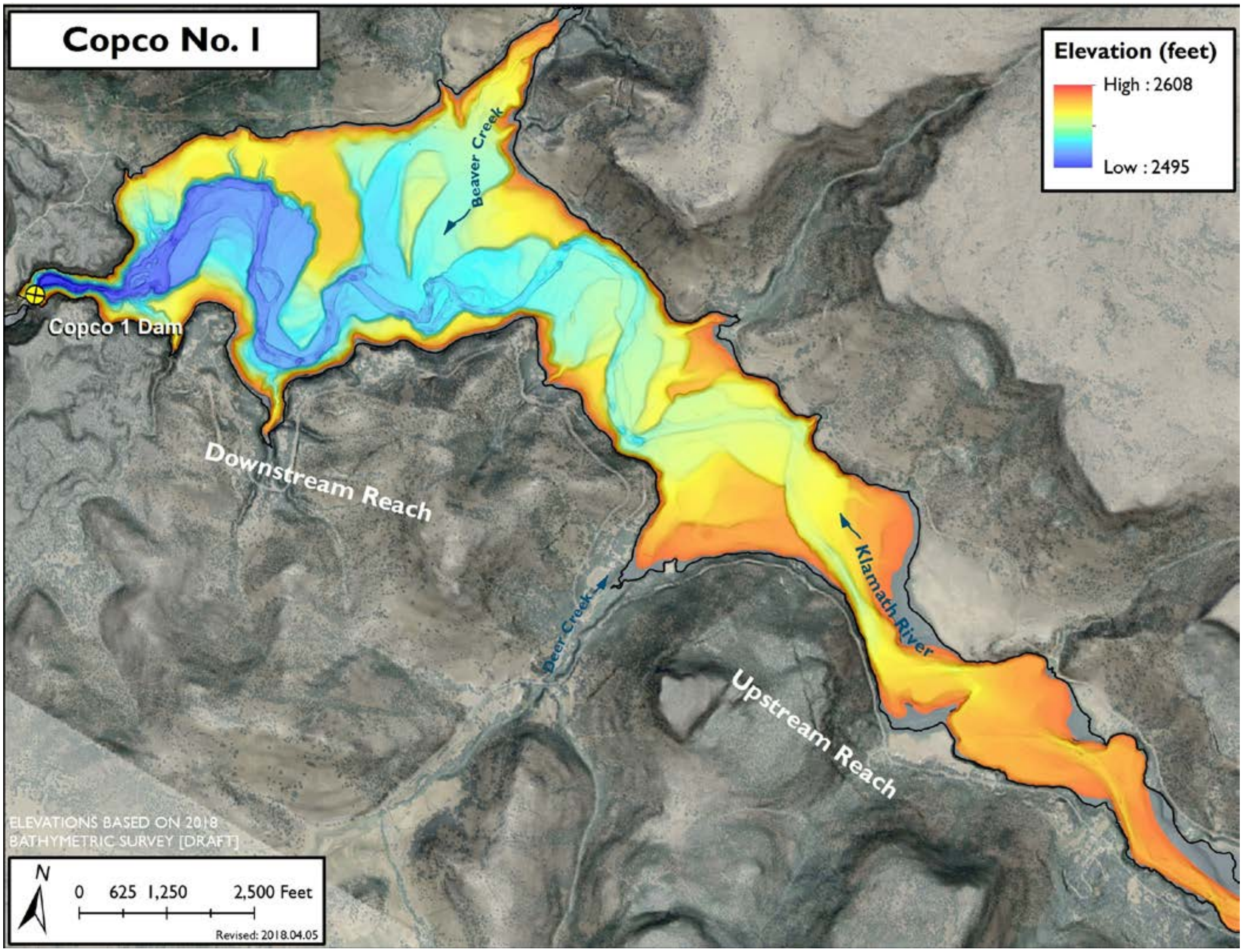


Figure 3-9 Slopeshades of bare earth 1 m LiDAR overlaid with aerial imagery and 2018 1-m bathymetry of Copco Reservoir area.

3.2.2 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 ft and 60 ft at the dam site and at RM 200, respectively. In the Downstream Reach, shallower depths are present on the ancestral lake bed surfaces. Upstream of RM 201, depths are relatively uniform and are 10 ft or less. Bedrock cliffs, some formed by post-dam erosion of volcaniclastic rocks and diatomite, line portions of the reservoir margin.

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 (USBR, 2011c). Sediment thicknesses decrease longitudinally with distance upstream from the dam and decrease laterally with increasing elevation above the historical channel (USBR, 2011c). Maximum deposit thicknesses are 10 to 12 ft immediately upstream from the dam. Deposit thicknesses are 6 to 10 ft in the historical floodplain (i.e., the Q100 footprint) downstream of RM 206. In the Downstream Reach, the reservoir sediment is, on average 55% clay, 35% silt, and 10% sand (USBR, 2011c), and is underlain at the pre-dam contact by varying concentrations of fluvial sand and trace gravels (USBR, 2010) and a thick layer of fine-grained, but resistant, diatomite. In the Upstream Reach, the coarser reservoir sediment comprises approximately 30% clay, 45% silt, and 25% sand on average (USBR, 2011c) and is similarly underlain by varying concentrations of fluvial sand and trace gravels (USBR, 2010) and a thinner layer of diatomite. Intact organic fragments (e.g., roots, twigs, bark, and wood) were only found at the pre-reservoir contact in a single core (USBR, 2010). The in-situ reservoir sediments in both reaches have high moisture contents of nearly 300% with low cohesion, low strength, and high erodibility (USBR, 2011). The measured friction angle from a sediment core approximately 1 mile upstream from the dam is approximately 27 degrees.

Climate conditions at Copco No. 1 (Figure 3-10) are warmer than J.C. Boyle. Average daily minimum temperature is similarly below freezing from November to May, but temperatures do not reach as low as at J.C. Boyle. The average maximum daily temperature is hotter with temperatures above 90 deg. for July and August. Precipitation is greater in the winter and summers are typically dry. Mean monthly precipitation amounts in July and August, when temperatures are hottest, are 0.88 and 0.36 inches, respectively.

3.3 Iron Gate

KRRC subdivides discussion of the Iron Gate Reservoir into two reaches 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 195, and the Upstream Reach extends upstream from RM 195 to the upstream extent of the reservoir at RM 199 (Figure 3-11).

3.3.1 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 (Fall Creek, Jenny Creek, and Camp Creek) contributed appreciable sediment to the mainstem and mapped geomorphic features were coincident with the confluences (USBR, 2011c). Figure 3-12 shows construction of the Iron Gate Dam and conditions upstream of the dam.

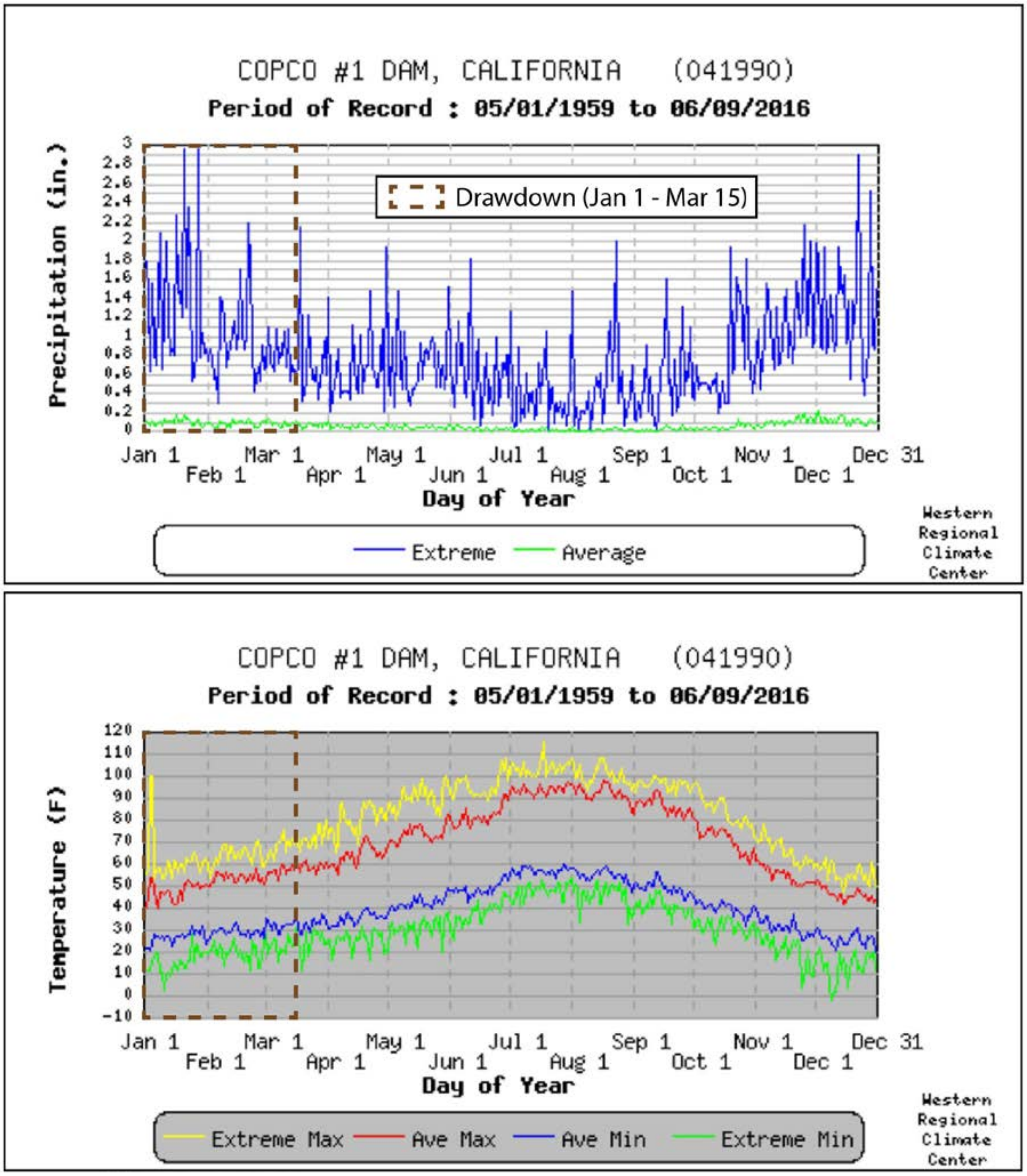


Figure 3-10 Daily temperature (top) and precipitation (bottom) data from Copco #1 Dam, California weather station. Data from Western Regional Climate Center.

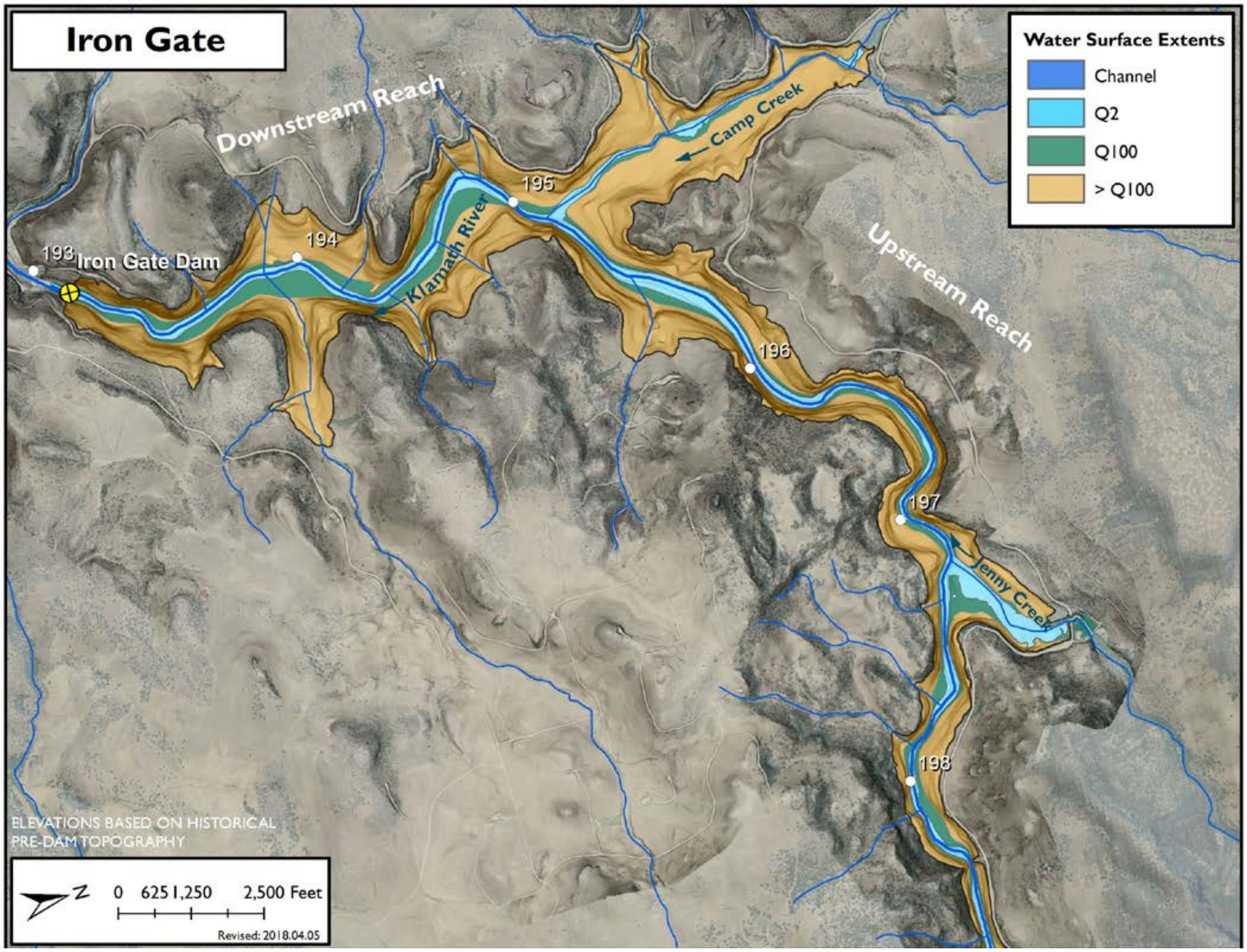


Figure 3-11 Slopeshades of bare earth LiDAR overlaid with aerial imagery and historical topography of Iron Gate Reservoir area with flood inundation boundaries for the 2-year (Q2) and 100-year (Q100) floods.

In the Downstream Reach, Camp Creek, which flows into the present-day Mirror Cove, likely contributed a considerable amount of sediment to the mainstem (USBR, 2010), and there was a large alluvial fan at the historical confluence (Figure 3-13). Camp Creek is vertically incised nearly 10 ft into the fan surface. Downstream of the Camp Creek confluence at RM 195, there was an increased frequency of mapped alluvial terraces, fans, floodplain, and unvegetated bars along the mainstem channel (USBR, 2011c), and the width of the Q100 inundation extent increased accordingly (Figure 3-11). 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 photos at several locations coincident with the wider 100-year floodplains. Anthropogenic disturbance, including mining and road construction, is visible in the bathymetry on the river-left floodplains at RM 194 and RM 195 (Figure 3-13).

Figure 3-12 Photo of Iron Gate Dam during construction and showing reservoir area.

In the Upstream Reach, geomorphic features were largely absent from RM 195 to RM 198, with a notable exception at the confluence with Jenny Creek, which likely contributed a substantial amount of sediment (USBR, 2010), judging by its large contributing area and the volume of sediment it deposited in Iron Gate Reservoir. The channel and floodplain were narrow and topographically confined as indicated by the narrow flood extent widths (Figure 3-11). Near RM 199 and downstream of the Fall Creek confluence, the valley bottom widened, and there was a sequence of mapped alluvial fans and terraces (USBR, 2011c). 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.

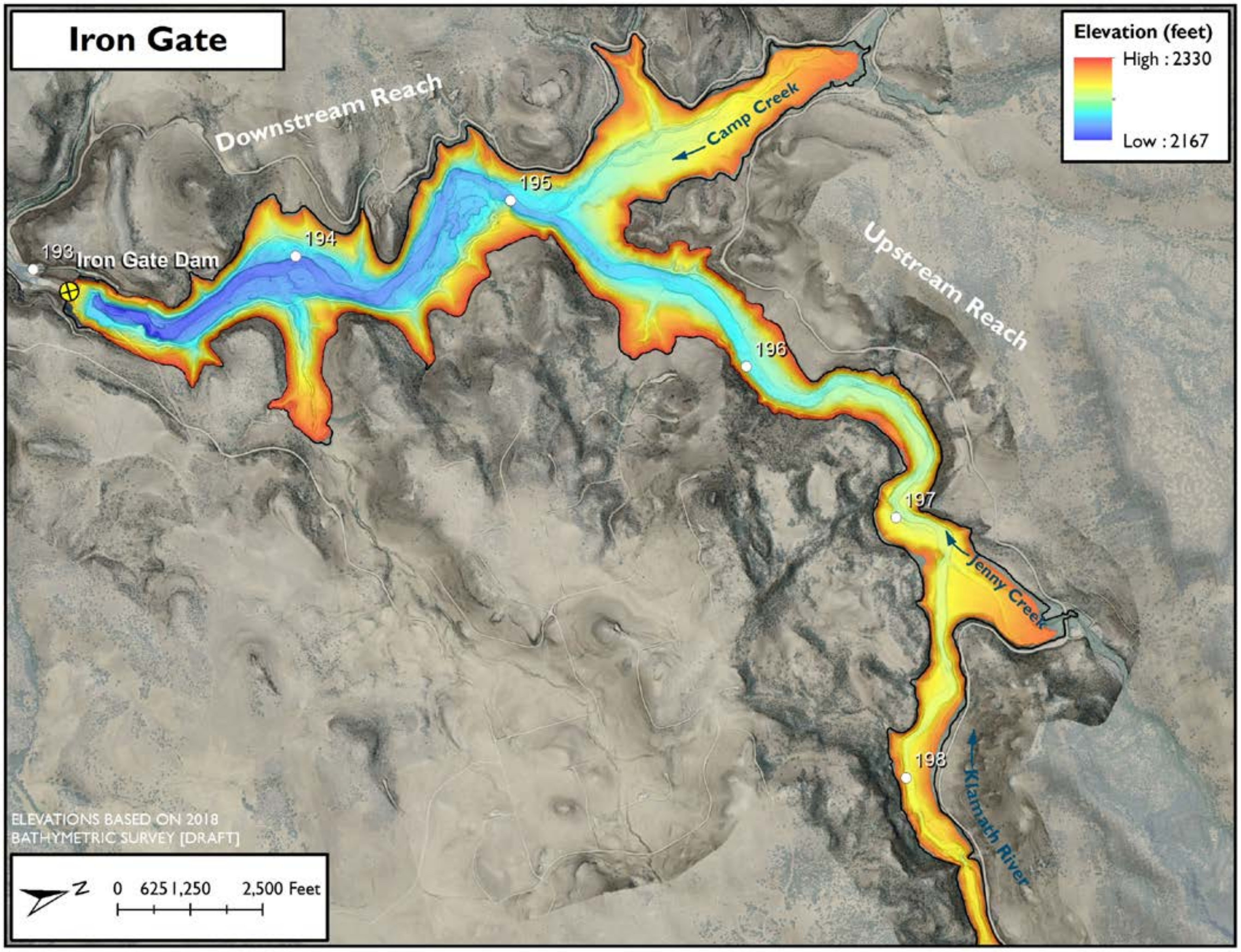


Figure 3-13 Slopeshades of bare earth 1-m LiDAR overlaid with aerial imagery and 2018 30 cm bathymetry of Iron Gate Reservoir area. River miles and reach designations are noted.

3.3.2 Current Conditions

The Iron Gate Reservoir geometry is consistent with inundation of a cross-sectionally uniform, deep, and narrow canyon, whereby reservoir width and water depth decrease 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 ft near the dam (Figure 3-13).

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 high concentration of dead algae and organic matter (USBR, 2011c). Sediment thicknesses are deeper in the historical channel than the historical floodplain and current reservoir margins. Maximum sediment thickness is 4 to 5 ft and decreases with distance upstream from the dam. Mirror Cove has relatively uniform sediment thicknesses of 2 to 3 ft.

The maximum sediment thicknesses of 5 to 6 ft 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 (USBR, 2011c). Reservoir deposits are underlain by fine-grained weathered Tertiary volcaniclastic material with varying concentrations of gravel and sand (USBR, 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 (USBR, 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 (USBR, 2010). The accumulated in-situ reservoir sediments have 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 (USBR, 2011c). The measured friction angle from a sediment core located at RM 195.5 is approximately 32 degrees (USBR, 2011c).

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, USBR, 2011c). Rushes and invasive yellow star thistle are more abundant on the banks of southern aspect slopes, whereas oak are on the banks of northern aspect slopes based on site surveys and observations (USBR, 2011c). Willows are primarily found on the margins of Mirror Cove and on the banks upstream of Fall Creek (USBR, 2011c).

Temperature and rainfall patterns at Iron Gate are expected to be adequately described by the data from the Copco No. 1 Dam weather station (Figure 3-10) information and description.

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Chapter 4: Anticipated Reservoir Conditions

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4. ANTICIPATED RESERVOIR CONDITIONS AFTER DRAWDOWN

KRRC proposes drawdown of all three reservoirs for the months of January, February and March to take advantage of high flows that will maximize erosion of stored sediments and minimize downstream impacts to aquatic resources. This section provides an overview of the general conditions expected in the reservoirs after drawdown and focuses on the characteristics of the residual reservoir sediments and expected revegetation. Each reservoir has distinct features and characteristics, so additional information and description of the likely response of the individual reservoir areas are also discussed below for each reservoir. Table 4-1 summarizes historical water features in each of the reservoirs.

Table 4-1 Summary of mainstem river, side channel, tributaries and area currently inundated in each reservoir

Location	Mainstem River Length* (mi)	Side Channel Length* (mi)	Tributary Length* (mi)	Number of Tributaries*	Inundated Reservoir Area (acres)	Exposed Reservoir Area (acres)
J.C. Boyle	3.3	-	0.2	10	347	222
Copco No. 1	6.9	1.2	1.5	18	972	863
Iron Gate	6.8	-	2.5	52	942	840
Total	**17.0**	**1.2**	**4.2**	**80**	**2,261**	**1,925**

**USFWS 2009*

4.1 Conditions Common to All Reservoirs

KRRC's contractor will simultaneously draw down the J.C. Boyle, Copco No. 1, and Iron Gate reservoirs, and the accumulated sediment will 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. USBR used both one-dimensional (1D) and two-dimensional (2D) sediment transport models to predict likely sediment transport and river conditions in the reservoirs after dam removal. USBR estimated 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 (USBR, 2011c).

The 2011 Plan (USBR, 2011c) summarizes the previous hydraulic modeling completed by USBR and responses of the reservoir areas to drawdown. Forecasted steps in the evolution of the reservoir deposits include initial erosion of reservoir deposits during drawdown, slumping of saturated sediment deposits toward the river channel due to low shear strength and draining of water from the pore spaces in the deposits, and drying, consolidation, cracking and hardening of remaining deposits (USBR, 2011c). Next steps in the process include the establishment of herbaceous vegetation, erosion of the floodplain deposits during storms, and the gradual weathering of the deposit (USBR, 2011c).

KRRC based discussion herein of the conditions anticipated at the individual reservoirs after drawdown on previous studies and analysis documented by USBR (2011c) and the results from experimental testing of reservoir sediments and revegetation completed in 2017 and 2018. Testing focused on 1) changes in reservoir sediment properties when exposed to cycles of wetting and drying, and 2) evaluation of reservoir sediments as growth medium and the success of specific revegetation species. Section 8.1documents the methodology, results, and implications of this experimental testing.

4.2 J.C. Boyle

KRRC expects the geomorphic evolution of the J.C. Boyle Reservoir in response to dam removal 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 bedrock prominent in the historical river channel bed. Narrow, but potentially several feet thick, deposits may persist outside the channel banks. The Upstream Reach will be exposed early during drawdown because the water depths are shallow. KRRC anticipates the channel here to preferentially erode its historical channel bed and leave the broad (approximately 1,000 ft wide) deposits on the channel margins relatively intact. KRRC does not anticipate significant slumping of these deposits during drawdown because of shallow depths (< 2 ft) and low topographic slopes (< 0.1 ft/ft). These deposits will reduce in height and volume by up to 50% as the material dries and consolidates. Water levels in the J.C. Boyle Reservoir are sensitive to river flows because of the small size of the reservoir. As a result, high flow events can inundate and modify the deposits in the period between the onset of drawdown and removal of the dam. A 5-year event, for example, will increase reservoir elevations by more than 20 ft (USBR, 2011b). There are only a few tributaries on these marginal deposits, and some are ephemeral, so KRRC expects little subsequent evacuation after removal of the dam. Given the low relief of the Upstream Reach, high flow events will periodically inundate and modify the remnant reservoir surfaces. The modeled 100-year flood inundates nearly the entire Upstream Reach (Figure 3-1). It is uncertain if pre-dam bedforms, such as the large mid-channel bar (Figure 3-2), will be reestablished post-drawdown.

The Canyon Reach is highly confined and will have relatively little upland or floodplain area available for revegetation. This geometry should efficiently evacuate the reservoir sediments, and the coarser pre-dam substrate will be exposed readily and support revegetation with woody riparian species in some locations. Drawdown in the Upstream Reach will expose a large low-gradient area of relatively thin reservoir sediments. The existing wetlands in the Upstream Reach, e.g., at the Spencer Creek confluence, may disappear after drawdown, but the seedbank germination study results suggest that wetlands may re-establish naturally, albeit in a new location closer to the historical channel. The sediments at J.C. Boyle contain the lowest amount of clay and the highest amount of arsenic of the three reservoirs, and they will be best suited for planting of native grassy vegetation and trees (e.g., Douglas fir, ponderosa pine, Oregon white oak) that are currently growing in the reservoir vicinity. Each planting zone species assemblage successfully established in the moist J.C. Boyle sediments, and the upland species were able to grow in the desiccated samples, albeit with frequent irrigation and moderate temperatures. Air temperatures at J.C. Boyle typically fluctuate diurnally above and below freezing during the winter months when drawdown is scheduled to occur. As a result, the sediments will drain and dry with warmer daytime temperatures but freeze at night. These conditions, which will persist for months in the Upstream Reach, will be challenging for young plants, particularly those with shallower root systems. Dried sediment thickness will only be on the order of a foot thick, so the roots of plants that establish in the sediments will have access to the historical floodplain surface and materials. The sediments and hydrologic conditions in the historical materials may be more suitable for plant establishment, although it is unknown how reservoir inundation may have modified these characteristics.

4.3 Copco No. 1

KRRC expects the reservoir sediments in the sinuous historical channel footprint to erode during drawdown, and large areal extents of residual sediments several feet in thickness will persist on the low gradient upland surfaces of the historical lake bed. KRRC proposes to begin the drawdown of the 2,609-ft elevation Copco Reservoir water surface on November 1, prior to drawdown of Iron Gate and J.C. Boyle reservoirs, at a rate 2 ft/day. Beginning January 1, drawdown rate will increase to a maximum of 5 ft/day.

The low-gradient, historical lake bed surfaces (elevation approximately 2,580 ft), which extend throughout the Downstream Reach, will be exposed in mid-January under all modeled hydrologic scenarios. These deposits will not be subjected to secondary inundation during large flow events in the period between drawdown and dam removal, except potentially in far upstream portions of the reservoir. These flat surfaces will not be accessible from the river. KRRC anticipates reservoir deposits on these low gradient upper surfaces (except at the edges of vertical bluffs) will be relatively stable and not subject to appreciable slumping or hydraulic erosion. The gradients on these surfaces are typically less than 2 degrees, as measured from the current high resolution bathymetric data, and are well below even the lowest estimates (6 degrees) for the aerial angle of repose for the reservoir sediments.

Larger tributaries, such as Deer Creek and Beaver Creek, can begin to rework their delta deposits and contribute bedload to the mainstem upon aerial exposure. The Deer Creek confluence (elevation approximately 2,560 ft) will be fully exposed in mid-January for dry and median years but as late as late-February for wet years and the notching drawdown option. The dynamic Beaver Creek confluence area (elevation approximately 2,540 ft) will be exposed in mid- to late-January for median to dry years and sometime in February for wet years, depending on the timing of flow events. Large events following aerial exposure will increase the amount of sediment reworking by the mainstem and tributaries. Increases in reservoir water surface elevation due to, for example, a 5-year flood are in the range of 5 to 15 ft.

Copco No. 1 Reservoir sediment thicknesses vary with pre-existing valley topography such that the lower elevation historical channel contains deeper deposits than higher elevation terraces and ancestral lake bed. USBR predicted the spatial patterns of erosion by two-dimensional morphodynamic modeling of Copco Reservoir during drawdown (USBR, 2011b). Erosion in excess of 5 ft was concentrated within the sinuous historical channel and in the cut-off meander bend, which will 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 spatial extent of modeled erosion is potentially a minimum prediction, and it is likely that more material will naturally evacuate from other areas during drawdown. The 2D modeling used the formulation for the erosion rate of fine-grained cohesive sediments and measured parameter values from Simon et al. (2010) to simulate erosion under easier to erode and harder to erode scenarios (Table 8-9). The model is far more sensitive to the modeled hydrology than the variation in the erosion rate parameters. The hard to erode τ_C and k values used were more than an order of magnitude lower and higher, respectively, than the maximum values measured in the wetting-drying experiments (Table 8-6). However, given the large proportion of sediment eroded during the drawdown period and its location in the historical channel, the modeling results do not change with the new shear strength data. Hardened, resistant sediment is more likely located in upland and higher elevation floodplain areas less affected by initial drawdown and erosion by the Klamath River.

Given the high relative elevation, low gradient, and large width of ancestral lake bed and upland surfaces, reservoir deposits 2 to 6 ft 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 the remaining sediments will undergo the physical changes associated with desiccation. The volume reduction during consolidation may lower the surfaces up to 50% of the deposit thickness, and KRRC expects cracks 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.

The historical Copco No. 1 valley topography was created by a complex sequence geologic and geomorphic events and a diversity of landforms and materials will be exposed following drawdown. The pre-dam valley relief was high in the Downstream Reach with elevation differences in excess of 50 ft between the channel bed and the higher elevation, low-gradient ancestral lake bed. These steep 5 to 50 ft tall banks on the outside banks of the meander bends and the material underlying much of the historical valley bottom are composed of fine-grained and porous diatomite. However, the diatomite, which is mechanically capable of supporting tall vertical bluffs when dry, has been inundated for 100 years, and the pores are likely now filled with water. The drawdown rates of 5 feet per day (0.2 inches per hour) likely exceed the hydraulic conductivity of the diatomite, and the combination of steep and tall valley geometry with saturated porous rock could lead to slope failure during drawdown. The effect of saturation on diatomite mechanical strength and the result of dewatering with drawdown are poorly constrained, but on-going data collection and analysis by KRRC are investigating the stability of the diatomite. The products of diatomite slope failure could persist in the valley bottom and potentially alter the course, but probably not dramatically, of the Klamath River away from the historical alignment and cause increased lateral erosion of diatomite bluffs. KRRC does not anticipate significant vertical incision into the historical valley floor post-drawdown because of the presence of bedrock grade control at the entrance to Ward's Canyon upstream of Copco No. 1 dam. As such, KRRC expects access by the Klamath River to its historical floodplain to only be limited by the presence of residual reservoir sediments in riparian areas.

The sediment texture at Copco Reservoir is on average much finer than that at J.C. Boyle and ranges from clay to silty clay loam on a USDA texture triangle, and the size grades from fine texture near the dam to the coarsest texture at the upstream portion of the reservoir. Textural gradations will be reflected in the vegetation palette, which will include a larger proportion of native perennial bunch grasses, trees and shrubs in the upstream area where coarser, well-aerated soils will be able to support these deep rooting species. Each planting zone species assemblage successfully established in the moist Copco sediments, and the riparian bank and riparian floodplain species were able to grow in the desiccated samples, albeit with frequent irrigation and moderate temperatures. Air temperatures at Copco typically fluctuate diurnally above and below freezing during the winter months when drawdown is scheduled to occur. As a result, the sediments will drain and dry with warmer daytime temperatures but freeze at night, a combination that will be challenging for young plants. Irrigation may not be possible in the ancestral lake bed uplands and many other upland portions of the Copco valley given the large areal extents and distance from surface water sources. Access to the upland areas must be from the road, rather the channel.

4.4 Iron Gate

At Iron Gate, KRRC anticipates the Klamath River 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 (USBR, 2011c). KRRC proposes to begin drawdown of the 2,330-ft elevation reservoir water surface on January 1. At maximum drawdown rates of 5 ft/day, Fall Creek (approximately 2,310 ft) will be completely exposed in the first week of drawdown and modification of the local deposits by Fall Creek are expected during subsequent storm events. The Jenny Creek delta (minimum elevation approximately 2,270 ft) will have full aerial exposure by mid-February for wet and above-normal years and mid-January for median and dry years (USBR, 2011b) and will experience reworking during subsequent high flows. The Jenny Creek delta has the thickest and coarsest deposits in the Iron Gate Reservoir and will function as a source of bedload to the mainstem. The Mirror Cove confluence area (elevation approximately 2,230 ft) won't be exposed until the end of January for median and dry years and the beginning of March for wet years USBR, 2011b), although upstream portions of Mirror Cove and its tributaries will rework their deposits (maximum sediment thickness 5 ft) at all stages of drawdown.

Most of the historical roads and the railroad along the Downstream Reach of Iron Gate (Figure 3-13) are not exposed until reservoir levels are below 2,230 ft. Assuming maximum drawdown rates, the road will not be exposed until the end of January for median and dry years and the beginning of March for wet years (USBR, 2011b). Several weeks will likely be required before reservoir sediment has stabilized and the certainty of road stability has been verified. Until that point, the floodplain in the Downstream Reach of Iron Gate and Mirror Cove may be inaccessible.

Drawdown operation at Iron Gate will be impacted not only by hydrology but also by releases from Copco and the discharge capacity of the diversion tunnel. KRRC's contractor will control the discharge capacity by a new slide gate, and values of 11,000 cfs, approximately a 5-year recurrence interval flood, are used in models of drawdown. A flow of this magnitude occurring after the onset of drawdown but before dam removal will result in an increase in the reservoir water surface elevation by up to 90 ft, which will backwater Klamath River nearly to the Fall Creek confluence and inundate the historical roads, most of Mirror Cove, and the Jenny Creek delta. This secondary inundation could persist for days to weeks depending the elevation and magnitude of the event and potentially re-saturate or erode residual sediments. Fine-grained sediments will be subject to potential breakdown from an additional cycle of wetting and drying. Secondary inundation is not expected in normal or dry years when flow events do not exceed the discharge capacity of the diversion tunnel.

Reservoir sediments do not exceed 5 ft in thickness except at the Jenny Creek delta, so KRRC expects residual sediment persisting after drawdown to reduce in thickness to less than 3 ft. Given the relatively more rapid drawdown proposed at Iron Gate and steep side slopes, reservoir deposit erosion from slumping should be more efficient (USBR, 2011c). There are several mapped low relief terraces, fans, and historical floodplains in the valley bottom (particularly in the Downstream Reach) on which larger areal extents of sediment may be stable (Table 8-1). 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, KRRC expects a larger areal extent of sediment relative to the mainstem areas to remain after drawdown. These deposits are only 2 to 3 ft thick, however, and will consolidate upon drying.

Challenging access into the Iron Gate canyon will limit active revegetation and restoration efforts. Germination and plant growth was successful in the reservoir sediments, but growing conditions were idealized relative to those in the restoration time period which go from below freezing temperatures during drawdown to hot and dry summer. Irrigation is logistically challenging with the steep canyon walls, which limit both groundwater and surface water access. The sediment texture at Iron Gate Reservoir is the finest of all three reservoirs with clay content up to 78% at the IG2 sampling site. Similar to other reservoirs, the sediment textural gradient progresses from finest near the dam to the coarsest at the upstream end of the reservoir and at the Jenny Creek confluence. This gradation will be reflected in the vegetation palette that will include a larger proportion of native perennial bunch grasses, trees and shrubs in the upstream area where coarser, well-aerated soils will be able to support these deep rooting species.

Chapter 5: Reservoir Area Restoration

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5. RESERVOIR AREA RESTORATION

This section provides an overview of the anticipated timeline and restoration plan for each reservoir area along with detailed descriptions for restoration actions. Restoration actions consist of strategic, physical alterations of the reservoir areas including grading and installation of large wood features, as well as revegetation techniques to maximize ecological recovery of the reservoir areas.

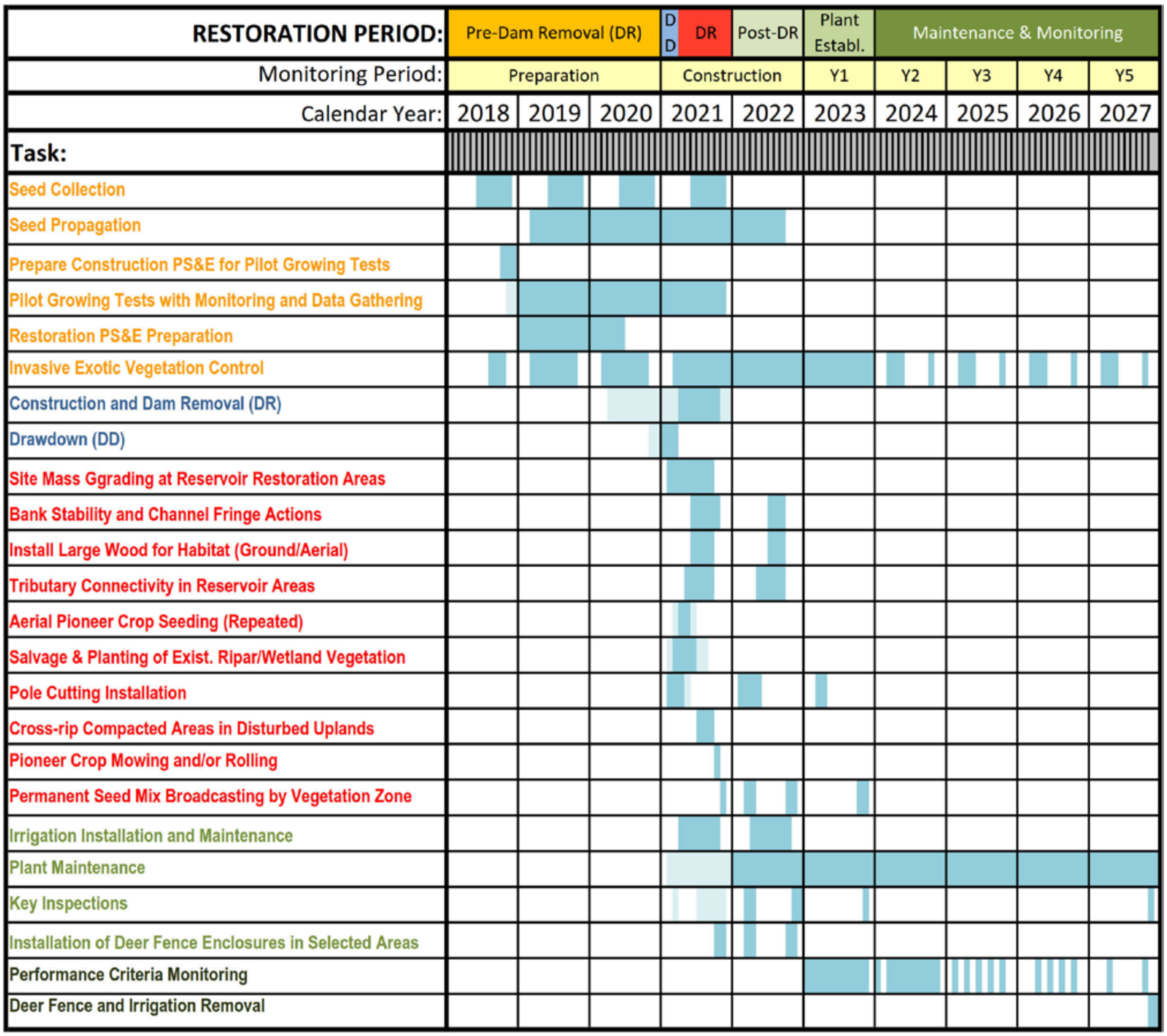
5.1 Restoration Time Periods

The 2011 Plan (USBR, 2011c) was developed with an emphasis on stabilizing remaining sediment in the reservoir areas after drawdown to minimize the potential for future, large-scale sediment releases in the Klamath River. In addition to sediment stabilization, the Klamath Restoration Working Group recommended additional actions for the reservoir areas to develop wildlife and aquatic habitat while at the same time restoring natural river function and processes. This RAMP seeks to combine revegetation practices with physical habitat restoration techniques to re-instigate sustainable river function and natural processes. To further describe restoration actions and critical time stages, the following time periods are defined:

1. **Pre-dam removal period** (1–2 years pre-drawdown) activities include: seed collection, seed propagation, IEV control, sediment testing, grow experiments.
2. **Reservoir drawdown period** (January to March, year of drawdown) activities include: reservoir drawdown with natural erosion and assisted evacuation of reservoir sediment deposits, initial stabilization of sediments and exposed areas with aerial seeding, salvage and plant existing wetland and riparian vegetation, evaluation of restoration sites.
3. **Dam removal period** (spring, summer and fall immediately after drawdown) activities include: additional seed application in problematic areas and in remaining unseeded reservoir deposits, irrigation system installation in bank riparian areas, IEV control, active restoration of identified floodplain areas by grading, large wood installation, and habitat features.
4. **Post-dam removal period** (after dam removal is complete) activities include: additional seeding in difficult and underperforming areas, IEV control, continued installation of pole cuttings and seed plantings, maintenance of existing and previously planted vegetation, modification and adaptive improvements to installed habitat features, and installation acceptance inspections to commence a 5-year monitoring period.
5. **Plant establishment period** (Year One, after completion of revegetation) activities include: continued monitoring and maintenance of vegetation, irrigation system maintenance, removal of IEV, fish passage monitoring, and enhancement and/or augmentation of habitat features as needed.
6. **Maintenance and monitoring period** (Years Two to Five, after completion of revegetation) activities will include: regular monitoring and report preparation, re-seeding and re-planting as necessary, IEV control, fish passage monitoring, irrigation system repair, and adaptive management and maintenance of physical habitat features.

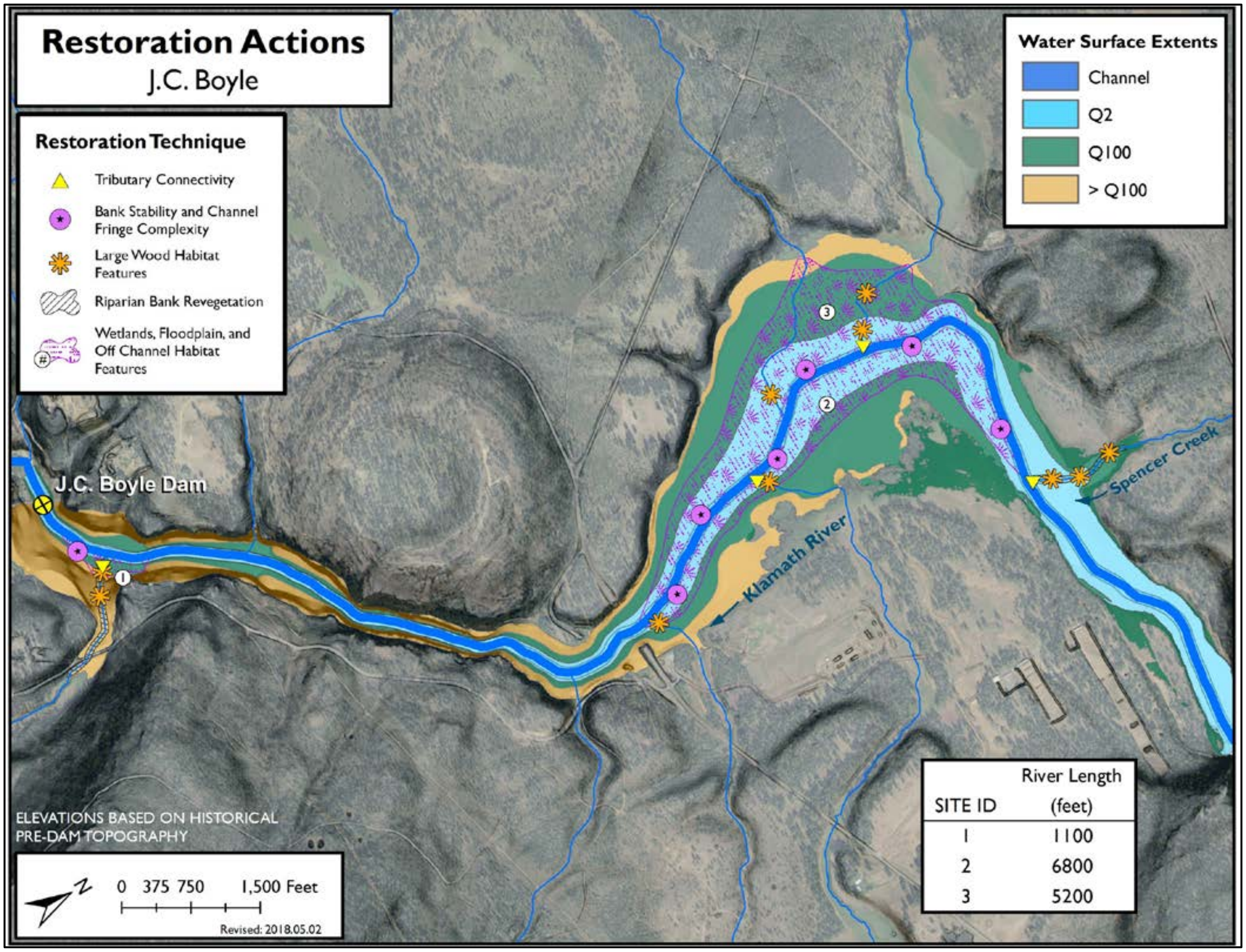
Table 5-1 details the restoration timeline with major tasks KRRC's contractor will implement in relationship to the reservoir drawdown and dam removal activities. A five-year monitoring period is incorporated in the timeline including an intensive one-year plant establishment period that will consist of close attention to monitoring and control of IEV, adaptive re-seeding and re-planting of vegetation in under-performing areas, and careful management of the riparian bank zone irrigation system.

Table 5-1 Restoration Timeline



5.2 J.C. Boyle Reservoir Restoration Overview

Figure 5-1 provides an overview map of the reservoir area with proposed restoration locations and techniques. This map shows the historical channel location, water surface inundation limits for the 2-year and 100-year peak flows based on pre-dam topographic surface, and areas above the 100-year water surface elevation contained within the existing reservoir extents.



Historical topography of J.C. Boyle Reservoir area with flood inundation extents for the 2-year (Q2) and 100-year (Q100) floods are shown for context. Length of river bordering the wetlands, floodplain, and off-channel habitat features restoration sites is included.

Figure 5-1 Map of historical Klamath River centerline, tributaries, and locations of potential restoration actions in JC Boyle Reservoir.

After drawdown, the existing reservoir will have two distinct areas as described in Sections 3 and 4. Little or no opportunity exists for restoration actions in the rocky reach downstream of the Highway 66 Bridge.

Upstream of the bridge, a large and relatively well-connected floodplain will support wetlands and off-channel habitat features. Therefore, at JC Boyle, the KRRC will conduct floodplain shaping and excavation of stored sediments to create areas for floodplain and wetland development along with habitat features that promote process-based restoration of the floodplain areas, and the KRRC will monitor and improve tributary connectivity to ensure volitional fish passage. The KRRC will strategically place LW on the floodplain and within the tributaries to maximize development of natural habitat features. The KRRC will limit habitat enhancement at the Spencer Creek confluence area to LW placement, using a helicopter, due to the probability of culturally significant resources and desire to minimize ground disturbance. The KRRC will construct bank stability measures where appropriate and install channel fringe complexity features in strategic locations to provide habitat only and will not hinder natural formative processes. All proposed restoration efforts will work in concert with the revegetation plans in the reservoir area to maximize the potential long-term habitat benefits.

Figure 5-2 Spencer Creek, a large tributary to JC Boyle Reservoir, provides a good opportunity as a reference site for the restored wetland and riparian zones at JC Boyle after drawdown.

The revegetation approach at JC Boyle Reservoir will be similar to other reservoirs; however, the KRRC will adjust the seed mix and planting palettes to reflect its higher elevation, shallower reservoir depth and different plant communities around the reservoir. KRRC will perform IEV control before the restoration implementation begins. Spencer Creek, which drains into the reservoir, will serve as a reference site for the revegetation portion of the restoration.

Because of the striking topographical contrast between the two reaches of the reservoir, there will be a large difference in the revegetation approach. The Upstream Reach above the Hwy 66 bridge has mostly gentle slopes and includes large and broad riparian floodplains that will have favorable hydrology for riparian and wetland habitat restoration, while the Canyon Reach downstream of the bridge passes through a narrow rocky gorge with minimal restoration opportunities.

Figure 5-3 The Canyon Reach of JC Boyle provides little opportunities for restoration because of its steep rock walls and bedrock river bottom that limit areas for vegetation to restore.

The development of broad segments of emergent wetlands and bank wetlands, as well as bank and floodplain riparian habitats on both banks of the Upstream Reach, will restore a high quality, well-functioning floodplain. Together, the wetland and riparian habitats may constitute up to 50% of the restored areas around the JC Boyle Reservoir; the largest percentage of the three reservoirs in these habitats. Because of the very gradual slope in parts of the Upstream Reach, this reservoir will also have a wider Rocky Wake Zone (RWZ). Because of the shallow depth and very gentle slope, in many areas, the RWZ will have finer remaining substrate left and restoration will be feasible without additional soil import.

The Canyon Reach will not be able to support much vegetation because the bedrock riverbed and the constricting rock wall bank conditions will result in high water velocities, expedited removal of any fine sediment, and very little suitable growing substrate along the narrow banks. KRRC's contractor will implement revegetation by seeding only areas with suitable growing substrate.

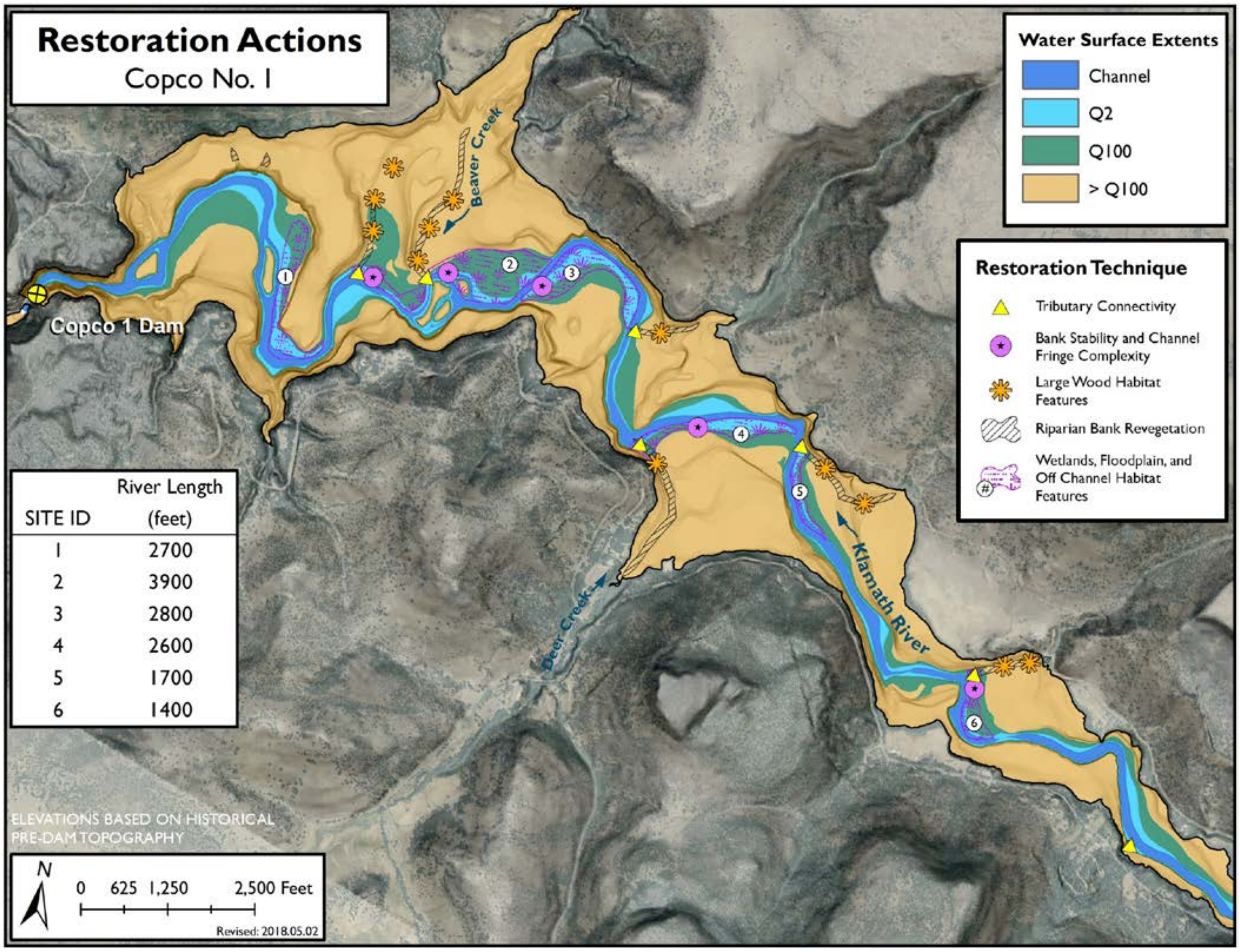
5.3 Copco No. 1 Reservoir Restoration Overview

Copco No. 1 reservoir area has the largest potential for active restoration due to the meandering nature of the river in this reach along with the wider canyon. Hydraulic modeling of the pre-dam topographic surface shows that the river was better connected with the adjacent floodplain at the downstream end of the reservoir and not well connected in the upper half of the reservoir during typical 2-year recurrence interval peak flows (Figure 5-4) along with proposed restoration locations and habitat features. This map shows the historical channel location, water surface inundation limits for the 2-year and 100-year peak flows based on pre-dam topographic surface, and areas above the 100-year water surface elevation contained within the existing reservoir extents. The majority of the area currently inundated is higher than the 100-year floodplain after drawdown and only a narrow band of area is contained in the 2-year floodplain.

During drawdown, KRRC will use barge mounted pressure sprayers to maximize the amount of stored sediment to evacuate the floodplain areas and minimize the amount of depositional sediment on the historical floodplains to promote river inundation on the historical floodplain during high flow events. After drawdown, the KRRC will excavate six areas identified for excavation of remaining sediments and grade those areas to historical floodplain elevation to create wetlands, connected floodplain areas, and off-channel habitat features. These areas are primarily within the historical 2-year floodplain and create ideal locations for restoration.

In addition to the floodplain grading areas, the KRRC will monitor and improve tributary connectivity to ensure volitional fish passage. The KRRC will strategically place LW on the floodplain and within the tributaries to maximize development of natural habitat features as designated. The KRRC will install bank stability and channel fringe complexity features in strategic locations to provide habitat only and will not hinder natural formative processes. All proposed restoration efforts will work in concert with the revegetation plan in the reservoir area to maximize the potential long-term habitat benefits.

The KRRC will focus the revegetation approach at Copco No. 1 on restoration of the wetland and riparian habitats, which will comprise approximately 25% of the restored area around the reservoir, the second largest area after JC Boyle. The KRRC will adjust the seed mix and planting plan to reflect the reservoir's higher elevation than Iron Gate, and different plant communities surrounding the reservoir. The KRRC will perform IEV control early in the revegetation process at Copco No. 1.



Historical topography of Copco No. 1 Reservoir area with flood inundation extents for the 2-year (Q2) and 100-year (Q100) floods are shown for context. Length of river bordering the wetlands, floodplain, and off-channel habitat features restoration sites is included.

Figure 5-4 Map of historical Klamath River centerline, tributaries, and locations of potential restoration actions in Copco No. 1 Reservoir.

The KRRC will use main tributaries, Beaver, Raymond, Spannaus, Long Prairie, and Deer Creeks for wetland and riparian habitat restoration at their confluence with the Klamath River, and will modify their streambeds to provide volitional fish passage. The Copco Reservoir is far more developed that the other two reservoirs, with 86% of the surrounding land being privately owned. The KRRC will use denser seeding and planting, and frequent monitoring in areas with large IEV infestations to safeguard the newly restored areas. Uplands below RWZ will be the largest restored vegetation zone, approximately 60% of the restored area around Copco.

Figure 5-5 Copco vegetation is denser than at Iron Gate, especially on north facing slopes.

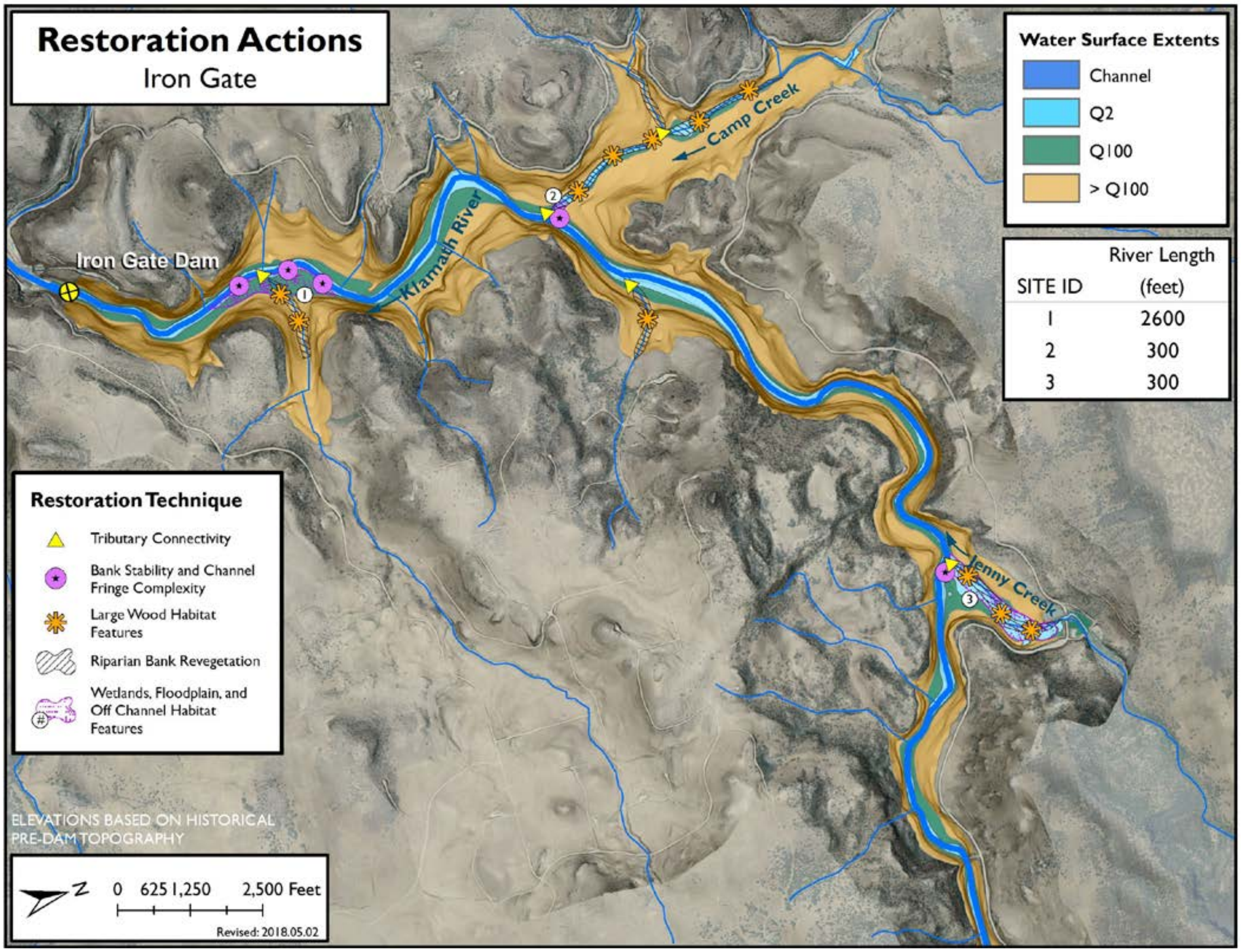
5.4 Iron Gate Reservoir Restoration Overview

The historical Klamath River in the Iron Gate reservoir area had very little floodplain connectivity due to the configuration of the narrow, confining canyon. Figure 5-7 shows the 2-year and 100-year inundation limits based on hydraulic modeling and pre-dam topography. The modeling shows that few areas exist for river-floodplain interaction and the primary areas of potential restoration are at the confluences with larger tributaries. However, KRRC identified culturally significant resources at the confluence areas which limit the amount of restoration that can be done in these areas.

Figure 5-6 Long Prairie Creek joins the reservoir just upstream of the town and provides an opportunity for wetland and riparian habitat restoration at its confluence with the river.

The KRRC identified three areas where wetlands, floodplain, and off-channel habitat features can be restored. The KRRC will excavate the areas to historical ground and grade the areas to maximize interaction with flows from the river and will add habitat features in those areas. Thee KRRC will augment several areas with LW and will ensure tributary connectivity for volitional fish passage in the tributaries. The KRRC will coordinate any restoration modifications around culturally significant resource areas to ensure minimal or no ground disturbance.

The Klamath River passing through the Iron Gate area has formed a very deep and narrow channel with steep rocky banks, providing little opportunity for the restoration or extensive wetland or riparian habitats. As a result, the KRRC will restore nearly 85% of the reservoir area bed after drawdown as uplands with Uplands below Rocky Wake Zone as the dominant planting zone. The KRRC will restore these areas similar to the other reservoirs with native grasses such as annual hairgrass, small fescue, squirreltail grass, blue wildrye, and California brome and with woody upland species such as western juniper, Oregon white and California black oaks. The KRRC will perform IEV control prior to drawdown at Iron Gate.



Historical topography of Iron Gate Reservoir area with flood inundation extents for the 2-year (Q2) and 100-year (Q100) floods are shown for context. Length of river bordering the wetlands, floodplain, and off-channel habitat features restoration sites is included.

Figure 5-7 Map of historical Klamath River centerline, tributaries, and locations of potential restoration actions in Iron Gate Reservoir.

5.5 Description of Restoration Actions

The KRRC will use both revegetation techniques and physical site modifications to initiate process-based restoration and long-term habitat formation to restore the reservoir areas post drawdown. The KRRC considered historical documentation of the reservoir areas before dam construction and reservoir area inundation, past performance of similar dam removal and restoration projects, and current restoration practices, to develop an effective technique useful for the reservoir areas as described below.

Figure 5-8 Steep banks and narrow valley of Iron Gate Reservoir limit opportunities for wetland and riparian habitat restoration.

The 2011 Plan (USBR, 2011c) focused 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 subsections describe the approach in this RAMP to restore the project area; specifically, the proposed sediment evacuation, revegetation process, the acquisition of native plant materials, the invasive exotic vegetation control, and the revegetation methodology.

5.5.1 Reservoir Drawdown Sediment Evacuation

A primary objective during the reservoir drawdown period is to maximize natural erosion of stored sediments. This objective has two purposes: 1) reduce the amount of un-natural, stored sediment remaining on the historical floodplain and reservoir area surfaces and 2) minimize the potential for future sediment releases in the Klamath River. For a median water year, hydraulic modeling predicted that approximately half of the stored sediment would naturally erode and vacate the reservoir area (USBR, 2011b). The existing sediment in the reservoir area is highly erodible and has a high water content. To further maximize the amount of sediment eroded during drawdown, KRRC's contractor will use additional manual augmentation during drawdown as described below.

Figure 5-9 Jenny Creek, the largest Iron Gate Reservoir tributary creek also provides the best opportunity for floodplain restoration at its confluence with Klamath River.

The KRRC will use sediment jetting with a barge mounted water jet (Figure 5-10) that has been used on past dam removal projects to maximize stored sediment erosion at the Copco No. 1 and Iron Gate reservoirs. The Contractor will develop a detailed plan for use of sediment jetting.

During reservoir drawdown, some areas near existing roads will provide easy access for machinery, such as bulldozers and excavators, and in those areas, the Contractor will grade and then transport the sediment. The KRRC will designate culturally sensitive areas prior to drawdown to ensure these areas are not entered with machinery. The Contractor will perform area grading between January and April of the drawdown year and will only grade depositional surface sediment and will not extend below the historical ground surface prior to dam construction. The Contractor will develop plans for this grading for approval prior to drawdown.

5.5.2 Tributary Connectivity

As KRRC's contractor lowers reservoir water surfaces during drawdown and beyond, tributaries will be further exposed creating longer reaches of free-flowing water conditions. Figure 5-11 shows where Iron Gate reservoir was drawn down in 2018 approximately 20 ft and how Jenny Creek interacts with the drawdown. The newly exposed tributaries will flow over depositional areas of fine sediment that will likely transport these sediments downstream; however, some larger sediment and debris may create fish passage barriers or un-natural discontinuities in the longitudinal profile. To rectify this, the KRRC will use 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, the KRRC may add LW to tributaries to promote habitat complexity as further described below.

Figure 5-10 Sediment jetting on Mill Pond reservoir using a barge and excavator with pump and spray nozzles to maximize stored sediment erosion during reservoir drawdown (photo from Envirocon)

Another aspect of tributary connectivity is volitional fish passage. Many of the tributaries have road crossing at the current reservoir water surface with culverts and stream crossings that do not allow volitional fish passage. In addition, there are historical tributary crossings that area currently within the reservoir inundation zone and will likely create fish passage barriers. The KRRC will prepare an inventory of fish passage barriers in the tributaries after reservoir drawdown and will rectify as many of these as funding allows.

Figure 5-11 Jenny Creek tributary on Iron Gate reservoir with reservoir drawn down approximately 20 ft showing deposition and small delta where it intersects with reservoir in 2018

5.5.3 Wetlands, Floodplain and Off-Channel Habitat Features

Incorporating natural features, such as surface undulations, 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. Likewise, floodplain roughness features can be supported to further instigate natural processes while enhancing wildlife habitat.

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.

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 5-12 Example of existing floodplain features upstream of Copco No. 1 reservoir (i.e., wetland area)

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 ft above to 0.5 ft below the design floodplain surface. Brush and wood increases IN soil moisture retention creates protective microsites for establishing seed and plants and promotes soil development by introducing organic material as illustrated in Figure 5-17.

5.5.4 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 LW create zones of complex hydraulic interactions that provide resting zones, feeding seams, cover and velocity refugia during high flow. Reaches that will 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 the establishment of riparian vegetation. Likewise, KRRC's contractor will not implement this restoration technique where it will disrupt natural, process-based channel and floodplain evolution within the reservoir areas.

Figure 5-13 Example of restored floodplain area six months after construction in an arid climate showing new vegetation and wood roughness elements that provide habitat complexity and immediate, large scale roughness

5.5.5 Large Wood Habitat Features

Large wood (LW) 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 similar to rock outcrops. 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.

Ground-Based Equipment Placement

Use of track hoes (Figure 5-14) and industrial log moving equipment are typical methods for moving and placing wood to build LW habitat structures along river and floodplain areas. KRRC's contractor will use these standard methods for construction in specific areas of the reservoirs based on accessibility and amount of residual reservoir sediment remaining. In culturally sensitive areas, KRRC's contractor will not use ground-based equipment to install LW.

Figure 5-14 Example of LW structure being built for habitat benefits using ground-based equipment

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 5-15) can lift loads in excess of 10,000 lbs. that is roughly equivalent to log lengths over 80 ft 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. It is planned that helicopter log placement will take place in areas that are difficult to access and in areas that will potentially disturb culturally significant areas if wood is placed by ground-based equipment.

The following sections contain additional details for each reservoir area and likely restoration actions. KRRC developed restoration actions for each reservoir with consideration to 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. KRRC envisions that the proposed restoration actions will be evaluated at the time of reservoir drawdown to adapt to conditions that are exposed in the reservoir areas. It is likely that some areas will be slightly modified to fit the surrounding terrain and may be limited by machinery access. Likewise, the areas identified represent the largest footprint that will likely be disturbed.

5.5.6 Revegetation

The reservoir area revegetation process will consist of six distinct periods listed above and described in more detail below. The aquatic and wildlife habitat restoration process will be closely dependent on the dam removal schedule and will be subject to changes that may be triggered by construction implementation or permitting and access issues.

Pre-Dam Removal Period (from 2 Years before Drawdown to Drawdown)

In the years before drawdown, the KRRC will focus its revegetation activities on acquisition and close review of existing data about the reservoirs, invasive exotic species mapping and control, collection and propagation of native plant seed in preparation for restoration implementation. The KRRC will conduct an on-site pilot growing test on sediments extracted from the reservoirs in order to determine the initial performance of the seeded vegetation on the substrate under actual field conditions. The KRRC will also survey listed plant and IEV, identify and biologically survey restoration reference sites, test plot growing experiments to determine the best prescriptions for successful establishment of desired species, test sediment, prepare contingency plans, and coordinate with relevant agencies.

Figure 5-15 Example of LW being transported and placed with a twin rotor helicopter

Drawdown Period (Drawdown Year - January to March)

The KRRC will aerially seed pioneer seed mixes with a variety of riparian and upland common native and non-native sterile species and mycorrhizal inoculant on all of the exposed reservoir basins during and/or immediately after the drawdown. The KRRC will apply these mixes as the reservoir water level drops and before the exposed sediments dry and form a surface crust, to facilitate expedited seed germination through retained residual soil moisture. The KRRC will re-seed any seeded areas that are re-inundated by larger storm events during the drawdown after flood waters recede. The exposed sediment will not be initially seeded with valuable, less common native species because it may not be able to reliably support native vegetation as it will not immediately possess typical topsoil characteristics; specifically, the soil microbiota component will be missing and many minerals such as iron, manganese, arsenic and vanadium will be at levels toxic to plant life because of their solubility when submerged. Once they are oxidized, within days after drawdown, their plant availability and toxicity will be greatly reduced (Wallace, 2017). Additionally, soil test results have indicated that most of the sediment samples are acidic, have a high clay content, high shrinkage and swelling factor, high organic content, no soil structure, and are at a high risk of compaction. The KRRC will use the pioneer plant seeding in order to develop soil structure, facilitate the conversion of sterile sediment into productive topsoil for native vegetation through the re-introduction of soil microorganisms into the sediment, and for erosion control. The KRRC will support natural movement of sediment out of the reservoir basins during drawdown by jetting sediment out of key riparian floodplain areas that will be essential for the correct hydrological function and connectivity to the river. The KRRC will transplant existing riparian and wetland plants that can be easily salvaged from the rim of the reservoirs to these newly formed riparian and wetland bank areas. Riparian and wetland zone specific seed mixes, tree and shrub seed, acorns, and pole cuttings will be installed in the riparian and wetland bank zones depending on feasibility and other factors such as weather, water level in the river, availability, and access.

Dam Removal Period (Drawdown Year - March through December)

The KRRC will continue the drawdown period restoration activities in the riparian and wetland bank zones into the dam removal period, including the harvesting and salvaging of existing live riparian and wetland vegetation. The KRRC will continue this work potentially into late May or early June. The KRRC will salvage existing riparian flora that will eventually die as a result of the drawdown as an inexpensive source of viable pole cuttings and mature, locally ecotypic rooted plant material. The KRRC will establish woody riparian species in riparian areas to perform many key ecological functions, provide shaded aquatic riverine habitat for fish, maintain cool water temperatures, and increase natural bank stability and function. To expedite the riparian bank zone development, the KRRC will install irrigation systems along key segments of the river banks where the riparian zone width will warrant this expense. Vegetation zones above the riparian bank zone will have only minimal activities occurring during the spring and summer seasons. The KRRC will monitor cover crop growth and establishment and supplement seeding or local irrigation in areas of poor performance or in case of drought. The KRRC will roll or mow the cover crop in the late fall and broadcast zone-specific seed mixes over the drying and disintegrating cover crop.

Post-Dam Removal Period (First Year after Dam Removal)

During the second year of revegetation, the KRRC will re-seed areas that failed to establish and will collect and install additional pole cuttings. The KRRC will maintain previously seeded and planted areas with intensive weed removal efforts and irrigation system upkeep. The KRRC will install deer fence enclosures in selected floodplain areas. In cases where cover crop mulch has moved/degraded or otherwise exposed bare soil, the KRRC will supplement seeding to help prevent excessive soil erosion. The KRRC will perform inspections during this period to confirm restoration work installation acceptance and an official start of the plant establishment period.

Plant Establishment Period (Year One after Completion of Revegetation)

The most important activities during plant establishment will be IEV control, herbivore control, and irrigation system maintenance. The Contractor will develop a Weed Control Plan with the key objective to limit IEV cover. The KRRC will monitor compliance the Weed Control Plan. The KRRC will monitor IEV and the implementation of timely control measures to control high and medium priority invasive exotic vegetation (e.g., Himalayan blackberry, yellow star thistle, Russian knapweed, and others listed in Table 5-4). The KRRC will control low priority IEV species only if they interfere with the successful establishment of native vegetation.

Maintenance and Monitoring Period (Years Two to Five after Completion of Revegetation)

The maintenance and monitoring period will consist of activities that will keep revegetation efforts on track to achieve performance criteria set for each monitoring year. 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). KRRC will base specific activities on the monitoring results and activity thresholds. For purposes of monitoring the revegetation plan success and achieving natural conditions, KRRC will develop performance criteria 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 in reference areas, and take corrective action when necessary to steer the development trend. KRRC will monitor plant species and cover, the density of woody riparian vegetation, acres of wetlands, and noxious weed levels. Monitoring will occur for a total of five years (one year of plant establishment period and four years of maintenance and monitoring period) or until the performance criteria have been met.

Plant Material Procurement

The KRRC will revegetate the reservoir areas during and after drawdown and dam removal as determined by the monitoring protocols. Although some degree of natural revegetation development will occur, the revegetation approach will use a combination of seeding, pole-cutting installation, tree and shrub seed planting (acorns, samaras, etc.), and salvage/ transplanting of existing vegetation to accelerate the natural succession to stable native plant communities. The KRRC will divide the former reservoir area beds into upland, floodplain riparian, bank riparian, and wetland planting zones and will employ different implementation techniques and plant species will be employed in each zone based on hydrology, sediment texture, slope aspect and other characteristics. Revegetation of each of the proposed planting zones is described in detail below in subsection 5.2.5.

Native Plant Seed Collection and Propagation

The KRRC will seed native grasses, sedges, rushes, forbs and shrubs 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 revegetate the large reservoir beds of the four dams the KRRC will require large quantities of seed, on the order of 200,000 lbs. of pure live seed (PLS).

Figure 5-16 Bluebunch wheatgrass (*Elymus spicatus*) is a perennial native bunchgrass that is common in the uplands above the reservoirs

The most efficient method for acquiring seed for the revegetation will be early collection of native seed from the project vicinity, and subsequent large-scale seed propagation. Because the Project needs a large amount of seed, and the procurement, collection and growing processes are time consuming, the KRRC is beginning this work in 2018. The KRRC will implement these tasks throughout the pre-dam removal, drawdown, dam removal and post dam removal periods.

Collected seed will be grown by specialty commercial growers to produce large amounts of native seed. To achieve good native vegetation coverage, successfully combat invasive vegetation, and effectively prevent soil erosion, KRRC's contractor will seed approximately 80 lbs of pure live seed (PLS) per acre in several steps resulting in the need for about 200,000 lbs. PLS for the 2,500 acres of the project area. To obtain this amount of seed, KRRC's contractor will gather 175 pounds of wild collected seed each of the four years before the 2022 fall season. It is expected that on average 7 lbs. of PLS/acre of wild collected seed will produce at least 2,000 lbs. PLS/acre in agricultural settings on specialized seed propagation farms. The commercial growers will plant native seed on approximately 25 acres, resulting in about 50,000 lbs. The commercial grower will clean and store the seed in climate controlled warehouses and in some cases pre-treat it. The KRRC contacted several large-scale growers and will engage one or more of them in the near future to propagate the native seed. The growers will collect native plant seed from existing vegetation around the reservoirs and within the larger Upper Klamath Basin Watershed. Vegetation inventories were completed around the reservoirs in 2009 and 2010 as part of the EIS/R preparation (USBR, 2011c). The KRRC will conduct a new seed collection areas reconnaissance survey utilizing the previous inventories, and including key tributaries, and other areas within the Upper Klamath River Watershed with an elevational range similar to that around the reservoirs (2,300'–3,800'). The seed collection contractors will implement seed collection in a way that will not cause damage to the existing plant populations or parent plants. During seed collection activities by seed collection contractors, the KRRC will conduct several random inspections to ensure compliance with the specification limiting damage to parent plants. Time, budget or availability constraints may make it necessary to acquire some seed and plant materials from commercial seed companies or nurseries. KRRC will source commercially only species common in similar environmental conditions in the adjacent watersheds, or species that will not be able to reproduce in the project area. The KRRC will conduct investigations of conditions and timing to improve initial germination rate of seed material as part of pre-project test plot revegetation experiments described below in Section 5.6.4.

The KRRC will rely only on mycorrhizal inoculants to promote the long-term growth of seeded native species in the project area. The KRRC will not use fertilizers in the revegetation process unless necessary as determined by soil analyses in areas of poor vegetation establishment. Previously identified (USBR 2011a), and other important species suitable for the reservoir areas' seeding are listed in Table 5-2. The KRRC will use these species as the backbone of the revegetation for the Project and will collect other native species to be used 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 5-2).

The KRRC will collect Oregon white oak (*Quercus garryana*) and California black oak (*Quercus kelloggii*) acorns in the fall after dam removal, for cold stratification through the winter and early spring, and installation in mid- to late spring during the post-dam removal period in the riparian zones and mesic parts of the upland zones if feasible. The KRRC will collect and install additional acorns in the fall of the post-dam removal year. The KRRC will collect and plant seeds of other native woody species based on availability (Table 5-2 below).

Table 5-2 Seeded species Proposed for Collection and Propagation

Common name	Scientific name	Life Form
bigleaf maple	*Acer macrophyllum*	large deciduous tree
common yarrow	*Achillea millefolium var. lanulosa*	perennial herb
Spanish lotus	*Acmispon americanus [Lotus purshianus]*	annual herb
spike bentgrass, spike redtop	*Agrostis exarata*	perennial grass
white alder	*Alnus rhombifolia*	deciduous tree
western serviceberry	*Amelanchier alnifolia*	small deciduous tree
mugwort	*Artemisia douglasiana*	perennial herb
Oregon grape	*Berberis aquifolium*	small evergreen shrub
devil's beggartick	*Bidens frondosa*	annual herb
California brome	*Bromus carinatus*	perennial grass
incense cedar	*Calocedrus decurrens*	large coniferous tree
water sedge	*Carex aquatilis*	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
awlfruit sedge	*Carex stipata*	perennial herb
buckbrush	*Ceanothus cuneatus*	evergreen shrub
deerbrush	*Ceanothus integerrimus*	semi-deciduous shrub
birchleaf mountain mahogany	*Cercocarpus betuloides*	semi-deciduous shrub
western water hemlock	*Cicuta douglasii*	perennial herb
smooth dogwood	*Cornus glabrata*	large deciduous shrub
red-osier dogwood	*Cornus sericea*	large deciduous shrub
turkey mullein	*Croton [Eremocarpus] settiger*	annual herb

Common name	Scientific name	Life Form
tufted hairgrass	*Deschampsia caespitosa*	perennial grass
annual hairgrass	*Deschampsia danthonioides*	annual grass
saltgrass	*Distichlis spicata*	perennial grass
needle spikerush	*Eleocharis acicularis*	perennial herb
common spikerush	*Eleocharis macrostachya [palustris]*	perennial herb
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
western goldenrod	*Euthamia occidentails*	perennial herb
small fescue	*Festuca [Vulpia] microstachys*	annual grass
Idaho fescue	*Festuca idahoensis*	perennial grass
red buckthorn	*Frangula [Rhamnus] rubra*	evergreen shrub
Oregon ash	*Fraxinus latifolia*	deciduous tree
meadow barley	*Hordeum brachyantherum ssp. b.*	perennial grass
California barley	*Hordeum brachyantherum ssp. californicum*	perennial grass
Baltic rush	*Juncus balticus*	perennial herb
toad rush	*Juncus bufonius*	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
junegrass	*Koeleria macrantha*	perennial grass
rice cutgrass	*Leersia oryzoides*	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
field mint	*Mentha arvensis*	perennial herb
seep monkey flower	*Mimulus guttatus var. guttatus*	Annual herb
mat muhly	*Muhlenbergia richardsonis*	perennial grass
watercress	*Nasturtium officinale*	perennial herb
knotgrass	*Paspalum distichum*	perennial grass
hot rock penstemon	*Penstemon deustus*	perennial herb
royal penstemon	*Penstemon speciosus*	perennial herb
varied leaf phacelia	*Phacelia heterophylla var. virgata*	perennial herb
Lewis' mock orange	*Philadelphus lewisii*	deciduous shrub
ponderosa pine	*Pinus ponderosa*	coniferous tree
pine (Sandberg) bluegrass	*Poa secunda*	perennial grass

Common name	Scientific name	Life Form
water pepperweed	*Polygonum hydropiperoides*	perennial herb
Klamath plum	*Prunus subcordata*	small deciduous tree
chokecherry	*Prunus virginiana var. demissa*	small deciduous tree
Douglas fir	*Pseudotsuga menziesii var. menziesii*	coniferous 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]*	deciduous shrub
whitestem gooseberry	*Ribes inerme*	deciduous shrub
plateau (desert) gooseberry	*Ribes velutinum*	deciduous shrub
California rose	*Rosa californica*	deciduous shrub
Pacific blackberry	*Rubus ursinus*	deciduous shrub, vine
California dock	*Rumex californicus*	perennial herb
narrow-leaf willow	*Salix exigua*	deciduous shrub
red willow	*Salix laevigata*	large deciduous tree
arroyo willow	*Salix lasiolepis*	deciduous tree
shining willow	*Salix lucida ssp. lasiandra*	deciduous tree
blue elderberry	*Sambucus nigra ssp. caerulea [mexicana]*	large deciduous shrub
hardstem bulrush	*Schoenoplectus [Scirpus] acutus*	perennial herb
broadfruit bur reed	*Sparganium eurycarpum*	perennial herb
rigid hedge nettle	*Stachys ajugoides var. rigida*	Perennial herb
Lemmon's needlegrass	*Stipa [Achnatherum] lemmonii*	perennial grass
western needlegrass	*Stipa [Achnatherum] occidentalis var. occidentalis*	perennial grass
common snowberry	*Symphoricarpos albus*	deciduous shrub
creeping snowberry	*Symphoricarpos mollis*	deciduous shrub
tomcat clover	*Trifolium willdenovii*	annual herb
common cattail	*Typha latifolia*	perennial herb
stinging nettle	*Urtica dioica ssp. holosericea*	perennial herb
California grape	*Vitis californica*	deciduous vine
rough cockleburr	*Xanthium strumarium*	annual herb

Pole Cuttings

The KRRC will engage with restoration contractors to harvest and store live pole cuttings for the Project. The restoration contractor will plant live pole cuttings in the bank wetland, bank riparian and parts of floodplain riparian zones to expedite the recovery of these habitats to natural succession. In existing riparian areas along the Iron Gate, Copco and JC Boyle reservoir edges that contain robust populations of willows and other native riparian species suitable for pole cuttings harvest or whole plant salvaging and transplantation the restoration contractors will cut some of these parent plants 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. The restoration contractors will be engaged to harvest and store pole cuttings for the Project. The restoration contractors will harvest native species listed in Table 5-3 for pole cuttings, as close to planting period (winter to early spring) as possible, maintain the pole cuttings until planting time, and install the pole cuttings in the riparian areas as soon as access is feasible. If there is a need to ship the pole cuttings off-site for storage, the restoration contractors will ensure the pole cuttings are refrigerated and held for a maximum of 3 months to ensure viability (Tilley and John, 2012), (Logar and Scianna et al., 2005). The restoration contractor will plant the pole cuttings between February and March, if possible, and year-round with sufficient supplemental irrigation, or on high ground water table, if necessary.

Figure 5-17 Sandbar willow is an important riparian bank shrub that provides shade over water surface, reducing temperatures. The background tree is Oregon ash.

Table 5-3 Primary Pole Cutting Species to be Collected and Stored

Common name	Scientific name	Lifeform
western serviceberry [2]	*Amelanchier alnifolia*	small deciduous tree
smooth dogwood [3, 12]	*Cornus glabrata*	large deciduous shrub
red-osier dogwood [1, 8]	*Cornus sericea*	large deciduous shrub
black cottonwood [5, 11, 12]	*Populus balsamifera ssp. trichocarpa*	large deciduous tree
fragrant (three-leaf) sumac [6]	*Rhus aromatica [trilobata]*	deciduous shrub
California rose [11, 12]	*Rosa californica*	deciduous shrub
Pacific blackberry [7]	*Rubus ursinus*	deciduous shrub, vine
narrowleaf willow [1, 9, 7, 12]	*Salix exigua*	large deciduous shrub
red willow [1, 4]	*Salix laevigata*	large deciduous tree
arroyo willow [1, 12]	*Salix lasiolepis*	small deciduous tree
shining willow [1, 12]	*Salix lucida*	small deciduous tree
common snowberry [1, 10]	*Symphoricarpos albus*	deciduous shrub

Footnotes:

1 Source: Burgdorf, 2007. 2 Source: USDA, 2002. 3 Source: CNPS, 2014a. 4 Source: CNPS, 2014b. 5 Source: USDA, 2018. 6 Source: Taylor, 2004. 7 Source: WSU, 2003. 8 Source: CNPS, 2014c. 9 Source: Tilley and Loren, (2012). 10 Source: Darris, (2002). 11 Source: Holzworth and Batchelor, (1984). 12 Shaded rows indicate keystone species.

Invasive Exotic Vegetation Control

The KRRC will integrate the control of IEV with the revegetation work. The focus of this RAMP is on extensive seeding of diverse native species and a robust monitoring schedule for early detection and control of IEV as described below in Section 6.1.4. The KRRC will begin active control of IEV in the project areas several years before drawdown and will continue until the required performance criteria are met. The KRRC will use revegetation and weed control to accelerate succession and help reduce the amount of open space available for exotic species establishment.

The KRRC will evaluate all methods of invasive species control for both their benefits and their risks to the surrounding ecosystems. The KRRC will control IEV through manual weed pulling, mowing or cutting, mechanical eradication by tilling in larger areas, grazing, shading (covering ground with paper or black plastic), and solarization (covering ground with clear plastic). The KRRC will apply herbicides as a last resort and upon approval, application of herbicides will be used if necessary, either by brushing (stumps and cut stems), wicking and/or spraying. The benefits and constraints of each technique are summarized below:

- Hand pulling. The KRRC will use this method on a limited basis for controlling small IEV infestations, emerging infestations or infestations at the fringes of a large patch as hand pulling is typically more effective on annual species and species that are not rhizomatous.
- Mowing or cutting. The KRRC will use this method for invasive annuals and to reduce seed production in biennials and perennials to prevent seed set, exhaust the nutrient reserves, and reduce plant vigor, and reduce the buildup of thatch, as is common in infestations of medusahead and goat grass, so that native species seed has access to light for germination. The KRRC will use this method in areas where there are extensive solid stands of invasive species to avoid damage to native species.
- Tilling and Disking. The KRRC will use this method as an agricultural weed eradication method in solid stands of invasive species, in order to disrupt and bury the plant or to separate the root from the plant after soil dries out to have the largest impact. The KRRC will use this method only in level heavily infested areas where erosion is not a concern and culturally significant resources are not expected.
- Grazing. The KRRC will use this method of control of invasive vegetation palatable for cattle, sheep and goats and the timing, quantity and will select the type of livestock to address different invasive species.
- Solarization. This technique can kill not only the plant but the seeds of most plant species. (Moyes et al., 2005) and involves heating the soil by capturing the radiant energy from the sun, by air-tightly covering the infested ground with plastic for at least 4-6 weeks. The KRRC will use this technique only in areas where there are large swathes of invasive vegetation and during the warm season.
- Herbicides –The KRRC will use this method only when other methods prove to be ineffective or could potentially cause more harm than benefit within the environment. The KRRC will use only herbicides that have been approved for use by the BLM, California Department of Fish and Wildlife (CDFW), Oregon Department of Fish and Wildlife (ODFW), Regional Water Quality Control Board (RWQCB), U.S. Fish and Wildlife Service (USFWS) and NMFS in both California and Oregon. The KRRC will evaluate the effect of all potential herbicides on aquatic species. If herbicide application becomes the necessary method for effective IEV removal, the KRRC will consider only those application methods with the least side-effects to native vegetation and wildlife and will base application methods on plant reproduction, structure, and growth.

After a close review of available documentation on the past extent of IEV in the project area prepared by PacifiCorp's consultants and the BLM, the KRRC determined that the information is dated, and that surveys reflecting the current condition are needed in order to effectively eradicate IEV in the project area to the maximum extent feasible. The KRRC will survey an area from the existing water line to the project boundary to obtain information on the exact location of each invasive species and information on the diversity of invasive species in the limits of work, and develop a GIS based IEV map set for the project area in order to prepare an effective and targeted IEV eradication plan. The KRRC began IEV surveys in the project area in the fall of 2017. Based on California Department of Fish and Wildlife (CDFW) definition, and for the purposes of this Project: "*Invasive species are organisms that are not native to an environment, and once introduced, they establish, quickly reproduce, spread, and cause harm to the environment, economy, or human health*" (REF). Table 5-4 lists previously observed, and potentially occurring IEV species in the project area, and their state, county, and other agency invasiveness ratings. The KRRC will coordinate closely with the objectives of the various agencies with jurisdiction over the project area, because they will most likely steward this land in the long term. Based on Table 5-4 a final IEV control target species list will be developed consisting of plants with the largest potential to (1) spread quickly, (2) take over extensive areas, (3) compete for resources with native species, and (4) cause any other environmental damage. The KRRC will review the IEV control target species list and refine with the resource agencies and other stakeholders involved in the Project to form the backbone of the IEV removal plan which will span from the pre-dam removal period to the end of the KRRC long-term maintenance and monitoring period. The KRRC will adaptively manage IEV removal throughout the revegetation process as discussed.

Table 5-4 Invasive exotic plant species present in the project area with a potential to re-establish.

Scientific Name	Common Name	CDFA[1]	ODA[2]	Cal-IPC[3]	Klamath County[4]	Siskiyou County[5]	Klamath NF[6]	# of Agencies[7]	Priority[8]
Chondrilla juncea	skeleton weed	AW	B & T	Moderate	A	CA-A	High	5	High
Centaurea diffusa	diffuse knapweed	AW	B	Moderate	A	CA-A	High	4	High
Centaurea virgata ssp. squar.	squarrose knapweed	NR	A & T	Moderate	A	CA-A	High	4	High
Euphorbia esula	leafy spurge	AW	B & T	NR	B	CA-A	High	4	High
Onopordum acanthium	Scotch thistle	AW	B	High	B	CA-A	High	4	High
Acroptilon repens	Russian knapweed	BW	NR	Moderate	A	CA-A	High	3	High
Carduus acanthoides	plumeless thistle	AW	NR	limited	A	NR	High	3	High
Centaurea stoebe ssp.micr.	spotted knapweed	NR	B	High	B	CA-A	High	3	High
Cytisus scoparius	Scotch broom	BW	B	High	A	CA-C	High	3	High
Lepidium latifolium	perennial pepperweed	BW	B & T	High	B	NR	High	3	High
Lythrum salicaria	purple loosetrife	BW	B	High	A	NR	High	3	High
Carduus nutans	musk thistle	AW	B	Moderate	B	CA-A	High	2	High
Fallopia japonica	Japanese knotweed	BW	NR	Moderate	A	NR	High	2	High
Linaria dalmatica	Dalmatian toadflax	NR	B	Moderate	B	CA-A	High	2	High
Onopordum tauricum	Taurian thistle	AW	A	NR	NR	NR	High	2	High

Scientific Name	Common Name	CDFA[1]	ODA[2]	Cal-IPC[3]	Klamath County[4]	Siskiyou County[5]	Klamath NF[6]	# of Agencies[7]	Priority[8]
Sonchus arvensis	field sowthistle	AW	NR	NR	NR	NR	High	2	High
Tamarix parviflora	small flower tamarisk	NR	NR	High	NR	NR	High	2	High
Anchusa officinalis	alkanet	NR	B & T	NR	NR	NR	NR	1	Medium
Bromus madritensis ssp. rubens	foxtail brome	NR	NR	High	NR	NR	NR	1	Medium
Bromus tectorum	cheatgrass	NR	NR	High	NR	NR	NR	1	Medium
Centaurea solstitialis	yellow starthistle	CW	B	High	B	CA-C	Moderate	1	Medium
Cirsium ochrocentrum	Beaumont thistle	AW	NR	NR	NR	NR	NR	1	Medium
Convolvulus arvensis	field bindweed	CW	B & T	NR	NR	NR	NR	1	Medium
Crupina vulgaris	bearded creeper	AW,Q	B	Limited	NR	NR	NR	1	Medium
Dipsacus fullonum	teasel	NR	B	Moderate	A	NR	NR	1	Medium
Elymus caput-medusae	medusahead	CW	B	High	C	NR	NR	1	Medium
Foeniculum vulgare	fennel	NR	NR	Moderate	NR	NR	High	1	Medium
Halogeton glomeratus	saltlover	AW	B	Moderate	NR	NR	NR	1	Medium
Isatis tinctoria	dyer's woad	BW	B	Moderate	A	CA-B	Moderate	1	Medium
Linaria vulgaris	butter and eggs	NR	B	Moderate	A	NR	NR	1	Medium
Phalaris arundinacea	reed canary grass	NR	B & T	Not Listed	NR	NR	NR	1	Medium
Rubus armeniacus	Himalayan blackberry	NR	B	High	NR	NR	NR	1	Medium
Salvia aethiops	Mediterranean sage	BW	B	Limited	B	NR	High	1	Medium
Tribulus terrestris	puncture vine	CW	B	Limited	B	NR	High	1	Medium
Xanthium spinosum	spiny clotbur	NR	B	None	A	NR	NR	1	Medium
Aegilops cylindrica	goatgrass	BW	B	Watch	NR	NR	NR	0	Low
Avena barbata	slender oat	NR	NR	Moderate	NR	NR	NR	0	Low
Brassica nigra	black mustard	NR	NR	Moderate	NR	NR	NR	0	Low
Bromus diandrus	ripgut grass	NR	NR	Moderate	NR	NR	NR	0	Low
Cirsium arvense	Canada thistle	BW	B	Moderate	B	CA-B	Moderate	0	Low
Cirsium vulgare	bull thistle	NR	B	Moderate	C	CA-C	Low	0	Low
Conium maculatum	poison hemlock	NR	B	Moderate	B	NR	Low	0	Low
Festuca arundinacea	tall fescue	NR	NR	Moderate	NR	NR	NR	0	Low
Hirschfeldia incana	summer mustard	NR	NR	Moderate	NR	NR	NR	0	Low
Hordeum murinum	foxtail barley	NR	NR	Moderate	NR	NR	NR	0	Low
Hypericum perforatum	Klamath weed	CW	B	Limited	B	NR	Low	0	Low
Lepidium draba	hoary cress	BW	NR	Moderate	B	NR	Moderate	0	Low
Leucanthemum vulgare	oxeye daisy	NR	NR	Moderate	NR	NR	NR	0	Low
Marrubium vulgare	white horehound	NR	B	Limited	NR	NR	NR	0	Low
Mentha pulegium	pennyroyal	NR	NR	Moderate	NR	NR	NR	0	Low
Persicaria wallichii	Himalayan knotweed	BW	NR	Watch	NR	NR	NR	0	Low

Scientific Name	Common Name	CDFA[1]	ODA[2]	Cal-IPC[3]	Klamath County[4]	Siskiyou County[5]	Klamath NF[6]	# of Agencies[7]	Priority[8]
Rumex acetosella	common sheep sorrel	NR	NR	Moderate	NR	NR	NR	0	Low
Torilis arvensis	field hedge parsley	NR	NR	Moderate	NR	NR	NR	0	Low

Footnotes: (Lighter cells indicate a high priority to the corresponding agency)

1. California Department of Food and Agriculture (CDFA): California Noxious Weed List (CDFA, 2016); Ratings descriptions as follows:

“A” A pest of known economic or environmental detriment and is either not known to be established in California or it is present in a limited distribution that allows for the possibility of eradication or successful containment. If found entering or established in the state, A-rated pests are subject to state (or commissioner when acting as a state agent) enforced action involving eradication, quarantine regulation, containment, rejection, or other holding action.

“B” A pest of known economic or environmental detriment and, if present in California, it is of limited distribution. At the discretion of the individual county agricultural commissioner they are subject to eradication, containment, suppression, control, or other holding action.

“C” A pest of known economic or environmental detriment and, if present in California, it is usually widespread. If found in the state, they are subject to regulations designed to retard spread or to suppress at the discretion of the individual county agricultural commissioner. There is no state enforced action other than providing for pest cleanliness.

“Q” An organism or disorder suspected to be of economic or environmental detriment, but whose status is uncertain because of incomplete identification or inadequate information.

“W” This notation indicates that a plant is included in the CCR Section 4500 list of California State Noxious Weeds.

2. Oregon Department of Agriculture (ODA) Noxious Weed Policy and Classification System (ODA, 2017). (Equivalent to the Pacific Northwest Invasive Plant Council (PNW-IPC)). Ratings descriptions as follows:

A A weed of known economic importance which occurs in the state in small enough infestations to make eradication or containment possible; or is not known to occur, but its presence in neighboring states make future occurrence in Oregon seem imminent. Recommended action: Infestations are subject to eradication or intensive control when and where found.

B A weed of economic importance which is regionally abundant, but which may have limited distribution in some counties. Recommended action: Limited to intensive control at the state, county or regional level as determined on a site specific, case-by-case basis. Where implementation of a fully integrated statewide management plan is not feasible, biological control (when available) shall be the primary control method.

T A designated group of weed species that are selected and will be the focus for prevention and control by the Noxious Weed Control Program. Action against these weeds will receive priority.

3. California Invasive Plant Council (CAL-IPC). The Cal-IPC Plant Inventory (Cal-IPC, 2018). Ratings descriptions as follows:

High These species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment.

Moderate These species have substantial and apparent-but generally not severe-ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance.

Limited These species are invasive but their ecological impacts are minor on a statewide level or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic.

Alert An Alert is listed on species with High or Moderate impacts that have limited distribution in California, but may have the potential to spread much further.

Watch	These species have been assessed as posing a high risk of becoming invasive in the future in California.
4. Klamath County Board of Commissioners (KCBC). Noxious Weeds in Klamath County for the year 2018 (KCBC, 2018). Ratings descriptions as follows:	
A	A weed of known economic importance which occurs in the county in small enough infestations to make eradication/containment possible, or if not known to occur, but its presence in neighboring counties make future occurrence in Klamath County seem imminent.
B	A weed of economic importance which in some parts of the county is abundant, but may have limited distribution in other parts of the county. Where implementation of a fully integrated county wide management plan is infeasible, biological control shall be the main control approach.
C	A weed which in most parts of the county is abundant. While not subject to enforcement regulations, these species can cause similar economic and ecological impacts as other noxious weed species. Education and control recommendations will be the main approach.
5. Siskiyou Department of Agriculture (SDA). Identification and Characteristics of Invasive Noxious Weed Infestations. (SDA, 2015). Ratings:	
A	"A" Rated: A pest of known economic or environmental detriment and is either not known to be established in California or it is present in a limited distribution that allows for the possibility of eradication or successful containment. A-rated pests are prohibited from entering the state. A-rated pests are subject to state (or commissioner) enforced action involving eradication, quarantine regulation, containment, rejection, or other holding action.
B	"B" Rated: A pest of known economic or environmental detriment and it is of limited distribution. Subject to state endorsed holding action and eradication to provide for containment. At the discretion of the individual county agricultural commissioner they are subject to eradication, containment, suppression, control, or other holding action.
C	"C" Rated: A pest of known economic or environmental detriment and is usually widespread. They are subject to regulations designed to retard spread or to suppress at the discretion of the individual county agricultural commissioner. There is no state enforced action other than providing for pest cleanliness.
6. U.S. Forest Service (USFS-KNF): Klamath National Forest Noxious Weed and Non-native Invasive Plant List (KNF, 2013). Ratings descriptions as follows:	
High	These species are currently either limited in distribution, highly invasive, or not present on the KNF. Treatment may vary by location.
Moderate	These species are generally common, and are treated on a case by case basis depending on location (Wilderness and Research Natural Area (RNA) increase the priority for treatment).
Low	These species are either widespread throughout the KNF, or are not considered to be highly invasive in our area. Usually not treated unless located in a high priority area, such as Wilderness or RNA.
7. Number of Agencies Considering Plant a High Priority for Eradication	
8. Invasive Exotic Vegetation (IEV) Survey and Control Priority	

Integrated Pest Management in the project area will consist of the following key elements:

- Prevent invasive exotic weeds from establishing through use of weed-free plant materials and straw. KRRC will employ experienced seed production companies and will provide seed analysis for each collected and propagated species indicating seed purity, weed and hard seed amounts. KRRC will inspect any containerized plants or transplants for presence of invasive weeds. KRRC will allow only certified weed free straw.
- 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. See section 6.1.3 for further details about this schedule.

- Utilize appropriate and cost-effective strategies to reduce or eliminate weed populations. Typical methods include cultural, biological, mechanical, and chemical control methods.
- KRRC's contractor will use chemical herbicides only when they offer an effective method for control and eradication of noxious weeds and when all other methods have failed. Herbicides will 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.

KRRC's contractor will use the following best management practices 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, limits of work, 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 the limits of work, they will be classified according to the California Invasive Plant Council (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 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, which further discusses adaptive management and monitoring of the sites.

Irrigation

The project area lies in an inland area on the California/Oregon border with very high evapotranspiration rates and an extended dry season with little or no precipitation in the late spring, summer, and early fall. The KRRC will provide only the Bank Riparian Zone with an irrigation system in order to establish robust vegetation in that zone for the re-establishment of ecological functions in and along the river. The two planting zones below the Riparian Bank Zone (Bank Wetland and Emergent Wetland) will be able to draw sufficient amounts of water from the river and irrigation runoff. The KRRC will intermittently irrigation planting zones above the Riparian Bank Zone with a temporary irrigation system that will be setup only if initial restoration efforts are unsuccessful because of lack of water or extended drought. This temporary system will consist of aluminum latch lateral irrigation pipe with sprinkler risers. The KRRC will initially provide the seed of woody plants (oak acorns, juniper berries, pine nuts, Oregon ash samaras and shrub seeds) in planting areas above the Riparian Bank Zone with water through biodegradable, paper mache derived, donut shaped containers that will be installed in the ground and, surround the seed (Figure 5-19).

Figure 5-18 Aluminum Latch Pipe and Sprinklers

The KRRC will install independent irrigation systems in the Riparian Bank Zone. The KRRC will install a "permanent" irrigation system that is a surface mounted PVC pipe with tall irrigation risers and large throw rotary gear sprinkler heads for the duration of the KRRC maintenance and monitoring period. The KRRC will design the irrigation system with proper sprinkler spacing and pipe sizing to prevent erosion and runoff while matching the infiltration rate of the existing soil. The irrigation system will draw water from the river by portable, skid mounted, gas powered pumps set up on the bank of the river in heavy duty shallow plastic basins to prevent spills. In addition to pumps, the irrigation system will consist of main and lateral PVC lines, isolation, quick coupling and control valves, in-line filters, irrigation controllers and other accessories. Irrigation sprinklers will be installed on 4'-6' high risers braced in three directions with #4 rebar and spaced at a distance of 50'-80' and will provide full, head-to-head irrigation coverage. Irrigation heads will be installed at the boundary between the Bank Riparian and Floodplain Riparian Zones to allow for partial irrigation of the Floodplain Riparian Zone without full head-to-head coverage. Their throw, arc and angle will be fully adjustable to facilitate quick field adjustments. The precipitation rate of the nozzles used in the irrigation heads will closely match the soil infiltration and site evapotranspiration rates. Irrigation lines will be schedule 40 PVC pipe installed on the surface of the ground and anchored with U-shape bent #3 rebar staples. Pipes will be sized to maintain flow and pressure required for proper performance of each sprinkler head, while maintaining pipe water velocities below five feet per second, reducing risk of pipe damage and friction losses. Selected pipes will be sufficiently oversized to accommodate future expansion of the irrigation system into adjacent riparian areas upstream and downstream of the primary floodplain areas if this is necessary in order to provide water to these areas because of extended drought.

Figure 5-19 Irrigation cocoon installed around the base of a tree seedling.

Irrigation system control valves may be both remotely and manually operable and will be designed to operate each individual lateral branch of the system. This will enable the maintenance contractor to run laterals independently as necessary during irrigation events to accommodate areas with warmer aspects with larger amount of water. Valves will be grouped together and installed inside a locking valve box or series of boxes near the irrigation pump to facilitate easy central operation. An in-line filter with cleanable stainless steel #200 mesh screen elements will be installed on the main line downstream of the pump before it branches out. The filter will be important for reliable functioning of the irrigation head nozzles and even water distribution. Additional pre-filtering of river water will be also provided through the submersible suction basket anchored in a still area of the river. A metal wire mesh cage with openings small enough to prevent small fish entry will house the suction basket. The irrigation controllers will be either removable or mounted directly on top of control valves and will be adequately sized for the required number of irrigation valves. They will be either battery or ambient light powered and will allow for independent schedule setting of each individual irrigation valve. Other potential irrigation accessories important for smooth operation of the system will be quick couplers to allow for hose watering of selected areas, low point drainage valves for irrigation system winterization, pressure gages, and air relief valves. The irrigation system will be well designed both for potential flooding events and for vandalism or theft.

Figure 5-20 Carmel River riparian bank zone irrigation system

Revegetation Planting Zones

The project area will be divided into the following nine distinct planting zones based on expected hydrology:

1. Emergent Wetland
2. Bank Wetland
3. Bank Riparian
4. Floodplain Riparian
5. Uplands below Rocky Wake Zone
6. Rocky Wake Zone
7. Uplands above Rocky Wake Zone
8. Upland Stockpiles
9. Undisturbed Uplands

The KRRC will determine the distribution and planform of the planting zones within the project area by local hydrology, soils data, flood water surface elevations, historical maps and photographs, and reference site information. Initially, at the time of winter drawdown, KRRC's contractor will seed the project area with pioneer species capable of dealing with the poor soil conditions, inclement weather, and complex hydrology at the time of aerial seeding. The pioneer seed mix will contain common native plant species, sterile wheat, and mycorrhizal inoculant. The pioneer seed mix will be developed based on site pilot growing experiments to ensure quick erosion control, expedient reconstruction of topsoil microbiology, effective adaptation to initial sediment toxicity, and good invasive vegetation suppression. The KRRC will broadcast planting zone specific permanent seed at the end of the dam removal period, in the fall of the drawdown year. The KRRC will adaptively perform several repeat seedings as necessary during the first two years after drawdown in order to increase native vegetation coverage in underperforming areas.

The KRRC will select native species for the planting zones based on plants known to be native in the project area, expected to establish readily, and anticipated to thrive within their planting zones. The KRRC will conduct small-scale test plot growing experiments 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.

Figure 5-21 Existing emergent wetland zone with hardstem bulrush below Iron Gate Dam.

Emergent Wetland Zone

The emergent wetland zone will consist of restoration areas of low water velocities that occur approximately between the base flow water surface elevation and 2-ft water depth as they occur in several segments of the river near the reservoirs (Figure 5-21). These zones will be adjusted on a case by case basis and depending on local topography and modelled water velocities. Many emergent wetland areas within the drawdown areas are expected to support river imported wetland vegetation propagules readily. 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 the invasives' removal and replacement with native species. Potential invasive species can include reed canarygrass and tall fescue at the upper edges, tamarisk, pennyroyal, and purple loosestrife. Active revegetation of emergent wetland areas will consist of relocation of existing emergent vegetation from the rim of the reservoirs to suitable newly formed emergent wetland habitats with slower moving water. Wetland species such as common cattail, hardstem bulrush, broad fruit burr-reed, sedges, rushes, and spikerushes will be transplanted and installed using transplants and ballast buckets Figure 5-22 and Figure 5-24) made of coir fabric, and weighed down with cobbles to reduce their buoyancy and potential to be washed out during high flows. This will happen during or immediately after drawdown, in late winter or early spring. To prevent desiccation and die-off of the existing reservoir rim vegetation before relocation, small areas with high densities of existing emergent wetland vegetation will be bermed off with clayey soil and irrigated to maintain a pool of water or saturated soil until transplantation. The salvaged plants will be planted 20' on center (O.C.) along the banks of the river. The following spring, once the plants have established, propagules will be harvested from installed salvaged plants and planted 10' O.C., between the plants from the prior year. The native wetland plant species proposed for the emergent wetland zone are listed in Table 5-5.

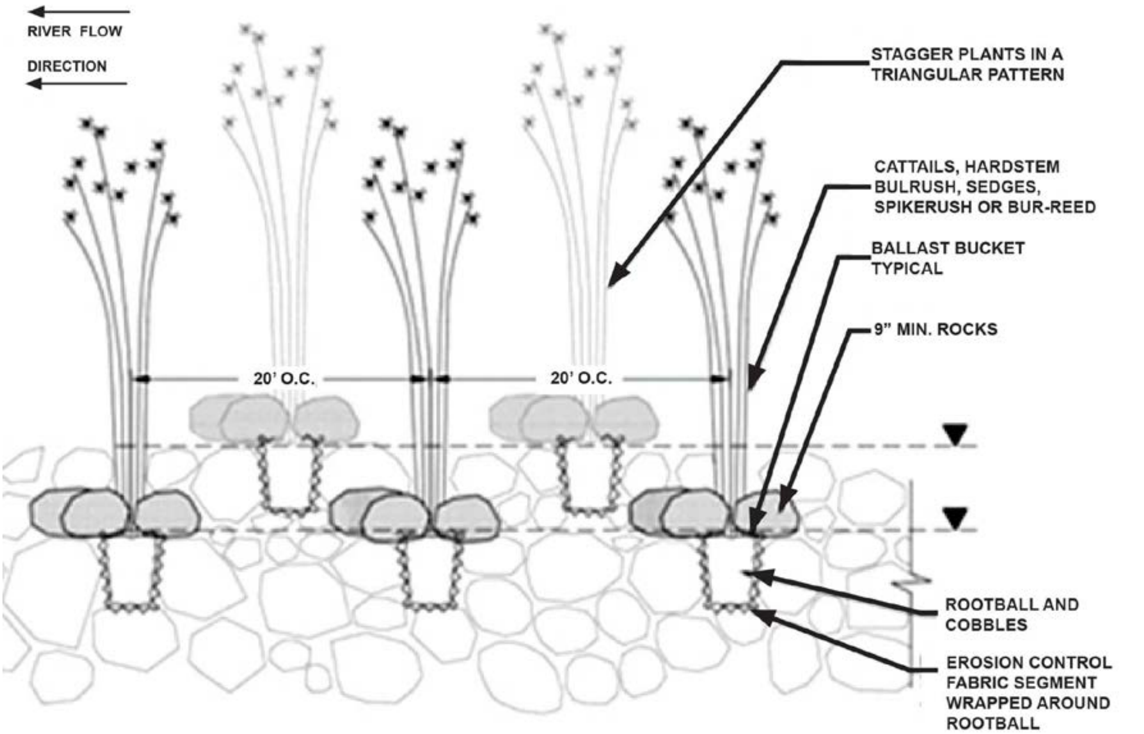


Figure 5-22 Coir fabric and cobble ballast buckets with emergent wetland vegetation.

Table 5-5 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 [lanuginosa]*	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
watercress *	*Nasturtium officinale*	perennial herb

Common name	Scientific name	Lifeform
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

* keystone species

Figure 5-23 Bank wetland area at J.C. Boyle Reservoir

Bank Wetland Zone

Bank wetland zones will be delineated as areas suitable for plant growth approximately between the base flow and 2-year flood event water surface elevations (Q_2), similar to where they currently occur within the project boundary (Figure 5-23). These zones will be adjusted on a case by case basis and depending on local topography.

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, the anadromous fish, and the high risk of invasive exotic plant establishment in this zone, it will be revegetated by seeding, transplanting of salvaged vegetation, pole cutting and ballast bucket installation. The proposed layout is shown in Figure 5-25 and the anticipated native wetland species are listed in Table 5-6. All of these plants are already present in the project area.

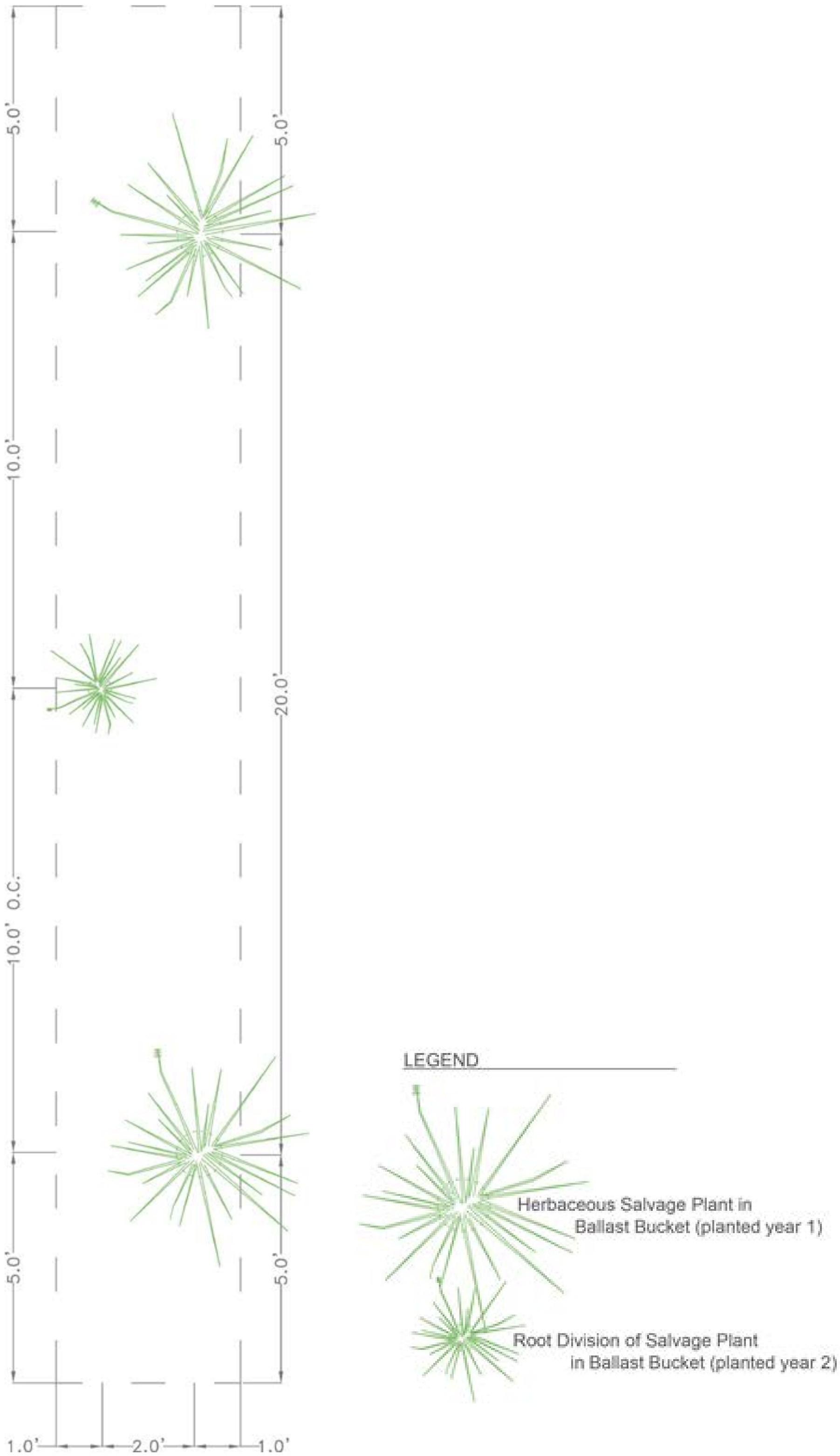


Figure 5-24 Emergent wetland typical plant layout.

Bank 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 5-4. The most widespread invasive exotic species present along the banks of the reservoirs are reed canarygrass (*Phalaris arundinacea*), pennyroyal (*Mentha pulegium*), and teasel (*Dipsacus fullonum*).

After reservoir drawdown, a re-assessment of areas selected for installation of salvaged riparian plants and pole cuttings 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 sediment depth, accessibility, soil texture, local topography, slope, aspect, and hydrology described in detail below.

Four pole cuttings and one transplant from the existing reservoir rim vegetation also be installed every 100 SF. This will occur in the initial stage of planting in the early spring after drawdown. Plant layout for all cuttings will be performed by the contractor's crews marking each planting spot with a pin flag for an overall review by a restoration ecologist. In the early spring of the following year, an additional one pole cutting per 100 SF will be laid out and installed (Figure 5-25).

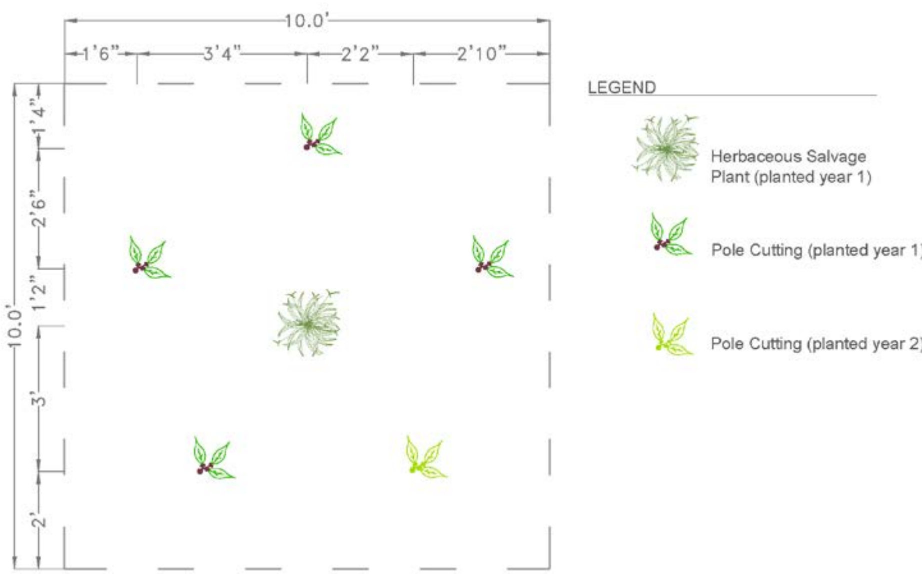


Figure 5-25 Bank Wetland Typical Layout

Table 5-6 Native plant species proposed for the 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
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

** keystone species.*

Bank Riparian Zone

Figure 5-26 Bank Riparian Zone on the Klamath River below Copco Dam. Sandbar willow at the water's edge, Oregon ash and black oak beyond

While the bank riparian zone will 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 2-3-year (Q_2-Q_3) to the 25-year (Q_{25}) flood water surface elevations (Q-lines) of the Klamath River and its tributaries 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 River 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 in the limits of work 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 5-7. Planting densities within the riparian-bank areas will be variable but will be on average approximately 2,673 woody plants per acre, or 5 pole cuttings and 1 transplant per 100 sq. ft. Similar to the bank wetland zone, one out of the 5 pole cuttings will be installed in the following spring, one year after drawdown (Figure 5-27).

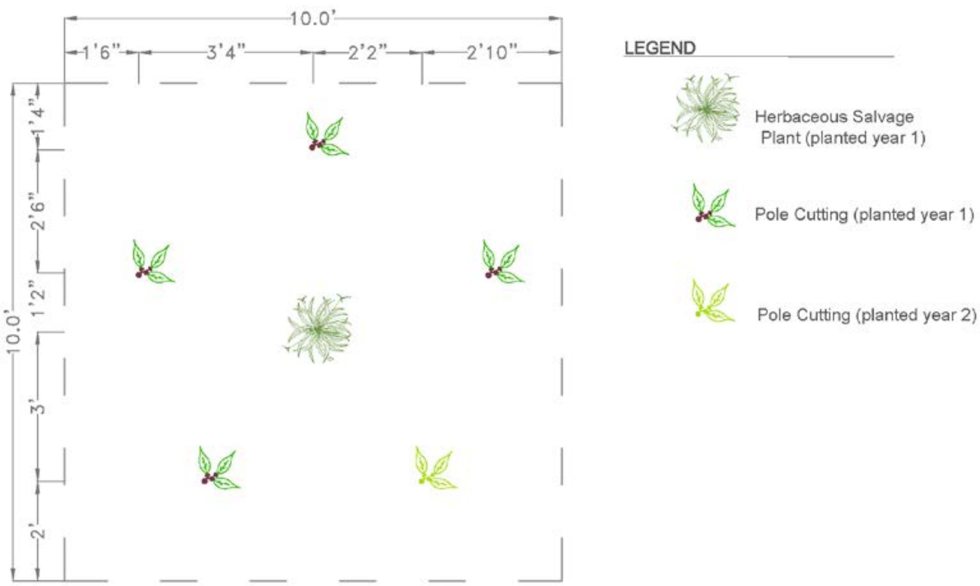


Figure 5-27 Bank Riparian typical plant layout.

Table 5-7 Bank Riparian Zone Proposed Species

Common name	Scientific name	Lifeform	Propagule
bigleaf maple	*Acer macrophyllum*	large deciduous tree	seed
spike bentgrass, spike redtop*	*Agrostis exarata*	perennial grass	seed
mugwort*	*Artemisia douglasiana*	perennial herb	seed, transplants
slender beak (wheat) sedge	*Carex athrostachya*	perennial herb	seed, transplants
clustered field sedge*	*Carex praegracilis*	perennial herb	seed, transplants
smooth dogwood*	*Cornus glabrata*	large deciduous shrub	cuttings
red-osier dogwood	*Cornus sericea*	large deciduous shrub	cuttings
tufted hairgrass*	*Deschampsia caespitosa*	perennial grass	seed
annual hairgrass	*Deschampsia danthonioides*	annual grass	seed
blue wildrye	*Elymus glaucus*	perennial grass	seed
small fescue	*Festuca [Vulpia] microstachys*	annual grass	seed
Oregon ash*	*Fraxinus latifolia*	medium deciduous tree	seed
meadow barley*	*Hordeum brachyantherum ssp. b.*	perennial grass	seed
toad rush	*Juncus bufonius*	perennial herb	seed
sword-leaved rush	*Juncus ensifolius*	perennial herb	seed, transplants
western rush*	*Juncus occidentalis*	perennial herb	seed, transplants
creeping (beardless) wildrye*	*Leymus triticoides*	perennial grass	seed, transplants
field mint*	*Mentha arvensis*	perennial herb	seed, transplants

Common name	Scientific name	Lifeform	Propagule
Lewis' mock orange*	*Philadelphus lewisii*	deciduous shrub	cuttings
black cottonwood*	*Populus balsamifera ssp. trichocarpa*	large deciduous tree	cuttings
California black oak*	*Quercus kelloggii*	large deciduous tree	seed
California rose*	*Rosa californica*	deciduous shrub	cuttings
Pacific blackberry*	*Rubus ursinus*	deciduous shrub, vine	cuttings
California dock	*Rumex californicus*	perennial herb	seed, transplants
narrowleaf willow*	*Salix exigua*	large deciduous shrub	cuttings
red willow*	*Salix laevigata*	large deciduous tree	cuttings
arroyo willow*	*Salix lasiolepis*	small deciduous tree	cuttings
shining willow*	*Salix lucida*	small deciduous tree	cuttings
common snowberry	*Symphoricarpos albus*	deciduous shrub	cuttings
California grape*	*Vitis californica*	deciduous vine	seed

**keystone species*

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 after drawdown. Key storm event water surface elevations will be used to determine the accurate extent and boundaries of this planting zone after drawdown. The 3, 5, 10, 25, 50 and 100-year storm water surface elevations will be modeled and in some areas sediment movement will be assisted with high pressure hosing to restore riparian bank and floodplain connectivity with the river. The bank riparian zone species that will be re-introduced in this zone are listed in Table 5-8.

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 (within the reach of the roots) 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 as described in detail in the Irrigation section above.

Floodplain Riparian Zone

Floodplain riparian zones will be delineated as those areas suitable for revegetation that occur approximately between the 25-year (Q_{25}) and 100-year (Q_{100}) 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.

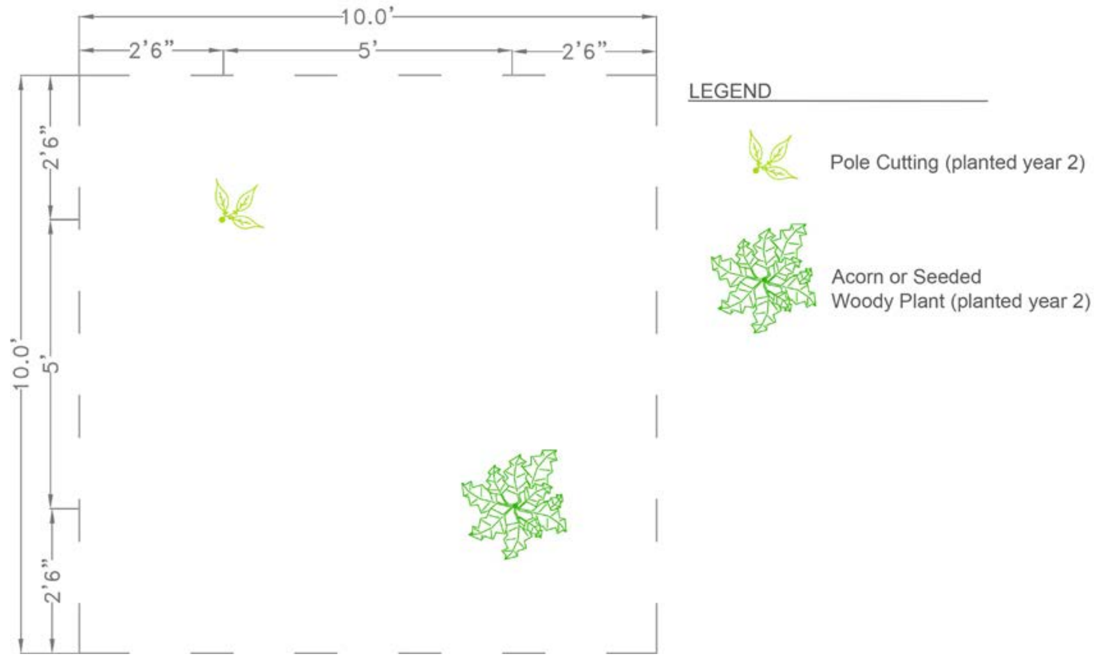


Figure 5-28 Floodplain Riparian typical plant layout.

Floodplain riparian zones will be seeded with a 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 and willow and cottonwood pole cuttings, will be planted in selected areas within this zone based on environmental factors such as soil texture, slope aspect and ground water depth. For every 100 SF, 1 pole cutting will be installed the first year. One acorn or other seed of a woody tree or shrub will be installed every 100 SF after the establishment of the aerial seeding (Figure 5-28). Acorns stay viable only for approximately six months and will be either planted shortly after their collection in October and November or cold stratified and planted early in the spring. 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. 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 of typical floodplain environments such as oxbows, floodplain depressions, overflow channels, seasonal wetlands and others. The riparian floodplain zone species are listed in Table 5-8. The average planting density on the riparian floodplain will be approximately 800 woody trees or shrubs per acre. Supplemental overhead irrigation of parts of the riparian floodplain zone may be provided in the form of temporary, surface mounted irrigation system that will draw water from the river.

Table 5-8 Floodplain Riparian Zone Proposed Species

Common name	Scientific name	Lifeform
bigleaf maple	*Acer macrophyllum*	large deciduous tree
Spanish lotus	*Acmispon americanus*	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 var. occidentalis*	perennial grass
common snowberry *	*Symphoricarpos albus*	deciduous shrub
creeping snowberry *	*Symphoricarpos mollis*	deciduous shrub

Common name	Scientific name	Lifeform
tomcat clover *	*Trifolium willdenovii*	annual herb

* keystone species.

Uplands below Rocky Wake Zone

Upland areas below Rocky Wake Zone will be areas suitable for revegetation that will extend from the post-removal 100-year flood water surface elevation to the lower end of the Rocky Wake Zone. These uplands will be the only formerly submerged areas where upland vegetation will be seeded on the sedimentary substrate. The restoration process will be the same as for the planting zones below; the pioneer seed mix with mycorrhizal inoculant will be aerially seeded in the early spring of 2021, and broadcast seeding of the native ecotypic permanent seed will be implemented in the fall. Because of the fine clayey texture of the sediment, the permanent seed mix for this upland zone will include species that are better adapted to highly conductive, low permeability soils. These species will be different from species that grow in the upland, coarser soil areas just above the reservoirs that will be used for the restoration of the current upland areas disturbed by the project activities. Typically, perennial bunch grasses, shrubs and trees dominate on well drained, coarse-textured soils, while primarily annual grasses and forbs thrive in clayey soils.

Figure 5-29 Grasses are an important component of the Upland Planting Zone. Their cover varies greatly with slope aspect.

Table 5-9 Uplands below Rocky Wake Zone Proposed Species

Common name	Scientific name	Lifeform
common yarrow *	*Achillea millefolium var. lanulosa*	perennial herb
California brome *[1]	*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

* keystone species

The revegetation seed mix listed above will be seeded in the fall of the first year and 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.

Figure 5-30 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

California black oak, Oregon white oak acorns, and other woody species seed will be planted in selected upland areas suitable for revegetation. They will be installed as soon as the weather begins to cool down and spring seeded areas become accessible to the restoration contractor's equipment and personnel. It is anticipated that this will occur in October of the drawdown/dam removal year. Fresh acorns will be harvested and planted immediately. Seeds of other woody species will be planted as appropriate based on environmental factors such as soil texture, slope aspect, local topography and hydrology as described below. The planting density in this zone will be four seeded woody plants per acre. Seed will be initially irrigated by the biodegradable donut-shape water bowl (Figure 5-31) made from recycled paper pulp (Cocoon).

Figure 5-31 Cardboard basin (Cocoon) tree planting of incense cedar

Water will be slowly delivered from the Cocoon filled with water through wicks placed near the seed. After the first season, trees will be self-sufficient and will 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 5-9) and will be planted at an average density of four woody plants per acre.

Rocky Wake Zone

Rocky Wake Zone will be an area of approximately 213 acres around the reservoirs where long term wake and wave action at the elevational range between the reservoir full and typical annual low water surface elevations (6'-7' range) resulted in gradual erosion and washing away of soil and fine textured sediment. Typically, only gravel, cobbles, boulders and bedrock is left. After drawdown, these areas could form a "bathtub ring" marking the original extent of the reservoirs with a continuous barren zone. Clean soil salvaged from the demolition of the dams, and sediment removed during the grading of the riparian floodplain areas will be imported over large segments of this zone and spread to a depth of 12" to provide substrate for vegetation. In some areas, the banks are very steep or form sheer cliffs. In these cases where soil cannot be safely kept on the existing grade without substantial erosion protection or other engineering measures, the rocky wake zone areas will not be restored. They will become a part of their existing rugged surroundings. During the initial aerial seeding with pioneer seed mixes, the Rocky Wake Zone will be avoided to the extent feasible because there will be no growing substrate to support the seed. The topsoil import in the Rocky Wake Zone will begin in the spring of 2021, and the soil covered areas will be seeded with the permanent seed mix in the late fall of 2021. The planting densities will be the same as in the Uplands below Rocky Wake Zone planting zone; four seeded woody plants per acre with irrigation cocoons. The risk of invasive species will be higher than in the Uplands Zone, because the Rocky Wake Zone is adjacent to the existing upland zones, where there is a large invasive species seed bank and a high percentage of invasive species dominated areas.

Disturbed Uplands

The Disturbed Uplands Planting Zone will be areas totaling approximately 136 acres that currently lie above the reservoirs and consist of existing developed areas proposed for demolition, and recreational areas that will be abandoned and removed after drawdown. Because the majority of these areas will not be ready for seeding until the end of the Dam Removal Period, they will not be included in the initial pioneer aerial seeding. They will be broadcast-seeded with the permanent native seed mix later, in the fall of 2021 and some in 2022. Soil preparation will vary based on past uses and activities. Areas with highly compacted soil, the result of the past presence of paving, vehicular traffic, intensive recreational activities or other human uses will be cross ripped to a depth of 24" before fall seeding in order to loosen the soil and improve its structure. It is assumed that 75% of the disturbed upland areas will need decompaction. Compacted areas under existing large trees and in their vicinity will not be ripped in order to protect the tree roots. The invasive exotic vegetation pressure will be intense in these areas because they are typically surrounded by areas heavily infested with non-native species such as cheatgrass, yellow star thistle, medusahead grass, goatgrass, and many others. The invasive exotic vegetation control will start early, several years before drawdown.

Figure 5-32 Erosion within the Rocky Wake Zone at Iron Gate Reservoir

Upland Stockpiles

The Upland Stockpile Zone (51 acres) will consist of areas where overburden material generated by the removal of the dams and other demolished structures in the project area will be deposited. It is assumed that the topsoil covering the stockpile areas will be heavily compacted. It will be cross-ripped to a depth of 24” or as feasible in preparation for seeding. The Upland Stockpile Zone will be seeded with the permanent native seed mix similar to plant list in table Table 5-10 in the fall of 2021 or as soon as the stockpiles become available for seeding in order to prevent their erosion. Because of the coarse debris within the core of the stockpiles and their sloping sides, these areas will be very well drained and dry during the long hot summers in the project area. Supplemental irrigation will be provided at least during several initial years of establishment in order to maintain vegetation in good condition. Similarly as with other upland zones, a very close attention will have to be paid to invasive species.

Undisturbed Uplands

The Undisturbed Uplands Planting Zone will consist of 148 acres of areas above the reservoirs that may be only minimally disturbed by the eradication of invasive exotic vegetation. They will go through active weed removal for at least three years before drawdown. Potential bare and disturbed patches resulting from invasive species removal will be reseeded both with the pioneer and the permanent native seed mixes. The majority of these areas will have existing native vegetation and only 30% is expected to need restoration.

Table 5-10 Uplands Above Rocky Wake Zone Seed Mix

Common name	Scientific name	Lifeform
common yarrow *	*Achillea millefolium var. lanulosa*	perennial herb
California brome *[1]	*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

* keystone species

1. Fast and prolific growth after seeding then gradually surrenders to other natives, protects habitat from initial exotic spp. invasion (GS pers. conv. Erin Lonergan, USFS botanist)

5.5.7 Cattle Exclusion Fencing

Areas around the reservoirs currently have open-range with cattle able to move freely around the reservoir areas. To protect revegetation efforts and to replace the function of the reservoirs as natural barriers, the

KRRC is proposing to use cattle exclusion fencing around the reservoir areas after drawdown. The proposed fencing will be a wildlife friendly design that excludes open-range cattle while allowing the natural movement of deer, turtles, and other wildlife. An approximate length of 34.5 miles of fence may be required to fully isolate the reservoir areas. The KRRC will place exclusion fencing, in accordance with applicable Federal, State, and county regulation and guidance, around the reservoir restoration areas where they abut grazing land. The KRRC will not fence areas of the reservoir perimeters that provide natural topographic (e.g., steep rocky terrain) or land use (e.g., residential areas, managed forests) barriers.

5.6 Data Gaps and Informational Studies

Several data gaps were identified in the 2011 Plan and the KRRC is gathering additional information and performing studies to maximize the likelihood for successful restoration. These data gaps are identified below and the KRRC has already addressed several of them using data collected in 2017 and others will be addressed later in 2018.

5.6.1 Revegetation Species

Optimization of revegetation effectiveness will depend on identification of the ideal revegetation species mix for each drawdown planting zone (i.e., upland, floodplain, riparian, and wetland) in each reservoir. Detailed proposed lists of native plant species appropriate for revegetation of each planting zone are provided in appropriate subsections above. These lists are based on past botanical surveys in the project area, early greenhouse growing experiments that were combined with the wetting-drying experiments (see Section 8.1), plant nutrient availability analyses, and knowledge of the cultural preferences of each native species, such as water, light and soil texture requirements. The KRRC will further refine these lists based on the proposed future vegetation surveys, and on the results from pilot test growing experiments that will be conducted for several years starting in the fall of 2018. Through these tests, the KRRC will determine optimal conditions for seed germination and identify best native species that will be capable of germinating on wet reservoir sediment under potentially freezing conditions during the January – March drawdown period.

5.6.2 Availability of Revegetation Materials

The KRRC will harvest pole cuttings from willows in riparian areas around the reservoirs where it will be transplanted to newly formed riparian areas. By thinning the willows' canopies, they will be better adapted for transplantation because their evapotranspiration will be substantially reduced. The KRRC will avoid areas with known habitat for sensitive species, such as the willow flycatcher (*Empidonax traillii*), and areas where sufficient water will be available for the riparian vegetation after drawdown during pole cutting collection and vegetation salvage.

The KRRC will salvage and transplant existing riparian and wetland vegetation currently growing in a narrow strip around the reservoirs, outside of areas where it can potentially survive after drawdown, to complement other reservoir revegetation efforts. Plant community inventories were completed around the reservoirs in 2009 and 2010 as part of the EIS/R preparation (USBR, 2011c), however, these lack sufficient detail regarding wetland and riparian species. The KRRC will conduct an updated vegetation inventory in 2018 and 2019. The KRRC will estimate the number of salvageable trees based on the inventory result and expects that a sufficient number of riparian trees will be available to supplement pole cutting installation.

To identify seed sources, the KRRC will conduct reconnaissance surveys in 2018 in areas within the upper Klamath River watershed that are within an elevational range of 500 ft below the Iron Gate Reservoir through 500 ft above the JC Boyle Reservoir. The KRRC will map the seed collection areas using global positioning system (GPS) and provide the maps to seed collection contractors that will begin work in late summer of 2018. The KRRC will conduct IEV surveys in 2018 to determine the extent of infestation within portions of the project area above the reservoirs. The KRRC will identify riparian vegetation around the reservoirs perimeters to inform the salvage potential of existing vegetation, the removal of invasive weeds, and more accurately characterize achievable vegetative conditions for restoration. The KRRC will perform new vegetation surveys in 2018 to provide a more recent and thorough baseline for the restoration approach

Specialized native seed propagation contractors will annually collect and propagate native seed in the project vicinity within the upper Klamath River watershed over a four-year period on large fields in farm settings to provide sufficient amounts of seed for both pioneer and permanent seeding.

5.6.3 Reference Site Selection

Establishment and good documentation of physical and ecological reference conditions is important for developing target conditions and performance criteria for restoration of various habitats in the project area. Existing vegetation surveys were completed along the margins of each reservoir in 2009 and 2010 (USBR, 2011c), but these studies were relatively coarse and were conducted over a short period of time. The KRRC will update and expand those surveys to include several reference areas for each planting zone at each reservoir. The KRRC will survey the reference sites for species diversity, vegetation cover, tree and shrub density and invasive exotic vegetation cover.

5.6.4 On-site Pilot Growing Test

The effectiveness of the restoration implementation will depend on correct selection of the best combination of plant species for each vegetation zone. A basic list of potential plants for revegetation of different drawdown zones in the reservoirs has been previously compiled by USBR (USBR, 2011c). However, KRRC selected plants with the implicit assumption that the existing vegetation present around the reservoirs will grow in fine, high organic matter, poorly drained sediment with absent soil biota that is diametrically different from the coarse, shallow and poor soil in the areas surrounding the reservoirs. During the pre-dam removal period the KRRC will update the species list for each vegetation zone in response to the information provided by the new vegetation surveys, the results from wetting-drying and growing experiments in the greenhouse (Section 8.1), plant nutrient availability analyses of the reservoir sediment samples, and test plot growing experiments at the project area.

The KRRC will implement project area test plot growing experiments in 2018 to examine the soundness of the restoration approach, and to refine the optimal seed mix for each vegetation zone in each unique reservoir setting. The KRRC will set up test plots near the reservoirs in locations with representative environmental conditions. The KRRC pilot experiment will be made up of twelve to sixteen 10'W x 10'L x 24"D test plots, each plot testing one of three-four treatments for four planting zones and zone seed mixes. The set of plots for each planting zone will be built to mimic the hydrology of that zone. Construction of these plots will include plastic liners to mimic wetland areas and raised beds with good drainage to approximate soil conditions in future upland areas. All plots will be irrigated. The test sites will be fenced to prevent predation by deer, theft and vandalism. The experimental design of the test plots will include different environmental parameters, such as reservoir sediment texture, surface treatment, cover crop seed mixes, irrigation, and hydrology. KRRC will use surface grab collected reservoir sediments to grow species of seed mixes from every vegetation zone. Sediment extracted from the bottom of the reservoirs (the anticipated growing substrate) will be placed in each plot to a depth of 2' (this will result in about a 1.2' thickness after the previously observed average shrinkage and drying of 60%. Scientists will regularly visit the site to monitor the experiment and to gather data for use in the vegetation species selection and restoration plan. The KRRC will finalize the seed mixes within each vegetation zone based on the test plot results.

Chapter 6: Monitoring and Adaptive Management

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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. The KRRC reviewed several dam removal monitoring and adaptive management plans as summarized in Table 6-1. These plans utilized a range of protocols and various levels of effort to monitor the projects. Common themes from these plans include monitoring for at least 2 years after dam removal with a focus on physical processes and vegetation. The KRRC is proposing that monitoring and adaptive management take place for 5 years after drawdown as described in the following sections.

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 monitoring 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 restoration of the reservoir areas 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 sites are trending towards or away from achieving project goals. Physical site characteristics have been identified as appropriate monitoring metrics using standard field techniques to 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 KRRC proposes the following actions to establish "baseline" or "initial conditions". The KRRC will use the initial condition reference data for monitoring and adaptive management related to reservoir restoration:

1. The KRRC will establish permanent ground photo points throughout the reservoir areas that enable sufficient vantage points of critical areas within the reservoirs. The KRRC will take photos to provide initial conditions for monitoring data to develop informed maintenance/corrective actions. The KRRC will monument 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. The KRRC will complete high resolution aerial photos, sub-meter accuracy, for the reservoir areas.
3. The KRRC will collect LiDAR for the reservoir areas after sediment evacuation and initial ground cover stabilization to create initial conditions surface models.

The KRRC will use the baseline data to 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. KRRC proposes a five-year monitoring plan.

6.1.1 Reservoir Sediment Stabilization

During an average water year, the KRRC expects 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 KRRC will vegetate the remaining sediments. The KRRC will construct habitat features to promote natural river processes that may create minor areas of erosion, but overall the remaining sediments will be stabilized. The KRRC will monitor sediment stability using 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 Reservoir Sediment Evolution Monitoring

The KRRC will conduct mapping of geomorphic features and sedimentary facies in the reservoirs to monitor reservoir sediment evolution following drawdown and identify the need for additional restoration actions. Fine-grained reservoir sediments not evacuated during initial drawdown are potential sources of suspended sediment that could be released during subsequent storm events if not stabilized and impact water quality. Deposit stabilization through active (e.g., planting and irrigating) revegetation techniques or erosion control measures (e.g., deposit excavation, erosion control mats) may be applicable where thick, fine-grained deposits persist in upland regions subject to overland flow and gully erosion and where revegetation efforts have been unsuccessful. In valley bottom and riparian locations where deposits are the thickest, dried and hardened residual reservoir sediments may physically obstruct flood waters from accessing the floodplain. In such cases, the KRRC will manually remove the obstructing deposits to increase floodplain connectivity. Restoration actions for deposit excavation may be triggered where sediment accumulations of specified threshold dimensions persist in riparian areas for more than a year after drawdown.

To document reservoir sediment evolution, the KRRC will map geomorphic features and sedimentary facies in the field and use remote analyses of bathymetric and LiDAR surfaces, aerial photos, and photo points. The KRRC will use viewshed GIS analysis to refine and optimize the locations of permanent ground photo points for monitoring and evaluate the ability to see post-drawdown features of interest (e.g., floodplains, regions with thick deposits) from specific vantage points prior to drawdown. The KRRC will compare the location and spatial extent of historical and post-drawdown geomorphic features of interest (e.g., channel banks, floodplains, and terraces) to modeled flood inundation extents (e.g., Figure 3-1, Figure 3-5, Figure 3-11). The KRRC will monitor residual reservoir sediment including the description of spatial extent and thickness, sediment texture and structure, and interpretation of the reservoir depositional environment and post-drawdown erosional environment (e.g., evolution by hillslope and gully processes or mainstem flooding). The KRRC will use field mapping to opportunistically target riparian and floodplain areas and locations where remote analysis has identified bare sediments and where erosion has exposed complete stratigraphic sections in the sediments. Estimates of residual sediment volumes will benefit from revised estimates of sediment thickness using the 30 centimeters (cm) resolution bathymetry and drill core data collected in 2018 along with historical topography and the previously collected sediment core data described in USBR (2011c).

The KRRC will conduct field inspection activities each year around April 1, and remote analysis will precede, and thereby inform, field mapping by several weeks. This timeline ensures both that the majority of large storms for the water year will have already occurred and that there will be sufficient time to prepare materials for permitting restoration actions during the "in water" work window to mitigate problematic residual reservoir deposits. The KRRC will use results of field and remote analyses to generate maps of residual reservoir sediments and geomorphic features that can be compared with surface run-off models and modeled flood inundation extents and can highlight possible locations for restoration actions.

6.1.3 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 to free-flowing systems. To address this uncertainty, the KRRC will enact a visual inspection and monitoring protocol 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

6.1.4 Revegetation, Invasive Exotic Vegetation Control and Natural Ecosystem Processes Restoration

To determine the progress and success of revegetation, invasive exotic vegetation control, and efforts to restore natural ecosystem processes, the KRRC will regularly monitor the project area for compliance with established performance criteria. The general approach to this monitoring will be to quantitatively record the progress, compare it to established performance criteria/reference site conditions, and take corrective action if and when necessary to guide further ecological succession on a trajectory to a fully functioning natural ecosystem. The key monitoring activities are summarized in Table 6-4.

Performance Criteria

For the purposes of monitoring, to determine the revegetation plan success, and to ascertain the degree of natural ecosystem processes re-establishment, the KRRC is proposing the following performance criteria for all native vegetation planting zones. The KRRC will refine these criteria once reference sites are identified and biometrically quantified.

Relative Vegetation Cover:

The relative vegetation cover for each project planting zone will be the following percentages of the average of the relative vegetation cover of approved reference sites for each monitoring year:

- Y1–70%

- Y2–75%
- Y3–80%
- Y4–85%
- Y5–90%

Rock outcrops, scree, and gravel covered areas and areas otherwise unable to support vegetation, will be excluded from the relative vegetation cover calculations.

Table 6-4 Summary of reservoir revegetation and invasive exotic vegetation monitoring metrics

Project Goal	Monitoring Technique	Monitoring Metrics	Frequency
Establish native vegetation cover	Visual inspection, aerial photography-based GIS desktop analysis, and ground based photo points	Relative vegetation cover	once per year
	ground based botanical surveys of selected sampling areas or along predetermined point intercept transects and photo points	Plant species diversity	once per year
	GPS identification of tree and shrub textural signatures to facilitate GIS desktop, field verification and data correction for complex/ambiguous areas, photo-documentation of tree and shrub growth, health and vigor from established on-the-ground photo point stations	Number of surviving trees and shrubs per acre	once per year
Minimize invasive exotic vegetation	GPS identification of textural signatures of IEV species, production of high resolution, drone generated aerial photo, a quantitative GIS based determination of relative percent cover, field verification and data correction, on the ground marking of IEV designated for removal, Daubenmire frame surveys along pre-determined transects for species not recognizable on aerial photography, photo-documentation of IEV cover from established on-the-ground photo point stations.	Invasive Exotic Vegetation Cover	Y1 – 20x/year Y2 – 10x/year Y3 – 5x/year Y4 – 4x/year Y5 – 2x/year

Plant Diversity:

The plant diversity for each project planting zone will be the following percentages of approved reference sites for each monitoring year:

- Y1–60%
- Y2–65%
- Y3–70%
- Y4–75%
- Y5–80%

Number of Surviving Trees and Shrubs per Acre:

The number of surviving trees and shrubs per acre will be the following percentages of the trees originally planted from seed for each monitoring year:

- Y1–90%
- Y2–85%
- Y3–80%
- Y4–75%
- Y5–70%

Naturally recruited native woody species shall count at 50%.

Invasive Exotic Vegetation Cover:

Percent relative cover by medium and low priority IEV shall be less than the average of the relative medium and low priority IEV cover in two nearby approved reference areas as follows:

- Y1–25%
- Y2–40%
- Y3–55%
- Y4–70%
- Y5–90%

No high priority invasive plants (as listed in Table 5-4 of this report) will be present in the limits of work.

Revegetation Monitoring Methodology

The KRRC will perform annual revegetation monitoring for five years after installation acceptance or until the performance criteria have been met. During the first monitoring year that will coincide with the Plant Establishment Period, IEV control will be crucial. During the plant establishment period, the KRRC will perform monthly monitoring during the cold season from November 1 through March 1, and bi-weekly monitoring the rest of the year, totaling approximately 20 visits. For the remaining four years of the 5-year monitoring period that will coincide with the Maintenance and Monitoring Period, the frequency of KRRC monitoring and maintenance will gradually decrease. In Year Two, the KRRC will conduct bi-monthly monitoring surveys will be conducted during the cool season from November 1 through March 1, and monthly surveys the rest of the year. In Year Three the KRRC will make 5 visits, one visit between November and April and four bi-monthly visits the rest of the year. In Year Four, visits will be bi-monthly from April through November, totaling 4 visits for the year. During the anticipated final year of monitoring and maintenance, the KRRC will make two visits, one in the spring and the other in the fall. During only one monitoring visit each year (approximately at the same time) the KRRC will gather data on performance criteria compliance needed to prepare the annual monitoring report. In the remaining monitoring visits, the KRRC will focus on identification of IEV populations and monitoring of restoration contactor compliance with the requirements of the plant establishment and maintenance contracts. The KRRC will base tasks for the maintenance period on the monitoring results, and performance criteria thresholds and 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). Monitoring will be conducted by qualified plant biologists with expertise in local native plant ecology and invasive species control, and will include the following tasks:

Relative vegetation cover determination:

- A walking visual inspection to document the progress of native vegetation establishment in selected sampling areas or transects in each planting zone.
- GPS identification of textural signatures of sample bare ground areas and different types of vegetation to facilitate GIS desktop analysis of aerial photography for woody and larger aerial cover species and relative vegetation cover determination.
- Production of high resolution, drone generated aerial photos with sub-meter accuracy to be used as the basis of GIS desktop analysis to accurately determine vegetation cover for herbaceous and woody species in the project area.
- Photo-documentation of revegetation progress from established on-the-ground photo point stations.

Plant species diversity:

- Botanical surveys in selected sampling areas or point intercept surveys along pre-determined transects in each planting zone.
- GPS identification of sample textural signatures for different types of vegetation to facilitate GIS desktop analysis of aerial photography.
- Photo-documentation of revegetation progress from established on-the-ground photo point stations.

Number of surviving trees and shrubs per acre:

- GPS identification of textural signatures of tree and shrub species to facilitate GIS desktop analysis of aerial photography to determine the number of surviving trees and shrubs per acre in the project area.
- On the ground field verification and data correction for complex or ambiguous areas.
- Photo-documentation of tree and shrub growth, health and vigor from established on-the-ground photo point stations.

Invasive exotic vegetation cover:

- GPS identification of textural signatures of IEV species where feasible to facilitate GIS desktop analysis of aerial photography to determine the invasive exotic vegetation cover, species and extent.
- Production of high resolution, drone generated aerial photography with sub-meter accuracy for GIS desktop analysis.
- A quantitative GIS based determination of relative percent cover of IEV species within the limits of work, and a list of IEV species with recommendations on priority and method of removal.
- On the ground field verification and data correction for complex or ambiguous GIS areas.
- On the ground marking of IEV designated for removal by maintenance contractor.
- Daubenmire frame surveys along pre-determined transects for herbaceous species not recognizable on drone generated aerial photography.
- Photo-documentation of IEV cover from established on-the-ground photo point stations. Numbered photo point locations, camera focal length, and directions will be established during the initial inspection and comparative photos from the same photo points, in the same directions, and same camera settings will be taken in subsequent inspections.

The KRRC will prepare and submit an annual monitoring report by December 31 of monitoring Year One through Five. Each annual report will cover both the geomorphic and revegetation monitoring scheduled for that monitoring year.

If any scheduled revegetation monitoring inspection reveal that any of the monitoring criteria have not been met, the monitoring report for that year will include an evaluation of the potential factors that may be hindering project revegetation and propose a plan for improving performance. Suggestions for improving performance may include specific recommendations for removal of invasive exotic species or for an adaptive plan for supplemental native plantings.

Natural Ecosystem Processes Restoration Monitoring

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 its tributaries. A healthy, vibrant, self-sustainable riparian corridor where target plant species recruit from naturally produced seed will help improve water quality, reduce thermal load (i.e., provides shaded aquatic riverine habitat), stabilize banks and sediment, slow and filter water, provide fish and wildlife habitat, and provide needed organic matter. Site monitoring to assess the achievement of this goal will be looking at monitoring metrics described above and determine if the reservoir areas are trending towards a restored natural ecosystem. KRRC will develop and implement corrective actions to improve the trend if it is not progressing toward a restored naturally functioning and self-sustaining ecosystem.

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 6-5 summarizes a simple framework for making decisions and actions based on monitoring of project metrics.

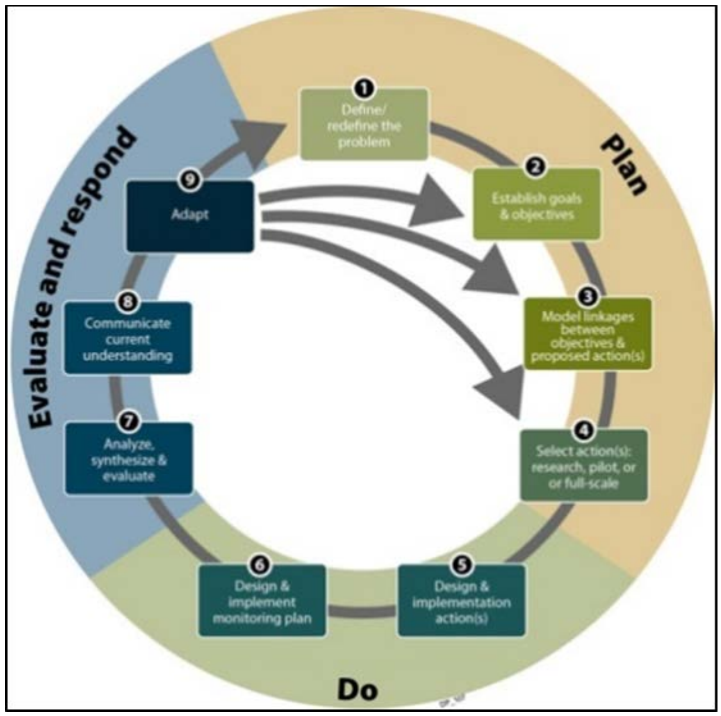

Figure 6-1 CDFW adaptive management diagram

Table 6-5 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) • Confer with project team to evaluate whether rates of progress toward objectives are appropriate

Conclusion Categories	Decisions and Actions
Conclusion 3 - Project is not meeting (or trending away from) objectives based on monitoring values of performance criteria.	• Evaluate causes • Confer with project team to assess the monitoring program to determine if appropriate data area being collected to assess and evaluate causes • Evaluate whether performance criteria metrics are appropriate • Develop a plan to address problems • 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 6-6 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 6-6 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) • Man-made or unnatural structure observed (Fail)	• Remove historical structure if it is problematic	Visual Inspection by Photo Points Physical Survey may be warranted if metric is found to be outside of threshold.
Fish Passage	• No unnatural barriers exceeding 6 inches • No unnatural channel headcut exceeding 6 inches	• No jump height barriers exceeding 6" (Pass) • Barriers/headcut present (Fail)	• Remove or rectify barrier • Restore and stabilize streambed through headcut	Visual Inspection by Photo Points 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) • Bank erosion threatening structures (Fail)	• Perform stabilization actions to limit/reduce extent of erosion • Perform survey to evaluate trends in instability	Visual Inspection by Photo Points** Physical Survey may be warranted if metric is found to be outside of threshold.
Vegetation coverage	• % relative vegetation cover • Plant diversity • Tree and shrub survival % • % cover invasive exotic vegetation	• Low vegetation cover • Low plant diversity	• Additional vegetation seeding planting • Seeding additional species • Seeding add'l trees and shrubs • IEV eradication	On the ground physical surveys, Photo Points, GIS based analysis of aerial photography,

6.3 Data Storage and Reporting

6.3.1 Data Storage

KRRC and Klamath Basin Monitoring Program (KBMP), or their designated representative will store and maintain monitoring data. 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 standardized to avoid redundant data and to ensure consistent data formats among sampling events.

6.3.2 Data Analysis and Reporting

After each monitoring event, KRRC will analyze survey data. KRRC will prepare a brief site action memorandum and provide it to KBMP; the memo will include:

- 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 each monitoring event site action memorandum,
- Monitoring metric conclusions based on metrics target thresholds observed over the monitoring season, and
- Any recommended maintenance or corrective actions.

KRRC will make these annual memos at the end of each calendar year. If significant issues or concerns are identified, KRRC will recommend future actions with sufficient time for planning and permitting prior to the "in water" work window. Lastly, KRRC will generate a final monitoring report 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 on 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.

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Chapter 7: References

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Chapter 8: Supplementary Information

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8. SUPPLEMENTARY INFORMATION

8.1 Experiments to Inform Restoration Decisions

The following sections detail the experimental methodology, results, and implications of two experiments that were completed in 2017 and 2018 to address existing restoration data gaps: 1) Investigation of the physical responses of reservoir sediments to wetting-drying, and 2) Grow tests to evaluate the suitability of reservoir sediments as a growth medium and identify species likely to succeed in revegetation efforts.

8.1.1 Reservoir Sediment Characteristics

Results of Previous Studies

Testing of reservoir sediment characteristics can provide insight into the expected evolution of the material during and following drawdown. Previous analyses (J.C. Headwaters, 2003; Shannon and Wilson, 2006, USBR, 2010; Strauss, 2010; Simon et al., 2010), which are summarized in USBR (2011b and 2011c), examined the physical and behavioral properties, including grain size, Atterberg limits, water content, cohesion, shear strength, erodibility, and changes associated with desiccation (drying). Important results include the high clay content particularly in the downstream reaches of each reservoir, high water content, low material strength, and high erodibility of the fresh, moist reservoir sediments and the significant increase in material strength and decrease in erodibility of the sediments once dried (Simon et al., 2010). Critical shear stress, τ_c, for moist sediments (67 to 82% water content by weight) was 0.58 to 1.1 Pascals (Pa) (0.012 to 0.023 pound-force/square foot [lbf/ft^2]), similar to stresses required to entrain sand, and values increased to 5.9 to 56 Pa (0.123 to 1.17 lbf/ft^2) for dried sediments (48 to 67% water content), similar to stresses required to transport gravel and cobbles. Reservoir sediments from J.C. Boyle were observed to decrease in porosity and in thickness and volume by 40% and 66%, respectively, when air dried, and significant crack development occurred in concert with the decrease in volume (USBR, 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.

USBR (2011b) simulated sediment evacuation and suspended sediment concentrations during drawdown using a 1D model for all reservoirs. They demonstrated that the rate of erosion of reservoir sediments was primarily a function of hydrology during drawdown and the low-level outlet capacity of the dams. The range in reservoir sediment volume eroded varied from 41% to 66% depending on if a representative hydrograph from a dry or wet year, respectively, was simulated. These 1D model simulations used the median values for τ_c (0.2 Pa) and the erodibility coefficient, *k*, measured by Simon et al. (2010). Model sensitivity analyses using the 25th and 75th percentile moist values (Simon et al., 2010) for τ_c (0.03 and 1.2 Pa, respectively) showed negligible effect (USBR, 2011b). For the 1D modeling, an above water angle of repose of 15 degrees was used (USBR, 2011b). However, values vary from 6 degrees (10H:1V, Shannon and Wilson, 2006), 18 degrees (2H:1V) PanGeo (2008), and 32 degrees from the drill core friction angle (Strauss, 2010). Sensitivity analyses using lower values of 5 and 10 degrees showed increased the duration of moderately elevated suspended sediment concentrations as result of sand deposition from Copco Reservoir in Iron Gate and subsequent remobilization. Effects on eroded sediment volume were not reported. A single value of angle of repose will not be representative of all grain sizes in the reservoir sediments or the increase in stable angle with desiccation of sand and fine-grained cohesive sediments.

Measurements of friction slopes and shear strengths were used to calculate stable sediment thicknesses as a function of slope and measured cohesion (Table 8-1) using an infinite slope assumption and the US Army Corps of Engineers Slope Stability Engineering Manual (see summary in USBR, 2011b). The minimum measured cohesion value was 0.7 pound-force/square Inch (lbf/in^2), but given the difficulty measuring this quantity on the saturated sediments, a lower cohesion value is more reasonable. Results suggest that slopes with gradients below 10% should be stable with more than 4 to 8 ft of reservoir sediments. Greater slopes and thicknesses are predicted to lead to slope failure or slumping.

Table 8-1 Stable depth (ft) of reservoir sediments as a function of slope and cohesion for saturated and draining sediments from USBR (2011b).

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

Sediment Sampling and Experimental Methodology

Additional testing of reservoir sediments was undertaken in winter 2018 to build upon these previous analyses. Sediments were monitored during desiccation, and experimental treatments targeted changes in physical properties of the sediment when exposed to cyclical periods of wetting and drying as would be experienced in the fall following drawdown. Samples (approximately 1 cubic foot [ft^3] each) were collected with a grab sampler from the uppermost 9 inches of substrate in 25 locations in total among the three reservoirs (Figure 8-1, Figure 8-2, Figure 8-3). Samples were placed into 15-inch by 23-inch containers to a depth of 4 to 5 inches and tested in a greenhouse environment. Control over environmental conditions in the greenhouse was limited by the thermostat and sprinkler characteristics and therefore do not simulate conditions at the reservoirs exactly. Greenhouse temperatures typically varied between 50 to 70 deg. F with extremes approaching 90 deg. F, and relative humidity ranged from 30 to 60%. Sample measurements included deposit dimensions and weight, time-lapse photography of volume changes and crack geometry development, infiltration rate, and shear strength, which was measured with a Torvane sampler and correlates with critical shear stress and the erodibility coefficient (see Simon et al., 2010). Samples were monitored during desiccation over a period of weeks until sample weight had stabilized (i.e., samples had fully dried out). Once dried, ¼ inch holes were drilled in the base of the sample containers to promote free draining, and samples were periodically rained on with an average application of 1.1 inches from the sprinkler system at a rate 1.65 inches per hour for a period of approximately 40 minutes. These rainfall events are similar to a 100-year event for this duration at the Copco climate station. Sample weight and shear strength were measured at the conclusion of rainfall events. Shear strength (τ_f, kPa) was compared to fractional sample weight $F = W/W_0$, where W is the measured sample weight (lbs) and W_0 is the initial weight (lbs) prior to desiccation.

Measured shear strength values were used to estimate variations in predicted erosion rates of reservoir sediments with desiccation using a simplified model. Critical shear stress (τ_c, Pa) and the erodibility coefficient (k, cm^3/N-s) are calculated from shear strength (τ_f, kPa) using empirical relationships from Simon et al., (2010): $\tau_c = 0.2151\tau_f^{1.5006}$ and $k = 0.7534\tau_f^{-0.6023}$. We use the rewritten form of the Ariathurai and Arulanandan (1978) excess shear stress relation for erosion rate (ε, m/s) of cohesive sediments from Partheniades (1965), $\varepsilon = k(\tau - \tau_c)$ for $\tau > \tau_c$ to explore the sensitivity of erosion rate to shear strength. Substituting the shear strength relationships for τ_c and k_d (Simon et al., 2010) shows that $\varepsilon = 0.8\tau_f^{-0.6}(\tau - 0.2\tau_f^{1.5})$ or $\varepsilon \propto \tau_f^{-0.6}\tau^1$. That is, the shear stress needed to cause erosion is a function of $\tau_f^{1.5}$, and for a given shear stress in excess of this critical value, erosion rate varies linearly with excess shear stress and with approximately the inverse square root of shear strength.

Results of Sediment Testing

Data collected during the drying of the samples confirmed many of the observations from previous studies. Wetting-drying tests were performed on paired samples from JCB1, CP2, and IG1, which are located near their respective dams where sediment deposits are thickest (Figure 8-1, Figure 8-2, Figure 8-3). Desiccation, which occurred solely through evaporative processes rather than gravity draining, resulted in significant reductions in fractional sample weight, F, and volume of up to 80% and 65%, respectively, over a period of one to two months (e.g., Figure 8-7, Figure 8-8, Figure 8-9 and Table 8-2, Table 8-3, Table 8-4). Over the first several weeks of drying, cracks several inches in width formed through the full thickness of the deposit and the sediment pulled back from the sides of the container (Figure 8-4, Figure 8-5, and Figure 8-6).

The increases in shear strength, (τ_f, kPa) were dramatic (Table 8-5, Table 8-6, Table 8-7) with reductions in fractional sample weight and tightly follow a negative power law (Figure 8-7, Figure 8-8, Figure 8-9). Shear strength increased rapidly after samples reached about 50% of the initial saturated weight, which occurred after several weeks. Maximum shear strength values were over two orders of magnitude greater than early, saturated measurements (Table 8-8). Samples eventually dried and hardened to the extent that the Torvane sampler could not be inserted into the sediment, and further measurements were not possible. Therefore, maximum shear strength values are potentially even higher than measured.

The maximum measured shear strength values were used to calculate changes in critical shear stress and the erodibility coefficient (Table 8-8). Critical shear stress increased by 2 to 3 orders of magnitude and were an order of magnitude greater than the maximum values, equivalent to values able to erode cobbles, that were measured by Simon et al. (2010) and used to model reservoir erosion (USBR, 2011b). Using the simple relationship for boundary shear stress for steady, normal flow, $\tau = \rho g H S$, a 2 to 3 order of magnitude increase in the depth-slope product would be required to initiate erosion in the dried sediment compared to the fresh, moist sediments. The decreases in erodibility, k, suggest decreases in erosion rate with desiccation by a factor of 6 to 30 for a given shear stress in excess of critical applied to the dried sediments (Table 8-8).

The effects of experimental rainfall events are visible in the shear strength and drying. While most of the rainfall was lost as surface runoff, some water entered the deposits resulting in maximum increases in *F* of 0.12 (approximately 6 lbs) at CP2b (Figure 8-8D). After wetting, reductions in shear strength were variable and generally ranged from 50 to 75 kPa. Wetted shear strength values were still two orders of magnitude greater than initial measurements (Figure 8-7 and Figure 8-8). The maximum decrease in shear strength was 200 kPa (see January 26 event in Figure 8-7D). Changes in deposit dimensions were negligible in response to rainfall events. An important response to cyclical wetting and drying was the disintegration and fracturing of the deposits into smaller fragments and dust. Most strikingly in the IG1 samples, new cracks and fractures appeared after each sequence of wetting and drying. In the IG1 samples, which had the highest clay content of the three wetting-drying samples, considerable disintegration occurred with additional watering even after seeding and root development (see Section 8.1.2).

Infiltration rates from single-ring infiltration tests were low (on the order of 10^{-2} inches per hour) on partially dried intact sediment surfaces. These rates are consistent with infiltration rates calculated from laboratory analyses of sediment texture (Wallace, 2017) using the Soil Water Characteristics model v. 6.02.74 (Keith Saxton, US Department of Agriculture [USDA]). On fully dried samples, water ponded in sediment depressions during greenhouse irrigation tests where rainfall rates were approximately 1.25 to 1.65 inches per hour. This observation provides an inferred upper limit on the infiltration rate. However, during single-ring irrigation tests on the dried samples, infiltration rates were very high, several inches per hour. These rates were influenced heavily by the presence of thin cracks in the deposit. The bulk infiltration rates for the reservoir sediment deposits were dominated by preferential flow paths along cracks and were much higher than expected from the high clay content of the sediments and reduction in porosity with desiccation.

Implications of Sediment Testing Results for Reservoir Evolution

The results presented above suggest additional complexities and potentially some deviations from the general reservoir response patterns described by USBR (2011c). Much of the water in the highly saturated sediment will drain rapidly with open-air exposure resulting in initial mass loss significantly greater than that measured in the greenhouse. Desiccation, and concomitant increases in shear strength, are expected to be more rapid in the field because of gravity draining even if temperatures were lower than in the greenhouse, where over a month of drying was required for the shear strength to increase over 50 kPa.

The remaining water content, however, could take weeks to evaporate out of the high clay content sediments, depending on meteorological and topographical conditions. Deeper sediments in thicker deposits will require longer to dry and stabilize if they are insulated from direct sunlight and the atmosphere by overlying sediment. Therefore, even though the surface sediments are dried and hard, the deposits could be deceptively unsupportive of heavy machinery in the weeks after drawdown, and the timing for such stability of the deposits remains poorly constrained. The dried material is firm but brittle, and surface-normal pressure (e.g., during tilling, soil compaction tests) resulted in fracture, rather than plastic deformation, of the sample deposits in the greenhouse. Field deposits will not have the shallow, hard boundary of the sample bin, so fracture behavior may differ somewhat. In situ sediment consolidation and strength was greater (and water content lower) at sediment depths of 6 to 10 ft (USBR, 2011b), so exposed basal sediments may not slump and erode as readily as surface sediments during drawdown.

Secondary erosion of the residual reservoir deposits is affected by the large increases in shear strength with desiccation, the prevalence of cracks, and the continued disintegration in response to wetting and drying cycles. Dried blocks tested in the lab retained high mechanical strength (critical shear stress values in excess of those required to transport cobbles) and may not readily erode (via rainsplash) nor reduce considerably in strength from rainfall alone. The low porosity and low infiltration rates of intact surfaces hindered the re-saturation of the deposits even with long durations of rainfall, such that high shear strength was retained. The prevalence of cracking will encourage gully erosion because the low infiltration rates will intensify surface run off and flow concentration in cracks. Gullies will incise and widen with time. The availability of erosive tools (i.e., sand and gravel) to abrade the fine-grained deposits may be an important factor encouraging gully erosion. Gullies closer to coarse sediment sources (e.g., near the steep hillslopes at Copco and Iron Gate) may have more effective secondary erosion than areas lacking those sediment sources (e.g., Upstream Reach of J.C. Boyle). The disintegration of sediments in response to wetting and drying cycles is effectively a reduction in the grain size of the sediment aggregates. Therefore, while the sediments retain high shear strength, they will be broken down smaller size classes that are more easily transported than the shear strength values suggest. Furthermore, the attrition rates of sediment aggregates are expected to be very high if mobilized, and the material will disintegrate rapidly. Flow routing and accumulation GIS analysis, particularly at Copco, could be used to predict locations where secondary erosion from hillslope runoff and gully erosion may be expected to occur. Such locations will be the first to naturally excavate reservoir sediments and expose historical soils in upland, terrace, and floodplain environments. Inasmuch as native vegetation might prefer the historical soils over reservoir sediments, these areas could be hubs for more targeted revegetation efforts.

The continued disintegration of the dried sediments to easily erodible fine particles and aggregates in response to wetting and drying suggests that the exposed reservoir sediments may be unstable post drawdown despite the initial increases in the shear strength. There is potential for the bare sediments to produce elevated suspended sediment concentrations during fall rain events if not stabilized with vegetation. The disintegration in response to wetting-drying was most dramatic in the IG1 samples, which suggests that high clay content enhances this effect. Therefore, we may expect this behavior to be a larger factor in deposit evolution in Iron Gate Reservoir and in the downstream portions of each reservoir. Vegetation was successful in reducing disintegration for the CP2 sample.

Infiltration results have important implications for surface run-off responses to precipitation, moisture availability for revegetation, deposit evolution by gully erosion, and associated river suspended sediment concentrations. High intensity rainfall (e.g., rainfall rates in the greenhouse, but also likely smaller events) will largely run off the intact sediment surfaces and flow preferentially in cracks and gullies. High surface runoff will reduce the amount of moisture absorbed into the low porosity, hardened surface sediments, and therefore less moisture will be available in the shallow subsurface for plant uptake relative to more mature soils with similar characteristics that lack the crack development. Infiltration will be dominated by preferential flow in cracks, and crack densities should be sufficient for the effective infiltration rate for the sediment body to be high.

Wetting and Drying Test Data and Figures

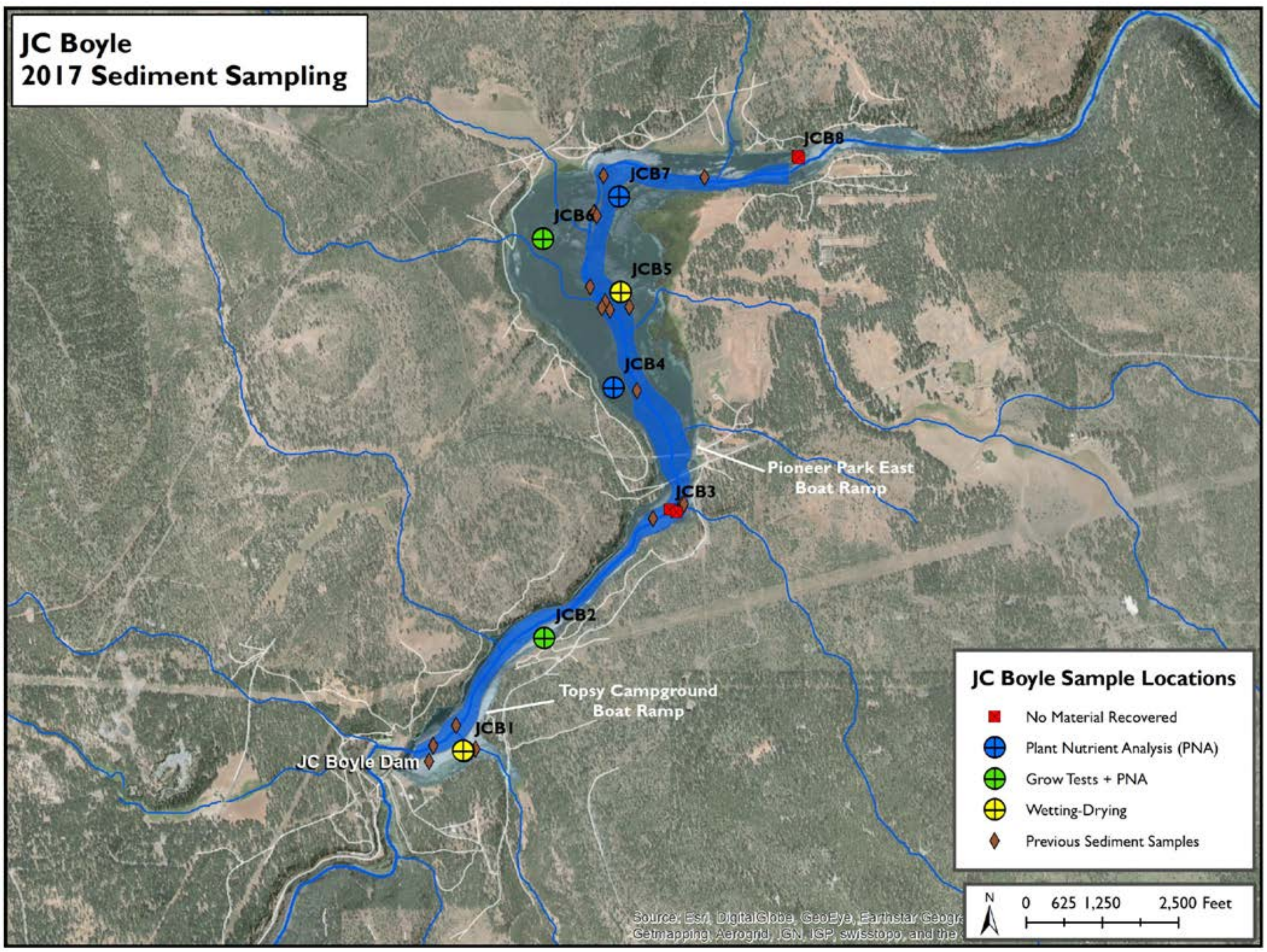


Figure 8-1 Sediment sampling locations at J.C. Boyle for wetting-drying, grow tests, and plant nutrient availability analysis.

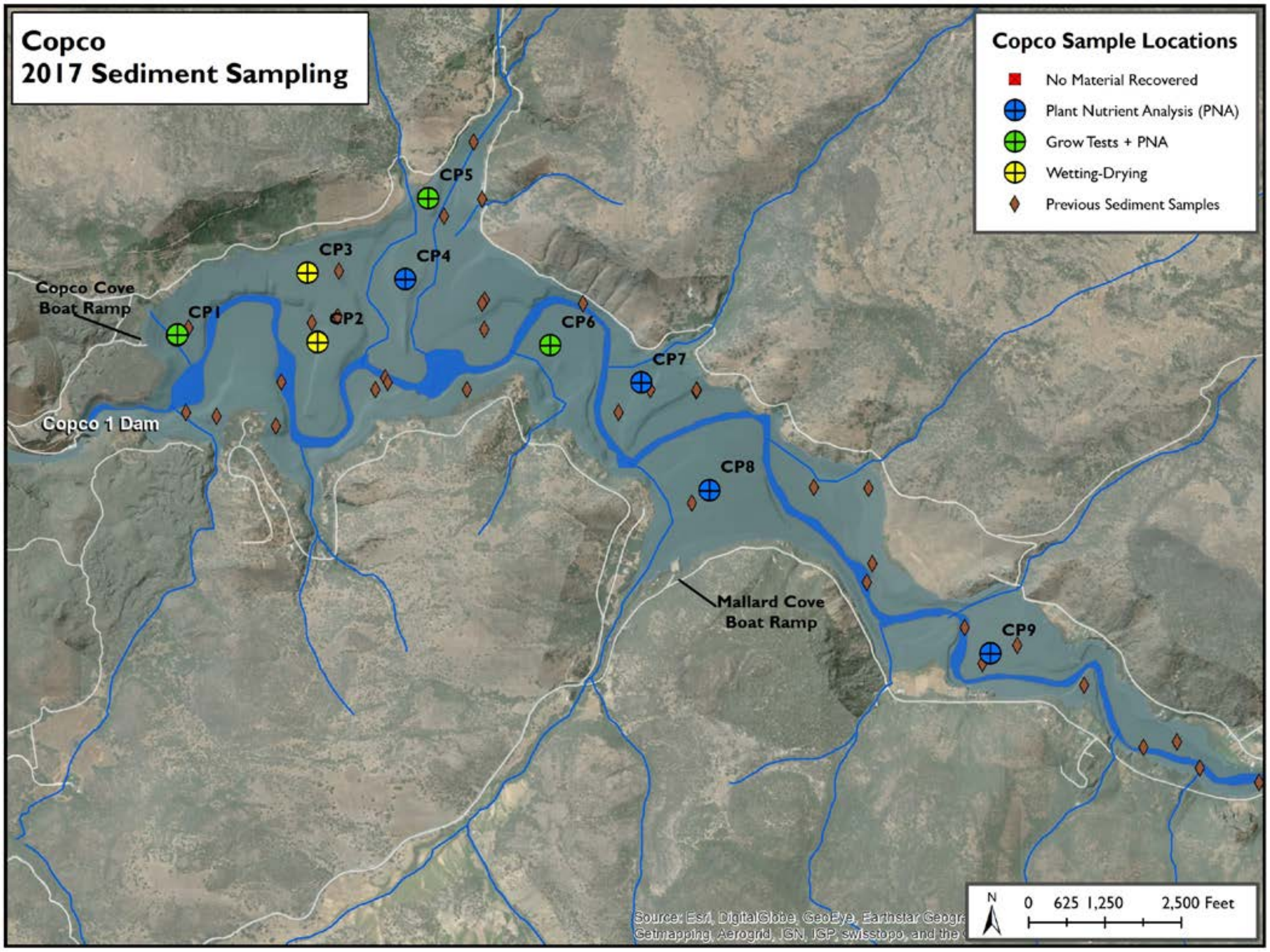


Figure 8-2 Sediment sampling locations at Copco for wetting-drying, grow tests, and plant nutrient availability analysis.

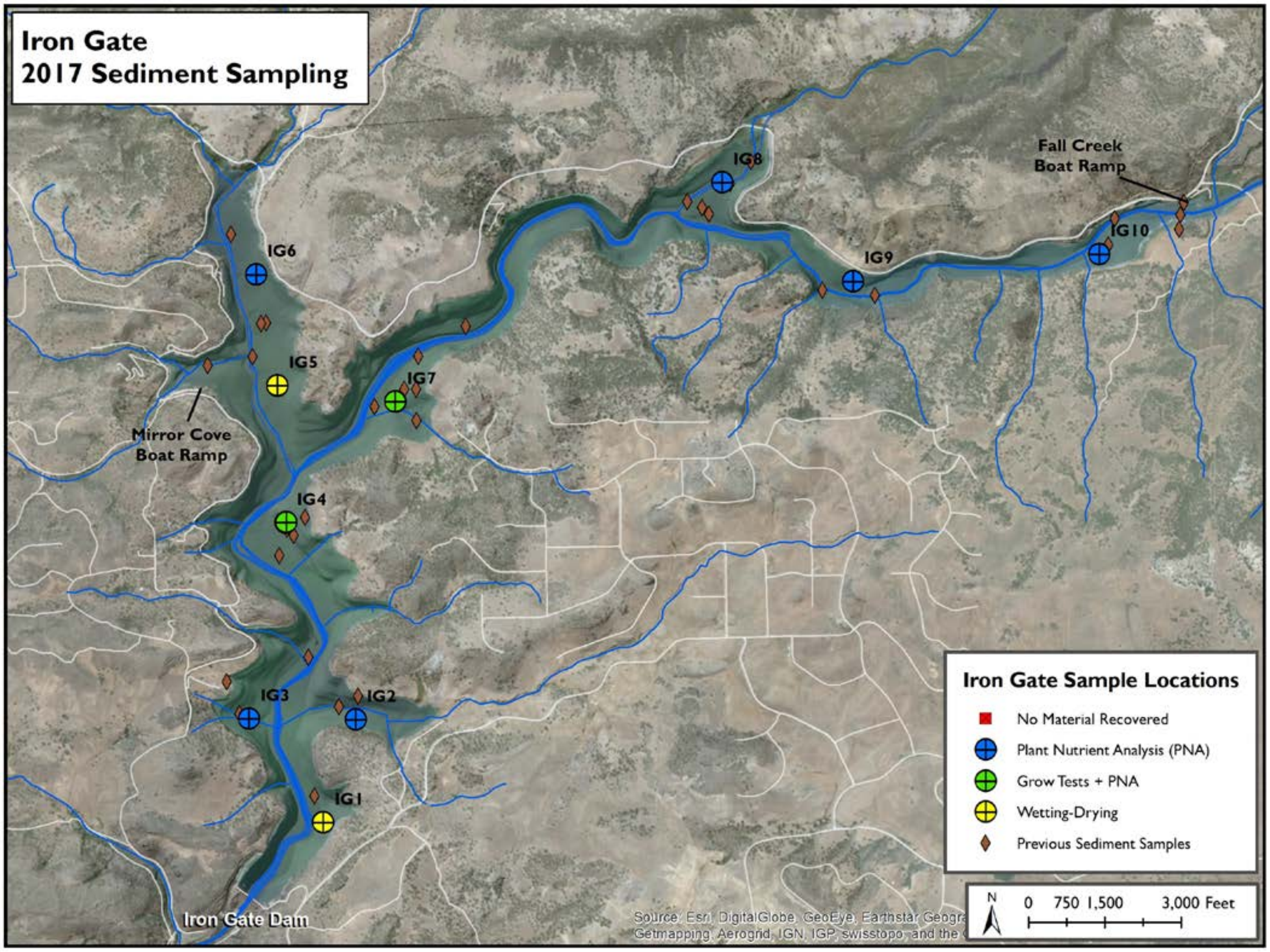
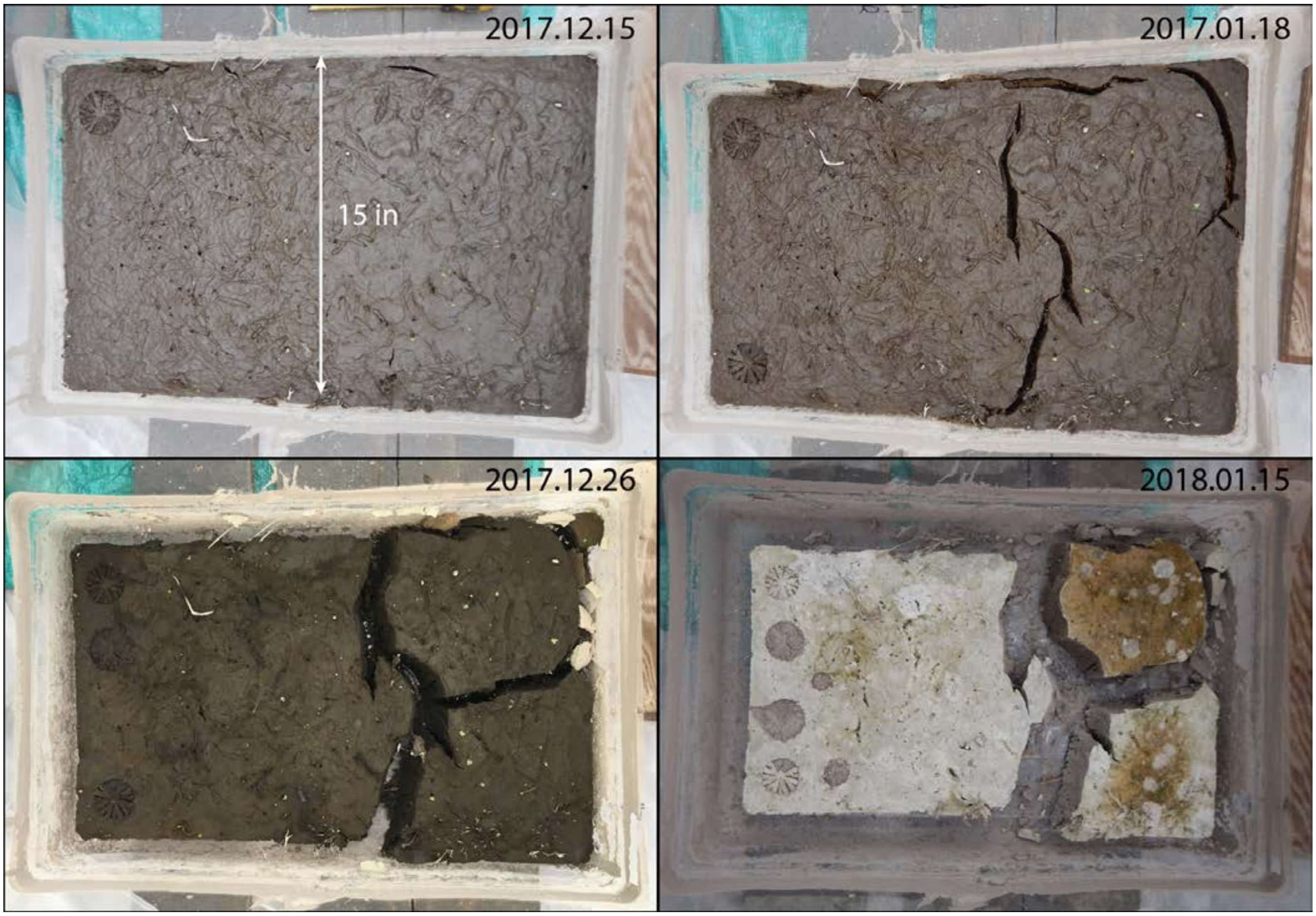
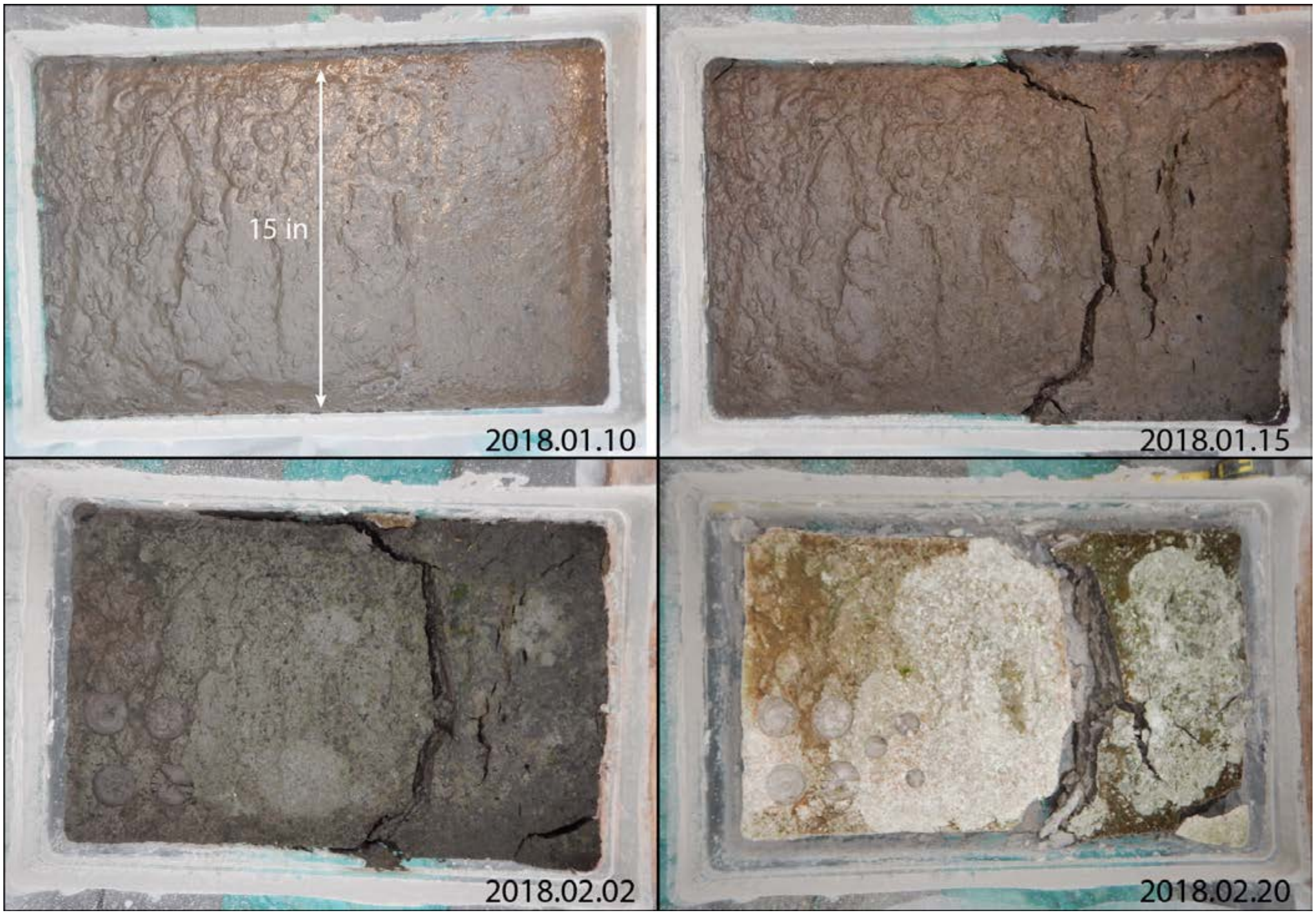


Figure 8-3 Sediment sampling locations at Iron Gate for wetting-drying, grow tests, and plant nutrient availability analysis.



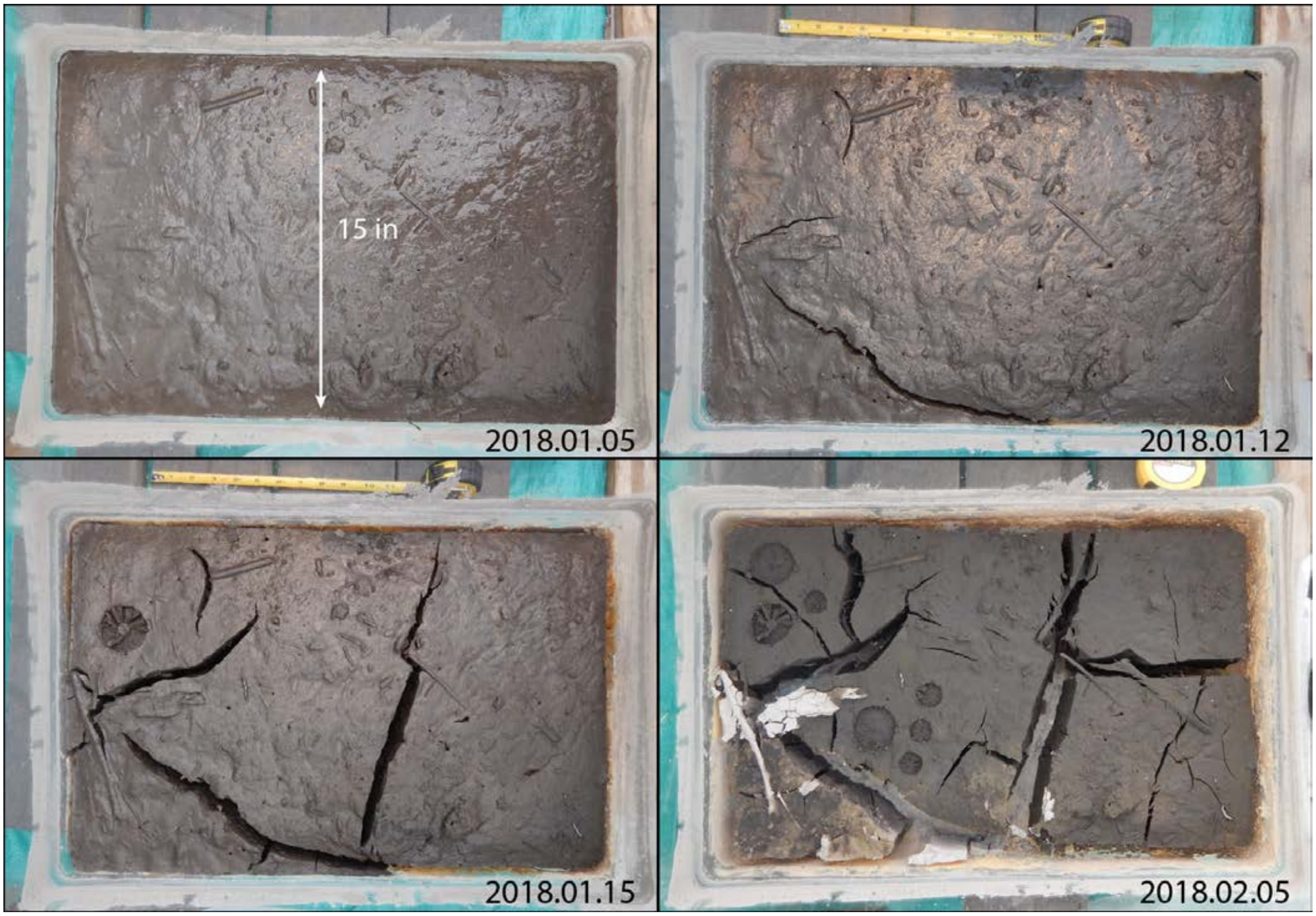
Locations of Torvane measurements are visible on the left side of the deposits.

Figure 8-4 Photos of desiccation and cracking of the J.C. Boyle sediment sample JCB1a.



Locations of Torvane measurements are visible on the left side of the February photos.

Figure 8-5 Photos of desiccation and cracking of the Copco sediment sample CP2a.



Locations of Torvane measurements are visible on the left side of the deposits.

Figure 8-6 Photos of desiccation and cracking of the Iron Gate sediment sample IG1a.

Table 8-2 Summary of physical changes during desiccation for J.C. Boyle samples.

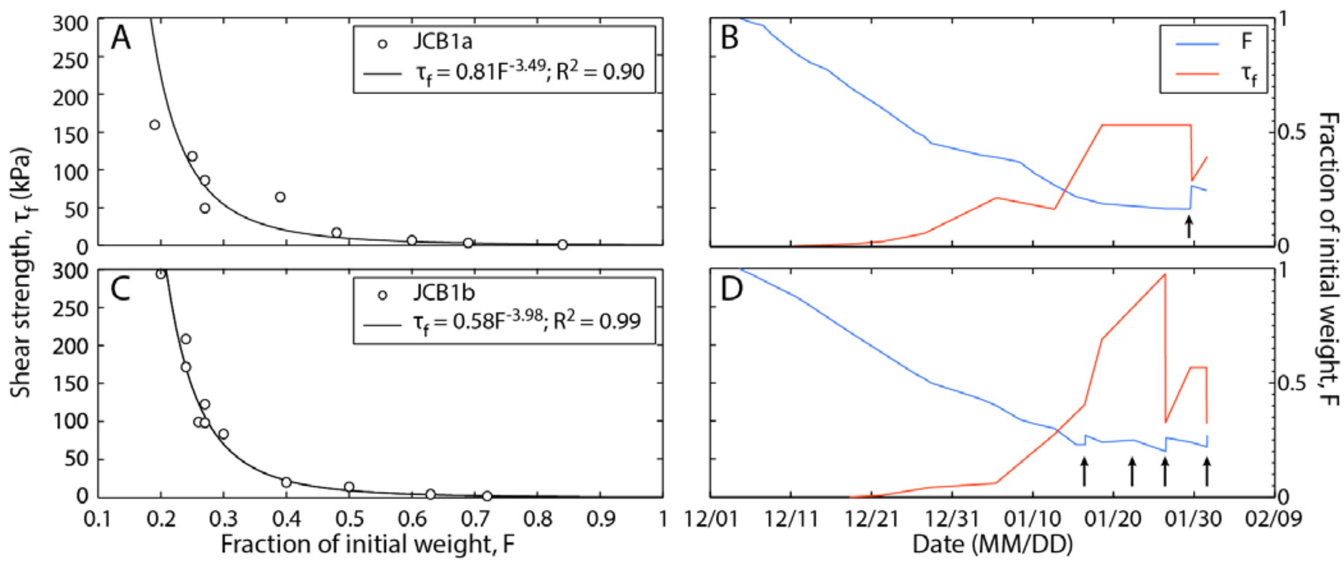
Quantity	JCB1a			JCB1b		
	Moist	Dry	% of Initial	Moist	Dry	% of Initial
Volume (cu. ft)	0.8	0.22	28	0.90	0.22	25
Thickness (in)	3.9	2.0	51	4.0	2.0	50
Weight (lbs)	46	8	17	47	10	21
Max crack width (in)		3			2.25	

Table 8-3 Summary of physical changes during desiccation for Copco samples.

Quantity	CP2a			CP2b		
	Moist	Dry	% of Initial	Moist	Dry	% of Initial
Volume (cu. ft)	0.82	0.32	39	0.82	0.33	40
Thickness (in)	4.1	2.0	49	4.1	2.0	49
Weight (lbs)	51	13	25	51	13	25
Max crack width (in)		2.2			1.3	

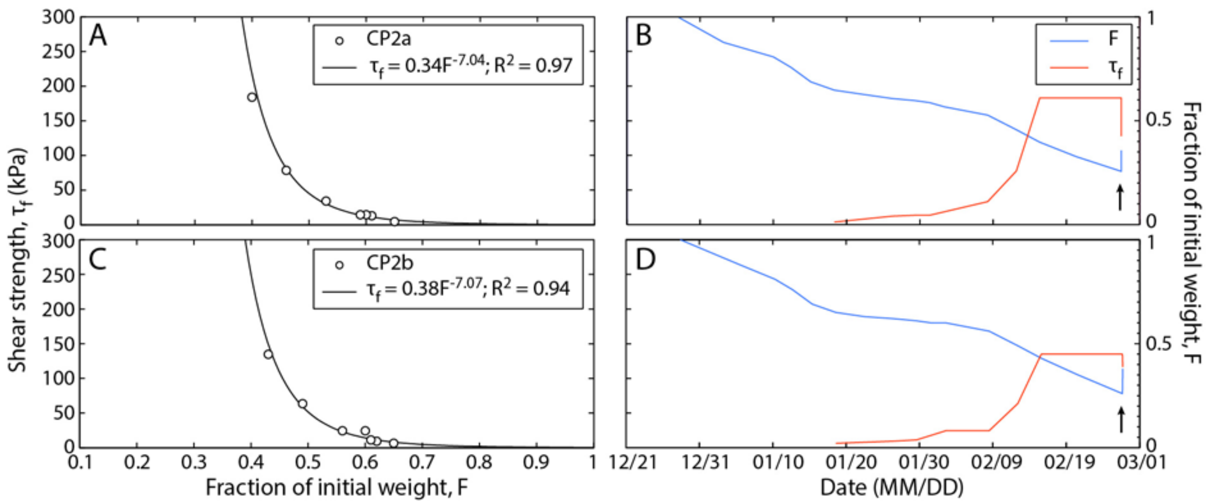
Table 8-4 Summary of physical changes during desiccation for Iron Gate samples.

Quantity	IG1a			IG1b		
	Moist	Dry	% of Initial	Moist	Dry	% of Initial
Volume (cu. ft)	0.95	0.31	33	0.92	0.28	30
Thickness (in)	4.1	2.3	56	3.9	2.0	51
Weight (lbs)	51	15	29	51	13	25
Max crack width (in)		2.0			2.2	



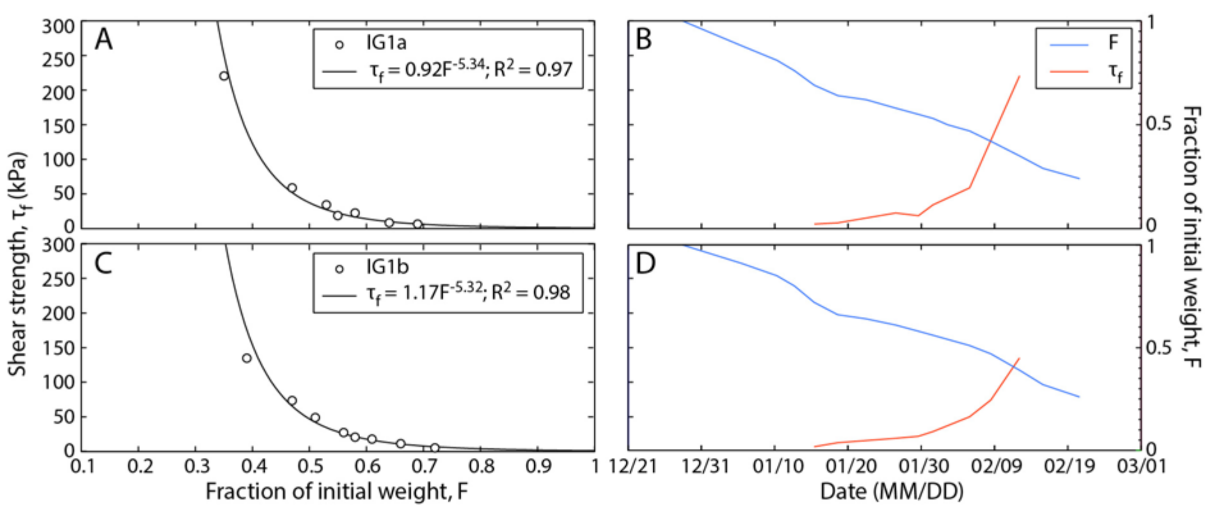
A,C) Shear strength, τf (kPa) vs. fraction of initial weight, F, with power law trendlines. B,D) Changes in τf (red line, left axis) and F (blue line, right axis) vs. time. Vertical arrows mark irrigation events that increased sample weight.

Figure 8-7 Shear strength and drying data for J.C. Boyle samples JCB1a (A,B) and JCB1b (C,D).



A,C) Shear strength, τ_f (kPa) vs. fraction of initial weight, F, with power law trendlines. B,D) Changes in τ_f (red line, left axis) and F (blue line, right axis) vs. time. Vertical arrows mark irrigation events that increased sample weight.

Figure 8-8 Shear strength and drying data for Copco samples CP2a (A,B) and CP2b (C,D).



A,C) Shear strength, τ_f (kPa) vs. fraction of initial weight, F, with power law trendlines. B,D) Changes in τ_f (red line, left axis) and F (blue line, right axis) vs. time.

Figure 8-9 Shear strength and drying data for Iron Gate samples IG1a (A,B) and IG1b (C,D).

Table 8-5 Results from desiccation of J.C. Boyle sediment samples

Quantity	JCB1a		JCB1b	
	Moist	Dry	Moist	Dry
Shear strength (τ_f, kPa)	0.59	159	1.57	294
Critical shear stress (τ_C, Pa; lbf/ft^2)	0.10 (0.002)	434 (9.06)	0.43 (0.009)	1090 (22.8)
Erodibility (k)	1.04	0.04	0.57	0.02

Shows moist and dry measurements of shear strength (τ_f) in kPa and calculated values of critical shear stress (τ_c) in Pa and lbf/ft^2 and the erodibility coefficient (k) from the Simon et al., (2010) relationships. Moist values are likely maximum values as material was too soft to sample with the Torvane at the outset of the experiments. Dry values are maximum values prior to wetting cycles.

Table 8-6 Results from desiccation of Copco sediment samples

Quantity	CP2a		CP2b	
	Moist	Dry	Moist	Dry
Shear strength (τ_f, kPa)	4.90	184	6.28	184
Critical shear stress (τ_C, Pa; lbf/ft^2)	2.34 (0.049)	538 (11.2)	3.39 (0.071)	538 (11.2)
Erodibility (k)	0.29	0.03	0.25	0.03

Shows moist and dry measurements of shear strength (τ_f) in kPa and calculated values of critical shear stress (τ_c) in Pa and lbf/ft^2 and the erodibility coefficient (k) from the Simon et al., (2010) relationships. Moist values are likely maximum values as material was too soft to sample with the Torvane at the outset of the experiments. Dry values are maximum values prior to wetting cycles.

Table 8-7 Results from desiccation of Iron Gate sediment samples

Quantity	IG1a		IG1b	
	Moist	Dry	Moist	Dry
Shear strength (τ_f, kPa)	6.47	221	5.30	135
Critical shear stress (τ_C, Pa; lbf/ft^2)	3.55 (0.074)	707 (14.8)	2.62 (0.055)	338 (7.05)
Erodibility (k)	0.245	0.029	0.276	0.039

Shows moist and dry measurements of shear strength (τ_f) in kPa and calculated values of critical shear stress (τ_c) in Pa and lbf/ft^2 and the erodibility coefficient (k) from the Simon et al., (2010) relationships. Moist values are likely maximum values as material was too soft to sample with the Torvane at the outset of the experiments. Dry values are maximum values prior to wetting cycles.

Table 8-8 Summary results from desiccation of sediment samples

Sample	$\Delta\tau_f$ (kPa)	$\Delta\tau_c$ (Pa)	Max(k)/min(k)
JCB1a	159	434	29.2
JCB1b	294	1089	23.4
CP2a	184	536	9.7
CP2b	135	334	6.3
IG1a	221	704	8.4

Sample	$\Delta\tau_f$ (kPa)	$\Delta\tau_c$ (Pa)	Max(k)/min(k)
IG1b	135	335	7.0

Shows maximum increases in shear strength ($\Delta\tau_f$, kPa) and in critical shear stress ($\Delta\tau_c$, Pa), and proportional decrease in the erodibility coefficient (max(k)/min(k)) from beginning to end of the experiments.

Table 8-9 Cohesive sediment parameter values for 2D morphodynamic modeling of Copco Reservoir drawdown and evolution under three scenarios

Scenario	Critical shear stress (τ_C, Pa)	Erodibility coefficient (k, cm^3/N-s)
Easy-erode	0.2	20.0
Medium-erode	0.25	2.0
Hard-erode	2.0	0.5

Source: USBR (2011b) using data from Simon et al. (2010).

8.1.2 Reservoir Revegetation and Grow Tests

A primary component of this RAMP is revegetation of the former reservoir areas. Successful revegetation is essential for stabilizing reservoir deposits, establishing critical habitat, and restoring natural ecosystem functions. General long-term revegetation patterns will be influenced by local topographic conditions (e.g., aspect, elevation), subsurface hydrology, and sediment texture. 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. 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.

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 short-term resistance to invasion by exotic annual grasses, but long-term resistance 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. 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.

Large areal extents of reservoir sediments are likely to persist after drawdown, and the success of revegetation efforts will be largely determined by the ability to grow plants in the reservoir sediments. Reservoir sediments differ from native soils, so testing has been undertaken to evaluate revegetation options.

Results of Previous Testing

A seedbank study of reservoir sediments was conducted in 2010 (USBR, 2011c) to evaluate the natural availability of viable seed material in the reservoir deposits. Samples from each reservoir were placed in greenhouse with 12 hours of supplemental daylight, temperatures between 70 and 95 deg. F, and irrigated with 0.1 inches daily from a sprinkler system (USBR, 2011c). The seedbank germination study found that most of the extant seeds that successfully germinated were native wetland-type species, and the highest germination densities were from sediment proximal to existing wetlands along reservoir perimeters (USBR, 2011c). Wetland seeds are better adapted to the anoxic conditions in the reservoir substrate than species from other ecogeomorphic areas or "planting zones" (i.e., upland, riparian bank, riparian floodplain). Some existing perimeter wetlands are expected to vanish with the changing hydrologic conditions (e.g., lowering water table) post-drawdown. These results suggest that some natural wetland succession is possible post-drawdown at springs and tributaries historically or currently associated with wetlands, but upland and riparian vegetation will need to be actively revegetated.

Grow Test Experimental Methodology

Revegetation "grow tests" and plant nutrient availability (PNA) lab analyses were undertaken in Winter 2018 to evaluate reservoir sediments as a growth medium and to identify the ideal seed mix for a cover crop and for each planting zone in each unique reservoir setting. Surface grab samples (2 ft^3 per location) of reservoir sediments were collected in the same field effort as the sediments for the wetting drying experiments. In a greenhouse environment, fully saturated reservoir sediment was distributed into four (one for each planting zone) freely draining 10 inch by 10 inch sample containers to a depth of approximately 6 to 7 inches (Figure 8-11Figure 8-10). Seeds were placed on the surface of the moist sediments in a 6 x 6 grid (36 seed locations per container, multiple seeds per location depending on seed species) and supplemented with mycorrhizal inoculant. The species lists for each planting zone is presented in Table 8-6. For the first two weeks, the sediment surface was moisturized daily with a spray bottle, and greenhouse conditions were maintained at approximately 55 deg. F and 55% relative humidity. After two weeks, a greater (0.1 to 0.25 inch) but less frequent (twice per week) irrigation amount was applied to the plants with a sprinkler system, and a greater temperate range mimicking natural diurnal cycles (55 to 70 deg. F) was imposed. After several weeks, temperatures were increased to over 100 deg. F with the same irrigation schedule. Control over environmental conditions was limited in the greenhouse, and the ability to simulate, for example, realistic freezing temperatures and low intensity rainfall was not possible.

Each bin corresponds to a planting zone (clockwise from top left): riparian bank, riparian floodplain, cover, upland. The experimental set up was identical for each of the three grow test reservoir samples.

Figure 8-10 Grow test sample layout for J.C. Boyle sample JCB6 immediately after seed placement (left) and after six weeks (right).

Grow tests were also performed on the fully desiccated sediment from the concluded wetting and drying experiments to evaluate the effectiveness of secondary revegetation in the fall. Attempts were made to till one of the sediment samples by hand using a 1/8 inch screw. The high strength and brittleness made tilling the deposit without fracturing the deposit all the way through a challenge. Instead, the footprints of the Torvane tests (n >= 7 per sample) were considered representative of “tilled” sediment. Samples were irrigated for 5 minutes, and 0.2 to 0.4 ounces of each seed mixture were distributed loosely across each sediment surface. Imbedding seeds was not an experimental option given the high strength of the dried sediment. JCB1a, JCB1b, and IG1a were seeded with the Upland seed mixture, IG1b and CP2a were seeded with the Riparian Floodplain seed mixture, and CP2b was seeded with the Riparian Bank seed mixture. Samples were irrigated daily with approximately 0.4 to 0.5 inches of rainfall with an average intensity of 1.3 to 1.5 inches per hour. This rainfall represents an approximately 10-year event based on climate data from the Copco #1 Dam weather station (Western Regional Climate Center). After 2 weeks, irrigation was applied for 20 to 30 minutes twice per week at a rate of 2.5 inches per hour. After 8 weeks, temperatures in the greenhouse were increased, with daily maximums over 100 degrees, to mimic summer conditions. The irrigation regime was kept constant.

The suitability of the reservoir sediments as a growth medium was also assessed with a plant nutrient availability (PNA) analysis. Physical and chemical characteristics of the reservoir sediment samples were tested by a soils lab to identify any chemical deficiencies or excesses that could inhibit plant growth. Four to six cups of material were extracted from several locations in each surface grab sample and composited into a single sample for the analysis. A first round of samples (JCB4, JCB7, CP4, CP7, CP8, CP9, IG2, IG3, IG6, IG8, IG9) were composited and packaged in Ziploc bags on the research vessel and sent to the lab in December. A second round (JCB2, JCB6, CP1, CP5, CP6, IG4, IG7) was packaged and analyzed in January from sediments that had been stored for several weeks in the sealed polycarbonate sample bins in a storage unit.

Results of Grow Tests

Results from the grow tests demonstrate the ability of the reservoir sediments to support plant growth for species from each planting zone. Successful germination and plant growth occurred in 76%, 71%, 80%, and 81% of the seed locations for riparian bank, riparian floodplain, upland, and cover seed mixtures, respectively. Results (e.g., Table 8-10) allowed for identification of species that were unsuccessful in growing in the reservoir sediments. In general, clustered field sedge, creeping wildrye, chick lupine, western needlegrass, and silverleaf scorpionweed has low growth success.

Most of the seeds germinated in a period of one to two weeks. After four weeks, species growth was healthy, and species mortality was undetectable. The volume of each deposit decreased with time even with the irrigation. Initial deposit surface dimensions were approximately 10 by 10 inches with a thickness of 6 inches. After six weeks, the samples had pulled back from the sides of the container resulting in 7- by 7-inch surface dimensions, and the thickness decreased to 3 inches. Plant growth was initially unaffected by the change in deposit volume. Cracks did not development in the interior of the deposit surfaces and was at most minor along the deposit edges. Presumably the material strength increased considerably with decreases in deposit volume given the patterns observed during wetting-drying experiments. Despite changes in volume and material strength, root development was extensive and visible in the sides of the deposits, in some cases extending through the full deposit thickness. There were no systematic differences in plant growth for the different planting zones or the reservoirs. After eight weeks of plant growth, some of the sample sediments dried out, and the densely packed plants began to die. The porosity and available pore water were expected to steadily drop with desiccation, and the water demand of the growing plants was expected to increase. The irrigation rate was not increased to accommodate the decreasing soil water supply and increased demand. The initial seed density at the start of the experiments was higher than expected in the field, and that density increased as the deposit contracted. Complete mortality occurred in several weeks after temperatures were increased to over 100 deg. F without an increase in irrigation frequency or intensity. A subsequent reduction in temperature to 80 deg. F and reseeding was unsuccessful on these samples.

On the seeded wetting-drying samples, germination and growth were most successful on the fresh sediment surfaces found in narrow cracks and in the footprints of the Torvane tests (Figure 8-11). Germination was less successful for seeds on the majority of the undisturbed sediment surfaces, which had a film of fungus, not introduced experimentally, that caused the discolorations visible in the photos of the dried samples (Figure 8-4 and Figure 8-5). Some germination did occur on the undisturbed surfaces, but it took an extra week or two relative to the disturbed and fresh sediment surfaces. Plant growth was healthy on all samples until the daily maximum temperatures were allowed to increase to over 100 degrees, at which point there was some plant mortality, particularly in the IG1 samples, which had the highest clay content and appeared to desiccate more rapidly between irrigation events.

Plant growth is visible in cracks and the round Torvane scars.

Figure 8-11 Grow test on wetting-drying sample JCB1b taken two weeks after seeding with the upland seed mixture.

The PNA test results were similar amongst samples from the three reservoirs. In general, the samples are moderately acidic, fine-textured, low in calcium, and high in magnesium and organic matter. The average pH of the samples ranged from 6.2 to 6.5, which is slightly more acidic than the optimum range of 6.5 to 7.5. The sediments have been submerged in an anaerobic environment, so they contain high levels of iron, manganese, and vanadium due to microbial respiration (Wallace, 2017).

However, there were some systematic variations in metal concentrations between samples from the first (December 2017) and second (January 2018) rounds of lab analyses. The 2018 sample concentrations were greater than 2017 concentrations by a factor of 2 to 10 depending on the metal. Plant extractable concentrations of most of the analyzed elements (e.g., phosphorus, potassium, iron, manganese, zinc, copper, magnesium, sodium, sulfur, arsenic, barium, cobalt, lead, nickel, and vanadium) depend strongly on the degree of aeration of the sediment, whereby higher concentrations are associated with lower degrees of aeration. This suggests that the 2017, which were stored in Ziploc bags for a period of 2 weeks were more aerated than the samples stored in the storage unit for a period of 5 weeks. This is perhaps because standing water was present in the storage unit samples, so the degree of aeration was lower than those sediments mixed and bagged on the research vessel.

Implications of Grow Test Results for Reservoir Revegetation

The grow test results suggest that the reservoir sediments are a suitable medium for plant growth and that soil supplements, while potentially helpful, are not needed. The majority of the species in each planting zone mixture were successfully able to germinate and grow. The development of root systems will increase infiltration rates in uncracked sediment, stabilize disintegrated sediments, and accelerate soil development.

Planting and growing conditions in the greenhouse were an idealized representation of some of the factors affecting plant growth in the field. Minimum temperatures in the greenhouse were near 50 deg. F and cannot mimic the cold and below-freezing temperatures possible at the reservoirs during the drawdown when many of the seeds will be planted. Colder conditions in the field, particularly at J.C. Boyle, are harsh on young plants, and germination rates will potentially be lower. Summers around the reservoirs are hot and dry. At the Copco #1 Dam weather station, average maximum monthly temperatures exceed 89 deg. F and average total monthly precipitation less than 0.6 inches for July, August, and September (Figure 3-10). In similar simulated conditions in the greenhouse, plant growth in the wetting-drying samples, which received greater irrigation, was successful, whereas the grow test samples, which received less irrigation were not. Furthermore, the drastic changes in the sediment when desiccated (e.g., increase in sediment shear strength, reduction in porosity, reduction in concentrations of certain essential plant extractable elements) will be concurrent with high temperatures and dry conditions. The twice-per-week lower intensity irrigation failed to resaturate the grow test samples once they had been fully desiccated desiccated, and reseeded plant growth was unsuccessful, even with temperatures reduced to 80 deg. F. These environmental conditions and their effect on the reservoir sediments will severely limit the survival of plants established in the reservoir sediments in the spring after drawdown.

Revegetation will resume with cooler conditions and return of rainfall in the fall. The decrease in sediment strength observed after wetting should help with seed germination but to what degree is unknown. Root development during the spring may improve infiltration rates in the unfractured sediments, relative to the wetting-drying experimental samples, and help initiate soil development and increase soil moisture in the shallow subsurface. Plant growth was possible in the wetting-drying grow tests, but rainfall amounts were similar to 10-year events for that time duration and were applied daily. As such, they represent considerably more water than expected from natural precipitation. However, most the rainfall was lost as run-off, so infiltration is perhaps more similar to lower intensity, longer duration events that may occur in fall. Where feasible, irrigation will be a beneficial supplement to natural precipitation.

The wetting-drying grow test results suggest that fresh and disrupted (e.g., tilled) surfaces are more favorable for plant germination and growth. The initial sediment surface morphology of both types of grow tests was more uniform than expected in the reservoirs, where sediments will have experienced some degree of slumping and erosion. Microtopography may be more prone to desiccation between rainfall events than smooth surfaces, but the grow tests results suggest that microtopography on the reservoir sediment surfaces may create small depressions and surface roughness that can catch seeds and increase the soil surface area to which the seeds are exposed. Germination may be more successful as a result. Crack density and microtopography as a result of slumping should be sufficient in the post-reservoir surface to not require tilling of the sediment surface.

Subsurface conditions and hydrology will be more favorable for plant growth in the field than in the experimental set up. The thickness of the experimental sediment deposits varied from 2 to 3 inches in the dried wetting-drying samples and 3 to 7 inches in the dry and moist grow test samples, respectively. Roots for the planted species are capable of penetrating deeper than the sample thicknesses to access moisture that is not present in near-surface sediments during dry periods. The degree to which this effect will compensate for certain more idealized environmental conditions in the greenhouse is unknown.

The PNA analysis did not reveal any major chemical deficiencies or excesses that would inhibit germination and plant growth in the reservoir sediments. The high iron, manganese, and vanadium concentrations are more suitable for aquatic, rather than upland, species growth. Plant-available arsenic concentrations at J.C. Boyle are comparable to the arsenic limits for herbaceous and woody plants but should not impact grassy species and other arsenic-tolerant plants. Plant extractable chemical concentrations, as opposed to total concentrations, of these metals are expected to decrease following drawdown with exposure to the atmosphere. The desiccated reservoir sediments will have lower concentrations of these potentially problematic elements than the fresh reservoir sediments, but germination will be more difficult in the dried sediments, which will be considerably firmer and have less available pore water. Therefore, seeding moist, rather than dried, sediment should have greater success, with the caveat that growth will be sensitive to colder air temperatures. The grow test results support this approach and suggest that the high metal concentrations do not have a noticeable impact on plant growth.

Grow Test Data and Figures

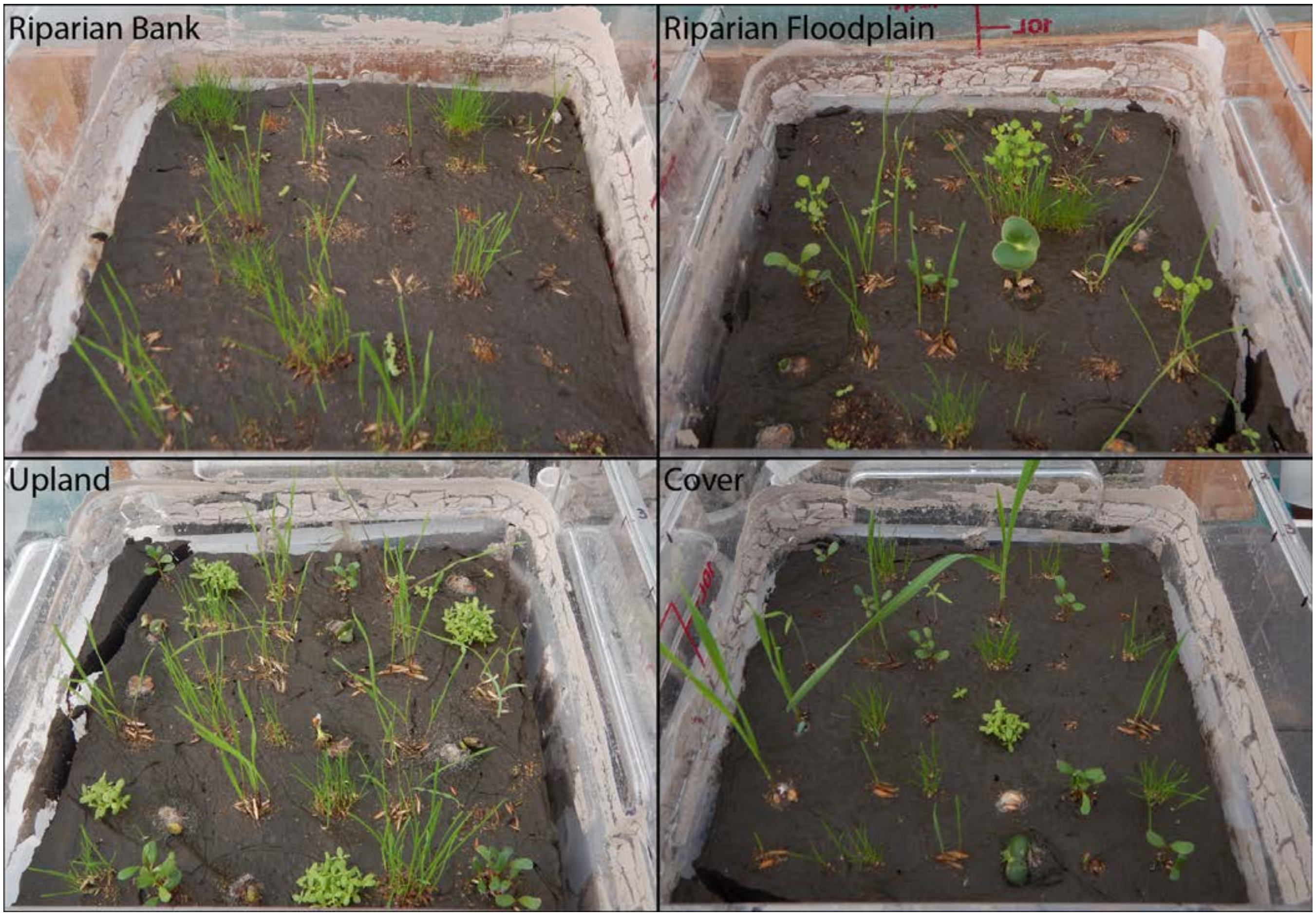
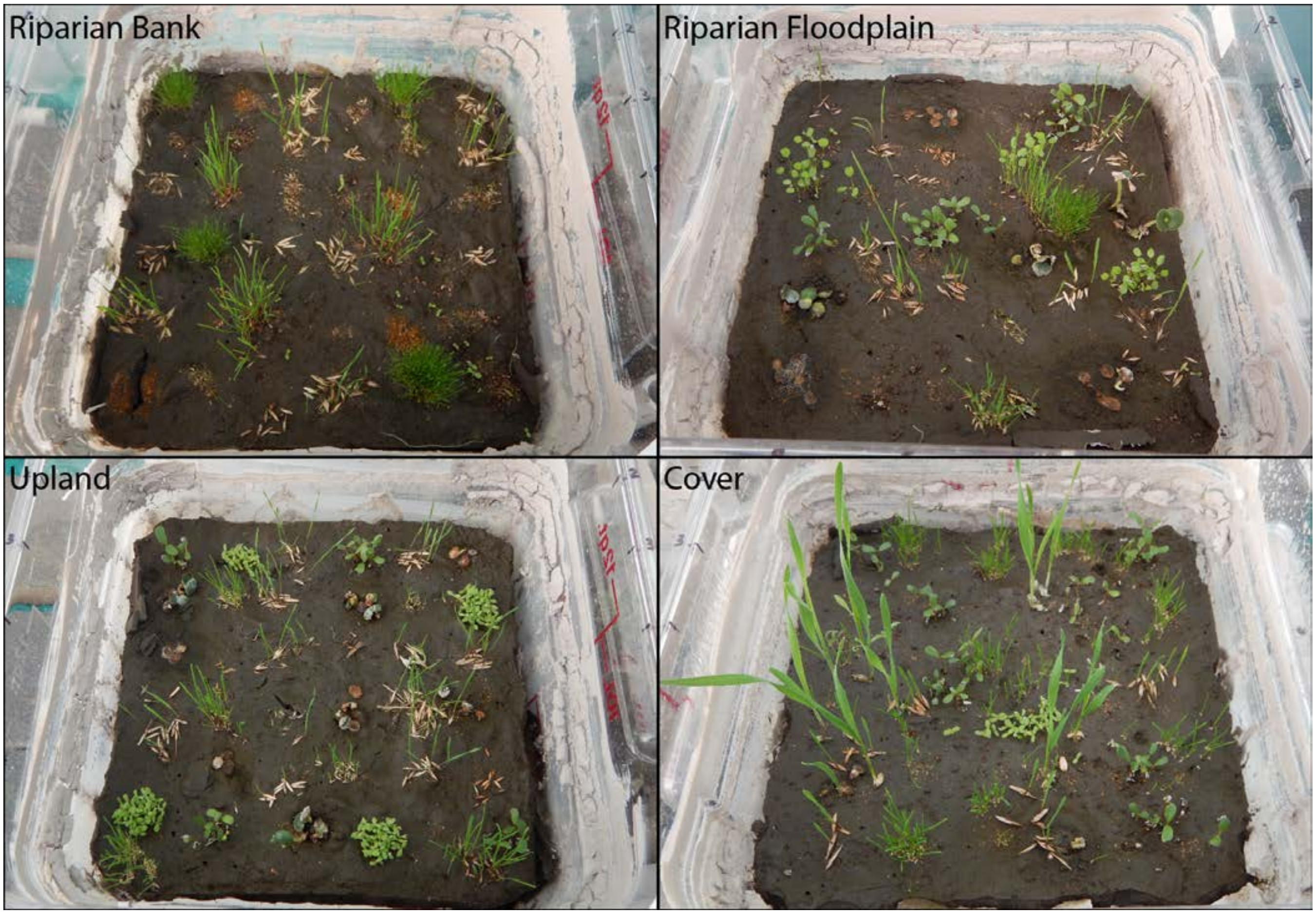
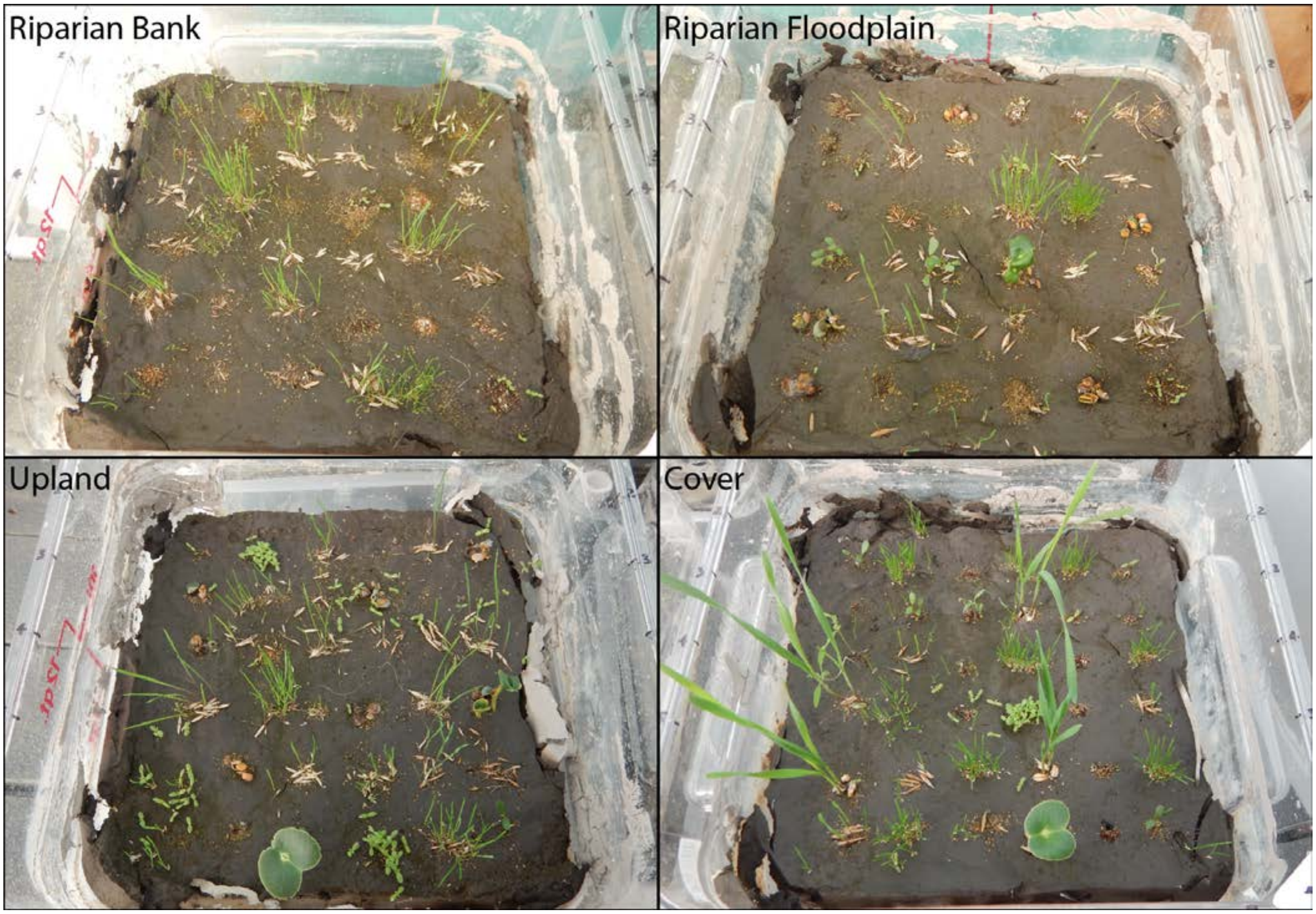


Figure 8-12 Photos of grow tests for J.C. Boyle sediment sample JCB6 taken three weeks after seed placement.



Species in the seed mixtures correspond to post-removal vegetation zones (riparian bank, riparian floodplain, and upland) and a cover crop mixture. Inside length of sample containers is approximately 10 inches.

Figure 8-13 Photos of grow tests for Copco sediment sample CP6 taken three weeks after seed placement.



Species in the seed mixtures correspond to post-removal vegetation zones (riparian bank, riparian floodplain, and upland) and a cover crop mixture. Inside length of sample containers is approximately 10 inches.

Figure 8-14 Photos of grow tests for Iron Gate sediment sample IG4 taken three weeks after seed placement.

Table 8-10 Species list and grow test results for each planting zone.

Species	Seed locations per sample	Plant count - J.C. Boyle JCB6	Plant count - Copco CP6	Plant count - Iron Gate IG4	Average number of plants per location
Riparian Bank					
Agrostis exarata	4	130	150	80	30
Carex praegracilis	4	0	0	21	2
Deschampsia danthonioides	4	7	24	23	5
Elymus [Leymus] triticoides	4	2	0	3	0

Species	Seed locations per sample	Plant count - J.C. Boyle JCB6	Plant count - Copco CP6	Plant count - Iron Gate IG4	Average number of plants per location
Hordeum brachyantherum ssp. *brachyantherum*	4	16	38	23	6
Juncus bufonius	4	30	15	26	6
Artemisia douglasiana	4	17	18	24	5
Festuca [Vulpia] microstachys	3	28	35	32	11
Deschampsia caespitosa	4	29	37	15	7
Elymus glaucus	1	3	3	2	3
Riparian Floodplain					
Leymus triticoides	4	7	3	0	1
Artemisia douglasiana	4	25	12	32	6
Trifolium willdenovii	3	17	30	3	6
Acmispon americanus [Lotus purshianus]	3	14	21	10	5
Lupinus microcarpus var. *densiflorus*	3	1	2	6	1
Lupinus microcarpus var. *microcarpus*	3	0	0	2	0
Stipa [Achnatherum] occidentalis var. *occidentalis*	4	6	0	0	1
Elymus [Pseudoroegneria] spicatus	1	5	3	5	4
Elymus glaucus	2	8	10	8	4
Hordeum brachyantherum sspp. *Brach*	1	5	6	6	6
Bromus carinatus	1	3	5	3	4
Poa secunda	1	15	15	6	12
Festuca [Vulpia] microstachys	1	20	15	15	17
Koeleria macrantha	1	10	8	5	8
Leymus cinereus	1	3	3	6	4
Agrostis exarata	1	20	35	40	32
Elymus elymoides	1	4	5	3	4
Hordeum brachyantherum ssp. *californicum*	1	5	3	6	5
Upland					
Acmispon americanus [Lotus purshianus]	4	23	22	4	4
Lupinus microcarpus var. *densiflorus*	4	2	3	6	1
Lupinus microcarpus var. *microcarpus*	4	1	0	7	1
Elymus [Pseudoroegneria] spicatus	4	21	25	25	6
Achillea millefolium var. *lanulosa*	4	50	85	60	16
Poa secunda	3	45	60	29	15
Stipa [Achnatherum] occidentalis var. *occidentalis*	3	0	1	2	0
Festuca [Vulpia] microstachys	2	18	30	20	11

Species	Seed locations per sample	Plant count - J.C. Boyle JCB6	Plant count - Copco CP6	Plant count - Iron Gate IG4	Average number of plants per location
Elymus elymoides	2	12	11	11	6
Hordeum brachyantherum ssp. *californicum*	2	10	18	9	6
Koeleria macrantha	2	16	11	4	5
Elymus glaucus	1	5	3	5	4
Bromus carinatus	1	4	3	0	2
Cover					
Acmispon americanus	7	21	41	11	3
Phacelia hastata	5	0	1	5	0
Phacelia tanacetifolia	4	3	6	7	1
Triticale sterile	2	2	7	4	2
Elymus x Triticum	2	1	5	5	2
Bromus carinatus	5	10	16	21	3
Deschampsia elongata	8	75	145	140	15
Achillea millefolium	1	10	20	25	18
Lupinus microcarpus var. *densiflorus*	1	1	0	1	1

Notes: Data were collected three weeks after seed placement. The seed locations per sample are out of a potential 36 locations available in each sample bin.

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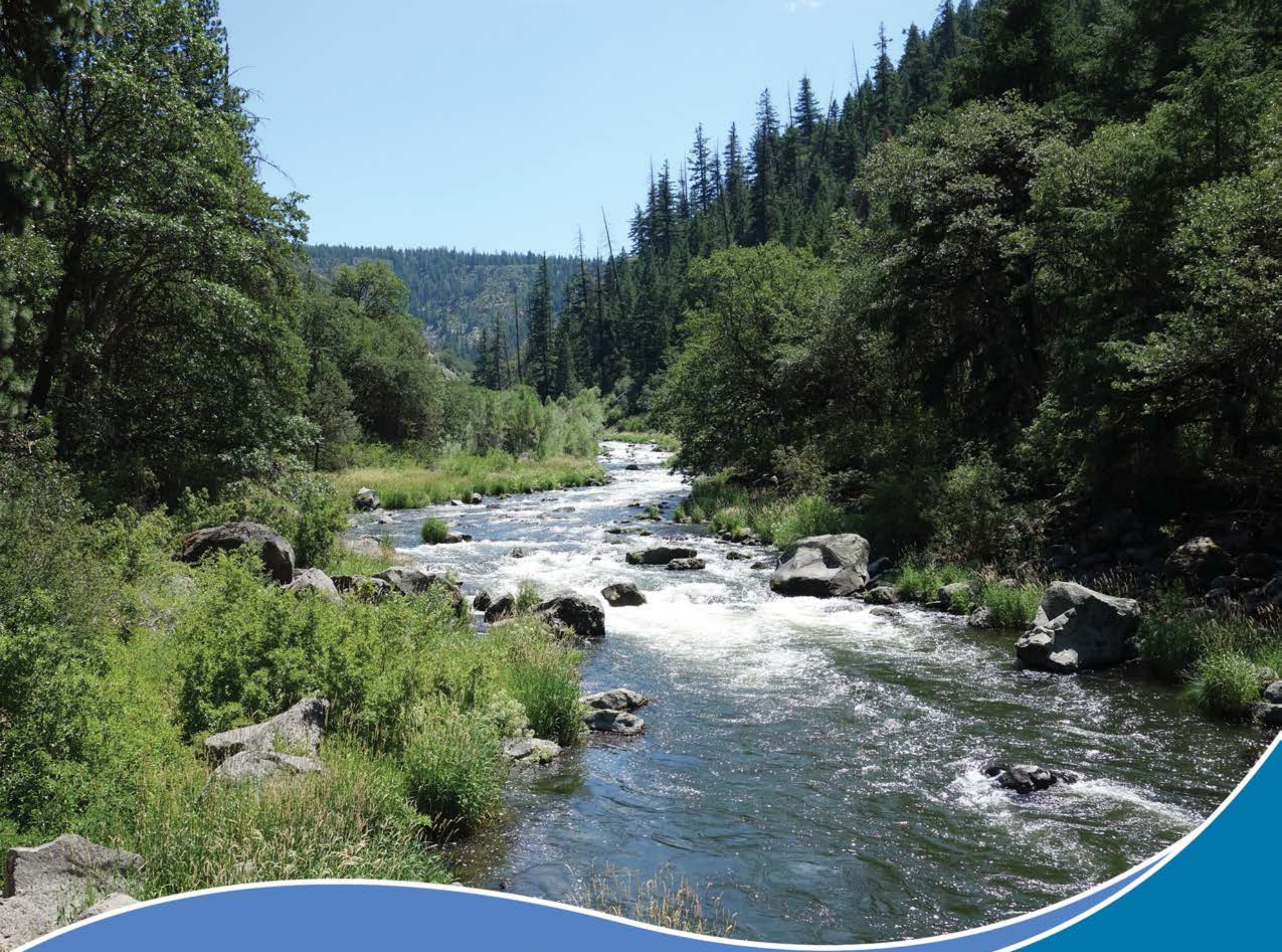

Definite Plan for the Lower Klamath Project

Appendix I - Aquatic Resources Measures

KLAMATH RIVER RENEWAL CORPORATION

June 2018

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Acronyms

AR	aquatic resource
ATWG	Aquatic Technical Work Group
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
DPS	distinct population segment
EIS/R	Environmental Impact Statement/ Environmental Impact Report
ESU	evolutionary significant unit
km	kilometers
KRRC	Klamath River Renewal Corporation
mi	miles
NMFS	National Oceanic and Atmospheric Administration
ODFW	Oregon Department of Fish and Wildlife
PIT	passive integrated transponder
Rkm	river kilometer
RM	river mile
SONCC	Southern Oregon/Northern California Coastal
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service ,
USGS	U.S. Geological Survey
yd^2	square yards

Executive Summary

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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 Environmental Impact Statement/ Environmental Impact Report (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 removal of four dams on the Lower Klamath River (Project). The three key periods of time during the reservoir drawdown year include: (1) reservoir drawdown completed by the end of March, (2) volitional fish passage by October 1, and (3) free-flowing river conditions at all four facilities by December 31. While these time periods are referenced throughout Appendix I, the term “the Project” refers to these three time periods and is used more generally in the document to describe the Project and Project effects.

The proposed AR measures are adapted from the AR measures included in the 2012 EIS/R. The AR measures are now proposed as part of the Project include:

Mainstem Spawning

KRRC will develop and implement a monitoring and adaptive management plan 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 [river mile (RM) 193.1] to the upstream extent of J.C. Boyle Reservoir [RM 234.1]) and in the Iron Gate Dam to Cottonwood Creek (RM 185.1) reach will be monitored by KRRC for 2 years following the start of reservoir drawdown to ensure fish passage between tributaries and the Klamath River. KRRC-led monitoring of the four tributary confluences in the Hydroelectric Reach will occur from April 1 in the year of reservoir drawdown through March 31 in the year that is two years post-drawdown. KRRC-led monitoring of the five tributary confluences in the 8-mile reach from Iron Gate Dam to Cottonwood Creek will occur from January 1 of the year of reservoir drawdown, through December 31 in the year following the drawdown year. Tributary confluences in both reaches will be monitored by KRRC at variable frequencies depending on the season and the drawdown year (see Section 3.1.1). Monitoring will also be triggered in response to a 5-year or greater flow event on the Klamath River at the USGS Klamath River Below Iron Gate Dam CA gage (#11516530). KRRC and the ATWG will also convene periodically during the 2-year monitoring period to review monitoring frequency to ensure volitional passage is maintained between the Klamath River and select tributaries. If present, confluence obstructions will be actively removed by KRRC during the 2-year monitoring period to ensure volitional passage for adult Chinook salmon, coho salmon, steelhead, and Pacific lamprey.

KRRC will complete a spawning habitat evaluation on the Klamath River and four tributaries in the Hydroelectric Reach. If spawning habitat post-reservoir drawdown does not meet target metrics, KRRC will convene with ATWG to determine appropriate spawning gravel augmentation locations and methods on the mainstem Klamath River in the Hydroelectric Reach. If tributary spawning gravel habitat is less than the target values following reservoir drawdown, KRRC and the ATWG will convene to prioritize additional habitat restoration actions (e.g., gravel augmentation, gravel retention treatments) that KRRC will undertake to increase the amount of tributary habitat available to compensate for the loss of steelhead redds.

Outmigrating Juveniles

KRRC has planned three actions to offset reservoir drawdown effects on outmigrating juvenile anadromous salmonids and Pacific lamprey. First, KRRC will complete a sampling, salvage, and relocation effort to relocate juvenile salmonids, particularly yearling coho salmon, from the Klamath River between Iron Gate Dam and the Trinity River confluence during the late-fall or winter prior to reservoir drawdown.

Secondly, KRRC will develop an adaptive management plan to assess and restore tributary-mainstem connectivity in the Hydroelectric Reach and the 8-mile reach from Iron Gate Dam downstream to Cottonwood Creek (same task as described above in Mainstem Spawning). KRRC monitoring of the of the four tributary confluences in the Hydroelectric Reach will occur from April 1 in the year of reservoir drawdown through March 31 in the year that is two years post-drawdown. KRRC monitoring of the five tributary confluences in the 8-mile reach from Iron Gate Dam to Cottonwood Creek will occur from January 1 of the year of reservoir drawdown, through December 31 in the year following the drawdown year. KRRC will monitor tributary confluences in both reaches at variable frequencies depending on the season and the drawdown year (see Section 4.1.2). Monitoring will also be triggered in response to a 5-year or greater flow event on the Klamath River at the USGS Klamath River Below Iron Gate Dam CA gage (#11516530). KRRC and the ATWG will also convene periodically during the 2-year monitoring period to review monitoring frequency to ensure volitional passage is maintained between the Klamath River and select tributaries. If present, KRRC will actively remove confluence obstructions during the 2-year evaluation period to ensure volitional passage for juvenile Chinook salmon, coho salmon, steelhead, and Pacific lamprey.

The third component of the outmigrating juveniles measure will include KRRC monitoring water quality conditions at 13 key tributary confluences downstream from Iron Gate Dam. KRRC and the ATWG will coordinate on a weekly basis from January through June in the year of reservoir drawdown and will convene during that time period if tributary water temperatures reach 17°C (7-day average of the daily maximum values) and Klamath River suspended sediment concentration exceeds 1,000 mg/L, or if observed behaviors of juvenile salmonids inhabiting tributary confluences necessitate salvage. If the tributary water temperature trigger of 19°C (7-day average of the daily maximum values) and Klamath River suspended sediment concentration trigger of 1,000 mg/L (7-day sustained daily maximum) are met, or if juvenile salmonids inhabiting tributary confluences exhibit stressed behavior, a salvage effort will be completed. Based on ATWG guidance, KRRC may conduct a multi-day salvage effort for juvenile fish at the Shasta and Scott rivers and single day salvage efforts at each other tributary confluence area by a 4-person crew and 2 transport trucks. The KRRC salvage effort will be coordinated with the ATWG and will reflect water quality conditions in the tributary confluences, outmigrating juvenile salmonid numbers and observed behavior, and other environmental conditions (e.g., weather and streamflow forecast) as necessary.

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 (CDFW) into the Klamath River later than the typical release schedule. Water quality monitoring stations established by KRRC prior to reservoir drawdown will be used by KRRC to determine when conditions in the mainstem Klamath River are suitable for the release of hatchery-reared coho salmon.

Suckers

The Project will result in lethal effects to Lost River and shortnose suckers inhabiting the Klamath River reservoirs. Since the two sucker species are lake-type suckers, suckers inhabiting the Hydroelectric Reach reservoirs will not persist following the Project. KRRC will conduct an adaptive management plan that includes sampling, salvage, and relocation of Lost River and shortnose suckers in the Hydroelectric Reach reservoirs. KRRC will translocate suckers 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. KRRC will salvage and relocate up to a maximum of 3,000 suckers to the receiving waters. During the course of these actions, KRRC does not anticipated that the entire populations of suckers residing in the Hydroelectric Reach reservoirs will be recovered.

Freshwater Mussels

Freshwater mussels located in the 8-mile long reach from Iron Gate Dam downstream to the Cottonwood Creek confluence, are anticipated to experience high mortality due to suspended sediment concentrations and bedload deposition. The KRRC will prepare a reconnaissance, salvage, and translocation plan for up to 20,000 mussels located in the deposition reach. During the course of these actions, KRRC does not anticipate that the entire population of mussels residing below Iron Gate Dam will be recovered.

AR measures that were included in the 2012 EIS/R that are not proposed as part of the Project based on consultation with the ATWG and additional information gained from recent dam removal projects include:

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-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, project 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.

Chapter 1: Introduction

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1. INTRODUCTION

In 2012, the Department of the Interior developed the 2012 EIS/R (USBR and CDFG 2012) to disclose the potential effects of the Project. The 2012 EIS/R identified significant short-term effects to the aquatic biological community. The 2012 EIS/R included AR plans to attempt to mitigate the possible short-term adverse effects of the Project. In 2017, KRRC assembled the 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 will best meet the intent of the previous AR mitigation measures. The ATWG included fisheries scientists representing CDFW, Oregon Department of Fish and Wildlife (ODFW), U.S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NMFS), Yurok Tribe, Hoopa Valley Tribe, Karuk Tribe, and The Klamath Tribes.

Through a series of nine meetings between April 28 and October 26, 2017, KRRC and the ATWG reviewed recent similar dam removal projects and new scientific information that has been developed since the 2012 EIS/R to update the 2012 AR measures. Updated AR measures are proposed to be implemented as part of the removal of four dam developments 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.

During the reservoir drawdown year, reservoirs will be drawn down by the end of March, followed by volitional fish passage by October 1, and free-flowing river conditions at all four facilities by December 31. project effects are anticipated to be short-term in nature, with long-term benefits ultimately outweighing the Project’s impacts to the aquatic biological community. The aquatic effects of the Project will primarily occur from the release of reservoir sediment during reservoir drawdown. The purpose of Appendix I is to provide background on the 2012 EIS/R AR measures, information gained from other large dam removal projects, and provide KRRC’s and the ATWG’s rationale for the revised AR measures included in the Definite Plan.

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Chapter 2: Dam Removal Benefits and Effects

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2. DAM REMOVAL BENEFITS AND EFFECTS

This section identifies benefits that have been observed after other dam removal projects in the Pacific Northwest and the Project's anticipated long-term benefits to the Klamath River ecosystem.

2.1 Fisheries Benefits of Recent Dam Removals in the Pacific Northwest

Removal of large dams from rivers in the western United States, has been completed to, among other things, restore access and connectivity to historical habitats which can provide a multitude of benefits to native fish communities including increases in species richness (Catalano et al. 2007; Burroughs et al. 2010; Kornis et al. 2015) and life-history diversity (Hitt et al. 2012; Pess et al. 2014).

Several recent studies from the Pacific Northwest that provide an overview of the fish passage benefits associated with restoring access to historical habitat through dam removal efforts are summarized below.

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).

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; Liermann et al. 2017).

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 (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, NMFS, and 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 Project Benefits on the Klamath River Basin Aquatic Resources

The Project will provide long-term ecosystem benefits to the Klamath River Basin. The following anticipated long-term benefits discussion is based on the 2012 EIS/R and *the Klamath Dam Removal Overview Report for the Secretary of the Interior: An Assessment of Science and Technical Information* (NMFS 2013).

2.2.1 Access to Historical Habitat

Iron Gate Dam located at RM 193.1 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 193.1) to the upstream extent of J.C. Boyle Reservoir (RM 234.1), and 49 tributaries accounting for over 420 miles of historical aquatic habitat throughout the basin upstream of Iron Gate Dam. More specifically, the Project will allow access to historical habitat (Table 2-1) totaling approximately 76 miles for coho salmon, 300 miles for Chinook salmon (Huntington 2004), and 420 miles for steelhead (Huntington 2004; 2006). In addition to increasing the quantity of available habitat, unique habitats will also be accessible with the Project. 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 volume of 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

NMFS 2013
cfs – cubic feet per second

Historical anadromous fish population estimates suggest the potential productivity of the Klamath Basin upstream from Iron Gate Dam (RM 193.1). 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]	
	Steelhead	300,000[5]	221,000[4] – 750,000[5]	
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

Chinook Salmon

The Project will benefit fall Chinook salmon by restoring access to over 300 miles of historical habitat (Table 2-1) in the Klamath Basin upstream from Iron Gate Dam (e.g., 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

Reservoir	Mainstem Habitat (mi)	Side Channel Habitat (mi)	Tributary Habitat (mi)
Iron Gate	6.81	-	2.49
Copco	6.87	1.24	1.51
J.C. Boyle	3.32	-	0.19
Total	17.00	1.24	4.18

Source: Cunanan 2009

mi - miles

Coho Salmon

After implementation of the Project, 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; NMFS 2007) and approximately 22.4 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.

Steelhead

The Project will 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 restoring 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.

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 as a result of the Project, 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. The Project 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

The Project 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 will 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). The Project 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 currently 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, the Project 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 22.4 miles of reservoir habitat to riverine and riparian habitat will improve water quality by restoring the nutrient cycling and aeration processes provided by a natural channel.

2.2.3 Hydrograph

With the Project, 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 survival and productivity of Chinook and coho salmon. High infection rates by the myxozoan parasite *Ceratonova shasta* (*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 193.1). 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
2005	All	0.41	0.38
2007	All	0.28	0.10
2008	All	0.6	0.51
2009	All	0.5	0.58
2010	Wild/Unknown	0.12/0.15	0.04
2011	Wild	0.2	0.11
2012	Wild/Unknown	0.06/0.00	0.08
2013	Wild	0.18	0.06
2014	Wild	0.67	0.18
2015	Wild/Unknown	0.66/0.96	0.29

Source: USFWS 2016

Prevalence of Infection references annual summaries of weekly collections aimed to monitor weekly disease rates. The Infected Population Estimate references estimates for the prevalence of C. shasta *infections in the population of juvenile Chinook salmon.*

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

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

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

The Project 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

The Project will 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 are expected to decrease in the Klamath River downstream from Iron Gate Dam and will 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 will 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 Project will have long-term ecosystem benefits. Primary ecosystem benefits that will be realized include restored access to historical habitat upstream of Iron Gate Dam for aquatic organisms (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 *C. 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 Anticipated Short-term Effects of the Project

Short-term effects from the Project 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). The Project's short-term 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).

2.3.1 Suspended Sediment Effects

The 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 193.1) 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.

2.3.2 Bedload Effects

Bedload mobilized by the Project is anticipated to affect the Klamath River between Iron Gate Dam (RM 193.1) and Cottonwood Creek (RM 185.1). 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.

2.3.3 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.

2.3.4 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 Project (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 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, KRRC evaluated the 2012 EIS/R worst-case scenario effects for developing the updated AR plans. The 2012 EIS/R considered the potential 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. The 2012 EIS/R anticipated that mitigation would reduce short-term effects for fall Chinook salmon and Lost River and shortnose suckers (from significant to less-than-significant), but mitigation would not reduce effects to less than significant levels for the other species. The Project as analyzed in the 2012 EIS/R 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).

Chapter 3: Mainstem Spawning

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3. MAINSTEM SPAWNING

The objective of the mainstem spawning measure is to address the short-term project effects on anadromous fish that migrate and spawn in the mainstem Klamath River and its tributaries during the two years following drawdown. The 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 project effects. The updated measure, based on the 2012 EIS/R AR-1, proposed as part of the Project 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 193.1) and Cottonwood Creek (RM 185.1); 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 needed to support 2,100 Chinook redds on the mainstem and 179 steelhead redds in Hydroelectric Reach tributary streams. The measure as currently proposed represents the best available actions and opportunities to offset potential impacts to Chinook salmon and coho salmon spawning redds from reservoir drawdown, and to reduce effects to migrating adult steelhead and Pacific lamprey affected by reservoir drawdown.

3.1 Proposed Measure

Based on a review of the 2012 EIS/R AR-1 presented in Section 3.2, input from the ATWG, and recent fisheries literature, the KRRC concluded that an updated measure is necessary to offset the anticipated short-term effects of the Project on mainstem spawning Chinook and coho salmon, as well as migrating adult steelhead and Pacific lamprey. The updated measure requires KRRC to develop and implement 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:** KRRC will evaluate tributary-mainstem confluences, four sites in the Hydroelectric Reach and five sites in the 8-mile reach from Iron Gate Dam (RM 193.1) to Cottonwood Creek (185.1), for 2 years (see Table 3-1 for proposed schedule). Monitoring frequency will be variable based on the season and year. Additionally, any 5-year flow event of 10,895 cfs or greater on the Klamath River recorded at the USGS Klamath River Below Iron Gate Dam CA gage (#11516530) within the first two years following reservoir drawdown, will trigger a monitoring effort. If tributary confluence blockages are identified during monitoring, necessary means will be employed to remove the obstructions to ensure volitional passage for adult Chinook salmon, coho salmon, steelhead, and Pacific lamprey. The ATWG will also convene periodically during the 2-year monitoring period to review monitoring frequency to ensure volitional passage is maintained between the Klamath River and select tributaries.

- **Action 2:** KRRC will complete a spawning habitat evaluation of the Hydroelectric Reach and newly accessible tributaries following reservoir drawdown. A target of 44,100 yd^2 of mainstem spawning gravel will be required to offset the effects to 2,100 mainstem-spawning fall Chinook salmon redds. If mainstem spawning gravel availability is less than the target values following reservoir drawdown, KRRC will consult with the ATWG to plan and implement spawning gravel augmentation in the former Klamath River reservoirs and Hydroelectric Reach. A target of 4,700 yd^2 of tributary spawning gravel is required to offset the effects to 179 tributary-spawning steelhead redds. If tributary spawning gravel habitat is less than the target values following reservoir drawdown, KRRC will meet with the ATWG to prioritize additional habitat restoration actions (e.g., gravel augmentation, gravel retention treatments) that will be implemented by KRRC to increase the amount of tributary habitat available to compensate for the loss of steelhead redds.

The proposed actions are intended to ensure adult salmonid and Pacific lamprey access to mainstem and tributary spawning habitat in the Hydroelectric Reach and between Iron Gate Dam and Cottonwood Creek following the Project. 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.

Tributary-Mainstem Connectivity Monitoring

To ensure that spawning habitat is accessible during and 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 (Table 3-1). Tributary confluences in the Hydroelectric Reach may be affected by sediment deposits and debris obstructions as the reservoirs are drawn down. Tributary deltas may create fish passage barriers that will limit upstream migration of anadromous salmonids and Pacific lamprey. Monitoring frequency will be variable based on the season and year (Table 3-1). Additionally, any 5-year flow event or 10,895cfs or greater on the Klamath River recorded at the USGS Klamath River Below Iron Gate Dam CA gage (#11516530) within the first two years following reservoir drawdown will trigger a monitoring effort.

Table 3-1 Mainstem Spawning Measure monitoring frequency for tributaries in the Hydroelectric Reach and Iron Gate Dam (IGD) to Cottonwood Creek reach for the drawdown year and post-drawdown year.

Monitoring Reach	Monitoring Period	Monitoring Frequency
Hydroelectric Reach 4 tributaries	Drawdown Year (2021-2022)	
	April 1 – June 30	Bi-weekly
	July 1 – September 30	Monthly
	October 1 – December 31	Weekly
	2nd Year (2022-2023)	

Monitoring Reach	Monitoring Period	Monitoring Frequency
	January 1 – March 31	Weekly
	April 1 – June 30	Bi-weekly
	July 1 – September 30	Monthly
	October 1 – December 31	Bi-weekly
IGD to Cottonwood Creek 5 tributaries	Drawdown Year (2021-2022)	
	January 1 – March 31	Weekly
	April 1 – June 30	Bi-weekly
	July 1 – September 30	Monthly
	October 1 – December 31	Weekly
	2nd Year (2022-2023)	
	January 1 – March 31	Weekly
	April 1 – June 30	Bi-weekly
	July 1 – September 30	Monthly
	October 1 – December 31	Bi-weekly

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 192.6) downstream to Cottonwood Creek (RM 185.1). From Bogus Creek downstream to Willow Creek (RM 188.0), 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 the Project.

Species that could 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 have volitional fish passage conditions during and following drawdown.

Tributary confluences to be monitored by KRRC in the 2-year period following reservoir drawdown 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 233.4), Shovel Creek (RM 212.0), Fall Creek (RM 199.8), and Jenny Creek (RM 197.4). These tributaries were selected based on having historical or potential habitat for adult salmonids (Huntington 2006).

Tributary confluences will be evaluated for 2 years in both reaches to identify project-related tributary confluence obstructions. Obstructions will be actively removed during the 2-year monitoring period to ensure volitional passage for adult Chinook salmon, coho salmon, steelhead, and Pacific lamprey

Tributary Connectivity Maintenance

Tributary confluences in both reaches will be monitored at variable frequencies depending on the season and year (see Table 3-1). Tributary obstructions that limit fish passage will be remedied through appropriate manual or mechanical means necessary to address obstructions. Example removal methods may include removing sediment using hand tools or hydraulic equipment. Removed gravels and large woody debris will be placed in the Klamath River downstream of the tributary confluence. Removed fine sediments will be placed on the adjacent floodplain or outhauled for disposal. The removal effort will be to the extent necessary to ensure volitional passage for adult and juvenile Chinook salmon, coho salmon, steelhead, and Pacific lamprey.

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.

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 3-2). 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 reservoir drawdown and sediment release. 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 3-2 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 reservoir drawdown and sediment release	2,100	179[1]
Surface area per spawning redd (yd^2)	21	26
Spawning habitat area to address redd loss (yd^2)	44,100	4,700

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

Spawning Habitat Monitoring

To quantify the available spawning habitat upstream of Iron Gate Dam, KRRC will implement field surveys and remote sensing following reservoir drawdown. Boat or aerial surveys will be conducted on the mainstem Klamath River between Iron Gate Dam (RM 193.1) and Keno Dam (RM 239.2) 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 3-3). The area of available spawning habitat will be estimated from the mouth to the first natural barrier. If artificial (manmade) fish passage barriers are located during the tributary reach reconnaissance, they will be noted as potential restoration actions to increase the availability of tributary spawning habitat.

Table 3-3 Hydroelectric Reach tributaries to be assessed for existing spawning habitat

Tributary	Tributary Confluence Location at the Klamath River (RM)	Tributary Length to First Barrier (mi)
Jenny Creek	197.4	1.0
Fall Creek	199.8	1.2
Shovel Creek	212.0	2.7
Spencer Creek	233.4	9.0

Response to Spawning Habitat Availability

KRCC will prepare a report summarizing the spawning habitat surveys and outline and prioritize actions to augment spawning habitat if the existing spawning habitat amounts to less than the 44,100 yd^2 of mainstem and 4,700 yd^2 of tributary spawning habitat targets in the Hydroelectric Reach. KRRC will consult with the ATWG for input on potential spawning gravel augmentation locations in the mainstem and on other tributary habitat restoration actions in tributaries to increase the availability of spawning habitat. Currently, if existing spawning habitat does not meet targets, spawning gravel augmentation will be completed in the mainstem Klamath River between Shovel Creek (RM 212.0) and the upstream extent of Copco Reservoir (RM 209.0). Mainstem gravel will be added at a rate of 7.0 cy (21 yd^2 x 1 ft depth) per compensatory mainstem redd. KRRC anticipates augmented gravel will to be redistributed with subsequent high flows, broadening potential spawning habitat over larger areas of the treated mainstem reaches. Tributary spawning habitat restoration actions to be completed in Jenny Creek, Shovel Creek, Fall Creek, and/or Spencer Creek could include removal of artificial fish passage barriers, or placement of large woody debris to trap and retain spawning gravels. Spawning gravel augmentation will be prioritized based on anticipated spawning habitat benefits.

In summary, the updated measure includes development and implementation of a monitoring and adaptive management plan overseen by KRRC with consultation by the ATWG. 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 the start of reservoir drawdown and tributary confluence 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 augmented with supplemental spawning gravel or enhanced through additional restoration actions (e.g., large wood placement to retain spawning gravels) if spawning habitat area metrics are not met by existing habitat conditions following reservoir drawdown.

3.2 Summary of the Affected Species, Project Benefits and Effects, Recent Fisheries Literature, the 2012 EIS/R AR-1, and the Proposed Measure

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

3.2.1 Affected Species

Species identified in the measure 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 Project Effects on Measure Species

Short-term effects of the project (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 193.1) 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 3-4 includes the likely and worst-case effects to adult anadromous fish species downstream from Iron Gate Dam.

Table 3-4 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).

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 Project. 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 Project 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 Project 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).

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 Project 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 Project 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 from Iron Gate Dam downstream to the Shasta River confluence and represents approximately 8 percent of the total, basin-wide escapement (USBR and CDFG 2012).

Steelhead – Summer and Winter

High suspended sediment concentrations resulting from the Project 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 Project 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 will 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 Project 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 project effects. Project 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).

Pacific Lamprey

The Project will 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 Project 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), will not be affected by the Project. 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 the Project.

3.2.3 2012 EIS/R AR-1

The 2012 EIS/R AR-1 (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 project 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 234.1) if consistent with post-Project 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 the project.

3.2.4 KRRC's and ATWG's Review of AR-1 for Feasibility and Appropriateness

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 discussed 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 will 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.

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 192.6). KRRC and the 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.

KRRC and the 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 192.6) vary widely, the average number of fish returning to the Klamath River upstream of the Shasta River confluence (RM 179.3) is substantial (Table 3-5) 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, 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 3-5 Fall Chinook salmon, coho salmon, and winter steelhead return metrics for Iron Gate Hatchery from 2000 to 2016

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

Source: CDFW 2016
[1] The peak winter steelhead return to Iron Gate Hatchery from 2000 to 2016 was 631 fish. Using the 2012 EIS/R calculation method, 80 percent of fish returning to Iron Gate Hatchery migrate upstream after December 15th. Under the worst-case scenario, 71 percent of mortality is predicted to occur due to the 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.

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

KRRC and the 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 suffered mean mortality of 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, 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.

Impacts to Wild Fish Populations Inhabiting Relocation Streams

KRRC and the 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. KRRC and the ATWG also concluded that there would be few viable options for recipient tributary streams based on genetics and disease concerns.

The 2012 EIS/R 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 in the Upper Klamath Basin that is expected to rely primarily on natural recolonization of the Klamath River and associated tributaries upstream of Iron Gate Dam (T. Wise, ODFW, personal communication). CDFW is likewise concerned with introducing coho and 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 192.6) 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 192.6), 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 193.1) 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 have been 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 had 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 193.1) 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, KRRC and the 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.

Adult Coho Salmon Location at Time of the Reservoir Drawdowns

KRRC and the 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 likely that the small numbers of coho that do spawn in the mainstem river are mostly of Iron Gate 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 project effects. Attempting to capture small numbers of mainstem spawning coho salmon would likely impact greater numbers of coho than would be impacted by project activities.

Overall, KRRC and the 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.

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 project effects on adult salmonids and Pacific lamprey. The following sections provide updated population information for winter steelhead and Pacific lamprey and identifies project effects uncertainties 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 EIS/R 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 Although returns to Iron Gate Hatchery may not be indicative of broader trends in adult winter steelhead returns to the Klamath River, these data do provide an updated metric for estimating anticipated effects of the Project on adult 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 provides additional 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). *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 minimize 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 Project 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 fall Chinook salmon are muted by the fact that any cohort is made up of several age classes of spawners. Grilse and adult returns the year following dam removal will be comprised of age-2, 3, 4, and 5 fish that will be in the ocean during the Project. Benefits of the Project that are expected to be evident the first year following dam removal 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 the Project 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 Project.

3.3 Measure Summary

The 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 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 EIS/R AR-1, 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 2012 EIS/R AR-1 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 proposed measure are warranted.

The proposed measure includes the development and implementation of a monitoring and adaptive management plan to offset Project effects on mainstem spawning. Proposed actions include a 2-year tributary confluence monitoring effort that begins in January of the drawdown year and addressing sediment and debris obstructions that block volitional passage between the Klamath River and key tributaries. The second action includes a spawning habitat evaluation on the Klamath River and tributaries in the Hydroelectric Reach following reservoir drawdown, or approximately March of the drawdown year. If existing spawning habitat conditions do not meet target metrics in the mainstem Klamath River, then spawning gravel augmentation will be completed. If the existing spawning habitat conditions do not meet target metrics in the key tributaries in the Hydroelectric Reach, then the ATWG will be consulted to identify priority restoration activities to increase tributary spawning habitat availability (e.g., large woody debris placement for gravel retention).

Chapter 4: Juvenile Outmigration

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4. JUVENILE OUTMIGRATION

The objective of the measure is to address project effects on juvenile anadromous fish in the Klamath River downstream from Iron Gate Dam. The 2012 EIS/R AR-2 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 the Project. Trapped fish would have been trapped, 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 proposed measure, based on the 2012 EIS/R AR-2, includes three actions: (1) sampling and salvaging yearling coho salmon from key locations in the Klamath River from Iron Gate Dam (RM 193.1) to the Trinity River confluence (RM 43.4) and relocating captured fish to constructed off-channel ponds prior to reservoir drawdown; (2) monitoring and ensuring tributary-mainstem connectivity; and (3) monitoring juvenile salmonids and water quality conditions at the 13 key tributaries, and salvaging and relocating juvenile salmonids if water quality thresholds are exceeded. The proposed actions are the best opportunities based on available science to offset the effects of reservoir drawdown on juvenile anadromous fish.

4.1 Proposed Measure

Based on a review of the 2012 EIS/R AR-2 presented in Section 4.2, input from the ATWG, and recent fisheries literature, the KRRC concluded AR-2 should be modified to offset the anticipated short-term effects of the Project on outmigrating juvenile fish. The proposed measure includes three actions targeting juvenile salmonids.

- **Action 1:** KRRC will sample and salvage overwintering juvenile coho salmon from the Klamath River between Iron Gate Dam (RM 193.1) and the Trinity River (RM 43.4) confluence prior to reservoir drawdown. Sampling and salvage sites will focus primarily on alcoves, side channels, and backwatered floodplain features adjacent to the mainstem Klamath River. 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:** KRRC, with input from the ATWG, will prepare a monitoring and adaptive management plan to monitor tributary-mainstem connectivity. Beginning in January of the drawdown year and continuing for 2 years, tributary-mainstem confluences, including four sites in the Hydroelectric Reach and five sites in the 8-mile reach from Iron Gate Dam (RM 193.1) to Cottonwood Creek (RM 185.1), will be monitored with a variable frequency based on the season and year (see Table 4-1 for proposed schedule). Additionally, any 5-year flow event of 10,895 cfs or greater on the Klamath River recorded at the USGS Klamath River Below Iron Gate Dam CA gage (#11516530) within the first two years following reservoir drawdown, will trigger a monitoring effort. If KRRC identifies tributary confluence blockages during monitoring, KRRC will employ necessary means to remove the obstructions to ensure volitional passage for juvenile Chinook salmon, coho salmon, steelhead, and Pacific lamprey. Juvenile salmonids are expected to benefit from the Project because it will restore

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:** KRRC will prepare and implement a monitoring and adaptive management plan that will include detailed information related to monitoring juvenile salmonids and water quality conditions in 13 key tributary confluences between Iron Gate Dam (RM 193.1) and the Trinity River (RM 43.4). Tributary water temperatures and mainstem suspended sediment concentrations will be monitored by KRRC from March 1 to July 1 of the drawdown year. If water quality triggers are exceeded, KRRC and the ATWG will convene to evaluate the data and determine if juvenile salmonids will be salvaged from the tributary confluences and relocated to cool water tributaries, existing off-channel ponds, and/or to the Klamath River downstream from the Trinity River confluence.

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.

Reconnaissance

KRRC will sample up to 15 sites between Iron Gate Dam (RM 193.1) and the Trinity River (RM 43.4) during December one year prior to the start of reservoir drawdown 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 will 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 upstream of the Trinity River that will be sampled include alcoves, side channels, and backwatered floodplain areas that do not have sufficient tributary inflows to provide refuge from expected high SSC in the mainstem Klamath River during reservoir drawdown. Priority will be given to sites closer to Iron Gate Dam where SSC are expected to be highest. Final site selection for the reconnaissance effort will be determined in consultation with ATWG.

Overwintering Juvenile Salmonids Salvage and Relocation

Following KRRC's reconnaissance effort, an overwintering yearling coho salmon relocation effort will be conducted by KRRC in December prior to reservoir drawdown. KRRC salvage efforts will take place as close to scheduled drawdown as possible to avoid capturing coho salmon that are migrating to overwintering habitats located in tributary streams or in the lower Klamath River below the Trinity River confluence. The number of sites will be based on the results of the 2019 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. A minimum of two weeks will be allocated to the salvage and relocation effort. 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 existing off-channel ponds located on Seiad Creek (RM 131.9), West Grider Creek (RM 131.8), Horse Creek/ Middle Creek (RM 116.0), Stanshaw Creek (RM 77.1), and Camp Creek (RM 57.4) or other natural beaver ponds or floodplain channels that are located in close proximity to the salvage sites and that are unaffected by elevated SSCs in the mainstem Klamath River. Coho salmon will be relocated to the off-channel habitat located closest to the salvage site and will be transported by using aerated buckets with lids or by transport truck if necessary. Other native fish captured during the seining and trapping effort, such as juvenile steelhead and juvenile Chinook salmon will be relocated 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. Final relocation sites will be identified after the completion of the reconnaissance effort and in consultation with the ATWG.

4.1.2 Action 2: Tributary-Mainstem Connectivity Monitoring

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

Tributary-Mainstem Connectivity Monitoring

To ensure that rearing habitat is accessible following reservoir drawdown, KRRC will complete fish passage monitoring and adaptive actions at the confluence areas of key Klamath River tributaries and side channels upstream and downstream of Iron Gate Dam for a 2-year period beginning with reservoir drawdown (see Table 4-1 for proposed schedule). Tributary confluences in the Hydroelectric Reach may be affected by sediment deposits and debris obstructions as the reservoirs are drawn down. Tributary deltas may create fish passage barriers that will 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 192.6) downstream to Cottonwood Creek (RM 185.1). From Bogus Creek (RM 192.6) downstream to Willow Creek (RM 188.0), 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 the Project.

Species that will 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 reservoir drawdown include Bogus Creek (RM 192.6), Dry Creek (RM 190.9), Little Bogus Creek (RM 189.8), Willow Creek (RM 188.0), and Cottonwood Creek (185.1). 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 233.4), Shovel Creek (RM 212.0), Fall Creek (RM 198.9), and Jenny Creek (RM 197.4). These tributaries were selected based on having historical or potential habitat for adult salmonids (Huntington 2006).

Tributary confluences will be monitored according to the schedule presented in Table 4-1. If present, confluence obstructions will be actively removed by KRRC during the 2-year evaluation period to ensure volitional passage for juvenile Chinook salmon, coho salmon, steelhead, and Pacific lamprey. In addition to the monitoring effort outlined in Table 4.1, the tributary confluences will also be monitored by KRRC after any flow that is greater than a 5-year flow event that occurs during the first two years following reservoir drawdown.

Table 4-1 Outmigrating Juveniles Measure monitoring frequency for tributaries in the Hydroelectric Reach and Iron Gate Dam (IGD) to Cottonwood Creek reach for the drawdown year and post-drawdown year.

Monitoring Reach	Monitoring Period	Monitoring Frequency
Hydroelectric Reach 4 tributaries	Drawdown Year (2021-2022)	
	April 1 – June 30	Bi-weekly
	July 1 – September 30	Monthly
	October 1 – December 31	Weekly
	2nd Year (2022-2023)	
	January 1 – March 31	Weekly
	April 1 – June 30	Bi-weekly
	July 1 – September 30	Monthly
	October 1 – December 31	Bi-weekly
IGD to Cottonwood Creek 5 tributaries	Drawdown Year (2021-2022)	
	January 1 – March 31	Weekly
	April 1 – June 30	Bi-weekly
	July 1 – September 30	Monthly
	October 1 – December 31	Weekly
	2nd Year (2022-2023)	
	January 1 – March 31	Weekly
	April 1 – June 30	Bi-weekly
	July 1 – September 30	Monthly
	October 1 – December 31	Bi-weekly

Tributary Connectivity Maintenance

KRRC will monitor tributary confluences in both reaches at variable frequencies depending on the season and time period (see Table 4-1). Project-related tributary obstructions that limit fish passage will be remedied by KRRC through appropriate manual or mechanical means necessary to address obstructions. Example removal methods may include removing sediment using hand tools or hydraulic equipment. Removed gravels and large woody debris will be placed in the Klamath River downstream of the tributary confluence. Removed fine sediments will be placed on the adjacent floodplain or outhauled for disposal. The removal effort will be to the extent necessary to ensure volitional passage for adult and juvenile Chinook salmon, coho salmon, steelhead, and Pacific lamprey.

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 and lamprey ammocoetes from tributary confluence areas.

Tributary and Mainstem Water Monitoring and Juvenile Fish Salvage

KRRC will develop a monitoring and adaptive management plan that will include monitoring juvenile salmonids and water quality conditions in 13 key tributary confluences between Iron Gate Dam (RM 193.1) and the Trinity River confluence (RM 43.4). Tributaries to be monitored include Bogus Creek (RM 192.6), Dry Creek (RM 190.9), Cottonwood Creek (RM 185.1), 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 between March 1 and July 1 of the drawdown year. SSC will be measured continuously following drawdown at water quality stations throughout the mainstem Klamath River including Iron Gate Dam, Seiad Valley, and Orleans. A standing weekly call with the ATWG will be established beginning in January of the year of reservoir drawdown. On a weekly basis, the ATWG will evaluate current water quality conditions in the Klamath River downstream of Iron Gate Dam and tributaries, recent observations of fish behavior from agency and tribal biologists and technicians, and upcoming hydrologic and meteorological forecasts. If key tributary water temperatures reach 17 °C (7-day average of the daily maximum values) and Klamath River SSCs remain elevated above 1,000 mg/L, or if observed behaviors of juvenile salmonids inhabiting tributary confluences necessitate salvage, the ATWG will convene to organize the logistics for juvenile salvage and relocation efforts. The ATWG may also deem that a salvage effort is necessary based on the presence of large numbers of juvenile salmonids at tributary confluence areas if observations of fish behavior indicate that stress coupled with forecasted conditions are likely to lead to high mortality of juvenile fish.

The salvage effort will include capturing fish from confluence areas, loading them to aerated transport trucks, and relocating them to cool water tributaries or off-channel ponds including, but not limited to the Seiad Creek complex (RM 131.9). The Seiad Creek complex includes constructed off-channel ponds and connected cool water tributary channels. The complex provides juvenile salmonids with a variety of habitats that they can choose to use. If the number of salvaged fish exceeds the capacity of the Seiad Creek complex, juvenile salmonids may also be relocated to Beaver Creek (RM 163.3), Cade Creek (RM 110.9), Elk Creek (RM 107.2), Tom Martin Creek (RM 144.6), and Sandy Bar Creek (RM 77.8) as well as constructed off-channel ponds located on West Grider Creek (RM 131.8), Camp Creek (RM 57.4), and Stanshaw Creek (RM 77.1). Juvenile Chinook salmon, steelhead, and Pacific lamprey ammocoetes may be transported to the mainstem Klamath River below the confluence of the Trinity River if suitable tributary habitat is unavailable closer to the salvage sites, or if the estimated carrying capacity of those tributary sites has been reached. A multi-day salvage effort will be conducted at the confluence of the Shasta and Scott rivers and single day salvage efforts will be conducted at other tributary confluence areas by a 4-person crew and 2 transport trucks during the March 1 to July 1 monitoring period. Multiple salvage and transport days may be necessary at the Shasta and Scott River confluences based on juvenile salmonid abundance in the two tributaries.

4.2 Summary of the Affected Species, Project Benefits and Effects, Recent Fisheries Literature, the 2012 EIS/R AR-2, and the Proposed Measure

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

4.2.1 Affected Species

Species identified in the measure 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 Project Effects on Measure Species

Short-term effects of the Project 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 193.1) 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 4-2 includes the 2012 EIS/R analysis of the likely and worst-case effects to anadromous outmigrating juveniles downstream from Iron Gate Dam.

Table 4-2 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+ Rearing[1]	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 as analyzed in the 2012 EIS/R (USBR and CDFG 2012; Vol. I, pp. 3.3-129 to 3.3-168).

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 Project. 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 Project 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 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 from the tributaries described above 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 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).

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 the Project are expected to be relatively minor because of varied life histories. During juvenile salmonid outmigration trapping conducted at Big Bar (RM 49.7) on the Klamath River between 1997-2000, very few Chinook were captured outmigrating through the lower river 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 Project 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, 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 Project, 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).

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 Project 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 the Project 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 the Project (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 Project 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 project effects.

Pacific Lamprey

The Project would likely 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 Project 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 Project. 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 measure 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 Pacific Lamprey Ammocoetes.

4.2.3 2012 EIS/R AR-2

The 2012 EIS/R AR-2 (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 have been operated to capture downstream migrants prior to their entry into the mainstem Klamath River. Captured juveniles would have been transported and released at sites downstream of the Trinity River or other locations with suitable water quality.

4.2.4 KRRC and the ATWG's Review of AR-2 for Feasibility and Appropriateness

KRRC and the ATWG assessed the feasibility and appropriateness of the 2012 EIS/R AR-2 through multiple planning meetings held 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 the 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 2012 EIS/R AR-2 feasibility and appropriateness based on fisheries literature and ATWG input.

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).

KRRC and 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 the Project. KRRC and 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.

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

KRRC and the 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 the Project. 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. KRRC and the ATWG concluded that large scale efforts aimed at trapping, handling, and releasing juvenile salmonids were likely to cause unnecessary harm to juvenile salmonids.

Potential Imprinting and Straying Issues

KRRC and the 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.

The proposed salvage and transport of juvenile salmonids may experience similar imprinting and straying issues as those outlined for the 2012 EIS/R AR-2. However, the proposed measure is anticipated to address a smaller number of juvenile salmonids and the fish that are transported would otherwise likely perish. Given the potential mortality of juvenile fish remaining in adverse water quality conditions in tributary confluences, the lesser risk of elevated stray rates was deemed an acceptable risk by the ATWG.

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 project 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.

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 Project 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 Additional Information Related to Suspended Sediment Concentration Effects on Outmigrating Juvenile Salmonids

4.3.1 Introduction

The following additional information is on the effects of suspended sediment concentrations on outmigrating juvenile salmonids, which is intended to be addressed through implementation of the proposed measure. This information includes a review of recent juvenile salmonid outmigration data for the Klamath River and select tributaries, comparing outmigration periods to anticipated suspended sediment concentrations from USBR sediment modeling, and assessing potential juvenile salmonid avoidance behaviors related to high suspended sediment concentrations.

Results of KRRC's additional analysis suggest juvenile Chinook salmon, coho salmon, and steelhead generally outmigrate from tributaries to the Klamath River after peak suspended sediment concentrations are anticipated to occur. However, early outmigrating juvenile Chinook salmon and coho salmon from the Shasta River and Scott River are most susceptible to anticipated suspended sediment concentrations associated with reservoir drawdown. Fish may reduce their exposure to high suspended sediment levels by seeking clear water tributary confluences, entering clear water tributaries and off-channel ponds, and expediting their downstream migration. Measures to further reduce suspended sediment impacts to early outmigrating salmonids include implementing an adaptive monitoring and salvage plan.

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

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

Screw Trap Data

Screw trap data provided by USFWS, CDFW, Yurok Tribe, and Karuk Tribe (referenced as "acquiring entity") were reviewed and summarized by KRRC. The screw trap data analysis focused on 2008 to 2015, and provides an updated data set extending the period of record for screw trap data reviewed in preparation of the 2012 EIS/R (Reclamation and CDFG 2012). Screw trap data from the Klamath River and tributaries to the Klamath River (Table 4-3) were reviewed to assess juvenile salmonid outmigration timing and relative abundance. Reported data include both juvenile outmigration population estimates and trap catch numbers. Outmigration estimates were generally provided by the acquiring entities for juvenile fall Chinook salmon due to the sufficient abundance and trap catch of individuals in the mainstem and tributaries. Outmigration estimates are computed by multiplying the number of caught fish by a correction factor that approximates trap efficiency. Compared to trap catch numbers, outmigration estimates are a better representation of the potential number of outmigrating juvenile salmonids from the watershed upstream from the trap location.

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

Table 4-3 Juvenile outmigration trap information and reporting data for Klamath River and Tributary Traps.

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

Reach	Trap Location	Trap Type	Acquiring Entity	Reporting Data
	Trinity River[4] (Confluence at RM 43.4)	RST	USFWS	Chinook (age-0+) catch Coho (age-0+) catch Steelhead (age-0+) catch
Lower Klamath River	Blue Creek[5] (Confluence at RM 16.0)	RST	Yurok Tribe	Chinook (age-0) estimates Coho (age-0 and age-1+) catch Steelhead (age-0 and age-1+) catch

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

4.3.3 Suspended Sediment Concentration Analysis

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

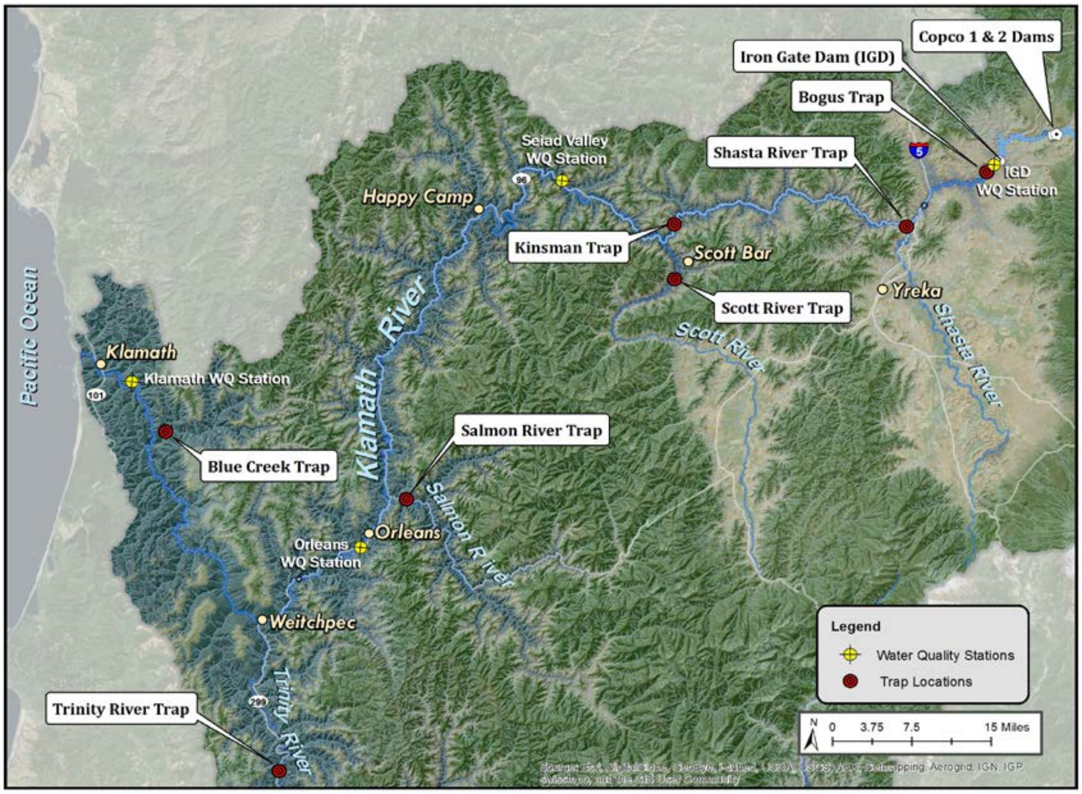


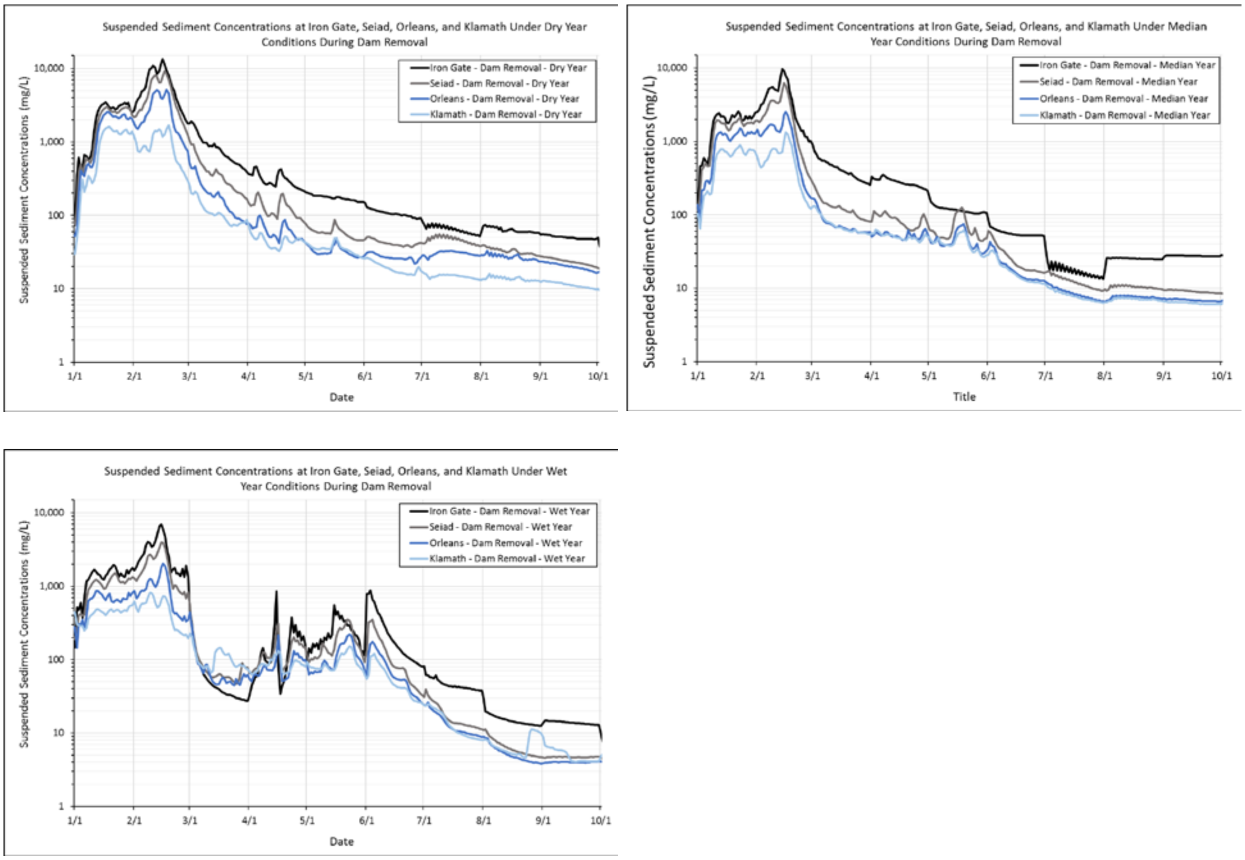
Figure 4-1 Screw trap and suspended sediment modeling stations on the Klamath River.

Juvenile Salmonid Suspended Sediment Exposure

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

Juvenile Salmonid Outmigration Travel Time

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



Modeling output is presented for the Klamath River at Iron Gate, Seiad Valley, Orleans, and Klamath modeling stations. Graphs include dry year (2001, upper left), median year (1976, upper right), and wet year (1984, lower left).

Figure 4-2 Modeled suspended sediment concentrations associated with reservoir drawdown and dam removal.

Table 4-4 Suspended sediment modeling output stations and summary results.

Suspended Sediment Modeling Station	Approximate Location (river mile)	Wet Year / Dry Year Peak SSC (mg/L)	Wet Year / Dry Year Cumulative Days with SSC above 1,000 mg/L	Wet Year / Dry Year Cumulative Days with SSC above 3,000 mg/L
Iron Gate Dam	193.1	6,988 / 13,385	54 / 57	12 / 33
Seiad Valley	131.9	3,999 / 9,223	41 / 50	4 / 19
Orleans	59.0	2,046 / 5,157	11 / 45	0 / 11
Klamath	2.5	819 / 1,670	0 / 28	0 / 0

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

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

Juvenile Salmonid Suspended Sediment Exposure Effects

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

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

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

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

Outmigration and Suspended Sediment Concentration Results

The following section presents a review of select screw trap data and suspended sediment concentration results compiled by KRRC. All outmigration and suspended sediment data are presented by Julian week (Table 4-5). Outmigration histograms represent weekly average number of outmigrants based on the sampled time period, generally 2008 to 2015. Salmon River outmigrant data are presented for two representative years rather than as multi-year averages due to limited data availability. Juvenile outmigration variability plots presented in section 4.4, illustrate the plasticity of outmigration timing. Outmigration timing is influenced by flows, water temperature, and other environmental factors.

Table 4-5 Julian week correspondence with months of the year

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

Upper Klamath River

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

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

Klamath River – Bogus Trap Results

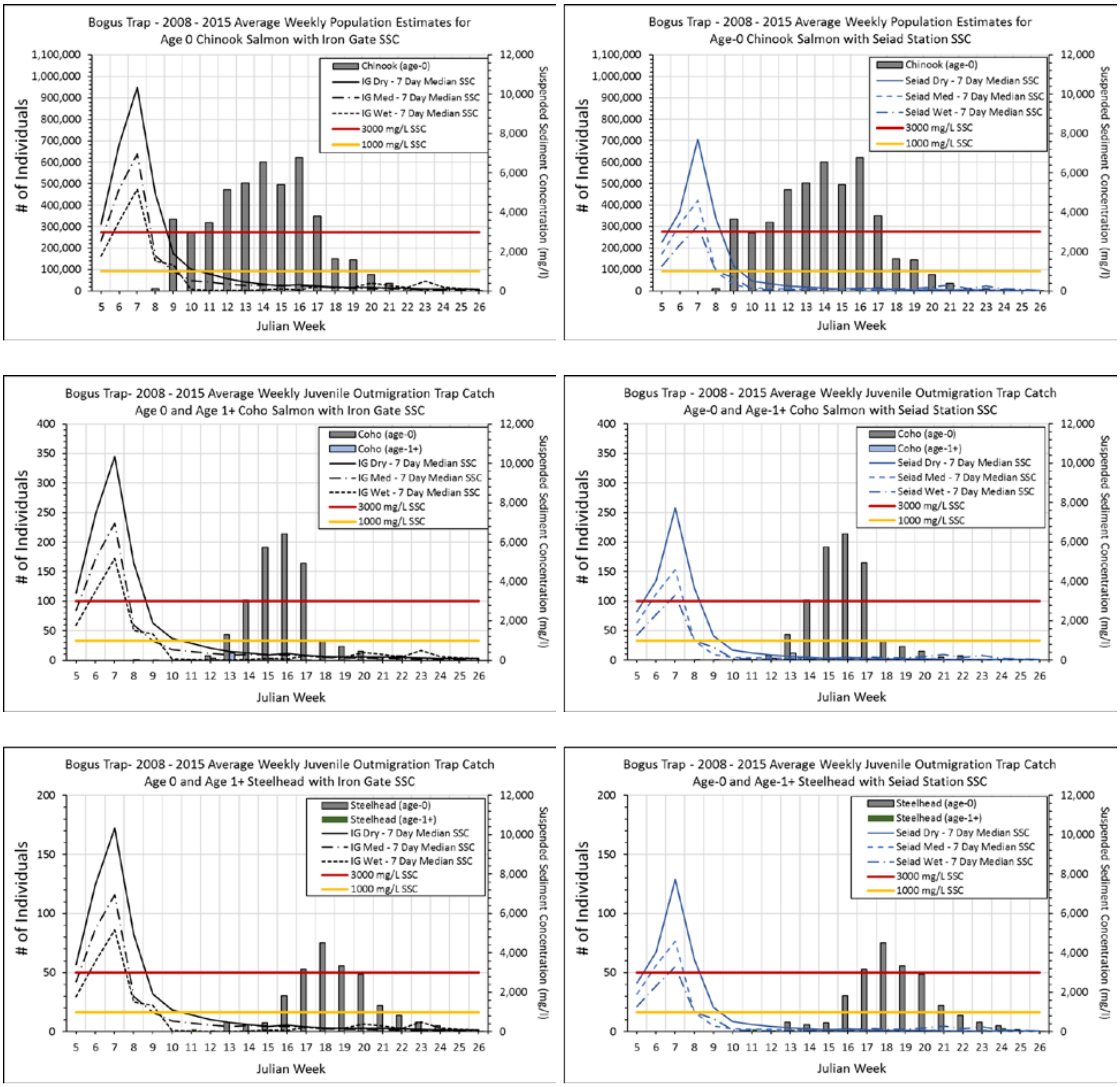
USFWS maintains the Bogus Creek trap located on the Klamath River downstream from Bogus Creek. The net frame trap samples outmigrants from Bogus Creek and the mainstem Klamath River. The Chinook salmon (age-0) outmigration window based on the sample period is from late February through June with an average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

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

Shasta River Trap Results

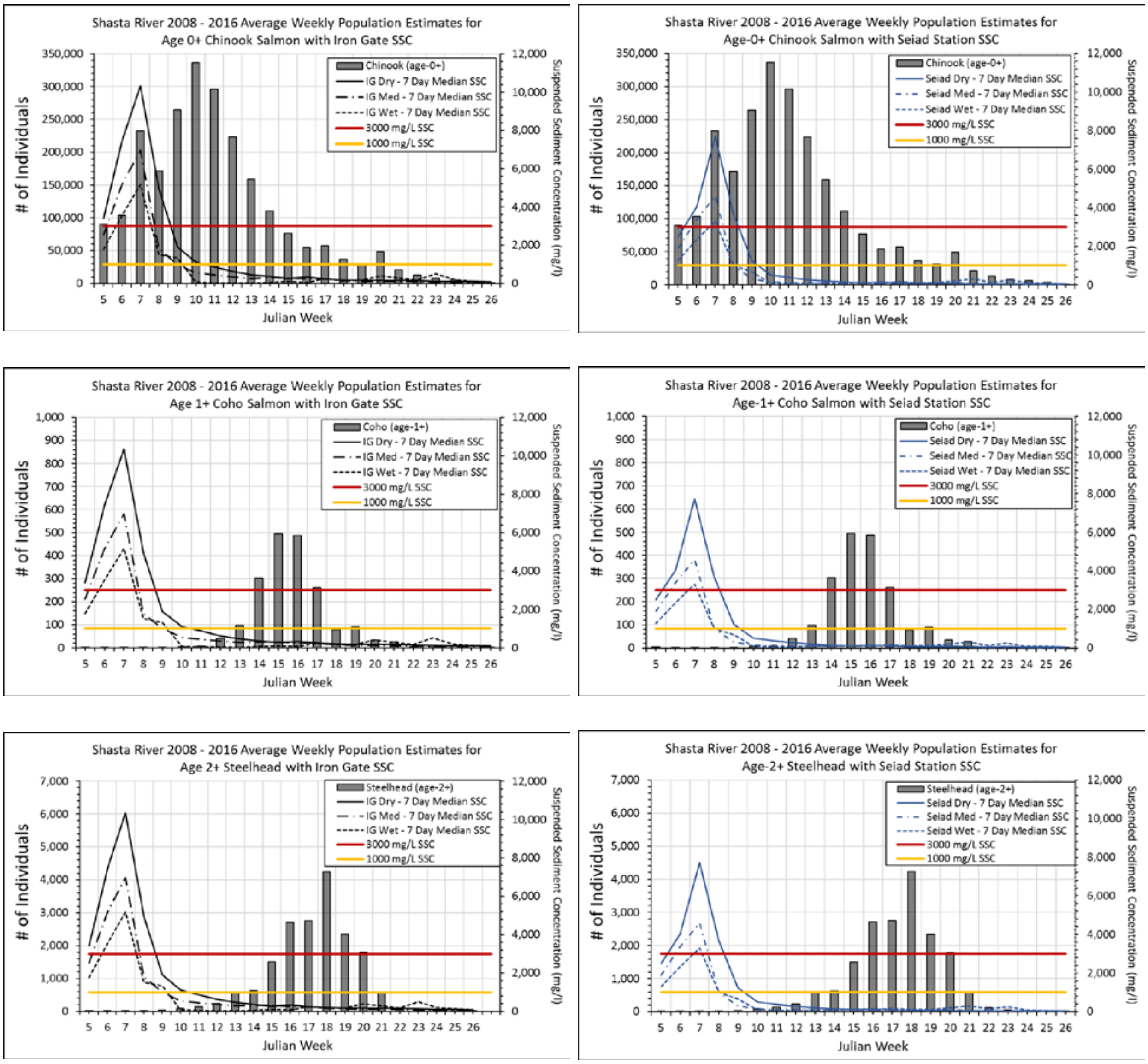
CDFW maintains the Shasta River rotary screw trap located near the Shasta River-Klamath River confluence. Chinook salmon (age-0+) outmigration from the Shasta River tends to occur earlier than in downstream tributaries and the mainstem Klamath River (Figure 4-4). On average, the outmigration begins in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

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



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

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



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

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

Klamath River – Kinsman Trap Results

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

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

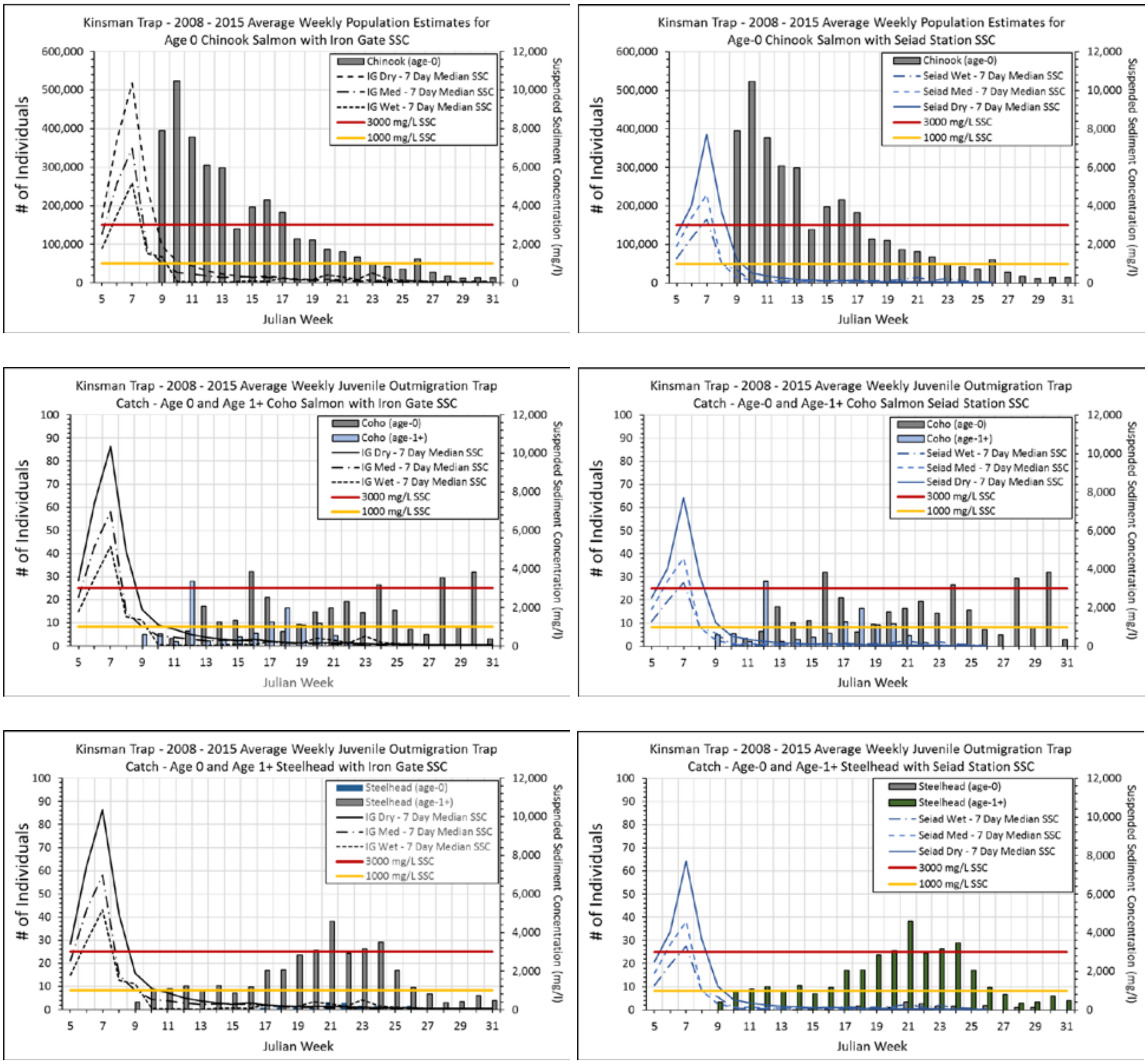
Scott River Trap Results

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

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

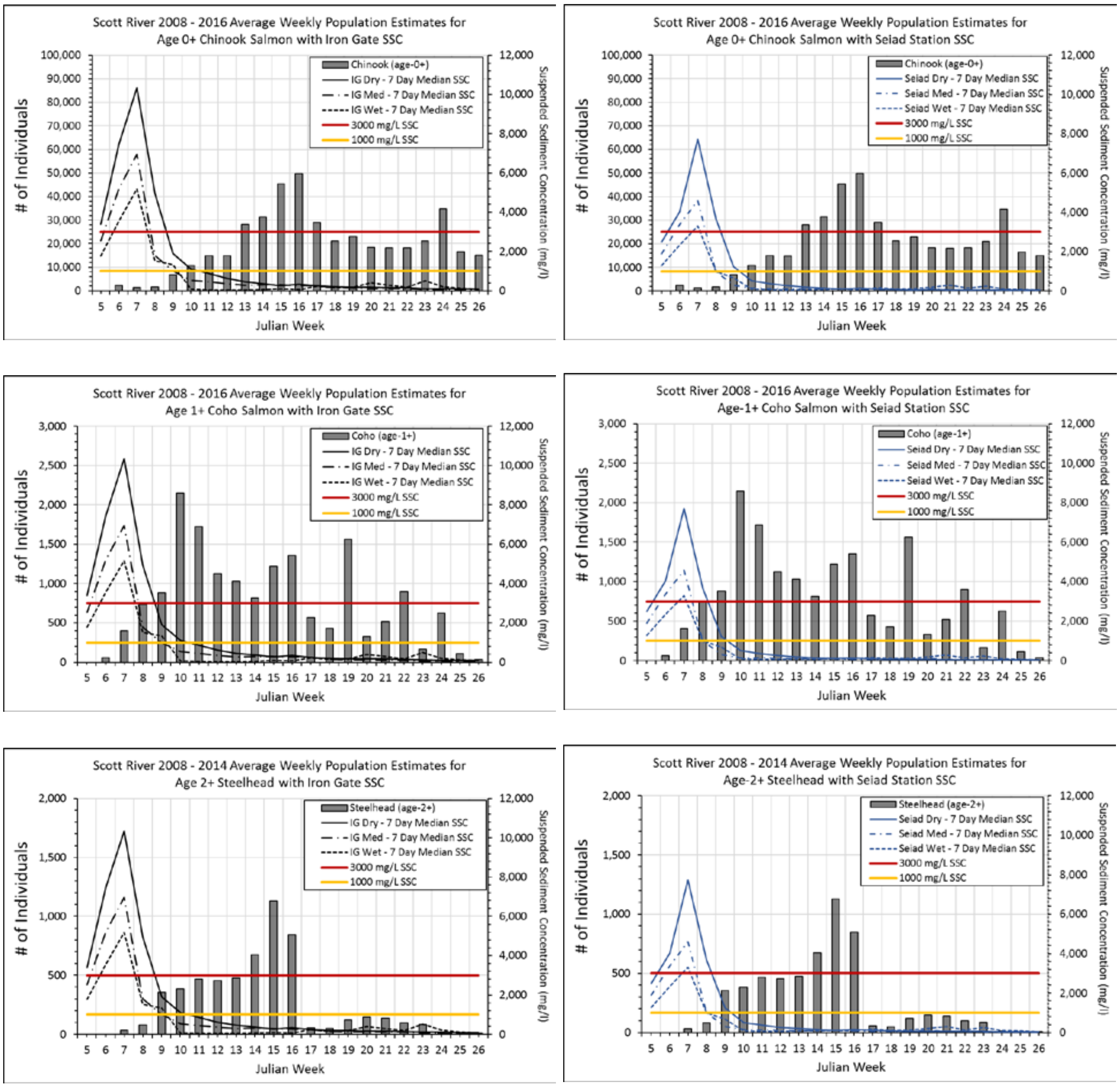
Middle Klamath River

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



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

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



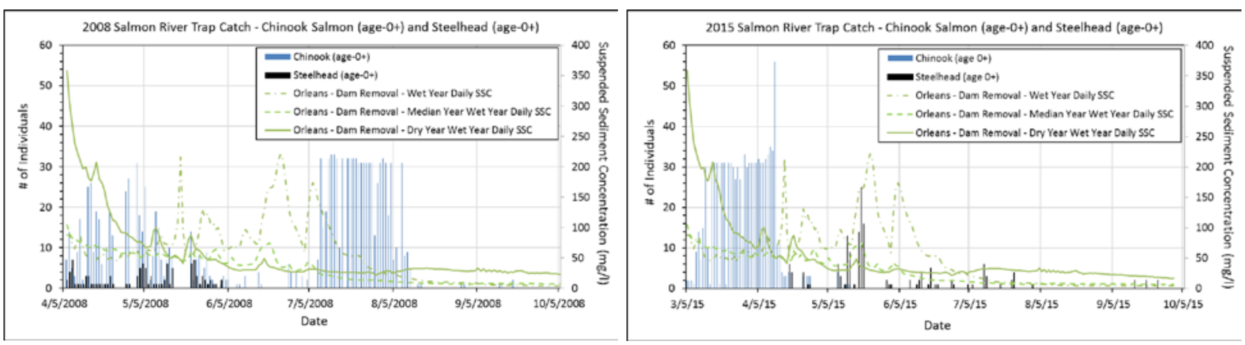
The left column of plots includes the modeled suspended sediment concentrations at the Iron Gate Dam station; the right column includes the modeled suspended sediment concentrations at the Seaid Valley station. Outmigrating coho salmon appear to be proportionally more vulnerable to peak suspended sediment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

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

Salmon River Trap Results

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

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



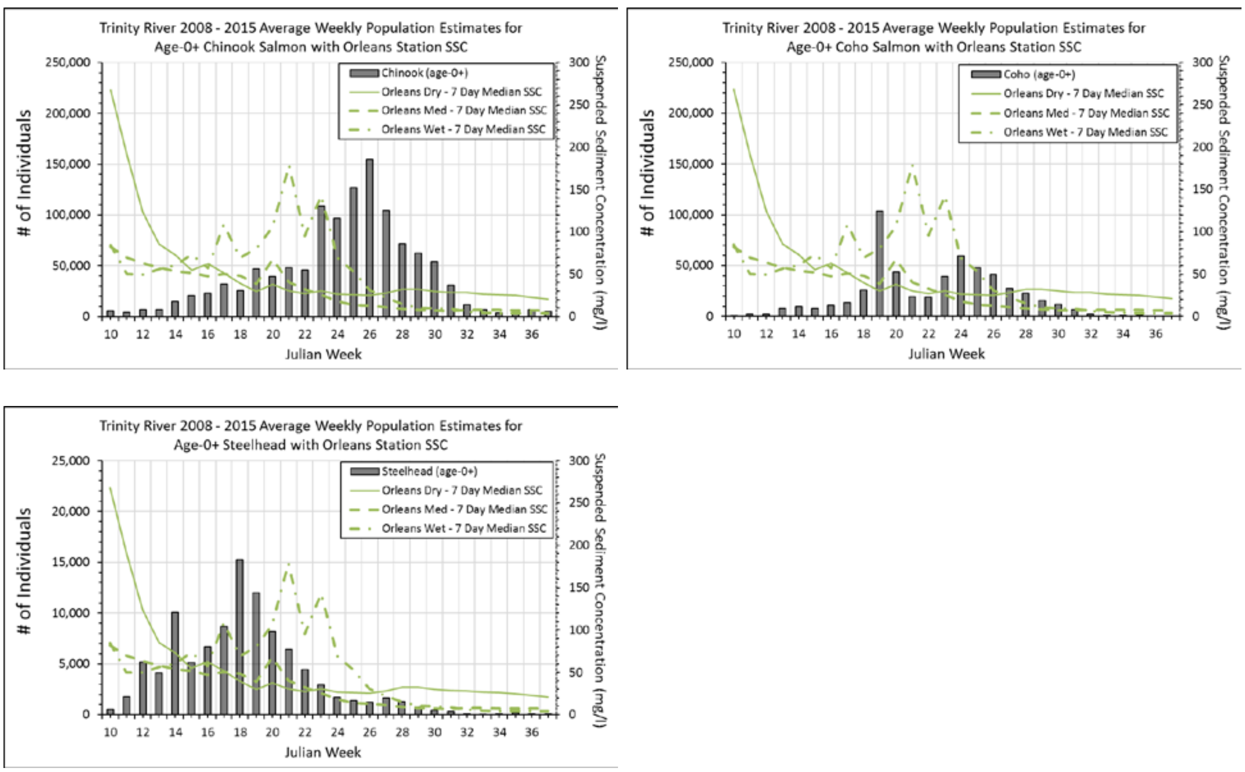
Anticipated suspended sediment concentrations from the Orleans station are also presented. Suspended sediment concentrations during the outmigration period are less than the mortality thresholds of 1,000 mg/L and 3,000 mg/L.

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

Trinity River near Willow Creek Trap Results

USFWS and Yurok Tribe maintain a screw trap on the Trinity River at RM 21.1. The Trinity River joins the Klamath River at RM 43.4. Suspended sediment concentrations for the Orleans modeling station and Chinook salmon (age-0+), coho salmon (age-0+), and steelhead (age 0+) population estimates based on 2008 to 2015 screw trap data are presented in Figure 4-8. Steelhead peak outmigration is earlier than Chinook and coho salmon outmigration timing. The outmigration values include both hatchery and naturally-produced juveniles and age-0 smolts comprise the majority of the sampled outmigrants.

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



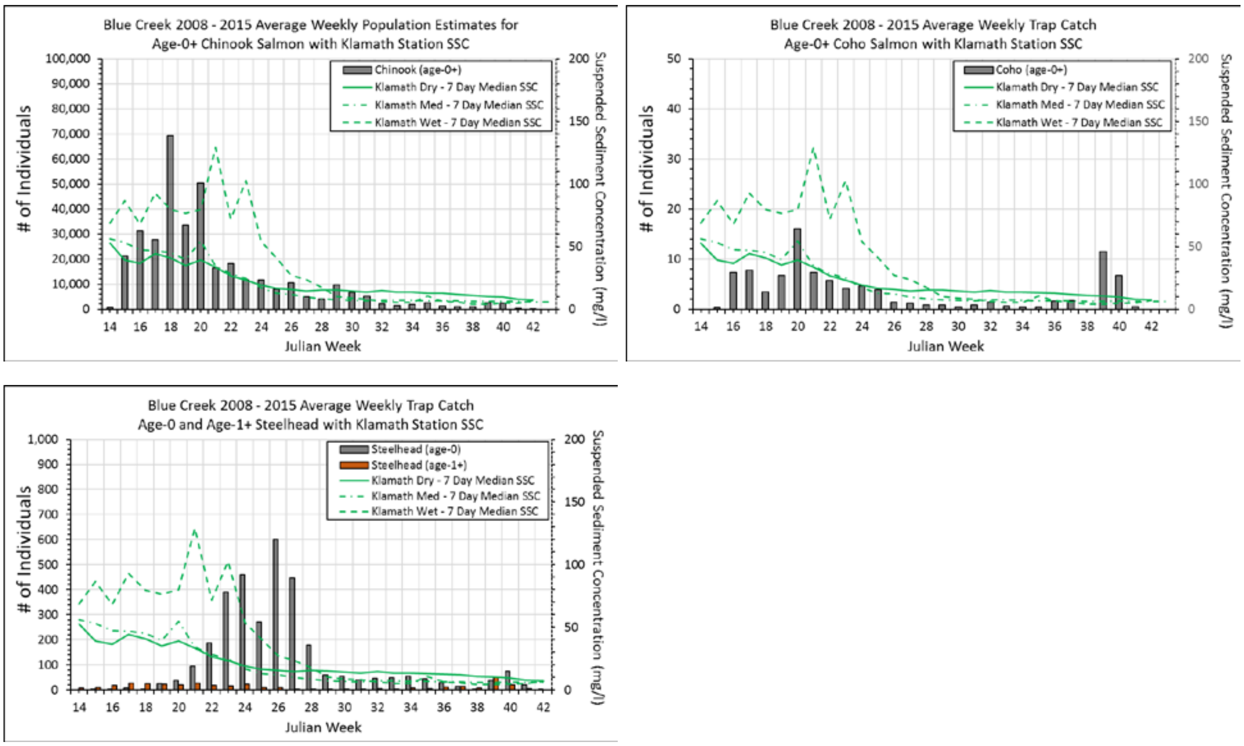
Anticipated suspended sediment concentrations from the Orleans station are also presented. Suspended sediment concentrations during the outmigration period are less than the mortality thresholds of 1,000 mg/L and 3,000 mg/L.

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

Lower Klamath River

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

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



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

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

Outmigration and Dissolved Oxygen

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

For all water year types (wet, median, dry), the predicted dissolved oxygen minimum values would occur by approximately RM 188-190 (~3-5 miles downstream from Iron Gate Dam) and would return to at least 5 mg/L by approximately RM 175-177 (2 to 4 miles below the Shasta River confluence. The North Coast Basin Plan water quality objective for dissolved oxygen is expressed as percent saturation; at 90 percent saturation, the water quality objective for November through April, assuming average February (2009) water temperatures, would be 9.6-10.6 mg/l. Based on the spreadsheet model results, recovery to the North Coast Basin Plan water quality objective of 90 percent saturation would occur generally within the reach from Seiad Valley (RM 131.9) to the mainstem confluence with Clear Creek, or within a distance of 62-93 miles downstream from Iron Gate Dam, for all water years.

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

Outmigration and Suspended Sediment Summary

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

4.3.4 Juvenile Salmonid Suspended Sediment Avoidance Behavior Review

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

Avoidance Behavior

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

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

Exposure to Organics-based Suspended Sediment

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

4.3.5 Summary of Additional Information on Potential Project Effects on Juvenile Outmigration

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

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

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

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

4.4 Juvenile Salmonid Outmigration Variability Plots

4.4.1 Introduction

KRRC prepared outmigration variability plots for trap data from the Klamath River and select tributaries. The plots provide an indication of the variability of outmigration timing by species and trap location. Outmigration variability is related to flow, water temperature, food resources, and other biological and environmental cues. The following sections review outmigration variability based on recent juvenile outmigration data.

4.4.2 Upper Klamath River – Bogus Net Frame and Kinsman Trap Results

Population estimates developed from Bogus net frame and Kinsman rotary screw trap catch data were aggregated for the 2008 to 2015 period. Variability plots were developed to assess outmigrant population variability for each location over the 10-year period (Figure 4-10). Weekly population estimates tended to be the most variable in the middle portion of the outmigration period when years with large population estimates created data outliers. Chinook salmon were the most abundant of the three analyzed species.

4.4.3 Upper Klamath River – Shasta River and Scott River Trap Results

Population estimates developed from Shasta River and Scott River rotary screw trap catch data were aggregated for the 2008 to 2016 period (Shasta River coho analysis from 2009 to 2016). Variability plots were developed to assess outmigrant population variability for each location over the 11-year period (Figure 4-11). Weekly population estimates tended to be the most variable in the middle portion of the outmigration period for age 0+ Chinook salmon. Chinook salmon were the most abundant of the three analyzed species.

4.4.4 Middle Klamath River –Trinity River Trap Results

Population estimates developed from Trinity River rotary screw trap catch data were aggregated for the 2008 to 2015 period. Variability plots were developed to assess outmigrant population variability for the trap location over the 10-year period (Figure 4-12). Weekly population estimates tended to be the most variable for coho salmon due to their overall small population size.

4.4.5 Lower Klamath River – Blue Creek Trap Results

Population estimates developed from Blue Creek rotary screw trap catch data were aggregated for the 2008 to 2015 period. Variability plots were developed to assess outmigrant population variability for the trap location over the 10-year period (Figure 4-13). Population estimates were generated for age 0+ Chinook salmon and age 0+ steelhead. Estimates were not generated for coho due to low catch. Chinook salmon had larger population estimates relative to steelhead.

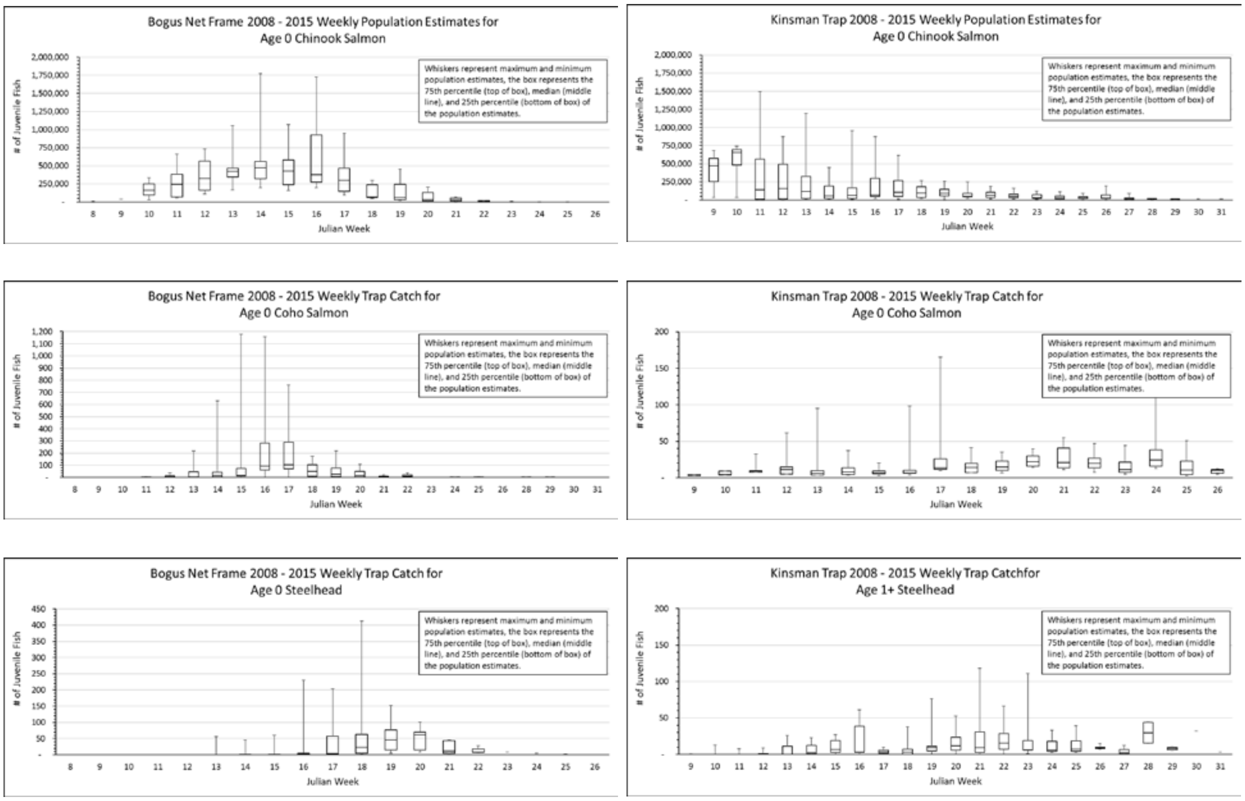


Figure 4-10 Chinook salmon, coho salmon, and steelhead weekly population estimates and trap catch results for the Bogus net frame and Kinsman rotary screw trap on the Klamath River.

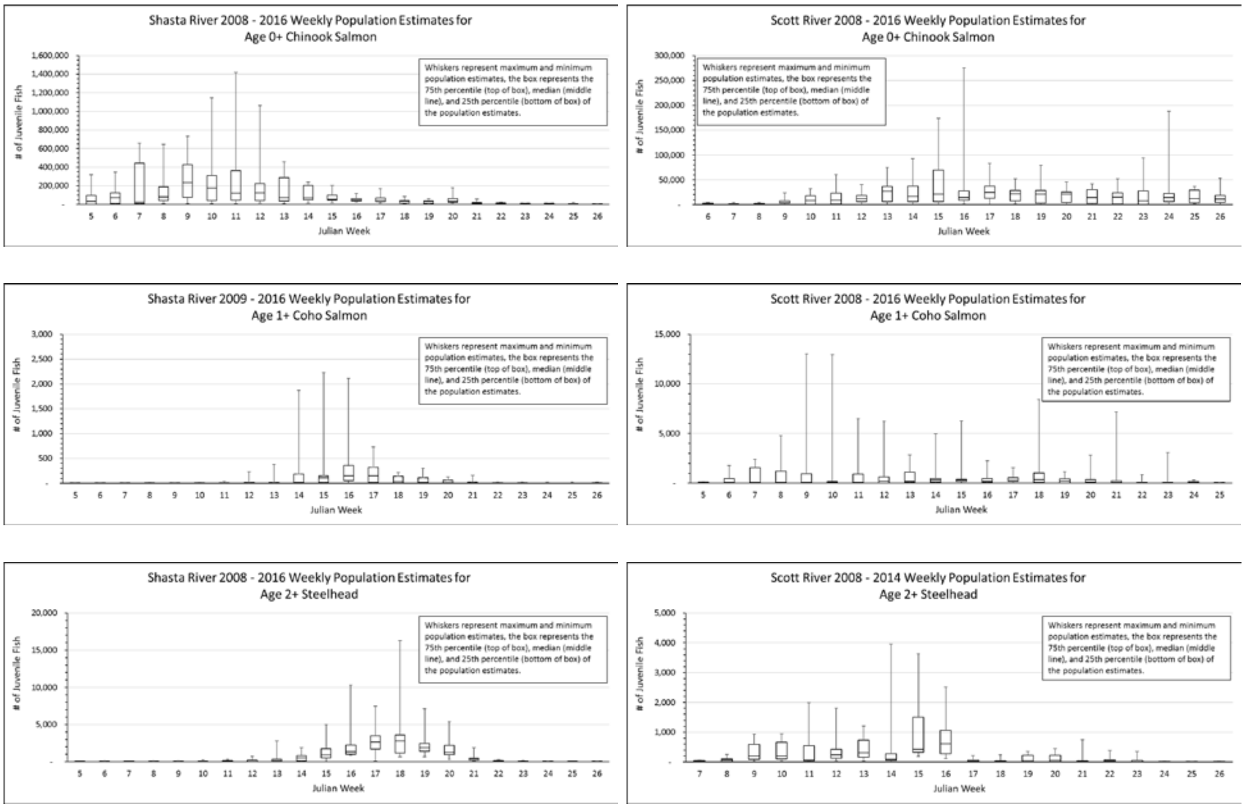


Figure 4-11 Chinook salmon, coho salmon and steelhead weekly population estimates for the Shasta River and Scott River traps.

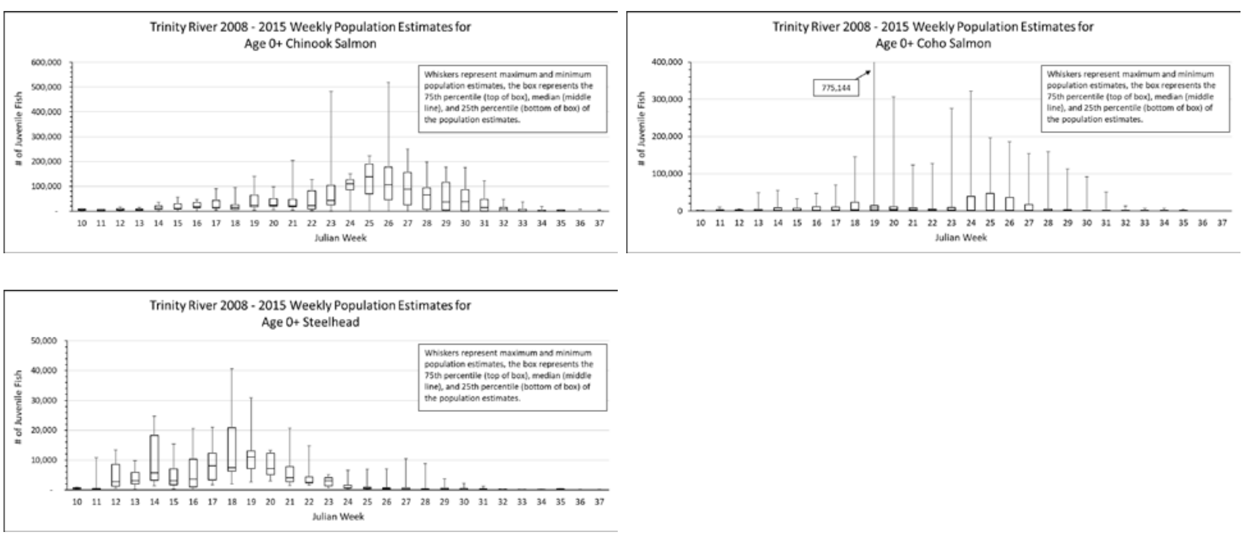


Figure 4-12 Chinook salmon, coho salmon and steelhead weekly population estimates for the Trinity River trap.

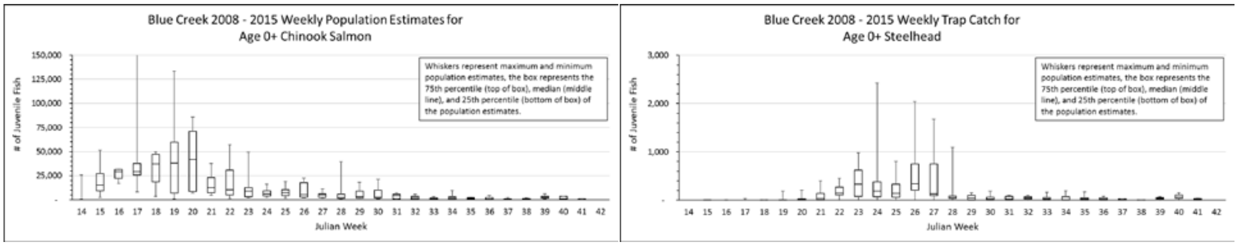


Figure 4-13 Chinook salmon and steelhead weekly population estimates for the Blue Creek trap.

4.5 Summary

The Project is anticipated to have significant short-term effects, but long-term benefits, for fall Chinook salmon, coho salmon, winter steelhead, and Pacific lamprey. KRRC's proposed outmigrating juveniles measure 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, nearby off-channel ponds, or in the Klamath River downstream of the confluence of the Trinity River. KRRC's proposed three-pronged approach is anticipated to offset the short-term effects to outmigrating juvenile salmonids.

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Chapter 5: Fall Pulse Flows

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5. FALL PULSE FLOWS

The objective of AR-3 in the 2012 EIS/R was to address reservoir drawdown and project effects on anadromous fish that migrate and spawn in the mainstem Klamath River and its tributaries. Specifically, the 2012 EIS/R AR-3 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. In 2012, the fall pulse flows were anticipated to reduce the effects of elevated suspended sediment concentrations on anadromous fish inhabiting the Klamath River.

However, KRRC and the ATWG have concluded 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 based on a review of the best available science regarding Klamath River fisheries and project effects. In particular, 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 would therefore be either infeasible and/or unnecessary to implement depending on the meteorological conditions prior to the Project. Therefore, KRRC will not implement fall pulse flows to offset the suspended sediment effects related to the Project.

5.1 Summary of the Affected Species, Project Benefits and Effects, Recent Fisheries Literature, and the 2012 EIS/R AR-3

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

5.1.1 Affected Species

Species identified in the measure include:

- Coho salmon *(Oncorhynchus kisutch)* – Southern Oregon/Northern California Coastal (SONCC) 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 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 Project Effects on AR-3 Species

Short-term project effects (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). The 2012 EIS/R analysis predicted that approximately 2,100 fall Chinook salmon redds and approximately 13 SONCC coho salmon redds would 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 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 from the 2012 EIS/R.

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 an overview of the 2012 EIS/R analysis of species-specific effects (USBR and CDFG 2012; Vol. I, pp. 3.3-129 to 3.3-168).

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 increased sediment during implementation of the Project. However, the 2012 EIS/R anticipated direct mortality of redds and smolts from the upper Klamath River, mid-Klamath River, Shasta River, and Scott River population units. No mortality was 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 Project 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 were anticipated to 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 Project are thought to be from returning hatchery fish (NOAA 2010). Based on the range of escapement estimates in Ackerman et al. (2006), the 2012 EIS/R concluded that 13 redds would 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).

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 Project was 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 middle or lower Klamath River, where suspended sediment concentrations resulting from the Project are expected to be lower due to dilution from tributaries.

Suspended sediment was 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 was anticipated to 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 were constructed in the mainstem Klamath River and represented approximately 8 percent of total, basin-wide escapement (USBR and CDFG 2012).

Steelhead – Summer and Winter

High suspended sediment concentrations resulting from the Project were 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 Project 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 Project 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 project effects. Project modeling results suggests the loss of up to 1,988 winter steelhead redds and up to 130 summer steelhead redds.

Green Sturgeon

Under the 2012 EIS/R most-likely-to-occur scenario and worst-case scenario, the 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 project-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 project 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 the Project.

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 the Project. 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

The 2012 EIS/R AR-3 (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 Project.

The 2012 EIS/R AR-3 suggested that water releases from the Klamath River Hydroelectric Reach reservoirs would mimic the natural hydrograph during a wet year prior to the dam deconstruction project, and flows would 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 AR-3 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 2012 EIS/R AR-3 also specified that spawning surveys could be conducted prior to reservoir drawdown to monitor the measure's effectiveness.

5.1.4 KRRC's and the ATWG's Review of AR-3 for Feasibility and Appropriateness

KRRC assessed the feasibility and appropriateness of the 2012 EIS/R 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 Project. The ATWG's major concerns regarding the 2012 EIS/R 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.

Each of the ATWG's concerns are discussed in greater detail below.

Uncertainty of Water Availability Prior to Reservoir Drawdown

The ATWG is concerned 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 uncertainty and executing the measure may not be feasible. 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.

Tributary Flows Influencing Tributary Spawning

The ATWG concluded 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 found 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 observed 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 the ATWG concluded that the prescribed fall pulse flows would have little or no effect on tributary streamflow and would not likely result in any additional tributary spawning during a dry year, and therefore should not be implemented as part of the Project.

Water Needs for Sediment Evaluation During Reservoir Drawdown

The 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 due to insufficient water during reservoir drawdown. By using available water prior to reservoir drawdown, the ATWG expressed concern that less water during reservoir drawdown would result in less sediment being evacuated in the first year, causing prolonged sediment effects beyond the Project.

As such, KRRC and the ATWG concluded that using available storage water in the fall prior to reservoir drawdown could 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 the Project.

Adult Coho Salmon Locations at Time of Reservoir Drawdown

KRRC and the ATWG concluded that since natural origin 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 the ATWG therefore found that project 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.

Green Sturgeon Outmigration Timing

KRRC and the ATWG found 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 the Project.

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 project effects on adult Chinook and coho salmon, and green sturgeon. Additionally, 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.

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.

5.2 Summary of Rationale for Eliminating AR-3

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 project. The 2012 EIS/R anticipated that these migratory behaviors in response to the fall pulse flows to reduce the effects of high suspended sediment concentrations on anadromous species in the mainstem Klamath River.

However, KRRC and the 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, the best available science suggests that higher mainstem flows would not 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 Project. Finally, implementing the fall pulse flows could also diminish available storage that could be used to maximize reservoir sediment flushing during reservoir drawdown. For these reasons, KRRC does not propose AR-3 as part of the Project.

Chapter 6: Iron Gate Hatchery Management

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6. IRON GATE HATCHERY MANAGEMENT

Under the Klamath Hydroelectric Project license, CDFW operates the Iron Gate Hatchery with funding from PacifiCorp. Under Section 7.6.6 of the KHSA, PacifiCorp will transfer the hatchery to CDFW at the time it transfers the Iron Gate Development to the KRRC. PacifiCorp will fund the operation of the hatchery for eight years after decommissioning of Iron Gate Development. CDFW will operate the hatchery; KRRC, PacifiCorp, and CDFW will enter into an agreement to implement these responsibilities.

The objective of the Iron Gate Hatchery management measure is to address reservoir drawdown and project effects on hatchery-produced Chinook salmon and coho salmon smolts that will 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 2012 EIS/R AR-4 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.

KRRC will cooperate with CDFW, which will implement this measure, so that Iron Gate Hatchery-reared yearling coho salmon scheduled to be released in the spring of the drawdown year would 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 removal, yearling coho salmon releases could be delayed to avoid lethal water quality conditions. 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. CDFW, which will operate Iron Gate Hatchery, will implement this measure pursuant to the terms of the Iron Gate Hatchery Agreement and Section 7.6.6 of the KHSA.

6.1 Summary Affected Species, Anticipated Project Benefits and Effects, Recent Fisheries Literature, and Proposed Measure

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

6.1.1 Affected Species

Species that the measure is intended to address include:

- Coho salmon *(Oncorhynchus kisutch)* – SONCC 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 Project Effects on Measure Species

The 2012 EIS/R concluded that short-term effects of the project would 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 were expected to be caused by high SSC levels and low dissolved oxygen concentrations in the Klamath River from Iron Gate Dam downstream to Orleans. The 2012 EIS/R concluded that hatchery-produced Chinook and coho salmon smolts 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 Project. Iron Gate Hatchery 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

Release Year	Chinook	Coho	Steelhead	Total
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	4,738,180	89,500	-	1,035,004
2016	4,612,598	27,568	-	4,642,182
2017	1,431,471	17,102	-	429,805
Total	91,595,074	1,305,040	958,588	89,077,379
Max	7,046,755	155,840	195,698	7,221,277
Ave	5,387,946	76,767	79,882	5,239,846
Min	1,431,471	17,102	18,461	429,805

6.1.3 2012 EIS/R AR-4

The 2012 EIS/R AR-4 (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 the Project. The first action is to delay the coho salmon yearling release until later in the spring (e.g., early to mid-May) in order to avoid peak SSC levels associated with the Project. The 2012 EIS/R anticipated that avoiding the peak SSC levels would reduce smolt mortality.

The 2012 EIS/R AR-4 provided an alternative action to the delayed smolt release approach, which 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 have been consistent with normal hatchery release schedules.

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

6.1.4 KRRC's and ATWG's 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. The ATWG's major concerns regarding the 2012 EIS/R AR-4 included:

- Iron Gate Hatchery water supply uncertainty during and after the Project.
- 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.

Iron Gate Hatchery Water Supply Uncertainty

The ATWG voiced concerns that the current water supply for the Iron Gate Hatchery is located in Irong Gate Reservoir which will no longer be operational following the Project. Additionally, high suspended sediment concentrations 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.

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 and that truck or equipment malfunction could also result in smolt losses during transport. Studies confirm that 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 therefore that transporting hatchery Chinook and coho salmon smolts long distances downstream from Iron Gate Hatchery could lead to high mortality rates.

Potential Chinook and Coho Salmon Juvenile Imprinting and Adult Straying Issues

The ATWG observed that how juvenile salmonids are handled and transported 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 ATWG concluded that 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 found 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 Summary

The 2012 EIS/R AR-4 included two strategies for addressing short-term project 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 Project. 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. KRRC therefore recommends to CDFW that the release schedule be delayed to that limited extent. However, KRRC does not propose the trucking option because of concerns about potential juvenile stress and mortality, as well as increased stray rates of returning adults due to insufficient juvenile imprinting.

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Chapter 7: Pacific Lamprey Ammocoetes

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7. PACIFIC LAMPREY AMMOCOETES

The objective of the 2012 EIS/R AR-5 was to monitor the distribution and abundance of Pacific lamprey ammocoetes downstream of Iron Gate Dam. The 2012 EIS/R AR-5 involved capturing and relocating Pacific lamprey ammocoetes from the Klamath River starting at, and extending 2 miles downstream from Iron Gate Dam (RM 193.1). 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.

However, the KRRC does not intend to implement AR-5 as part of the Project. Based on the best available information on lamprey ammocoete presence in the Klamath River downstream from Iron Gate Dam, it is expected that Project effects to Pacific lamprey ammocoetes in the 2-mile reach downstream from Iron Gate Dam (RM 193.1) will be minimal.

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

The following sections review the components of the 2012 EIS/R AR-5, anticipated project effects and benefits on Pacific lamprey ammocoetes, and recent fisheries literature relative to Pacific lamprey ammocoetes that support KRRC's decision not to include AR-5 as part of the Project.

7.1.1 Affected Species

Species intended to be addressed in the 2012 EIS/R AR-5 include:

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

7.1.2 Anticipated Project Effects on AR-5 Species

The short-term effects of the Project (high suspended sediment concentrations and low dissolved oxygen) are anticipated to result in high rates of ammocoete mortality, although there is uncertainty in how resilient ammocoetes are to extended periods of high suspended sediment concentrations and low dissolved oxygen (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. However, the best available science indicates that this overestimates 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 in the 2-mile reach of the Klamath River downstream from Iron Gate Dam

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

Source: USBR and CDFG 2012

The Project will 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). Short-term effects on Pacific lamprey ammocoetesin the Klamath River are anticipated to be substantial 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 Project will be most pronounced. However, most of the population (which spans nearly the entire northern Pacific Rim), would not be affected by the Project because of the species' wide spatial distribution and varied life history. 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 the Project.

The 2-mile reach of the Klamath River downstream from Iron Gate Dam (RM 193.1) was the focus of the proposed lamprey relocation efforts proposed in the 2012 EIS/R (Reclamation and CDFG 2012). However, 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). The low ammocoete density in this reach is presumably related to 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 by these sources 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).

The Project 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

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

- 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's and the ATWG's 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. The ATWG's major concerns regarding the 2012 EIS/R 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 feasibility and appropriateness of the 2012 EIS/R AR-5 based on supplemental information provided in the 2012 EIS/R, current fisheries research literature, and input from the ATWG.

Pacific Lamprey Ammocoetes Absence from Salvage Reach

Recent 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 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 recent ammocoete surveys were completed, Pacific lamprey ammocoete habitation in the 2-mile reach downstream of Iron Gate Dam is unlikely. The ATWG concluded that further allocation of resources to sample ammocoetes from this reach is not warranted.

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 in mind, 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 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.

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 lampreys 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 Project will be insignificant. The ATWG concluded that the potential loss of Pacific lamprey ammocoetes during the Project would be a temporary impact to the population and ammocoete mortality would constitute a minimal impact to the metapopulation.

7.2 Summary of Rationale for Eliminating AR-5

The Klamath River from Iron Gate Dam downstream to the Scott River (47 river miles) is referred to as a zone of low Pacific lamprey ammocoete densities. Recent sampling efforts conducted after the release of the 2012 EIS/R have detected few or no ammocoetes in this reach. Based on these sampling efforts and concerns regarding Pacific lamprey ammocoete relocation, KRRC does not propose AR-5 as part of the Project. Pacific lamprey are expected to benefit from the Project over the long-term due to the restoration of 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.

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Chapter 8: Suckers

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8. SUCKERS

The objective of the suckers measure is to address reservoir drawdown and project 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 2012 EIS/R AR-6 focused on trapping and hauling Lost River, shortnose, and Klamath smallscale suckers. Lost River and shortnose suckers will 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 revisions to AR-6 are necessary to address anticipated short-term effects of the Project. The measure proposed as part of the Project includes a step-wise adaptive process for sampling, salvaging, and releasing Lost River and shortnose suckers into waterbodies that will not be affected by project effects.

8.1 Proposed Measure

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

- **Action 1:** Lost River and shortnose suckers will be sampled in the Klamath River and in Hydroelectric Reach reservoirs in 2018, 2019, and 2020. River sampling will be completed in spring of 2019 and 2020, and reservoir sampling will be completed in fall of 2018 and 2019. Each sampling will require approximately 6 days for an estimated 24 days of sampling across the 2018 to 2020 period. 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 sucker abundance in the sampled reservoirs. 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 will be captured and relocated to isolated water bodies in the Klamath Basin. The proposed relocation of rescued suckers to isolated waterbodies is to ensure hybridized suckers do not mix with sucker populations designated as recovery populations in Upper Klamath Lake. An estimated 14 days will be required for salvage and release efforts. Due to the poor current understanding of Lost River and shortnose sucker populations in the reservoirs, we are unsure of the number of adult suckers inhabiting the reservoirs. Based on past study results (e.g., Desjardins and Markle 2000), we anticipate salvaging and translocating 100 adult Lost River and 100 adult 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 proposed actions are intended to reduce project effects on Lost River and shortnose suckers inhabiting the Hydroelectric Reach reservoirs. The following sections provide additional detail on the proposed actions.

8.1.1 Action 1: Reservoir and River Sampling

Lost River and shortnose suckers will be sampled in the Hydroelectric Reach reservoirs and the Klamath River in 2018, 2019, and 2020. Sampling in both the reservoirs and the Klamath River is anticipated to improve the number of fish encounters since suckers may not spawn every year (Buettner 2000) and the current population demographics are unknown.

River sampling will be completed in spring of 2019 and 2020, and reservoir sampling will be completed in fall of 2018 and 2019. 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 identified by species and sex, marked with a PIT tag (Burdick 2013), fin clipped for genetic material, measured, and released. Recaptured fish will be used to estimate sucker abundance, and fin clips will be used to determine the genetics of the sampled fish. Each sampling will require approximately 6 days for an estimated 24 days of sampling across the 2018 to 2020 period. 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 by managers to understand 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 will be captured and relocated to isolated water bodies in the Klamath Basin using similar methods as outlined for the sampling. The proposed relocation of rescued suckers to isolated waterbodies is to ensure hybridized suckers do not mix with sucker populations designated as recovery populations in Upper Klamath Lake. An estimated 14 days will be required for salvage and release efforts. We anticipate salvaging and translocating 100 adult Lost River and 100 adult 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). During the course of these actions, it is not anticipated that the entire populations of suckers residing in the Hydroelectric Reach reservoirs will be recovered.

In summary, the proposed measure 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 Affected Species, Anticipated Project Benefits and Effects, Recent Fisheries Literature, the 2012 EIS/R AR-6, and the Proposed Measure

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

8.2.1 Affected Species

Species intended to be addressed in the 2012 EIS/R 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 Project Effects on Measure Species

The 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). 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.

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 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

The 2012 EIS/R AR-6 (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 the Project, the 2012 EIS/R AR-6 called for Klamath smallscale suckers 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's and the ATWG's 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 of the ATWG regarding the 2012 EIS/R AR-6 include:

- Genetic integrity of salvaged suckers and effects on recipient populations.
- Relocation site availability.
- Klamath small scale 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 these concerns, AR-6 feasibility and appropriateness based on fisheries literature and ATWG input.

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 the potential relocation of 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, KRRC and the ATWG concluded that relocating salvaged suckers to Upper Klamath Lake could threaten recovery populations and alternative release locations are necessary.

Relocation Site Availability

Salvaged sucker relocation sites must be isolated from Lost River and shortnose sucker populations inhabiting critical habitat or recovery areas 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 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.

KRRC will coordinate with USFWS the release of salvaged suckers into Tule Lake or another isolated waterbody during the fall of 2020 salvage. USFWS will determine if/when suckers are translocated from Tule Lake to Upper Klamath Lake. USFWS' decision will in part depend on a better understanding of Hydroelectric Reach sucker genetics.

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 2012 EIS/R AR-6, Klamath smallscale sucker is not a federal or state listed species, and is not recognized as a tribal trust species. Therefore, KRRC and the ATWG agreed that Klamath smallscale sucker be removed from consideration in the proposed measure.

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). USFWS does not consider the preservation of the Hydroelectric Reach reservoirs or the sucker populations within them to be a requirement for Lost River and shortnose sucker species recovery.

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 prior to reservoir drawdown (2018 and 2019) 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 prior to drawdown. 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.

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 since the issuance of the 2012 EIS/R. 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 or fall of 2018.

8.3 Summary

The 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 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. The ATWG and KRRC have concerns with the 2012 EIS/R AR-6, 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. Therefore, KRRC and the ATWG determined that revisions to AR-6 were warranted.

The proposed measure, includes two primary actions including reservoir and river sampling, and sucker salvage and release into appropriate waterbodies selected by fisheries managers. The proposed measure is 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). During the course of these actions, it is not anticipated that the entire populations of suckers residing in the Hydroelectric Reach reservoirs will be recovered.

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Chapter 9: Freshwater Mussels

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9. FRESHWATER MUSSELS

The objective of the freshwater mussels measure is to address reservoir drawdown and project effects on freshwater mussels located in the Klamath River in the Hydroelectric Reach and downstream from Iron Gate Dam (RM 193.1). The 2012 EIS/R AR-7 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 will not be affected by the reservoir drawdown. Based on a review of the information discussed in greater detail below, KRRC and the ATWG concluded that a moderate scale freshwater mussel relocation effort is warranted. The proposed measure includes a freshwater mussel reconnaissance in 2019 followed by a limited freshwater mussel salvage prior to reservoir drawdown. Specifically, KRRC will salvage freshwater mussels from the 8-mile long Iron Gate Dam (RM 193.1) to Cottonwood Creek (RM 185.1) reach and translocate these mussels to the Klamath River between the upstream extent of J.C. Boyle Reservoir (RM 234.1) and Keno Dam (RM 239.2).

9.1 Proposed Measure

Based on a review of the 2012 EIS/R AR-7 presented in Section 9.2 below, input from the ATWG, and current freshwater mussels literature, the KRRC concluded that revisions to AR-7 are necessary to offset the anticipated short-term effects of the Project on freshwater mussels. The proposed measure 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:** KRRC will complete a reconnaissance in 2019 to assess the distribution and density of freshwater mussels in the 8-mile long bedload deposition reach from Iron Gate Dam (RM 193.1) downstream to the Cottonwood Creek confluence (RM 185.1). The reconnaissance effort will determine if the mussel beds identified in the 2007-2010 surveys are still present, and estimate abundance of a subset of the mussel beds in the reach.
- **Action 2**: Based on the reconnaissance, KRRC will salvage and relocate a portion of the freshwater mussels located between Iron Gate Dam and Cottonwood Creek prior to drawdown to reduce project effects to the mussel community. Up 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 234.1) and Keno Dam (RM 239.2).

The proposed measure is intended to reduce project effects on freshwater mussels located downstream from Iron Gate Dam. The following sections provide additional detail on the proposed measure 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 234.1) upstream to Keno Dam (RM 239.2) 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 project 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. During the course of these actions, it is not anticipated that the entire population of mussels residing below Iron Gate Dam will be recovered.

9.2 Summary of the Affected Species, Anticipated Project Benefits and Effects, Recent Literature, 2012 EIS/R AR-7, and Proposed Measure

The following sections review the components of the 2012 EIS/R AR-7, anticipated project effects and long-term benefits on freshwater mussels, and current freshwater mussel literature.

9.2.1 Affected Species

Species intended to be addressed in the 2012 EIS/R 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 Project Effects on Measure Species

Short-term effects of the Project (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 project implementation may also disrupt the current distribution of freshwater mussels downstream from Iron Gate Dam (Davis et al. 2013). Table 9-1 includes the likely and worst-case effects on freshwater mussel species in the Klamath River.

Table 9-1 2012 EIS/R anticipated effects summary for freshwater mussels

Species	Life Stage	Likely Effects	Worst Effects
California Floater Oregon Floater Western Ridged Western Pearlshell	All	Substantial reduction in populations	Substantial reduction in populations

Source: USBR and CDFG 2012

The following sections include descriptions of anticipated effects to freshwater mussels based on information 2012 EIS/R (Reclamation and CDFG 2012; Vol. 1, pp. 3.3-173 to 3.3-175) as well as additional information from additional freshwater mussel studies, some of which were completed after the publication of the 2012 EIS/EIR.

Freshwater Mussels

Available studies have 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 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 Project 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

The 2012 EIS/R AR-1 (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 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's and the ATWG's 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. The ATWG's concerns 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.

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. For that project, 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.

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.

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 worms, 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 Summary

The Project is anticipated to have significant short-term effects, but long-term benefits for freshwater mussels. The 2012 EIS/R AR-7 included a freshwater mussel salvage and relocation pilot study followed by an informed salvage and relocation plan prior to the Project. The proposed 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. KRRC will salvage and relocate freshwater mussels prior to the reservoir drawdown. It is not anticipated that the entire population of mussels residing below Iron Gate Dam will be recovered.

Chapter 10: References

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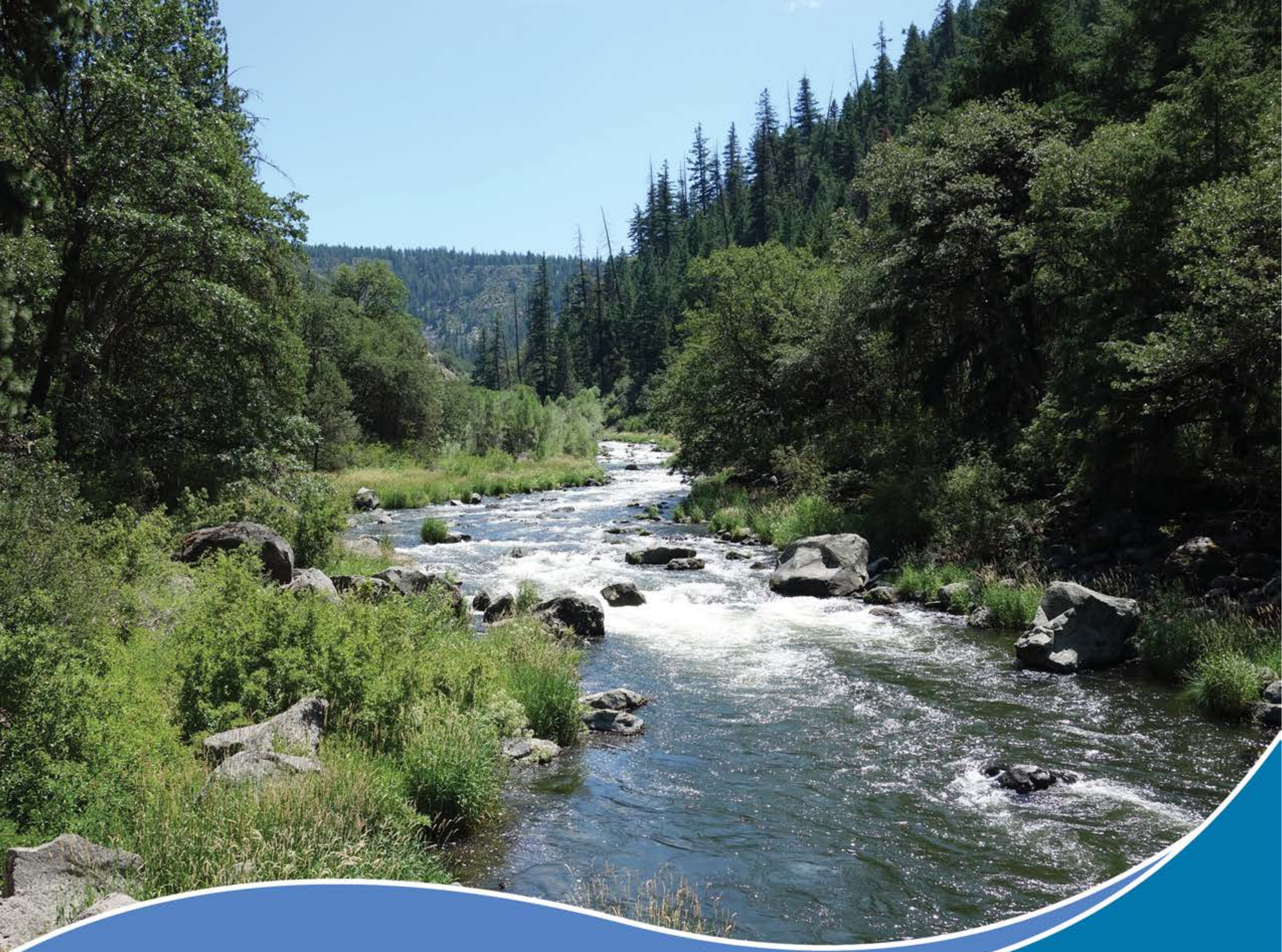

Definite Plan for the Lower Klamath Project

Appendix J - Terrestrial Resource Measures

KLAMATH RIVER RENEWAL CORPORATION

June 2018

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Attachments

Acronyms

BA	Biological Assessment
BLM	Bureau of Land Management,
BO	Biological Opinion
CDFW	California Department of Fish and Wildlife
CESA	California Endangered Species Act
CNDDB	California Natural Diversity Database
CNPS	California Native Plant Society
CWHRS	California Wildlife Habitat Relations System
DBH	diameter at breast height
EIS/R	Environmental Impact Statement/Environmental Impact Report
GIS	geographic information system
IPaC	Information for Planning and Consultation
MBTA	Migratory Bird Treaty Act
mph	miles per hour
NCASI	National Council for Air and Stream Improvement, Inc.
NED	National Elevation Dataset
NISIMS	National Invasive Species Information Management System
NMFS	NOAA National Marine Fisheries Service
NSO	Northern Spotted Owl
ODA	Oregon Department of Agriculture

ODFW	Oregon Department of Fish and Wildlife
ODSL	Oregon Department of State Lands
ONHP	Oregon Natural Heritage Program
ORBIC	Oregon Biodiversity Information Center
ORWAP	Oregon Rapid Wetland Assessment Protocol
RHS	Relative Habitat Suitability
USFWS	U.S. Fish and Wildlife Service
USFS	U.S. Forest Service
USGS	U.S. Geological Survey

Chapter 1: Northern Spotted Owl Measures

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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) within the project area. As FERC's designated non-federal representative pursuant to 50 CFR § 402.08, KRRC is developing a Biological Assessment to evaluate effects on NSO and other federally listed species. KRRC is coordinating with the U.S. Fish and Wildlife Service (USFWS) and NOAA National Marine Fisheries Service (NMFS) on the development of the draft Biological Assessment. The first step is to conduct surveys in suitable habitats as described below. If KRRC identifies NSO activity centers within the project area, the design plans and/or construction methods or sequencing will be modified to avoid and minimize potential effects on NSO.

The 2012 Final EIS/R (USBR and CDFW 2012) TER-2 described measures to reduce project impacts on nesting birds including NSO. The 2012 EIS/R 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 as part of the Project and will be implemented as described in the following sections. The objective of the proposed TER-2 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. KRRC will use that information to develop a plan in coordination with the USFWS and California Department of Fish and Wildlife (CDFW) to provide avoidance and minimization measures for NSO and NSO habitat and use.

1.2 Methods

Study methods include a desktop evaluation, selection of calling stations, and field surveys. Initially biologists compiled existing data on known NSO occurrences and spatial information on habitat suitability to select calling stations. KRRC conducted a field reconnaissance survey in October 2017 to view and refine calling station locations. The methodology for NSO surveys is based on the 2012 USFWS NSO Survey Protocol (USFWS 2012b).

1.2.1 Desktop Evaluation

KRRC conducted a desktop review of existing databases (including California Natural Diversity Database [CNDDB] and the Oregon Biodiversity Information Center [ORBIC]) 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 southeast of Copco No. 1 Reservoir (PacifiCorp 2004). Figures A-1 and A-2, respectively, show these detections.

In addition to the 2002-2003 PacifiCorp protocol surveys, information was obtained from 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).

BLM (Hayner 2017) confirmed there are no known 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 limits of work. USFS (Freeling 2017) confirmed a known NSO activity center located approximately 1.3 miles southeast of the eastern end of Copco Lake and over 5 miles southeast of the Copco No. 1 Dam and powerhouse. Based on CNDDB records, this activity center has been monitored by USFS since 1988. Surveys over the years have confirmed NSO nesting activity, and adults and young have been banded by USFS biologists.

Therefore, based on the desktop evaluation, no NSO activity centers have been documented within the disturbance distances established in the Biological Assessment (i.e., 1 mile from blasting at dams, 0.5 miles from limits of work) (Biological Assessment (BA), U.S. Bureau of Reclamation [USBR] 2011) for the anticipated construction activities. KRRC will confirm this through field surveys, as described below.

The J.C. Boyle powerhouse is located within designated critical habitat for NSO. KRRC does not anticipate effects on designated critical habitat at the J.C. Boyle facilities because removal of the facilities will not involve the removal of forest cover and will provide opportunities for habitat restoration. Removal of mature trees will occur at the proposed disposal site at J.C. Boyle, which does not provide suitable NSO habitat, as described below. The proposed disposal site is not located within designated critical habitat for NSO.

1.2.2 Selection of 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. Ongoing habitat alteration due to logging is not reflected in the USFWS or BLM habitat suitability data. It is likely that this alteration has reduced the habitat suitability for NSO within the noise disturbance areas.

Based on the habitat suitability information and verified during the field reconnaissance described below, 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, KRRC evaluated aerial imagery with topographic contours against the habitat suitability information and the 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 will occur, frequency, duration, and season) was used to outline potential calling stations based on the noise disturbance distances established in the BA. KRRC also considered Activities such as grading or other use of heavy machinery that may occur during restoration of the reservoir areas.

KRRC conducted a focused field reconnaissance in October 2017 by CDM Smith biologists and USFWS biologist Bob Carey to evaluate proposed calling stations. During the reconnaissance, these biologists visited each of the proposed calling stations and noted the habitat present, ambient noise and acoustics, topography, and accessibility for nighttime surveys. Based on the findings of the field reconnaissance, KRRC revised calling station locations as appropriate to cover existing suitable habitat and to ensure adequate coverage of all suitable habitat. Figures 1-3 in Attachment A show calling stations.

The boundaries of the proposed disposal site at J.C. Boyle Dam are still being refined, although KRRC has identified the general location. A portion of the approximately six-acre disposal site is disturbed; however, trees will be removed from a forested area consisting of approximately 2 acres. During the field reconnaissance in October 2017, KRRC noted that trees that may be removed at the disposal site consist primarily of Ponderosa pines ranging between approximately 16 to 30 inches diameter at breast height (DBH), with a majority of trees between 18 and 22 inches DBH. During the field reconnaissance in October 2017, it was noted that the forested habitat that occurs within a portion of the disposal site and surrounding the disposal site consists of an open canopy (30-40 percent cover; much less than the 70 percent or more cover that NSO prefer) with a lack of complex, multi-layered understories and mature forest habitat structure preferred by NSO. Therefore, the disposal site and vicinity is not suitable NSO habitat. However, the NSOs surveys, which KRRC has begun for the 2018 NSO breeding season, will confirm whether there is NSO use in the area.

During the field reconnaissance conducted in October 2017, KRRC also evaluated the habitat in the vicinity of the known NSO activity center southeast of the Copco Reservoir. In this area, the habitat consists of relatively young deciduous-oak woodland in the lower elevations with relatively open mixed forest at the higher elevations. Suitable NSO habitat at the higher elevations is outside the noise disturbance distance from Ager-Beswick Road that runs along the south side of the Copco Reservoir. The nearest NSO detection documented in the CNDDB is over one mile from the bridge that crosses the east end of Copco Lake. The NSO activity center itself is farther to the southeast. In addition, most of the NSO detections documented in the CNDDB are within a drainage and not within line-of-sight to the Project. Because suitable habitat is located outside the noise disturbance buffer from proposed project activities, KRRC will not conduct NSO surveys in the Copco area.

Habitat modification is defined as activities that occur in spotted owl nesting, roosting, or foraging habitat that reduce the canopy or other elements of spotted owl habitat at the stand-level (USFWS 2012b). KRRC does not anticipate project activities that may remove individual or small groups of trees or other vegetation, such as widening existing roads, to rise to the level of NSO habitat modification, given the lack of suitable nesting, roosting, or foraging habitat within the areas where those activities will be conducted. KRRC used a distance of 1.3 miles in California and 1.2 miles in Oregon for analyzing effects to nesting spotted owls from habitat modification such as timber harvest. Since the Project will not result in NSO habitat modification, avoiding noise disturbance is the focus of the surveys KRRC will complete during the 2018 NSO breeding season.

KRRC will apply the following NSO disturbance distances developed for the 2012 BA and 2012 Joint Preliminary Biological Opinion (2012 Preliminary BO) prepared for dam removal as proposed in 2012:

- 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 and field reconnaissance, KRRC determined that NSO protocol surveys will focus on suitable habitat around J.C. Boyle Dam and associated facilities, the disposal site, and haul and access roads. KRRC will not perform NSO protocol surveys for facilities associated with Copco No. 1 Dam, Copco No. 2 Dam, and Iron Gate Dam and associated reservoirs 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. KRRC may use a noise attenuation evaluation to evaluate the need for avoidance and minimization measures in accordance with the USFWS 2006 guidance (USFWS 2006) and agency input (Reilly 2017). KRRC has not yet evaluated noise attenuation from topography and other physical features as well as the duration of anticipated noise activities in certain areas.

1.2.3 Protocol Surveys

The 2012 BA and Measure NSO in the 2012 Preliminary BO called 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, KRRC does not anticipate the Project to result in modification of NSO habitat. Therefore, KRRC will conduct protocol surveys for noise-only disturbance consistent with the 2012 USFWS NSO Survey Protocol.

For noise-only disturbance, 1 year of protocol surveys is underway during the 2018 nesting season in suitable habitat within the noise disturbance areas shown in Figures 1 to 3 in Attachment A and as refined based on the field reconnaissance, noise attenuation evaluation, or other information. Figures 1 to 3 in Attachment A show the proposed survey locations on a habitat suitability model generated by USFWS, a habitat suitability model generated by BLM, and on an aerial photo showing the existing vegetation. KRRC only applied the BLM habitat suitability model to BLM lands within the project area.

KRRC is conducting NSO protocol surveys with a team of at least two biologists, with at least one spotted owl surveyor meeting the qualifications outlined in the USFWS NSO Survey Protocol developed in 2012. Visits are spaced out over the breeding season from March through August. KRRC conducted at least three of the visits before the end of June 2018.

Survey methods include nighttime spot calling and daytime stand searches. If KRRC detects a spotted owl 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. KRRC noted details of field efforts, including the methods used, weather conditions, and identified occupancy/nesting status, on field forms consistent with the 2012 USFWS NSO Survey Protocol.

Calling stations are shown in Figures 1 to 3 in Attachment A. Calling routes and stations were 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. KRRC determined the spacing of calling stations by the topography and acoustical characteristics of the area (e.g., background noise such as creeks); stations are spaced between 0.25 and 0.5 mile apart.

To summarize, KRRC is conducting NSO surveys as follows:

- KRRC is conducting six (6) disturbance-only protocol surveys in the J.C. Boyle project area during the 2018 breeding season.
- KRRC is conducting surveys 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. KRRC is also conducting surveys in suitable habitat surrounding the J.C. Boyle powerhouse, as shown in Figure 3 in Attachment A. As described above, suitable NSO habitat is outside the noise disturbance buffer in the Copco project area; therefore, KRRC is not conducting surveys in the Copco project area.
- Six survey visits are underway between March 15 and August 31, 2018, with at least three visits before the end of June. KRRC covers the project area in a span of 7 days for a complete visit. Complete visits are spaced at least 7 calendar days apart.
- Calling stations are at least 0.25 to 0.50 miles apart. Calling stations are shown in Figures 1 to 3 in Attachment A and may be revised further based on field conditions. KRRC identified a total of 18 calling stations: 11 within the 1-mile noise disturbance area around the J.C. Boyle Dam and 7 within 0.5 miles of the limits of work downstream of the J.C. Boyle Dam.
- KRRC is using nighttime spot calling surveys, with a minimum of 10 minutes spent at each calling station. KRRC will conduct follow-up daytime surveys if a spotted owl is detected during the nighttime spot calling surveys.
- KRRC is not conducting surveys 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).

KRRC will provide survey results to USFWS, CDFW, and ODFW following completion. Based on the findings, KRRC may conduct additional protocol surveys in 2019 (the next consecutive year following the 2018 surveys) in coordination with USFWS, CDFW, and ODFW.

1.3 Avoidance and Minimization Measures

KRRC will implement the following measures as part of the Project:

Measure NSO 1: KRRC will use the results of the 2018 field surveys to modify the design and/or construction plans and timing as appropriate, with an overall goal of preventing or minimizing impacts. KRRC will evaluate locations of the individual components of the Proposed Action, noise disturbances, and habitat geographic information system (GIS) layers to determine whether or not additional measures are needed.

Measure NSO 2: KRRC will conduct protocol-level surveys within suitable nesting, roosting, and foraging habitat (assessed by using best available GIS information, aerial photos, and coordination with the USFWS) as described above. If KRRC observes no nesting, no seasonal restriction will be required during project implementation. If KRRC observes nesting during the protocol surveys, a seasonal restriction (March 1–September 30) will be followed or a restriction buffer will be applied surrounding the nest to minimize the disturbance. Limited operating periods can be waived in the event of nest failure as confirmed by a biologist.

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, or it is determined in coordination with USFWS that there would be no effect on an NSO activity center.

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.

1.4 References

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Chapter 2: Bald Eagle and Golden Eagle Measures

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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 U.S.C. § 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 2012 EIS/R (Section 3.5) TER-3 described measures to reduce project impacts on bald and golden eagles. The 2012 EIS/R 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. KRRC has incorporated the proposed TER-3 into the Project and will implement it as described in the following sections. The objective of TER-3 is to identify, document, and confirm eagle presence, and eagle use of areas that may be directly or indirectly disturbed by project construction. KRRC will use that information to develop a plan in coordination with the USFWS and CDFW to provide avoidance and minimization measures for bald and golden eagles on eagle nesting, roosting, and foraging activities.

2.2 Existing Information

The Upper Klamath Basin is known to support bald eagle and golden eagle populations and provides suitable habitat for eagle nesting, roosting, and foraging.

2.2.1 Bald Eagle

The upper Klamath Basin supports a high number of nesting bald eagles and historically supports one of the largest wintering populations of bald eagles in the coterminous United States (Shuford et al. 2004). In previous 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 and near 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.

Based on recent monitoring of bald and golden eagle nests and territories in the Klamath region, there are a minimum of 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 (BLM 2017; USFWS 2017). Table 2-1 provides a summary of all known nests within 2-miles of the limits of work.

Oregon Cooperative Fish and Wildlife Research Unit conducted bald eagle nest surveys in the Klamath River area on March 27, 2002, and May 29, 2002 (PacifiCorp 2004). They recorded six known nests within and near 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 and near the project area. By agency request, exact nesting locations were not published in the PacifiCorp 2004 report. To continue to protect eagle nests, KRRC will not provide exact locations in this report.

2.2.2 Golden Eagle

Golden eagles are known to have historically nested on cliffs near 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 (PacifiCorp 2004).

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. KRRC conducted a field reconnaissance survey in July 2017. KRRC will use the viewshed analysis 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, KRRC has contacted regional experts, including Frank Isaacs of the Oregon Eagle Foundation. 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 becomes 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, KRRC conducted a viewshed analysis 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 limits of work. This analysis calculates all locations that are simultaneously visible from any observer point distributed along the limits of work. It considers topography but not vegetation.

Because the project area'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 to a feasible number, the analysis estimated observer points approximately every 20 feet along the 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 proposes limiting the surveys to those viewshed areas within 0.5 mile of the limits of work. This 0.5-mile 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 limits of work. Proposed construction activities associated with the removal 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. KRRC defined the survey area 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

KRRC is conducting bald and golden eagle surveys concurrently in 2018 by qualified avian biologists. To meet the project schedule, all eagle surveys will be complete by the end of 2018. The surveys are focusing 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 are employing a variety of techniques and multiple survey windows to capture seasonal activity.

2017 Surveys

KRRC conducted a field reconnaissance survey July 24-26, 2017. Surveyors assessed habitats in the project area by vehicle and on foot, noted bird activity, and attempted to locate 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. The reconnaissance survey primarily assessed habitat and site conditions, and was not a focused eagle nest survey.

2018 Surveys

The 2018 bald and golden eagle survey protocol was 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 are gathering information on eagle nesting behavior and habitat use within the survey area that could potentially be directly or indirectly affected by project activities. This information will provide a pre-construction baseline for monitoring eagles during project activities to assess whether such activities will adversely affect eagle behavior or habitat use.

A synthesized field survey to encompass bald and golden eagle nesting habitat use will include:

1. Breeding season surveys (late January through July 2018).
    a) KRRC conducted an initial nest search in late January and early February 2018, early in the breeding season when eagles are most likely to be found at nest sites, to determine occupancy. KRRC conducted this inventory and monitoring survey early in the season during courtship when the adults are mobile and conspicuous.
    b) KRRC conducted a second survey in early June 2018 to observe any changes in eagle behavior or mid-late season nesting activity.
    c) During these breeding season surveys, biologists have conducted 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. KRRC will conduct additional surveys during the early nesting season of the year prior to drawdown to determine continued activity and to observe eagle activity patterns to establish a baseline of normal behavior, prior to construction.

Based on accessibility, KRRC is conducting surveys on foot, with terrestrial vehicles and potentially by boat. KRRC may use motorized vehicles to transport KRRC biologists to the vicinity of nest site, but close access will be by foot to avoid disturbing nesting eagles if they are present. During the June 2018 survey, KRRC conducted helicopter surveys concurrently with ground-based surveys. During the aerial surveys, two biologists inspected suitable habitat such as treetops and cliffs for eagle nests. The biologists searched for historical/known nests to determine current nesting status, and searched for new nests based on observed eagle activity and locations of known or suspected territories. Biologists use binoculars and spotting scopes when surveying for nest occupancy. KRRC recorded detailed data 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 area and generated an initial viewshed analysis from the edge of the limits of work (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 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 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 2019 surveys.

2.4.2 Field Surveys

During the July 2017 reconnaissance survey, KRRC 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). KRRC presumed this nest 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; KRRC did not observe whitewash, prey remains, or juveniles. However, as there is high potential that bald eagles had already fledged prior to the survey date, some active nests may have been missed, especially if eagles used alternate or unknown nests. An additional nest location (BE3-1) within 0.5-miles of J. C. Boyle was provided after the reconnaissance survey was completed (Hayner 2017). KRRC surveyed this nest in 2018. Table 2-1 provides a summary table of known bald and golden eagle nests within 2-miles of the limits of work.

2.5 Avoidance and Minimization Measures

KRRC will use the results of the surveys described above 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. With implementation of the avoidance and minimization measures described below, KRRC does not anticipate that there will be a take of bald or golden eagles.

KRRC will implement the following measures to avoid or reduce the Project's potential impacts on bald and golden eagles:

- KRRC completed the survey of eagle use patterns prior to construction activities as described above. KRRC conducted surveys by a qualified avian biologist and included any facilities to be removed or modified to determine bird use patterns. KRRC conducted surveys during the time of year most likely to detect eagle usage.
- During the early nesting season of the year prior to drawdown, KRRC will conduct additional focused surveys for bald and golden eagle nests within the survey area using the survey plan outlined in Section 2.3.2.2. KRRC will conduct at least one pre-construction survey within 2 weeks prior to beginning ground disturbing activities.
- Wherever possible, clearing, cutting, and grubbing activities shall be conducted outside the eagle breeding period (January 1 through August 31);
- If active nests are present within 2 miles of limits of work, KRRC will establish a 0.5-mile restriction buffer in coordination with the resource agencies to ensure nests are not disturbed. If active eagle nests are present within 0.5 miles of limits of work, KRRC's contractor will halt construction activities until coordination with the resource agencies (i.e., USFWS and CDFW or ODFW depending on where the nest is located) determines construction can resume. If a nest is not within line of sight of project activities, 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, if it is determined that the activities would not jeopardize nesting success.

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Table 2-1 Summary of Bald and Golden Eagle Nests within 2 Miles of the Limits of Work (2017 Data)

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.

Chapter 3: Special Status Wildlife Species Measures

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3. SPECIAL STATUS WILDLIFE SPECIES MEASURES

3.1 Objectives

KRRC is conducting surveys in spring and summer 2018 to identify the special status wildlife species and their habitats that are present in the project area. These surveys will provide a baseline understanding of the presence and use of the project area by special status wildlife species and habitats, and enable KRRC to efficiently plan construction sequencing and conduct pre-construction surveys that may be necessary to avoid impacts on those species and their habitats from the Project. Findings of the 2018 special status wildlife surveys will be used for project design and construction planning and, in coordination with USFWS, CDFW, and Oregon Department of Fish and Wildlife (ODFW), to develop special status wildlife species avoidance and mitigation measures to be incorporated into any regulatory approvals that may be necessary for the Project. KRRC will conduct additional focused field surveys as required.

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. KRRC is also considering BLM and USFS Sensitive Species, Assessment Species, Tracking Species, and Survey and Manage species, where BLM and USFS lands occur in the project area; however, not all of these species are of regulatory concern. 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

KRRC has identified several special status wildlife species as occurring in the project area. PacifiCorp conducted comprehensive surveys of the project area in 2002 and 2003 and the findings were compiled in 2012 EIS/R (Section 3.5). PacifiCorp documented several special status wildlife species within 0.25 mile of the PacifiCorp facilities, reservoirs, and river reaches (PacifiCorp 2004, Attachment A). Information on special status wildlife species occurrences has also been obtained from USFWS, CDFW, ODFW, BLM, and USFS (Godwin 2017, Harris 2017, Henderson 2017, and Wray 2017). Most of the special status wildlife species 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 special status wildlife species have potential to occur in the project area, based on PacifiCorp surveys and information from ORBIC, CNDDB, and the USFWS Information for Planning and Consultation (IPaC) database.

Table 3-1 lists the special status wildlife species that KRRC identified as having potential to occur in the Klamath River watershed. 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 and identifies the proposed survey effort. KRRC based proposed survey efforts 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

KRRC conducted a field reconnaissance in July 2017. During the field reconnaissance, biologists visited proposed limits of work, focusing on areas with documented occurrences of special status wildlife species 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 are underway, concurrent with vegetation and habitat mapping efforts. During the spring and summer of 2018, biologists are recording 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). Findings of these surveys will provide a baseline understanding of the special status wildlife and habitats in the project area, facilitating efficient pre-construction surveys focused on specific locations of suitable habitat identified during the baseline surveys.

As part of the ongoing survey efforts, biologists are noting special status bird species that are using the reservoirs and limits of work, including dams and associated facilities, disposal sites, and haul and access roads around each. Using a boat, biologists are surveying 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).

KRRC established transects to cover terrestrial areas within 0.25 miles of dams and structures to be removed, disposal sites, and haul and access roads. Biologists are walking the length of each transect, noting species seen or heard and their behavior, as described above. KRRC is conducting night surveys for northern spotted owls, based on input from USFWS, CDFW, and ODFW, and entail calling from established survey stations along roads or walking transects and using a digital caller to elicit responses. These surveys are underway during both the spring and summer breeding season of 2018 (Section 1 discusses spotted owl surveys).

Based on input from USFWS, CDFW, and ODFW, focused surveys for amphibian and reptile species are not being conducted with the exception of surveys for western pond turtle (see "Other Focused Surveys" below). Rather, field surveys will identify suitable habitat for these species to determine if and to what extent suitable habitat will be modified or destroyed by project activities. KRRC will note amphibians and reptiles observed during the special status wildlife species surveys for birds and turtles.

KRRC is not conducting mammal trapping or other focused survey methods. KRRC will note any mammals or mammal sign, den sites, or excavated burrows observed during special status wildlife species surveys. (Section 4 discusses the survey plan for bats.)

3.3.3 Nest Surveys

All migratory birds are covered by the Migratory Bird Treaty Act (MBTA). 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).

KRRC conducted nest site surveys in May 2018. For some birds (e.g., raptors), nest surveys considered the viewshed analysis described under the Bald and Golden Eagle Measures (Section 2 of this Appendix) in identifying priority areas for surveys.

Nest site surveys focused on special status bird species that may return to the same nest locations (e.g., osprey, peregrine falcon, sandhill crane). 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 surveyed all nest platforms, transmission line towers, and reservoir and river shorelines for nests within 0.75 miles of limits of work, defined as the potential area within which construction activities may affect active nests (USBR and CDFW 2012, Section 3.5). KRRC will check nest sites identified in 2018 for occupancy in the year that construction activities are planned to commence. In coordination with the resource agencies (i.e., USFWS throughout the project area and in California, KRRC will consult with CDFW and in Oregon, KRRC will consult with ODFW), osprey nests within 0.75 miles of the limits of work may be removed or blocked from use following the breeding season in the year prior to drawdown. KRRC will closely monitor osprey nesting activity during the breeding season of the year prior to drawdown and the year of drawdown. Nests and nest platforms will be blocked and nesting material may be removed within both the limits of work and a disturbance buffer based on the proposed construction activities, vegetation and line of sight conditions, and other factors that contribute to the potential for nesting disturbance.

KRRC surveyed reservoir and river shorelines within 0.25 miles of limits of work for heron colonies in May 2018. KRRC will survey reservoir and river shorelines in spring of the year prior to drawdown for active heron colonies. If KRRC finds an active heron colony, a spatial buffer may be established in coordination with the resource agencies.

KRRC surveyed cliffs within 1 mile of limits of work in May 2018 for peregrine falcon nests. KRRC will survey these areas again in spring of the year prior to drawdown. If KRRC finds an active peregrine falcon nest, a spatial buffer may be established in coordination with the resource agencies.

KRRC surveyed documented nesting habitat for sandhill crane at J.C. Boyle Reservoir in May 2018 and will conduct an additional survey prior to construction (i.e., spring of the year prior to drawdown). KRRC will use a boat as needed to access these areas. If KRRC finds sandhill crane nesting, a spatial buffer may be established in coordination with the resource agencies.

During surveys, KRRC notes all species seen or heard, their approximate number and behavior (e.g., roosting, loafing, foraging, courtship, mating, incubating eggs, feeding young). KRRC records GPS coordinates for all active nests and spatial buffers established as needed in coordination with the resource agencies.

3.3.4 Other Focused Surveys

Several additional species with potential to occur in the project area have been identified by USFWS, CDFW, and/or ODFW as warranting additional consideration based on their status or potential status (i.e., species have been petitioned for listing on the federal and/or state level). These species include western pond turtle, foothill yellow-legged frog, Cascades frog, Siskiyou Mountains salamander, and tricolored blackbird. These species are discussed in the following sections.

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 recorded turtle use (Wray 2017). A petition for federal listing is currently being considered by USFWS, and a decision regarding listing is expected by 2021. 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. In early 2018, KRRC conducted 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, ODFW recommended additional pond turtle surveys. KRRC is coordinating with ODFW, USFWS, and CDFW on a preliminary scope for a study to determine 1) the abundance of western pond turtles in the J.C. Boyle Reservoir area and 2) where western pond turtles are overwintering in the J.C. Boyle Reservoir area. The study may include mark/recapture surveys, temperature monitoring and/or radio telemetry to determine overwintering locations. KRRC will conduct the study beginning in the late summer/fall through the spring of 2018 or 2019.

Foothill Yellow-legged Frog

The foothill yellow-legged frog is under review for federal listing and is a candidate for listing in California. Foothill yellow-legged frogs are not known to occur in the project reservoirs or tributary streams within the project area (PacifiCorp 2004). PacifiCorp surveys conducted in 2003 along the mainstem Klamath River and in stream segments directly adjacent to the mainstem channel did not detect foothill yellow-legged frogs, suggesting the species was extirpated from the project area. Farther downstream of the dams, foothill yellow-legged frogs are known to inhabit the lower reaches and tributaries of the Klamath River. In June 2009, float surveys along 3.5 km of the mainstem Klamath River downstream of the Blue Creek confluence found adults, juveniles, and egg masses. Egg masses were stranded on the bank, potentially due to wake disturbance from jet boats (Bettaso, pers. comm., 2017).

The findings of previous surveys indicate the species does not occur in the reservoirs but may be present several miles downstream. Because drawdown activities will occur prior to the main foothill yellow-legged frog breeding season, seasonal flows and sediment transport associated with drawdown are unlikely to affect egg masses or tadpoles downstream of the dams. KRRC is coordinating with USFWS, CDFW, and ODFW to determine the potential for impacts to the species. If, after further review and evaluation, it is determined that there is a high probability of take of the species as defined by CESA during the project implementation in California, focused surveys will be conducted during spring and summer of the year prior to drawdown for the purpose of estimating population information as needed for a California Incidental Take Permit.

Cascades Frog

The Cascades frog is under review for federal listing and is a candidate for listing in California. The species inhabits lakes, ponds, wet meadows, and streams at moderate to high elevations in the Cascades Range and is documented in the CNDDB within the Klamath National Forest. The species was not detected during PacifiCorp surveys (PacifiCorp 2004). Due to the presence of non-native predators such as bullfrogs and introduced sport fishes in the reservoirs, Cascades frog is unlikely to occur. Therefore, KRRC does not propose to complete focused surveys for this species. The KRRC has coordinated this decision with the resource agencies.

Siskiyou Mountains Salamander

The Siskiyou Mountains salamander is a California threatened species that is documented in the CNDDB along tributaries to the Klamath River in the Klamath National Forest. The species was not detected during PacifiCorp surveys (PacifiCorp 2004). The species is associated with rocky, forested areas and, specifically, stabilized talus in old-growth stands. The forests within the project area are heavily managed by timber harvest and do not provide suitable habitat for the Siskiyou Mountains salamander. Therefore, KRRC does not propose to conduct focused surveys. The KRRC has coordinated this decision with the resource agencies.

Tricolored Blackbird

The tricolored blackbird is under review for federal listing and is a candidate for listing in California. In February 2018, CDFW recommended listing the tricolored blackbird as threatened under CESA. The species forms large nesting colonies, most typically in dairy silage fields or other agricultural areas near wetlands. The species will use emergent-marsh habitat and may occur transiently in such habitats within the project area. However, there are no agricultural fields that typically support tricolored blackbird colonies in the project area. Therefore, KRRC does not anticipate nesting within the project area. KRRC is noting observations of the species during wildlife surveys in 2018, particularly within emergent wetland habitats. If KRRC finds nesting tricolored blackbirds in the project area during 2018 surveys, KRRC will survey the nesting location again in spring of the year prior to drawdown. If KRRC finds tricolored blackbirds nesting at that time, a disturbance buffer may be established in coordination with the resource agencies.

Willow Flycatcher

Willow flycatchers have been documented in the project area (PacifiCorp 2004, Attachment A). Willow flycatcher is a California endangered species. KRRC does not propose protocol surveys for willow flycatcher; 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, KRRC will conduct protocol surveys for willow flycatcher in spring of the year prior to drawdown in coordination with the resource agencies.

3.3.5 Pre-construction Nesting Bird Surveys

Prior to project activities that involve clearing of vegetation or other habitat, KRRC will conduct targeted, pre-construction bird surveys for all birds protected by the MBTA to avoid or minimize nesting disturbance. KRRC will conduct nesting surveys 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 limits of work. KRRC will map active nests 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.

KRRC will remove and discard cliff swallow nests along dam faces or structures during the non-nesting season to discourage swallows from returning to nest within the limits of work.

3.3.6 Construction Monitoring

KRRC will conduct biological monitoring during construction. KRRC will develop a detailed construction monitoring plan in coordination with the resource agencies.

3.4 Avoidance and Minimization Measures

The Project incorporates the following specific elements that will avoid or reduce potential impacts on migratory birds and their nests during construction:

- KRRC will conduct removal or trimming of any trees or other vegetation for construction outside of the nesting season (January 1 through August 20). This will 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 limits of work to determine if any migratory birds are present and nesting in those areas as described in Section 3.3.6.
- For raptors (other than eagles), KRRC will remove inactive nests before nesting season begins, to the greatest extent practicable and to the extent allowed under applicable laws and regulations. KRRC will conduct any nest removals in close coordination with CDFW, ODFW, and USFWS. KRRC will implement deterrent actions such as placing traffic cones or other exclusionary devices in nests or on nest platforms to prevent nesting in the year of construction. KRRC will remove all deterrents as soon as possible after construction activities have progressed to a point beyond the disturbance buffer for that species. KRRC will confirm buffer distances 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 by the biological monitor as appropriate. The buffer size established by the biological monitor will consider the species, noise effects, line of sight, and other site-specific considerations of the specific nest. KRRC may reduce the buffer size or allow certain project activities within the buffer if the biological monitor confirms that the activity is not disturbing the nest.
- KRRC may remove osprey nests within 0.75 miles of limits of work or block them from use following the breeding season in the year prior to drawdown if such removal is consistent with applicable federal and state law. Osprey nests that are removed may be replaced following construction or relocated to suitable areas outside of the project area.
- KRRC will conduct biological monitoring during construction. KRRC will develop a detailed construction monitoring plan in coordination with the resource agencies and will include the following measures:
  + Before any ground-disturbing work (including vegetation clearing and grading) begins 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 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. KRRC will issue species identification cards to shift supervisors; these cards will 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. KRRC will give an updated training to new personnel and in the event that a change in special-status species occurs.

  + KRRC's contractor will fence construction areas, including staging areas and access routes, 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 KRRC's contractor will maintain the fencing throughout the construction period. KRRC will implement additional exclusion fencing or other appropriate measures in coordination with the resource agencies to prevent use of limits of work by special-status species during construction.
  + To prevent entrapment of wildlife that do enter limits of work 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. KRRC's contractor will inspect trenches and pipes for entrapped wildlife each morning prior to onset of activity. Before KRRC's contractor fills such holes or trenches, they will be thoroughly inspected for entrapped animals. KRRC's contractor will allow any animals so discovered 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 will be allowed to escape unimpeded. A biologist approved by the resource agencies will 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, KRRC will monitor them 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:
  + KRRC's contractor will clearly delineate the limits of work and prohibit any construction-related traffic outside these boundaries.
  + KRRC's contractor will require construction crews 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.

- KRRC's contractor will dispose of 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 in closed containers only and removed at least once a week from the site. KRRC's contractor will fence the identified sites for trash collection to minimize access by wildlife.
- KRRC's contractor will not allow deliberate feeding of wildlife.
- KRRC's contractor will not allow pets in the limits of work.
- KRRC's contractor will not allow firearms in the limits of work.
- If vehicle or equipment maintenance is necessary, KRRC's contractor will perform it 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 will immediately report the incident to the construction foreman or biological monitor.
- The construction foreman or biological monitor will notify the resource agencies within 24 hours of the incident.

3.5 References

Bettaso, Jamie, Wildlife Biologist, USFS. 2017. Personal communication with Jennifer Jones, KRRC, November 16, 2017.

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.

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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/R). 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					
Franklin's bumble bee	*Bombus franklini*	Petitioned for federal listing	Generalist forager of wildflowers such as lupine, California poppy, and horsemint. Found only in southern Oregon/northern California between the coast and Sierra-Cascade ranges.	Not found during PacifiCorp surveys. Documented occurrences in meadows in Siskiyou County (CNDDB 2017).	Focused surveys are not proposed. Observations during general wildlife surveys and vegetation mapping will be noted.
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. Observations during general wildlife surveys and vegetation mapping will be noted.

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*	Proposed Survey Effort
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. Observations during general wildlife surveys and vegetation mapping will be noted.
Blue Mountains juga (snail)	*Juga sp. 2*	ONHP List 1	Freshwater	ORBIC occurrence near Rock Creek (ORBIC 2017).	Focused surveys are not proposed. Observations during general wildlife surveys and vegetation mapping will be noted.
Scale lanx (snail)	*Lanx klamathensis*	ONHP List 1	Freshwater	ORBIC occurrence near Rock Creek (ORBIC 2017).	Focused surveys are not proposed. Observations during general wildlife surveys and vegetation mapping will be noted.
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. Historic 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. Observations during general wildlife surveys and vegetation mapping will be noted.
Amphibians					
Tailed frog	*Ascaphus truei*	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*	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*	Petitioned for federal listing, BLM, OSS, CSSC, CC	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).	Observations during general wildlife surveys will be noted. Based on an initial evaluation of known occurrences and potential for impacts from project activities, focused surveys are not proposed. However, focused surveys may be conducted to obtain population estimate information as needed for a California Incidental Take Permit if found warranted based on further evaluation and agency input.
Cascades frog	*Rana cascadae*	Petitioned for federal listing, OSS, CSSC, CC	Montane aquatic habitats such as mountain lakes, small streams, and ponds in meadows; open coniferous forests.	Documented occurrence in Klamath National Forest (CNDDB 2017). Unlikely to occur in project reservoirs due to the presence of non-native predators such as bullfrogs and introduced sport fishes.	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). Unlikely to occur in project reservoirs due to the presence of non-native predators such as bullfrogs and introduced sport fishes.	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
Siskiyou Mountains salamander	*Plethodon stormi*	OSS, CT	Mixed conifer habitat of dense, pole-to-mature size, trees and stabilized rock talus. Active above ground only during spring & fall rains.	Documented occurrences along Klamath River in Klamath National Forest (CNDDB 2017). Not likely to occur in the project area due to lack of old growth forests with rock talus.	Focused surveys are not proposed. Observations during general wildlife surveys will be noted.
Southern torrent salamander	*Rhyacotriton variegatus*	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. Observations during general wildlife surveys and vegetation mapping will be noted.
Reptiles					
Western pond turtle	*Actinemys marmorata*	Petitioned for federal listing, 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).	Observations of the species and habitat will be noted during wildlife surveys and vegetation mapping. An additional study may include mark/recapture surveys, temperature monitoring and/or radio telemetry to determine overwintering locations.
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. Observations during general wildlife surveys and vegetation mapping will be noted.

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*	Proposed Survey Effort
Northern sagebrush lizard	*Sceloporus graciosus graciosus*	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*	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*	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 Name	Scientific Name	Status	Habitat	Occurrence in Project Area*	Proposed Survey Effort
Common loon	*Gavia immer*	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. Nesting colonies afforded special protection by CDFW	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*	CWL, 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*	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.

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*	Proposed Survey Effort
Snowy egret	*Egretta thula*	BLM, 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 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 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 River (CNDDB 2017).	Wildlife surveys will note presence and nesting colonies to identify potential for impacts from project implementation.
White-faced ibis	*Plegadis chihi*	BLM, ONHP List 4, CWL, Nesting colonies afforded special protection by CDFW	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.

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*	Proposed Survey Effort
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 buccinator*	OSS, FP	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*	CWL	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.

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*	Proposed Survey Effort
Northern harrier	*Circus cyaneus*	CSSC	Nests and forages in grasslands and emergent wetlands. Permanent residents in the project area 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*	BGEPA, BLM, CSSC, FP, CWL	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 measures.
Bald eagle	*Haliaeetus leucocephalus*	BGEPA, OSS, ONHP List 4, CE, FP	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 area. 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. See eagle measures.
Cooper's hawk	*Accipiter cooperii*	CWL	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.

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*	Proposed Survey Effort
Northern goshawk	*Accipiter gentilis*	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*	CWL	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*	BLM, OSS, ONHP List 4, CT	Dwells in open country and 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 area and includes the plains of the Great Basin in southeast Oregon and eastern northern California.	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. Focused surveys are not proposed.
Merlin	*Falco columbarius*	BLM, ONHP List 2, CWL	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.

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*	Proposed Survey Effort
Prairie falcon	*Falco mexicanus*	CWL	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, 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 area.	The project area 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, CWL	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.
Mountain quail	*Oreortyx pictus*	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.

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*	Proposed Survey Effort
Greater sandhill crane	*Grus canadensis tabida*	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*	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. Observations during general wildlife surveys and vegetation mapping will be noted.

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*	Proposed Survey Effort
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 will 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, CT, CSSC	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 near the J.C. Boyle Powerhouse, 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 J.C. Boyle Powerhouse.	Protocol surveys are proposed (see separate northern spotted owl measures).
Yellow-billed cuckoo	*Coccyzus americanus*	FT, BLM, CE	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. Observations during general wildlife surveys and vegetation mapping will be noted.

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*	Proposed Survey Effort
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, 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*	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.

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*	Proposed Survey Effort
Lewis' woodpecker	*Melanerpes lewis*	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*	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 CA listing	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.
American three-toed woodpecker	*Picoides tridactylus*	OSS	Montane coniferous forests with large stands of dead and dying conifers, including areas disturbed by fire.	Not documented during PacifiCorp surveys or listed on CNDDB or ORBIC for the project area.	Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation.
Olive-sided flycatcher	*Contopus cooperi*	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.

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*	Proposed Survey Effort
Willow flycatcher	*Empidonax traillii*	BLM, CE	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*	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*	CWL	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	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.

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*	Proposed Survey Effort
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 area 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*	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*	Petitioned for federal listing, BLM, CSSC, CC	Highly colonial species; requires open water, protected nesting substrate, and foraging area with insect prey within a few km of the colony. Historically found in large wetland complexes; nesting colonies are now typically found in agricultural areas such as dairy silage fields with wetlands.	Not documented during PacifiCorp surveys or listed on CNDDB or ORBIC for the project area. Nearest occurrences just north of Keno (Wray 2017). No agricultural fields typically used by the species for nesting colonies are present in the project area.	Wildlife surveys will note presence and nesting activity to identify potential for impacts from project implementation.
Mammals					
Townsend's big-eared bat	*Corynorhinus townsendii*	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 measures.

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*	Proposed Survey Effort
Yuma myotis	*Myotis yumanensis*	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, 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, 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 noctivagans*	OSS	Prefer temperate, northern hardwoods with ponds or streams nearby. The typical day roost for the bat is behind loose tree bark.	Not documented in project area. Range overlaps with project area.	See bat measures.

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*	Proposed Survey Effort
American pika	*Ochotona princeps*	OSS	Restricted to rocky talus slopes, primarily the talus-meadow interface. Often they occur above treeline up to limit of vegetation but also can be found at lower elevations in rocky areas within forests or near lakes. Occasionally they inhabit mine tailings or even piles of lumber or scrap metal.	Not documented in project area.	Focused surveys are not proposed. Observations during general wildlife surveys will be noted.
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)*	BLM, OSS, ONHP List 2, CC, 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.

Common Name	Scientific Name	Status	Habitat	Occurrence in Project Area*	Proposed Survey Effort
Sierra Nevada red fox	*Vulpes vulpes necator*	FC, OSS, CT	High elevation, open conifer woodlands and mountain meadows near treeline. Range includes the Sierra Nevada and southern Cascade mountains of eastern California, into southern Oregon and western Nevada.	Not documented in project area.	Focused surveys are not proposed. Observations during general wildlife surveys will be noted.
Wolverine	*Gulo gulo*	FPT, OT, CT, 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 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.

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

Notes:
*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:

BGEPA	Federal Bald and Golden Eagle Protection Act
BLM	Bureau of Land Management sensitive species -species that could easily become endangered or extinct; and/or Survey and Manage Species
CC	Candidate listing by California Department of Fish and Wildlife
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
CWL	California Department of Fish and Wildlife Watch List
FC	Federal Candidate Species
FE	Federal Endangered
FP	Fully protected under the California Fish and Game Code
FT	Federal Threatened
OC	Candidate listing by 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
OT	Listed as threatened by ODFW
OSS	Oregon Sensitive or Sensitive- Critical Species, East Cascades, West Cascades, and Klamath Mountains Ecoregions
USFWS	United States Fish and Wildlife Service

Chapter 4: Bats Measures

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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. KRRC will use the information collected during surveys 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 2012 EIS/R (Section 3.5) TER-6 describes measures to reduce impacts on special status bats. The 2012 EIS/R recommended surveys to identify the locations of active bat roosts in facilities that may be affected by the dam removal. KRRC has incorporated this measure into the Project and will be implemented as described in the following sections. KRRC has incorporated the recommended avoidance and minimization measures into the Project's 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 area. Table 4-1 lists these species.

Yuma myotis have been previously documented at structures within the project area (PacifiCorp 2004). Townsend's big-eared bat and *Yuma myotis* have 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 Methods

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 EIS/R (USBR and CDFW 2012, Section 3.5). Coordination with local bat experts is ongoing as of December 2017.

4.3.2 Bat Roost Surveys

KRRC will conduct bat roost surveys for 2 years prior to construction activities. KRRC will conduct roost surveys cautiously to avoid disturbing bats at roost sites. An initial site reconnaissance and daytime visual inspection of buildings and bridges within the areas where removal or improvements will occur for the Project was conducted during the summer 2017 maternity season and is further described in the Preliminary Results section. KRRC planned 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. KRRC will consider the need to assess significant roosting habitat outside of buildings 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 trees planned for removal) will be evaluated during survey efforts, or as otherwise dictated by the project schedule.

KRRC is using the data review, ongoing coordination with regional bat experts, and conditions observed during the initial 2017 reconnaissance survey and daytime visual inspections to inform the design of and need for future survey efforts outside of the maternity season. Table 4-2 provides recommendations for future surveys based on the 2017 reconnaissance survey. These recommended surveys are underway in 2018 to identify which species occupy the habitat throughout the year, understand how the habitat is utilized throughout the year, and quantify habitat usage. These 2018 surveys include dusk emergence surveys and pre-dawn re-entry surveys, using night vision and acoustic detection as appropriate. KRRC is implementing acoustic monitoring as needed to determine bat roost patterns. KRRC tailored the number and location of emergence/re-entry surveys and acoustic monitoring surveys to the size of each structure and the species which have the potential to occupy it. KRRC is conducting the emergence surveys when weather conditions are suitable for the evening emergence of bats (e.g., temperatures are warm enough and rain and wind are minimal).

Townsend's big-eared bat (*Corynorhinus townsendii*) is extremely sensitive to disturbance, and there is a high probability of roost abandonment, reproductive failure, and/or fatality from disturbance. Accordingly, when KRRC surveys roosts during the maternity and hibernation seasons, KRRC uses specialized survey techniques for any structures that are suspected to be occupied by this species. Survey methodologies for Townsend's big-eared bat were developed on a case-by-case basis and are dependent on the current level of disturbance, site conditions, types of roost structures present, and season. For structures with the possibility of occupancy by the species, KRRC is only conducting exterior surveys to determine use of structures during their maternity season (April 15-August 31, 2018), to the extent possible. KRRC is conducting interior surveys, whether conducted after non-detection surveys during the maternity season, or conducted outside of the maternity season, in a manner to avoid disturbing roosting bats.

KRRC will use the information obtained during the surveys 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. KRRC will consider and implement the Western Bat Working Group species-specific survey methodologies (http://wbwg.org/matrices/survey-matrix/) as appropriate.

The first year of winter hibernacula surveys that KRRC conducted in February-March 2018 were limited to structures at Copco 1 and 2 due to access constraints. KRRC is conducting additional roost surveys in May and June 2018. KRRC is conducting hibernacula surveys so as not to cause disturbance to hibernating bats. KRRC is conducting spring and fall migration surveys in approximately April/May and September/October, 2018. The level of survey effort throughout 2018-2019 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. KRRC will conduct additional site-specific surveys prior to demolition or modification of structures to confirm that bats have successfully been excluded or are otherwise not present (see Section 4.5, Avoidance and Minimization Measures)

4.4 Preliminary Results

KRRC conducted a general site reconnaissance and daytime visual inspections of most project structures 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). KRRC inspected the exterior and interior of most structures. 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, KRRC limited interaction with live bats to brief viewing to confirm presence only. Table 4-2 summarizes initial survey findings and future survey plans. Recommendations for future surveys are informed by habitat suitability, the presence of bats or bat sign, and the presence of entry and exit points.

KRRC did not inspect five structures at Copco Village due to time constraints. For houses that are currently inhabited, KRRC limited the inspection to the exterior. KRRC plans interior inspections of these structures 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:

- KRRC's contractor will remove the facility or modify it outside the bat roosting and breeding period where feasible (i.e. November 1 to March 1). If the facility is used as winter hibernacula (November 1 to March 1), then KRRC's contractor will remove the facility or modify it 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 during the fall migration period. KRRC will conduct humane bat exclusion by, or under the supervision of, a qualified bat biologist with experience in conducting exclusions and possessing a California Scientific Collecting Permit. KRRC will develop a bat exclusion plan and provide a copy to CDFW prior to initiation of exclusion activities for their information, technical expertise, and experience. The plan will include proposed exclusion methods for each structure and data describing the numbers of bats that have been observed emerging from the structures. Exclusion devices will be in place for at least 7 days to ensure all bats have had adequate time to exit. If climatic conditions occur that may deter roost exit (rain, cold temperatures, high winds, full moon, etc.), additional time will be added to the minimum number of nights the exclusion device is to remain in place. KRRC will monitor exclusion devices to ensure proper function.
- If demolition at a time when a structure is unoccupied and complete bat exclusion are both found to be infeasible at a given structure, KRRC will coordinate with USFWS and CDFW or ODFW, as appropriate to carefully remove the occupied bat habitat at a time when it will 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, KRRC will give preference to on-site and in-kind replacement roosting habitat. KRRC may retain facilities occupied by significant bat roosts, to the extent practicable.
- For those facilities that cannot be retained, KRRC will construct free-standing replacement bat roosts in coordination 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. Replacement roost structures will be in place prior to demolition of the existing facility. 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).
- KRRC will develop success criteria for replacement roost structures in coordination with bat specialists and the USFWS and CDFW or ODFW, as appropriate. Post-construction monitoring of the replacement roosts will occur seasonally (four times/year) until the earliest of the following: (1) up to five years after completion of project activities; (2) transfer of relevant Parcel B lands to the States and/or third parties; or (3) until the mitigation can be considered successful. After three years, adaptive management (i.e., reduced or discontinued monitoring of structures that have met criteria, or enhancement of structures that are not meeting criteria) will be applied as appropriate. KRRC will coordinate with the USFWS and CDFW or ODFW, as appropriate, to develop adaptive management strategies and determine that success criteria have been met.

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/R). 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. 2) Bridges, caves, mines, tree bark/hollows.	None	Yes

Common Name	Scientific Name	Status[1]	Suitable Habitat[2]	Known Occurrences within Project Area	Range Overlap?
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, 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[1]	Live Bats Present?	Evidence of Bats Found?	Survey Recommendation
J.C. Boyle Dam and Facilities				

Building Name	Suitability for Roosting[1]	Live Bats Present?	Evidence of Bats Found?	Survey Recommendation
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.
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.

Building Name	Suitability for Roosting[1]	Live Bats Present?	Evidence of Bats Found?	Survey Recommendation
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. Night roosting suspected from staining around outside lighting.	Emergence/re-entry 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.

Building Name	Suitability for Roosting[1]	Live Bats Present?	Evidence of Bats Found?	Survey Recommendation
Tin Pumphouse (across from light 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.
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.

Building Name	Suitability for Roosting[1]	Live Bats Present?	Evidence of Bats Found?	Survey Recommendation
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) blue/gray	High	No	No (inspected outside only - inside/attic not accessed).	Daytime interior (attic) 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.
[1]"Low" suitability for roosting was assigned to well-sealed structures with no points of entry/exit, and generally lacking cavities, crevices, and other external or internal features generally preferred by bats, such as roof spaces, soffits, fascias, weather boarding, spaces between roof felt/membrane and tiles/slates, window frames, cavity walls, flashing, and the like.				

Chapter 5: Special Status Plants Measures

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5. SPECIAL STATUS PLANTS MEASURES

5.1 Objectives

Special status plants include those species with federal status (federally listed as threatened, endangered, or proposed and candidate species), state threatened, endangered, or candidate species, Oregon Natural Heritage Program Lists 1 and 2, and California Rare Plant Rank 1 and 2. KRRC will develop measures to avoid or minimize potential impacts for special status plants located within areas potentially subject to ground disturbance.

The 2012 EIS/R (Section 3.5) TER-4 described measures to reduce impacts on special status plants. The 2012 EIS/R recommended surveys to identify the locations of special status plants that may be affected by the dam removal project. KRRC has incorporated this measure 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 USFWS, CDFW, and 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: ORBIC, CNDDB, and the USFWS IPaC database.

KRRC obtained additional information on the occurrence of special status plants in the project area from USFWS (Yreka), BLM (Klamath Falls), and USFS (Klamath National Forest).

Table 5-1 presents the list of special status plants that have potential to occur in or near the limits of work. This is a preliminary list of species with potential to occur; KRRC may obatain additional information through further coordination with resource agencies.

5.3 Methods

KRRC conducted a field reconnaissance in July 2017. During the field reconnaissance, biologists visited proposed limits of work 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, KRRC gathered qualitative information on habitats present and determined access for surveys. KRRC noted the potential presence of wetlands and other sensitive natural communities within the limits of work for future investigation during the spring and summer of 2019. Biologists also examined whether changes to existing conditions since the PacifiCorp surveys were conducted, including wildfires, development, agriculture and grazing, and logging activities.

Focused surveys are underway in 2018. KRRC completed the first survey in early to mid-May. KRRC will complete the second survey in mid-July. KRRC will conduct an additional survey in mid-April 2019 to encompass the range in bloom times for species with the potential to occur in the project area.

KRRC is conducting focused surveys for special status plants in areas where ground disturbing activities will occur for the Project. Surveys are 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 ground disturbing activities but along reservoir shorelines and other areas where changes in hydrology and geomorphology will occur due to the Project, KRRC will focus surveys 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, KRRC will visit reference populations 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 CDFW protocol, KRRC is conducting floristic surveys where ground disturbing activities will occur for the Project, identifying every plant taxon that occurs to the taxonomic level necessary to determine rarity and listing status. Floristic surveys are underway in 2018 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 walk parallel transects spaced 5 to 10 meters apart; transect spacing is varied as needed based on visibility and type of habitat present.

KRRC records GPS coordinates of all observed special status plants found such that a protection plan may 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.

5.4 Summary of Special Status Plant Survey Methods

In summary, special status plant surveys are underway in 2018 and entail the following:

- Detailed floristic surveys for special status plants within the areas where ground disturbing activities will occur for the Project 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 in areas such as reservoir shorelines where changes in hydrology and geomorphology will occur due to the Project.

5.5 Avoidance and Minimization Measures

- If any special status plants are found to occur within areas where ground disturbing activities will occur for the Project, and it is determined that the 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 area may be implemented, as determined in coordination with the resource agencies.
- The restoration plans being developed for both reservoir and non-reservoir areas will 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, measures will be implemented to clean construction vehicles and equipment where feasible 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/R). 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 the Limits of Work

Species	Status	Habitat	Location of Documented Occurrence(s)	Bloom Time	Proposed Survey Effort
Greene's mariposa-lily *Calochortus greenei*	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 limits of work 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 Highway 66); also west of Dam	May- September	Along reservoir margins and within limits of work 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 limits of work 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 limits of work 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 limits of work in suitable habitat
Bellinger's meadow-foam *Limnanthes floccosa ssp. bellingerana*	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 limits of work 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 limits of work in suitable habitat

Species	Status	Habitat	Location of Documented Occurrence(s)	Bloom Time	Proposed Survey Effort
Egg Lake monkeyflower *Mimulus pygmaeus*	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 limits of work 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 will occur at Jenny Creek at bridge
Red-root yampah *Perideridia erythrorhiza*	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 limits of work 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 limits of work 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 limits of work. No suitable ultramafic soils occur within 0.5 miles of limits of work (NRCS 2017).	March- April	None- suitable soils not present within limits of work

Species	Status	Habitat	Location of Documented Occurrence(s)	Bloom Time	Proposed Survey Effort
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 limits of work 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 limits of work 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 limits of work 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 limits of work 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 limits of work 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
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

Chapter 6: Vegetation Communities and Wetlands Measures

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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. KRRC will also use vegetation community mapping to identify suitable habitat for special status species (plants and wildlife). KRRC will also identify communities dominated by invasive plant species to aid in developing procedures to avoid or minimize their spread to areas without invasive plant infestations.

Based on the information in the 2004 PacifiCorp report, the 2012 EIS/R (Section 3.5) identified potential impacts on 244.4 acres of wetland and riparian habitat and TER-5 to provide compensatory mitigation. However, the 2012 EIS/R also identified that PacifiCorp estimated that 272 acres of wetland and riparian habitat would become re-established in the event of dam removal (as defined in Appendix I). If the Project does not result in a net loss of wetland and riparian habitat, then KRRC will not prepare a compensatory mitigation plan. The Project will comply with regulatory requirements in delineating wetlands and evaluating potential impacts to acreage and functions. The Project's 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 DBH was 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/R was published, there have not been any significant changes in habitats within the limits of work. Based on a review of historical aerial photography conducted by CDM Smith in 2018, timber harvest has been conducted in several locations within 0.5 miles of the 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 limits of work and are not on PacifiCorp land. KRRC did not identify major wildfires or other significant habitat alterations in the project area since the PacifiCorp surveys.

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

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. KRRC also observed evidence of cattle grazing. 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. KRRC noted a narrow drainage channel t the bottom of the ravine. The channel was dry during the July 2017 site reconnaissance.

Downstream of the J.C. Boyle 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.

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 KRRC noted feral horses 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 occidentali*s) 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*). KRRC observed Himalayan blackberry (*Rubus armeniacus*), and poison oak (*Toxicodendron diversilobum*) 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. KRRC noted several weedy species including teasel (*Dipsacus fullonum*), curly dock (*Rumex crispus*), lambsquarters (*Chenopodium album*), and oxeye daisy (*Leucanthemum vulgare*) 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. 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. KRRC onserved a few mature black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) and weeping willow (*Salix babylonica*). 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, KRRC observed large infestations of invasive yellow star-thistle and medusahead adjacent to the Copco Lake and Iron Gate Reservoir and other disturbed areas. KRRC also observed Himalayan blackberry 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.

KRRC obtained additional information on invasive species in the J.C. Boyle project area 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). KRRC anticipates that wetland and riparian areas similar to those that previously existed will become re-established along the restored Klamath River following restoration. In addition, KRRC expects the tributary riparian habitats 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.

KRRC did not conduct wetland surveys or focused delineations 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, KRRC observed several depressions to support coyote willow, sedges, and rushes, indicating the potential presence of wetlands in some areas. KRRC noted a narrow drainage channel 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 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. KRRC will evaluate the Iron Gate disposal site closely for wetland characteristics.

6.3 Methods

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 limits of work, surveys will entail spot-checking of PacifiCorp mapping. KRRC will conduct more detailed surveys of wetlands and special status plants within the limits of work.

6.3.1 Field Reconnaissance

KRRC conducted a field reconnaissance in July 2017. During the field reconnaissance, KRRC biologists visited proposed limits of work 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 limits of work. KRRC 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, KRRC noted that current conditions did not match the 2004 PacifiCorp mapping data in some places. KRRC will update vegetation community maps as needed to reflect existing conditions. KRRC will conduct initial verification 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.

KRRC will produce a crosswalk table that compares the classification system used in the 2004 report to other classifications (e.g., Manual of California Vegetation) to align the PacifiCorp data with current regulatory requirements. KRRC will also identify communities dominated by invasive plant species.

6.3.3 Wetlands

KRRC will delineate wetlands within the limits of construction around the dams and facilities, access and haul roads, and disposal sites 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, KRRC will use the Oregon Rapid Wetland Assessment Protocol (ORWAP) to assess functional values of wetlands.

PacifiCorp's mapping of wetlands and riparian habitats adjacent to reservoirs and/or associated with streams but outside the direct limits of work will be field verified by traversing the areas on foot and/or by boat, using binoculars as needed. KRRC will map previously unidentified wetlands and riparian habitats observed adjacent to reservoirs but outside the limits of work and described consistent with the PacifiCorp vegetation classification system described above. KRRC will map the boundaries of wetlands outside of the limits of work based on observed changes in vegetation, topography, and hydrology, but these areas will not be formally delineated.

6.4 Survey Plan Summary

KRRC's mapping of vegetation communities and wetlands will be complete by 2019 and will entail the following:

- Desktop verification of the PacifiCorp vegetation community mapping based on comparison with current aerial photography for the project area. KRRC will produce new maps 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.
- Map areas dominated by invasive species within the project area.
- Delineation of wetlands and riparian habitats within areas that will be affected by ground disturbing activities 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 areas that will be affected by ground disturbing activities.
- Map previously unidentified wetlands and riparian habitat noted adjacent to reservoirs but outside areas that will be affected by ground disturbing activities.

6.5 Avoidance and Minimization Measures

The Project will comply with regulatory requirements in delineating wetlands and sensitive vegetation communities 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.

- KRRC will incoirporate the results of the wetland delineation 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 where ground disturbing activities will occur or location of access and staging areas, or redesign of fill slopes to avoid wetland areas.
- KRRC's contractor will fence wetland areas adjacent to the areas where ground disturbing activities will occur with orange plastic snow fencing to demarcate work areas and prevent inadvertent impacts.
- The restoration plans developed for both reservoir and non-reservoir areas will include provisions for the establishment of wetland and riparian areas and other sensitive vegetation communities within the project area to result in no net loss of habitat acreage and functions.
- KRRC will monitor wetlands and other sensitive vegetation communities established in restored areas for up to five years or as required by permit requirements. KRRC will identify specific performance measures in the restoration plans and approved by the regulatory agencies.

To reduce potential impacts on water quality in wetlands and other surface waters during construction (for example, the wetlands around the confluence of Fall Creek and the Klamath River), KRRC will implement the following construction best management practices.

- KRRC's contractor will implement Pollution and erosion control measures to prevent pollution caused by construction operations and to reduce contaminated stormwater runoff.
- KRRC's contractor will keep oil-absorbing floating booms onsite and will respond immediately to aquatic spills during construction.
- KRRC's contractor will keep vehicles and equipment in good repair, without leaks of hydraulic or lubricating fluids. If such leaks or drips do occur, KRRC's contractor will clean them up immediately. KRRC's contractor will confine equipment maintenance and/or repair to one location at each project construction site. KRRC's contractor will control runoff in this area to prevent contamination of soils and water.
- KRRC's contractor will implement dust control measures, including wetting disturbed soils.

- KRRC's contractor will implement a Storm Water Pollution Prevention Plan 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.

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Attachment A

Northern Spotted Owl Figures

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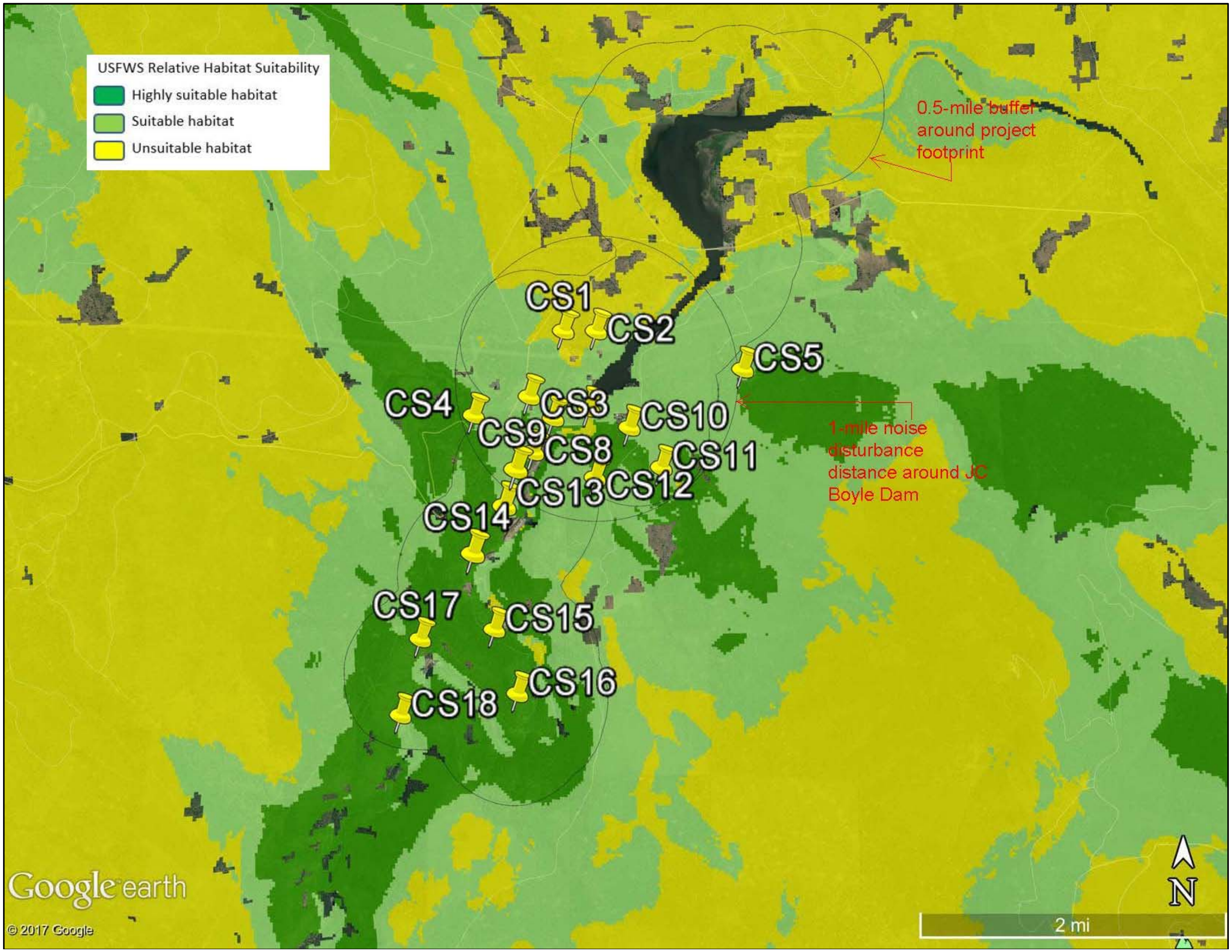
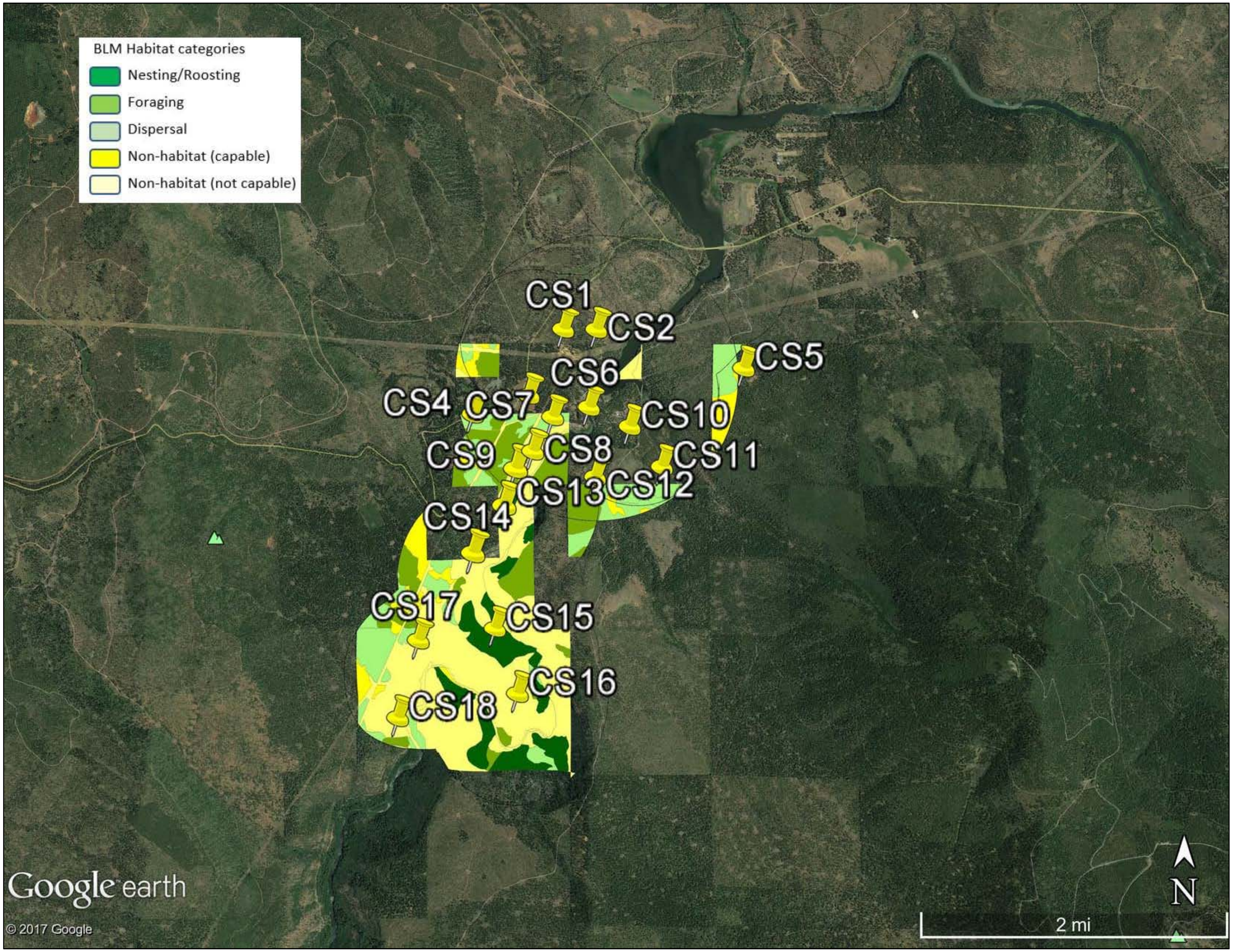


USFWS Habitat Layer

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

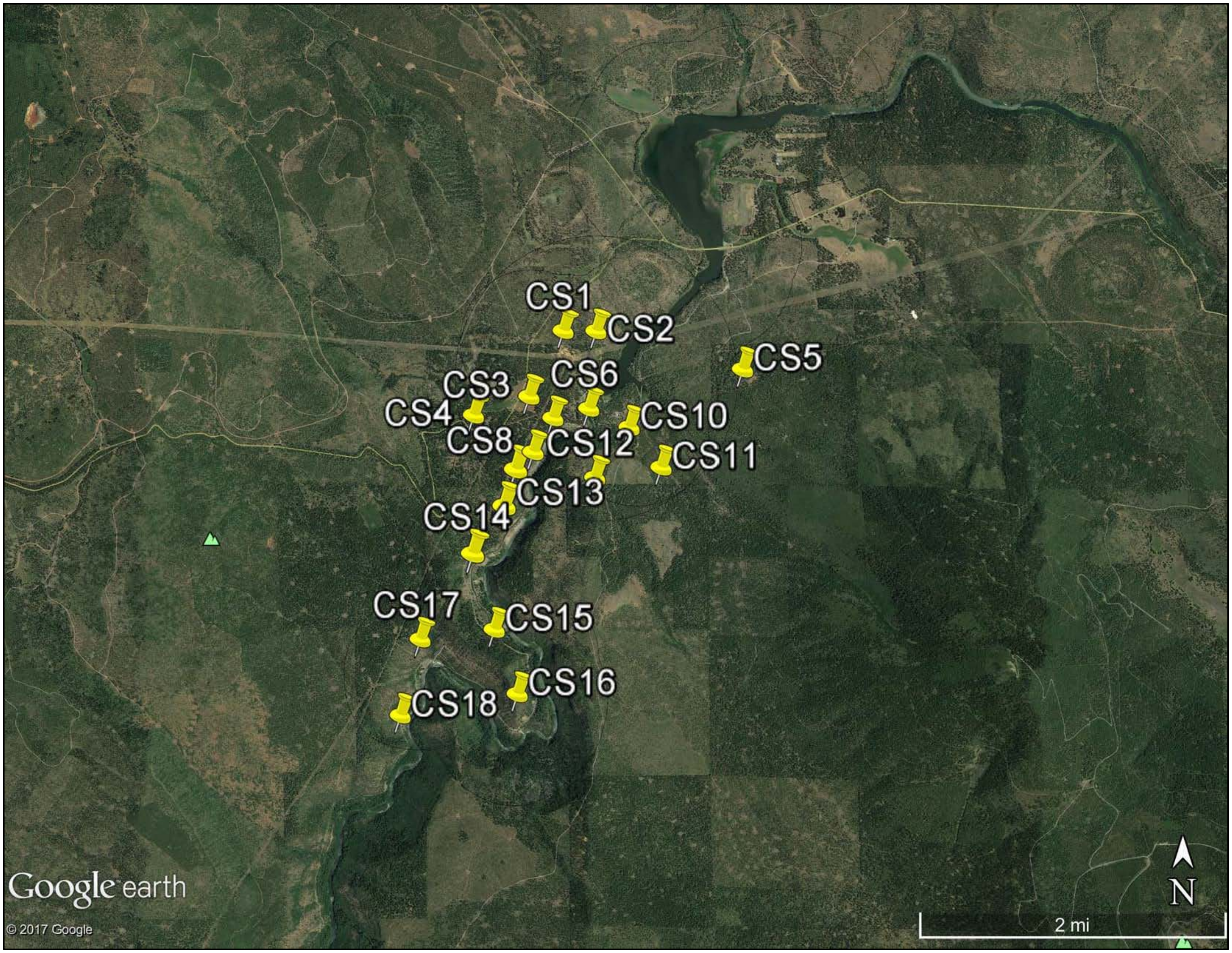
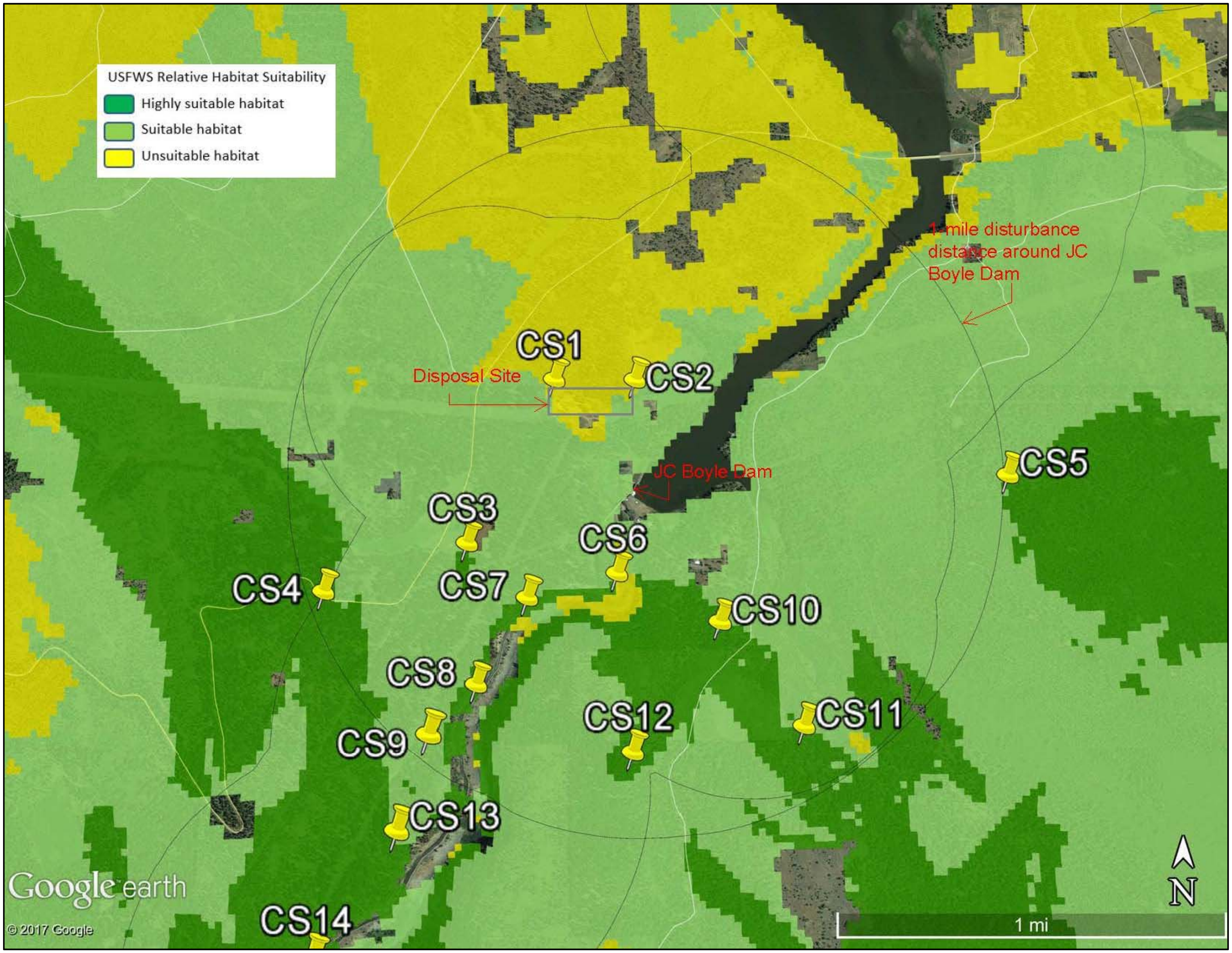


FIGURE 1: PRELIMINARY NSO CALLING STATIONS

JC Boyle Project Area

Sheet 3 of 3

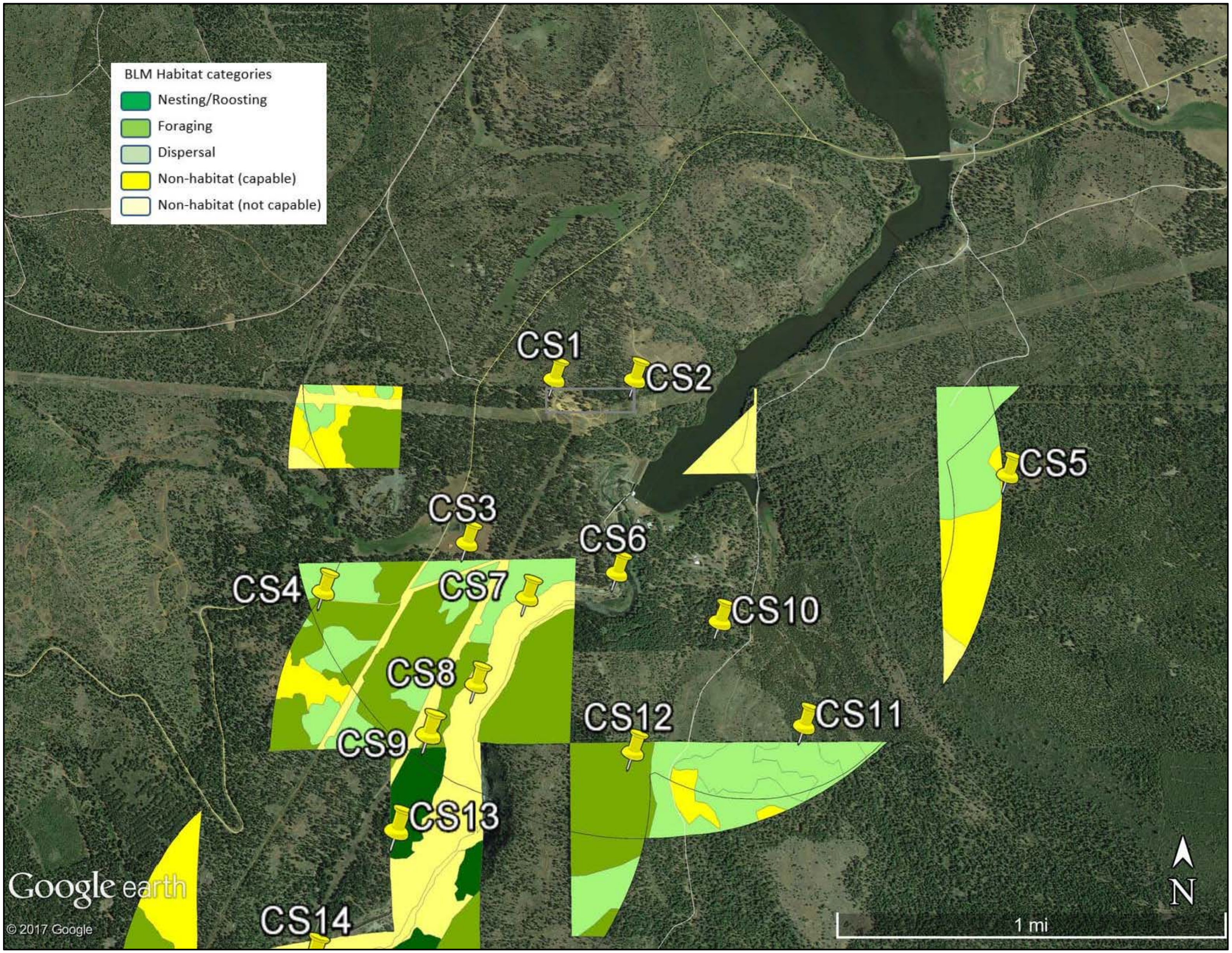


USFWS Habitat Layer

FIGURE 2: PRELIMINARY NSO CALLING STATIONS (USFWS HABITAT LAYER)

JC Boyle Dam

Sheet 1 of 3

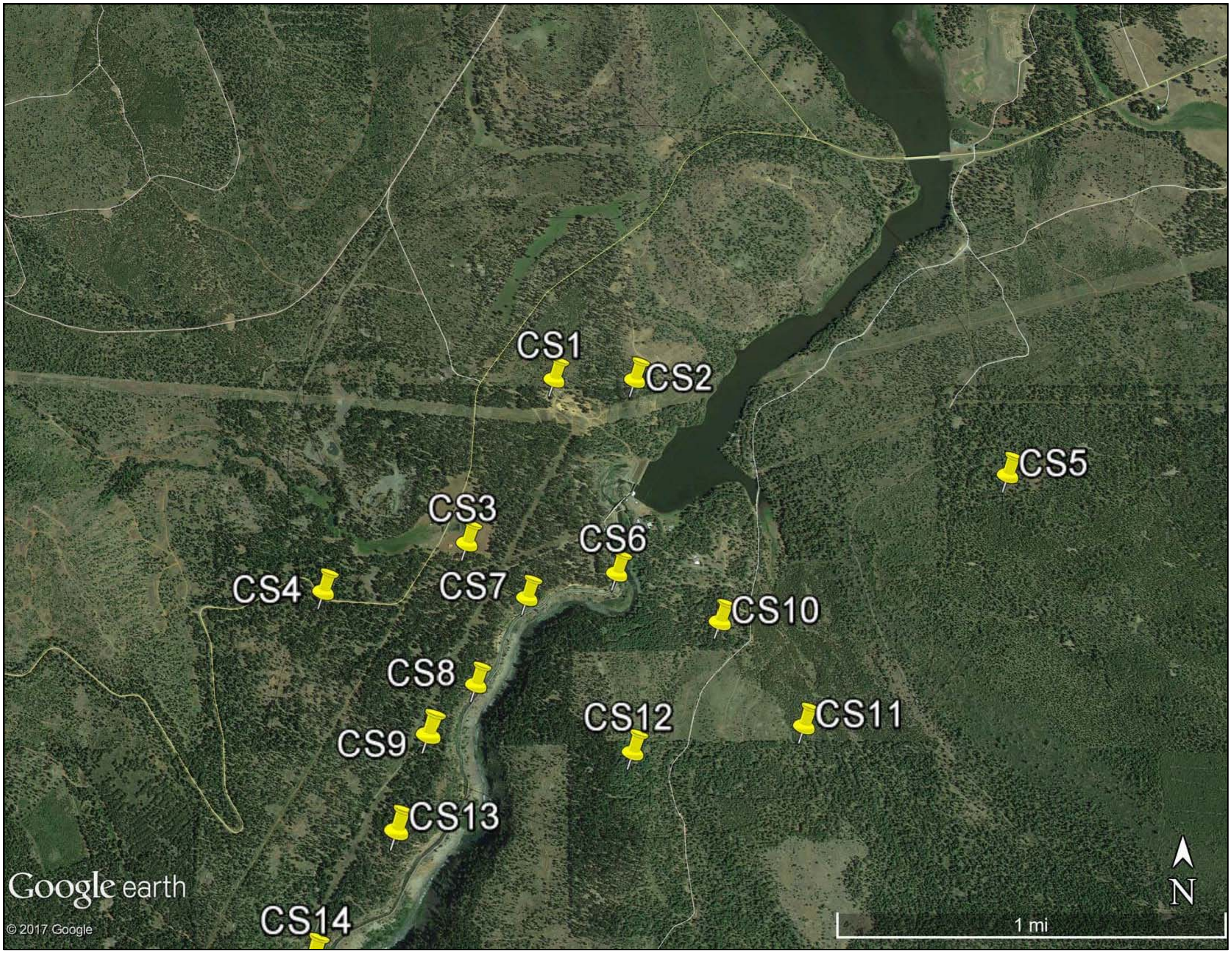


BLM Habitat Layer

Klamath River Renewal Corporation
Klamath River Renewal Project

FIGURE 2: PRELIMINARY NSO CALLING STATIONS (BLM HABITAT LAYER)

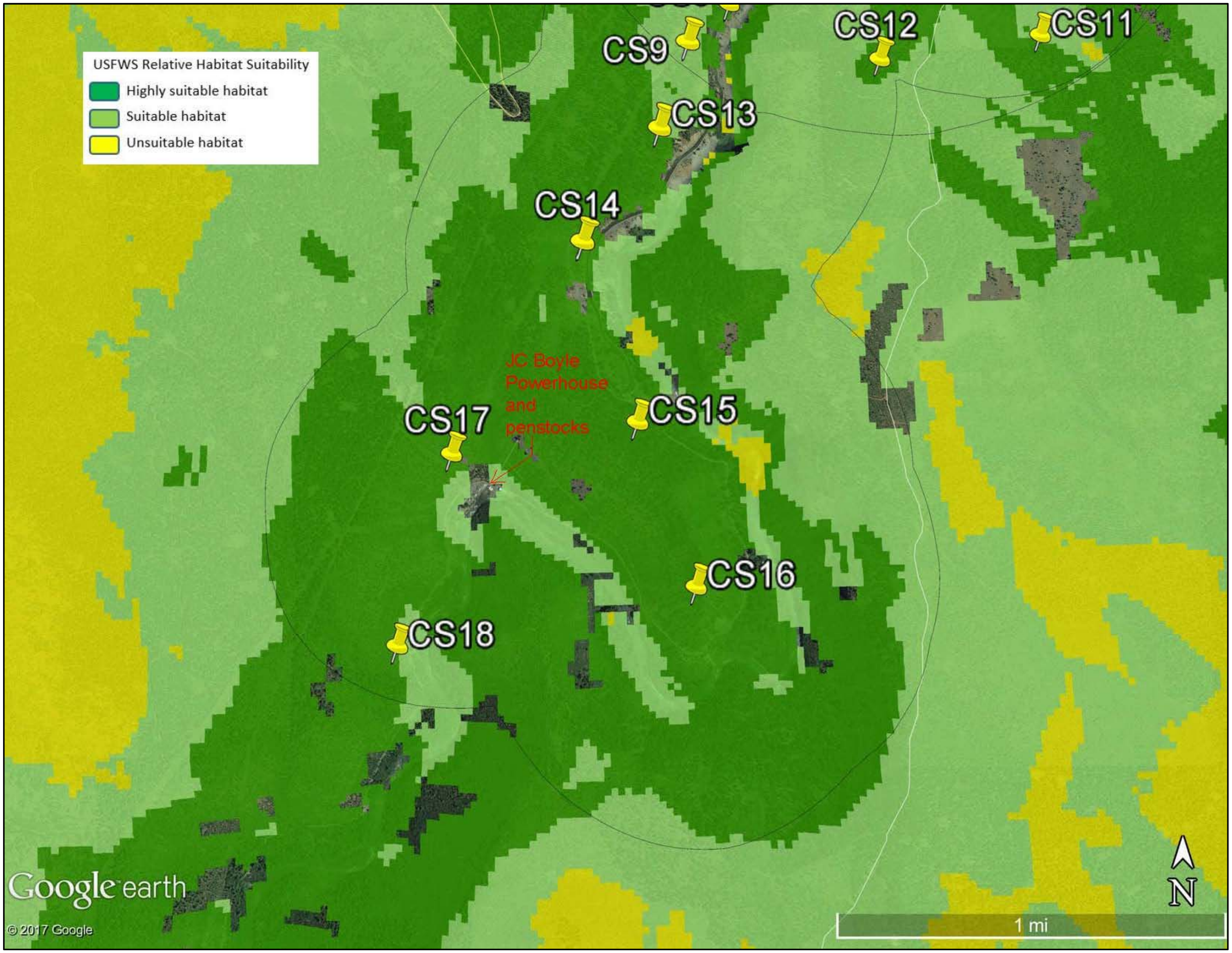
JC Boyle Dam
Sheet 2 of 3



Klamath River Renewal Corporation
Klamath River Renewal Project

FIGURE 2: PRELIMINARY NSO CALLING STATIONS

JC Boyle Dam
Sheet 3 of 3

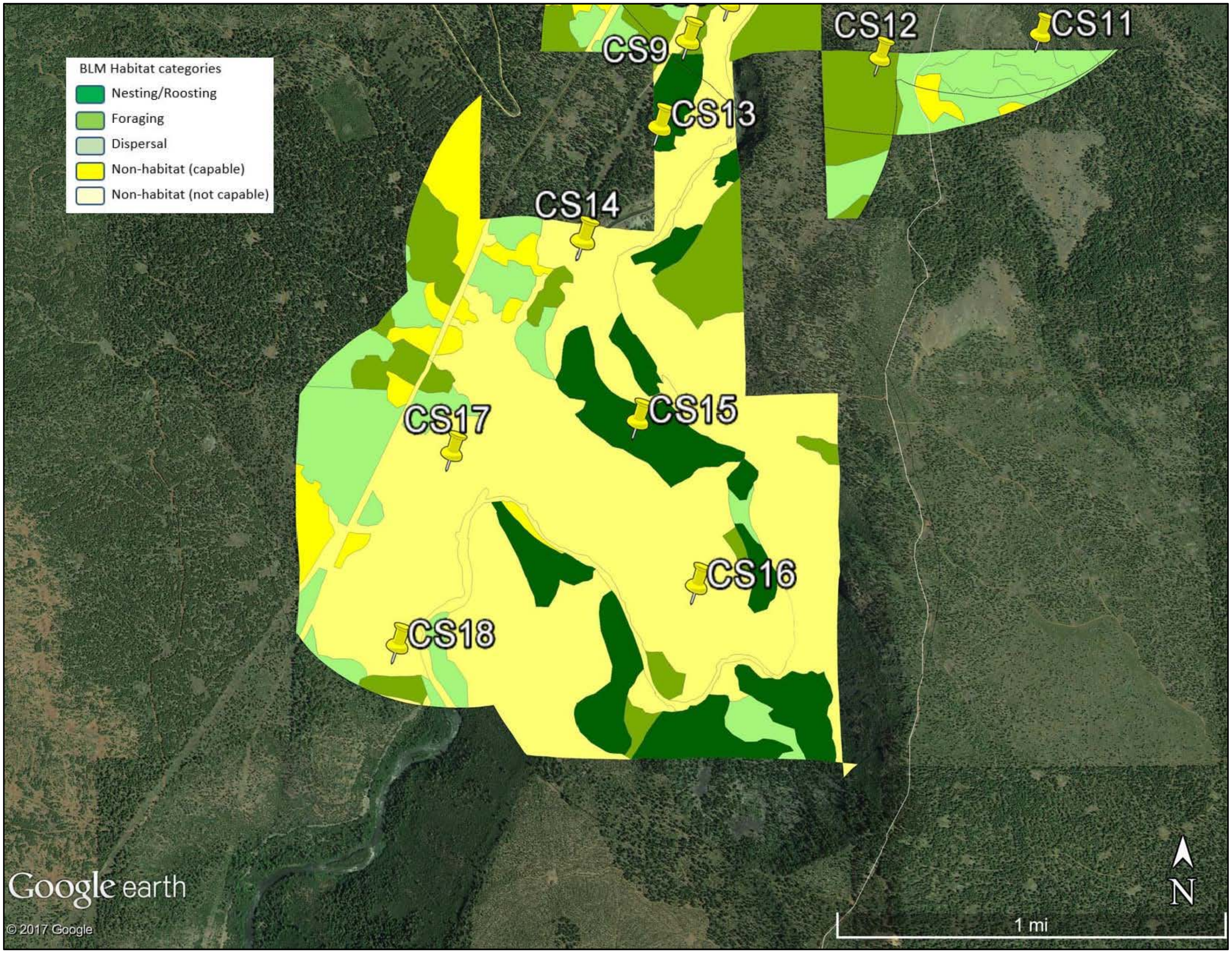


USFWS Habitat Layer

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

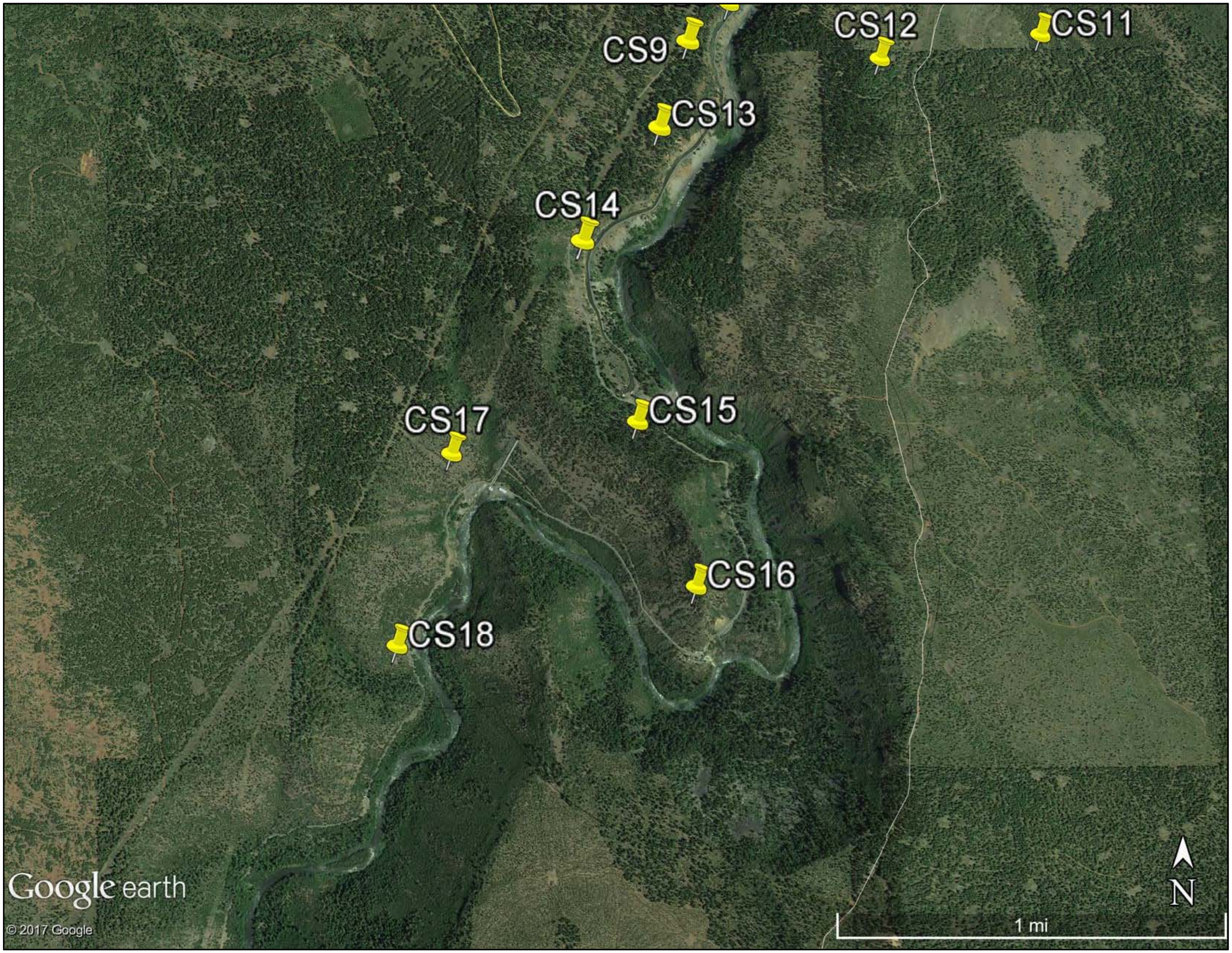
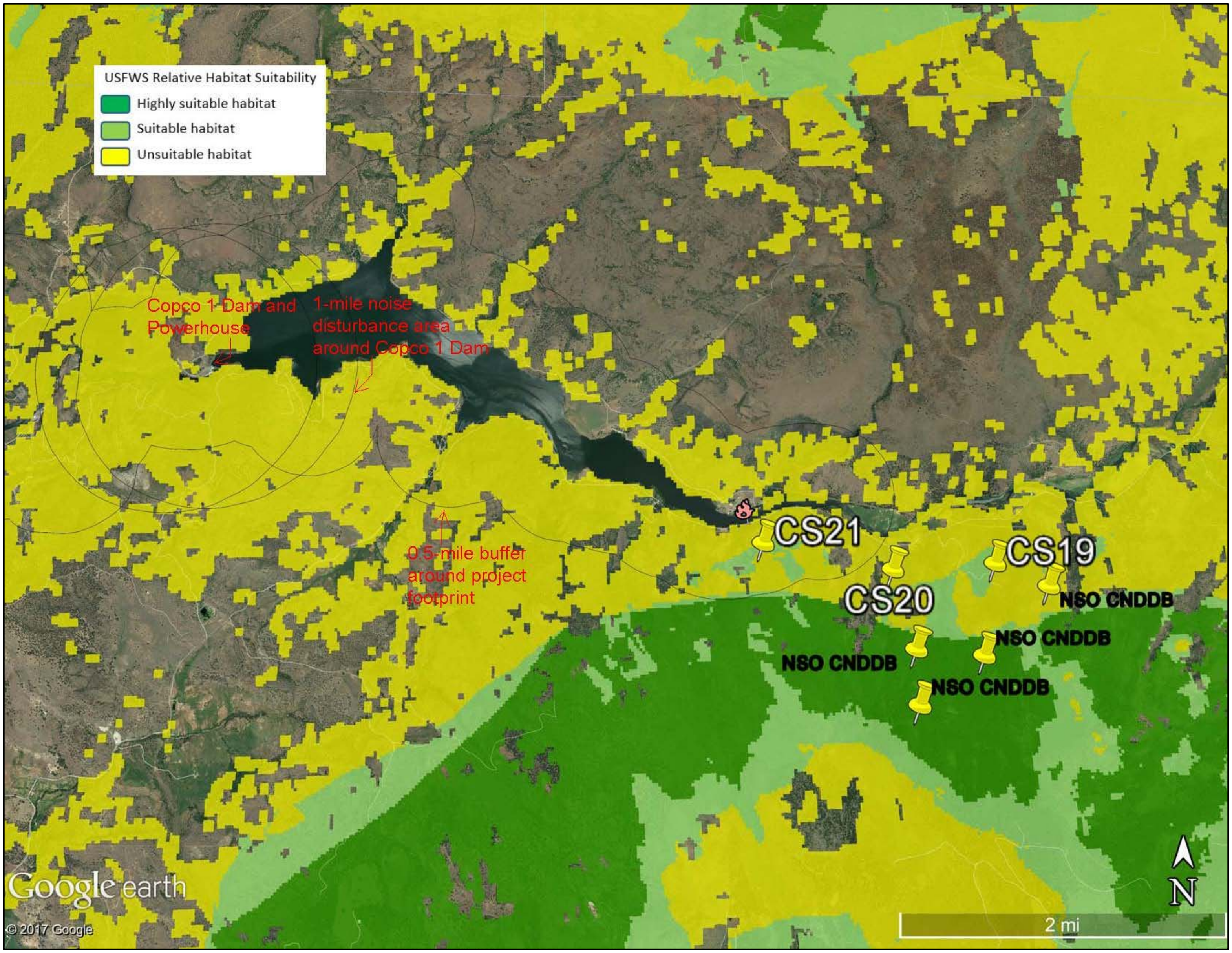


FIGURE 3: PRELIMINARY NSO CALLING STATIONS

JC Boyle Powerhouse and Penstocks

Sheet 3 of 3



USFWS Habitat Layer

Klamath River Renewal Corporation
Klamath River Renewal Project

FIGURE 4: PRELIMINARY NSO CALLING STATIONS (USFWS HABITAT LAYER)

Copco Reservoir
Sheet 1 of 2

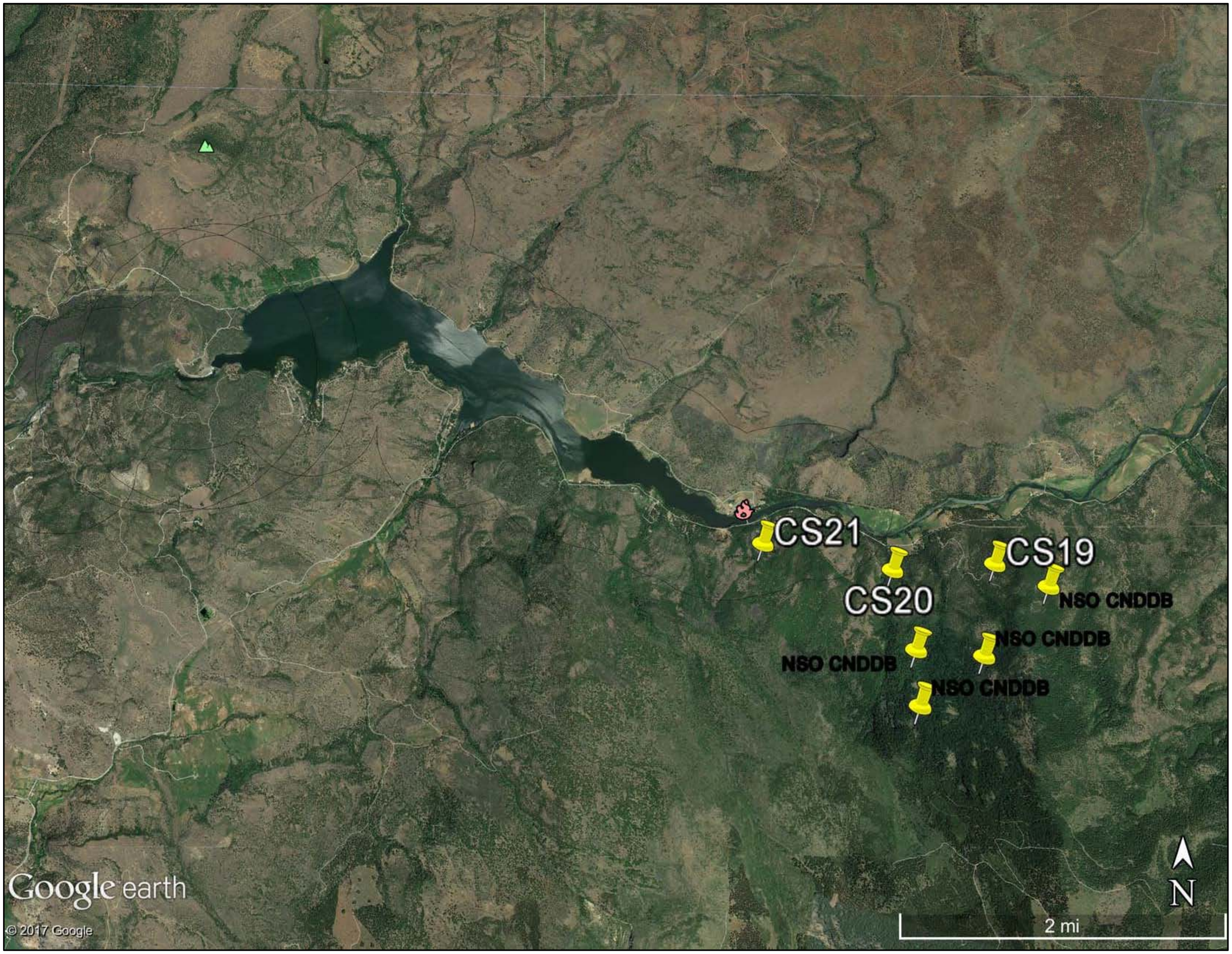
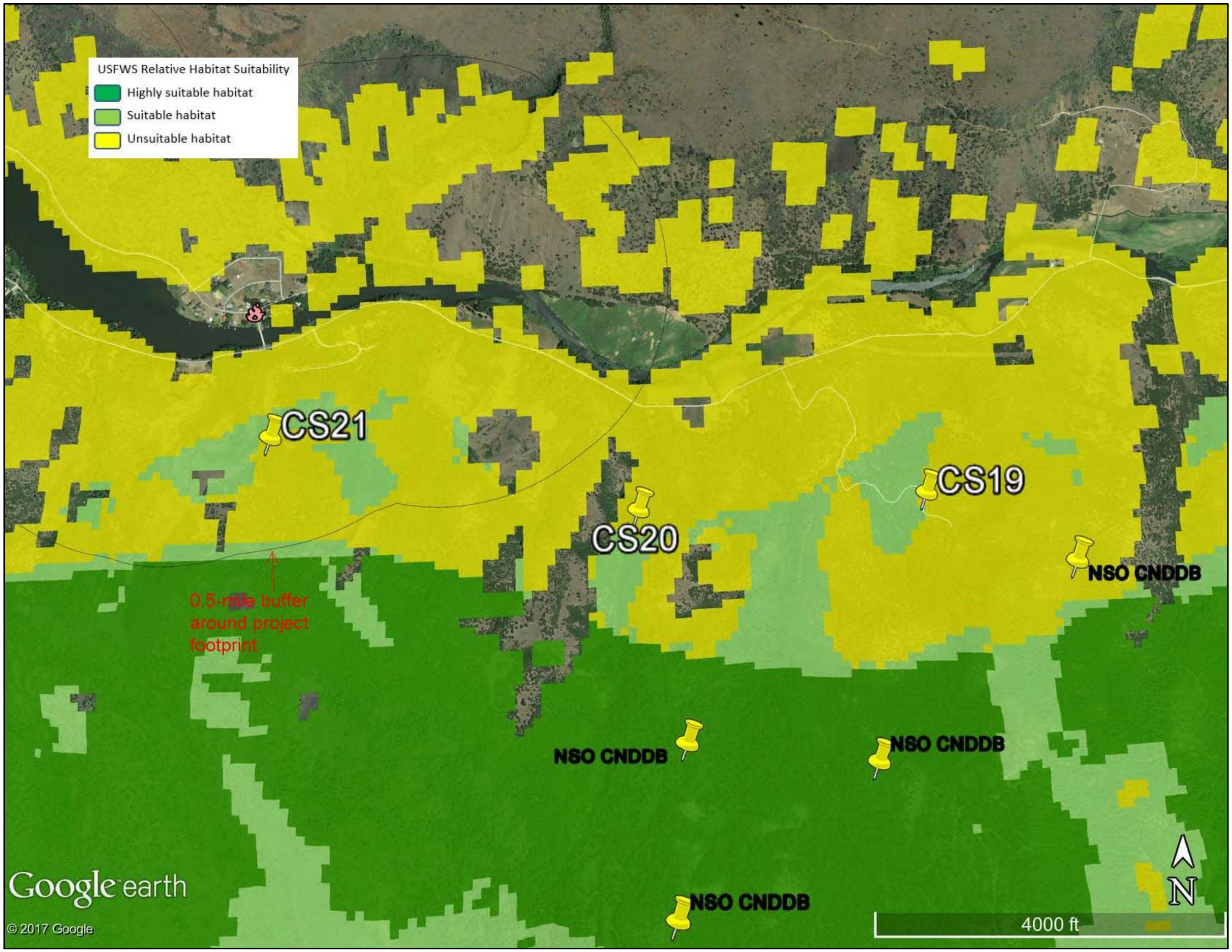


FIGURE 4: PRELIMINARY NSO CALLING STATIONS

Copco Reservoir
Sheet 2 of 2

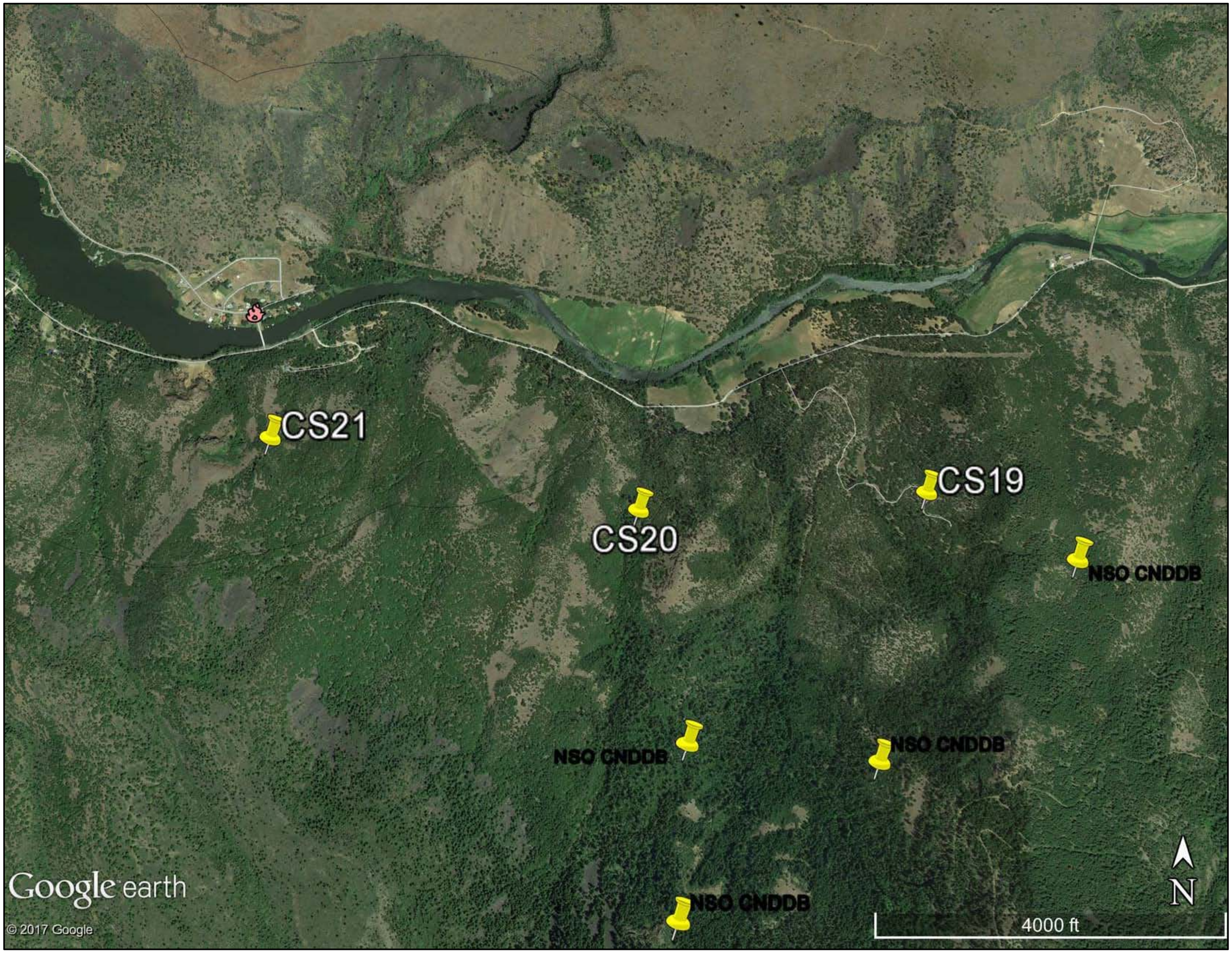


USFWS Habitat Layer

FIGURE 5: PRELIMINARY NSO CALLING STATIONS (USFWS HABITAT LAYER)

Copco Reservoir – Upstream End

Sheet 1 of 2



Klamath River Renewal Corporation
Klamath River Renewal Project

FIGURE 5: PRELIMINARY NSO CALLING STATIONS

Copco Reservoir – Upstream End

Sheet 2 of 2

Attachment B

Viewshed Analysis Figures and Eagles Table

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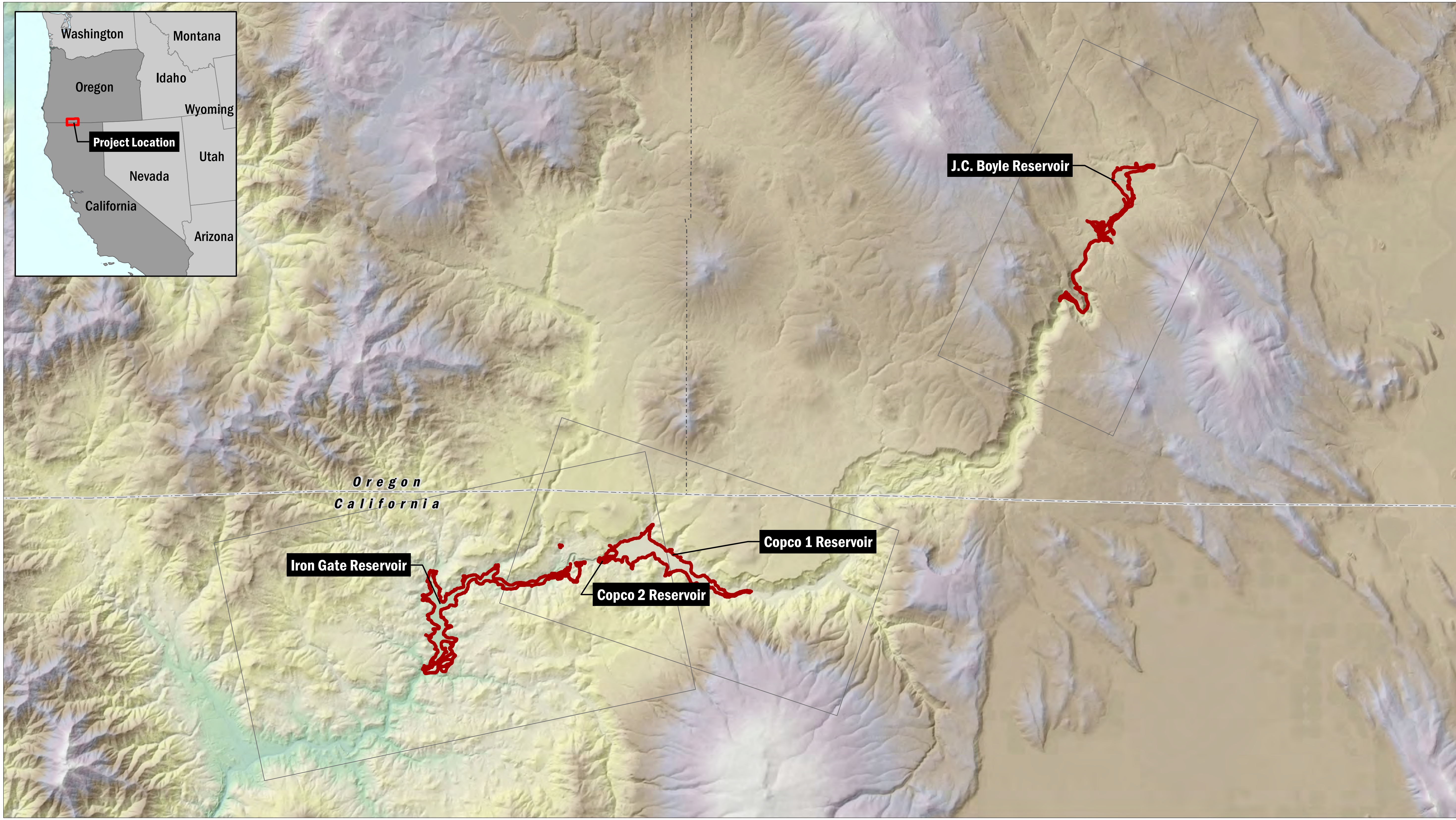
AECOM Oakland CA 8/30/2017 USER caitlin.jensen PATH \\Oakland\Oakland\Projects\Secure\Water\Klamath Dam\400-Technical\440 GIS\02_Maps\02_Map_Production_and_Reports\01_Field Maps\Biology\Viewshed\Fig1_ProjectFootprint_Viewshed_Overview.mxd



N

0 5
Miles

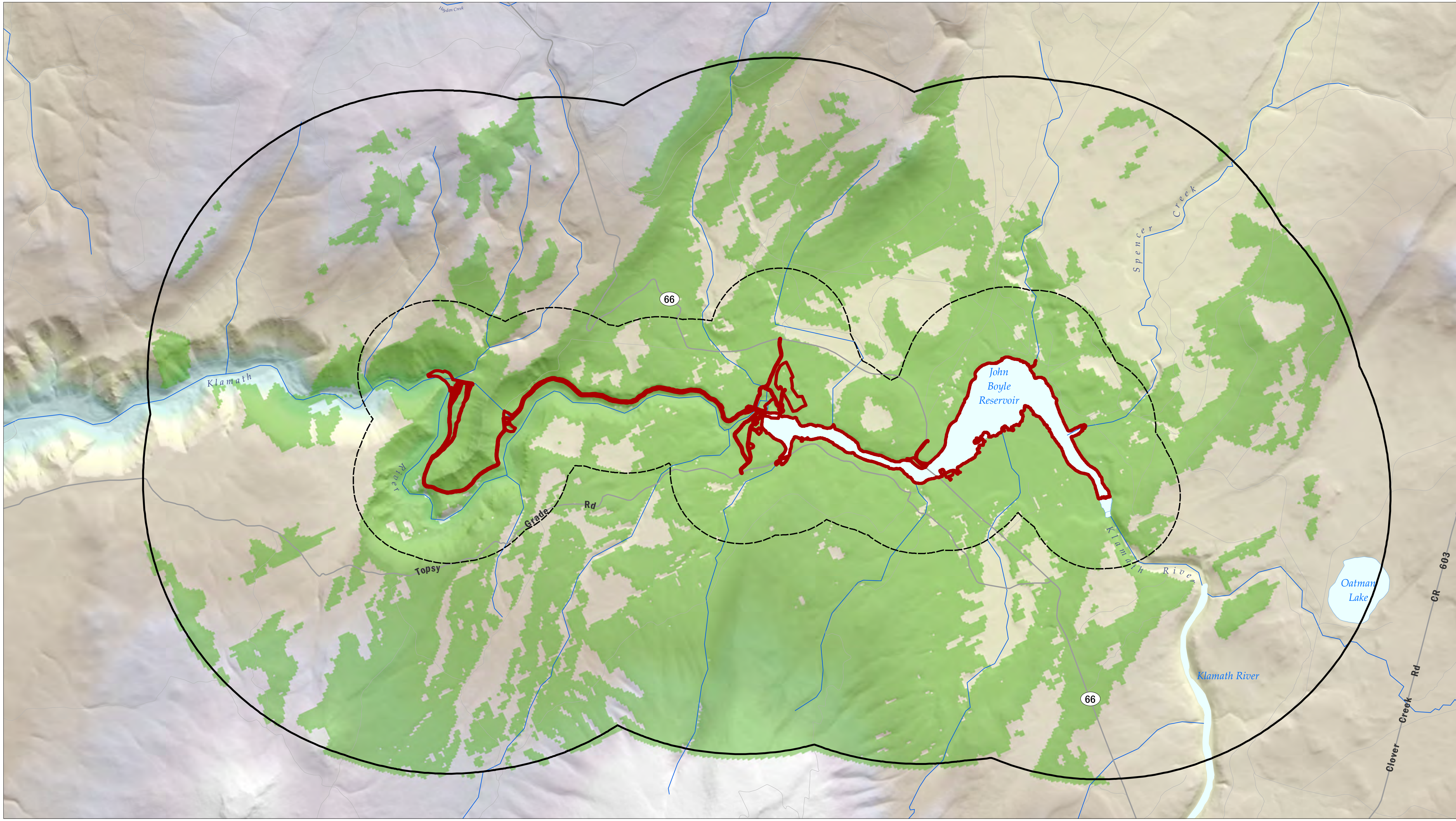
State Boundary
County Boundary
Project Footprint

USGS National Elevation Dataset, published 2013

AECOM
Klamath River Renewal Corporation
Klamath River Renewal Project

FIGURE 1: PRELIMINARY PROJECT FOOTPRINT VIEWSHED

Overview



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

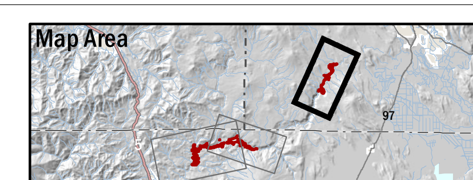
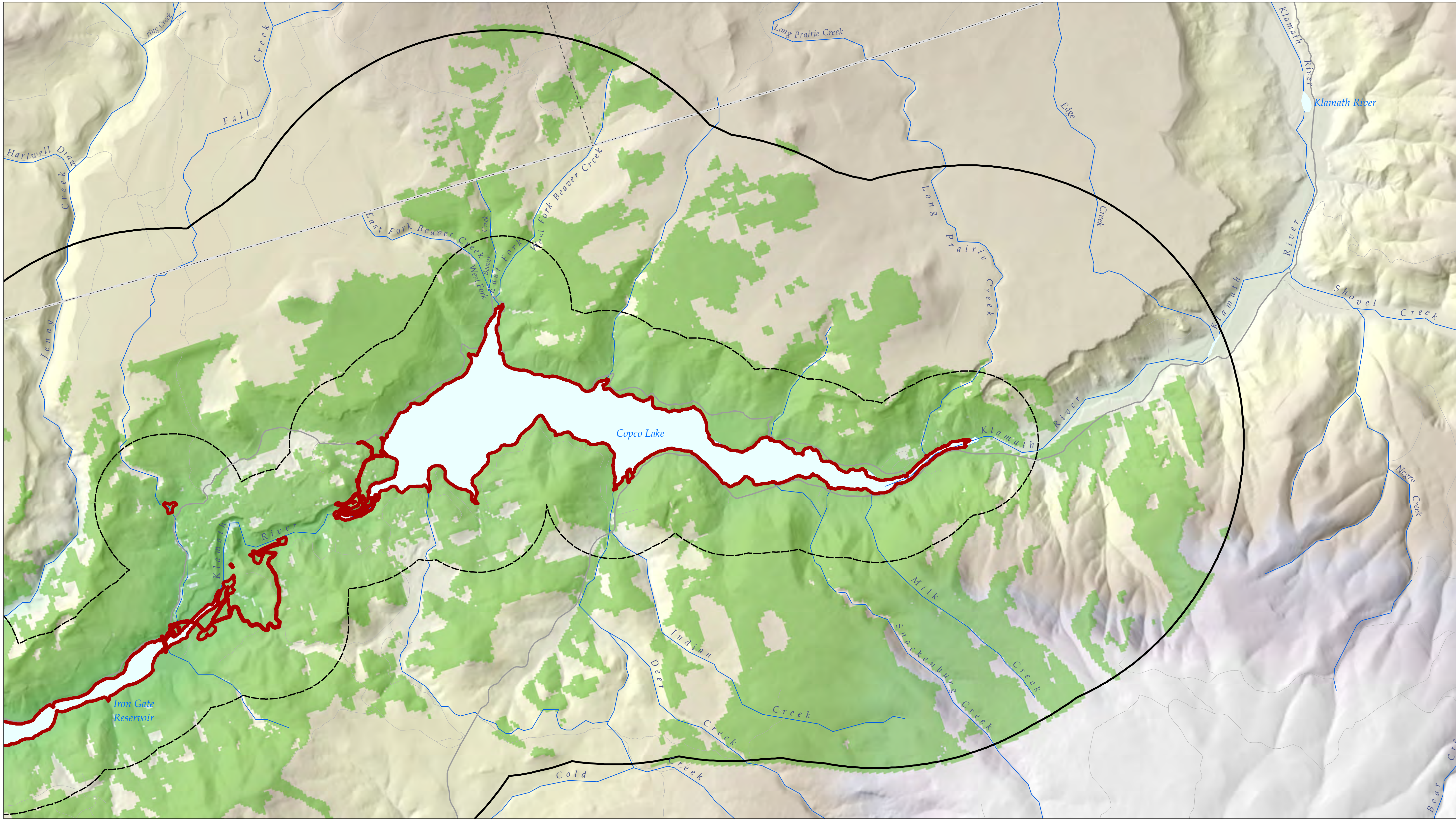


FIGURE 1: PRELIMINARY PROJECT FOOTPRINT VIEWSHED

J.C. Boyle Reservoir

Sheet 1 of 3



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

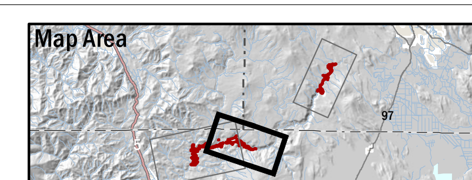
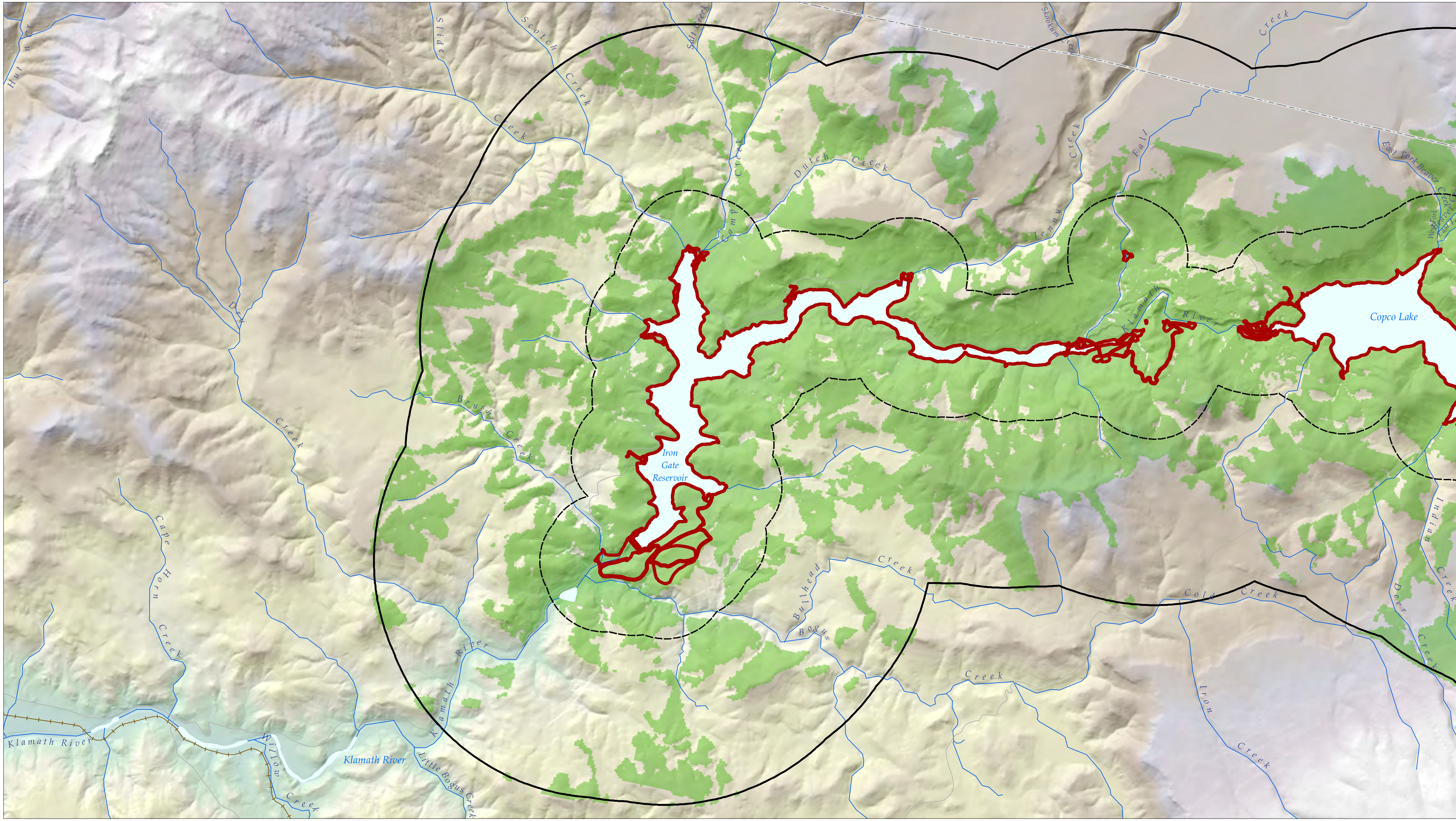


FIGURE 1: PRELIMINARY PROJECT FOOTPRINT VIEWSHED

Copco 1 and 2 Reservoirs

Sheet 2 of 3



AECOM
Klamath River Renewal Corporation
Klamath River Renewal Project

- 0.5-Mile Buffer
- 2-Mile Buffer
- Project Footprint
- Viewshed from Project Footprint

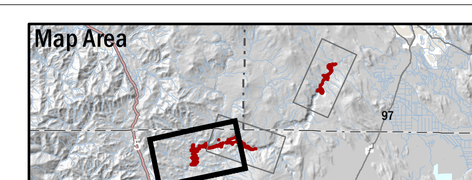


FIGURE 1: PRELIMINARY PROJECT FOOTPRINT VIEWSHED

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 K Road and Bridge Structure Data and Long-Term Improvements

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Access Roads and Haul Routes of Significance

Name of Road	Dam	County / State	Divided	Surface	Condition	Posted Speed (mph)	Haul or Access	Notes	Recommended Improvements	Temporary Traffic Control (Y/N)
The Dalles California Highway (US 97)	J.C. Boyle	Klamath, Oregon	Undivided	HMA	Good	65	Haul	Two lane State highway system, AC paved road with a soft shoulder. Proposed haul route to transport materials from J.C. Boyle Dam.	Improvements and upgrades to this highway for mobilization or hauling of materials are not anticipated for the Project. Pavement rehabilitation is unlikely during or post-construction.	Y (during pavement rehab only)
Green Springs Highway (OR66)	J.C. Boyle	Klamath, Oregon	Undivided	HMA	Fair	35-45	Haul	Soft shoulder for most part and a few locations with HMA.	Improvements and upgrades to this highway for mobilization and hauling are not anticipated for the Project. Pavement rehabilitation is unlikely during or post-construction.	Y (during pavement rehab only)
Keno Worden Road	J.C. Boyle	Klamath, Oregon	Undivided	HMA	Fair	35	Haul	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.	Improvements and upgrades to this highway for mobilization and hauling are not anticipated for the Project. Pavement rehabilitation is unlikely during or post-construction.	Y (during pavement rehab only)
Topsy Grade Road	J.C. Boyle	Klamath, Oregon	Undivided	AB with some asphalt	Good	n/a	Haul	Gravel road from OR66 becoming HMA for a portion alongside the Topsy Campground.	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.	Y (during repair/regrading)
J.C. Boyle Dam Access Road from OR66	J.C. Boyle	Klamath, Oregon	Undivided	Gravel	Fair	n/a	Haul		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.	N
J.C. Boyle Right abutment access road	J.C. Boyle	Klamath, Oregon	Undivided	AB	Poor	n/a	Haul		None.	N
J.C Boyle Disposal Access Road	J.C. Boyle	Klamath, Oregon	Undivided	Dirt	Fair	n/a	Haul		Regrade uneven or rutted areas of road surface. Minor widening in parts to allow two-way traffic.	N
Power Canal Access Road to powerhouse	J.C. Boyle	Klamath, Oregon	Undivided	AB	Poor	n/a	Access	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. Used for construction access only after the power canal has been completely removed.	Minor periodic roadway maintenance such as re-grading may be required to address roadway deterioration during construction.	N
J.C. Boyle Powerhouse Road	J.C. Boyle	Klamath, Oregon	Undivided	AB	Fair	n/a	Haul	Access road from forebay to powerhouse.	None.	N
Interstate 5 (I-5)	Copco 1,2, Iron Gate	Siskiyou, California	Divided	Asphalt	Very good	70	Haul	Rolling and mountainous terrain .	None.	N
Copco Road from I-5 to Ager Road	Copco 1,2 and Iron Gate	Siskiyou, California	Undivided	HMA	Good	n/a	Haul	From I5 to Ager Road.	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.	Y (during pavement rehab only)
Copco Road from Ager Road to Lakeview Road	Copco 1,2 and Iron Gate	Siskiyou, California	Undivided	HMA	Poor	35	Haul	From Ager Rd to Lakeview Rd. Poorly striped. No striped shoulder.	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.	Y (during pavement rehab only)
Copco Road from Lakeview Road to Daggett Road	Copco 1,2 and Iron Gate	Siskiyou, California	Undivided	HMA	Poor	35	Haul	From Lakeview Rd to Daggett Road. Poorly striped. No striped shoulder.	Improvements and upgrades for this road prior to dam removal are not anticipated. Pavement rehabilitation may be required during or post-construction.	Y (during pavement rehab only)
Copco Road from Daggett Road to Copco Access Road	Copco 1	Siskiyou, California	Undivided	asphalt then transitions to AB at 1.2 Mi. E. of Daggett Road	Fair	n/a	Haul	Very low traffic.	Improvements and upgrades prior to dam removal are not anticipated for the Project. Road surface maintenance may be required during or post-construction.	Y (during road surface maintenance only)

Access Roads and Haul Routes of Significance										
Name of Road	Dam	County / State	Divided	Surface	Condition	Posted Speed (mph)	Haul or Access	Notes	Recommended Improvements	Temporary Traffic Control (Y/N)
Copco Road between Copco 1 Access Road to Copco Road Bridge/Ager Beswick Road	Copco 1	Siskiyou, California	Undivided	Dirt/ HMA	Poor	n/a	Access	Road surface is primarily dirt and has very low traffic volume. One mile of road is asphalt pavement.	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 replacement and installing rock slope protection. Improvements and upgrades prior to dam removal are not anticipated. Road surface maintenance may be required during or post construction.	N
Copco Access Road between dam and Copco Road	Copco 1	Siskiyou, California	Undivided	Dirt	Fair	n/a	Haul	Dirt road with a hairpin bend. Landslides have occurred on the hillside above the hairpin bend. The lower side of 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 are assumed for the access road. Turnarounds for haul trucks will be at the powerhouse and at the disposal site of the staging area.	Y
Copco 1 Ager Beswick Road Barge Access	Copco 1	Siskiyou, California	Undivided	HMA	Fair-good	25	Access	Two-way undivided County road from Copco Bridge to Ager Rd intersection.	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.	N
Daggett Road	Copco 2	Siskiyou, California	Undivided	Dirt/AB	Poor	n/a	Haul	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 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. Approach roadways to Daggett Road Bridge will be realigned to new, relocated Daggett Road Bridge.	Y ("one-way" signs)
Lakeview Road between Copco Road and Disposal Site	Iron Gate	Siskiyou, California	Undivided	Gravel	Fair	20	Haul	One way hauling traffic.	Improvements and upgrades for mobilization and hauling are not anticipated. Minor road surface maintenance may be required during or post-construction.	Y (during roadway maintenance)
Powerhouse access road	Iron Gate	Siskiyou, California	Undivided	Gravel (before gate)/ asphalt (past gate)	Good	n/a	Haul	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.	Roadway maintenance to ensure adequate accessibility during construction. This road will not be needed following hauling and demobilization activities.	Y (during roadway maintenance)
Left abutment access road	Iron Gate	Siskiyou, California	Undivided	Gravel	Fair	n/a	Haul	Runs between Lakeview Road and left abutment of dam. The road is swing gate controlled and can be used as a haul route to remove materials from the Iron Gate dam structure to disposal site.	Periodic maintenance to ensure accessibility during construction. Road will be removed after dam removal activities.	N
Upstream Left abutment access road	Iron Gate	Siskiyou, California	Undivided	Gravel	Fair	n/a	Haul	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.	Periodic maintenance to ensure accessibility during construction. Road will be removed after dam removal activities.	N
Access Road from Long Gulch Recreational Facility to Lakeview Road (Disposal Site)	Iron Gate	Siskiyou, California	Undivided	Gravel	Fair	n/a	Haul	One way hauling traffic.	Maintenance to ensure adequate accessibility during construction. This road will not be needed following hauling and demobilization activities.	N
Access Road from Overlook Point Recreational Facility to Copco Road	Iron Gate	Siskiyou, California	Undivided	Gravel	Fair	n/a	Haul	One way hauling traffic.	Maintenance to ensure adequate accessibility during construction. This road will not be needed following hauling and demobilization activities.	N

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 of 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.	Regrade to conform with new Fall Creek Bridge immediately east of intersection.	Y (during regrading and bridge construction)
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

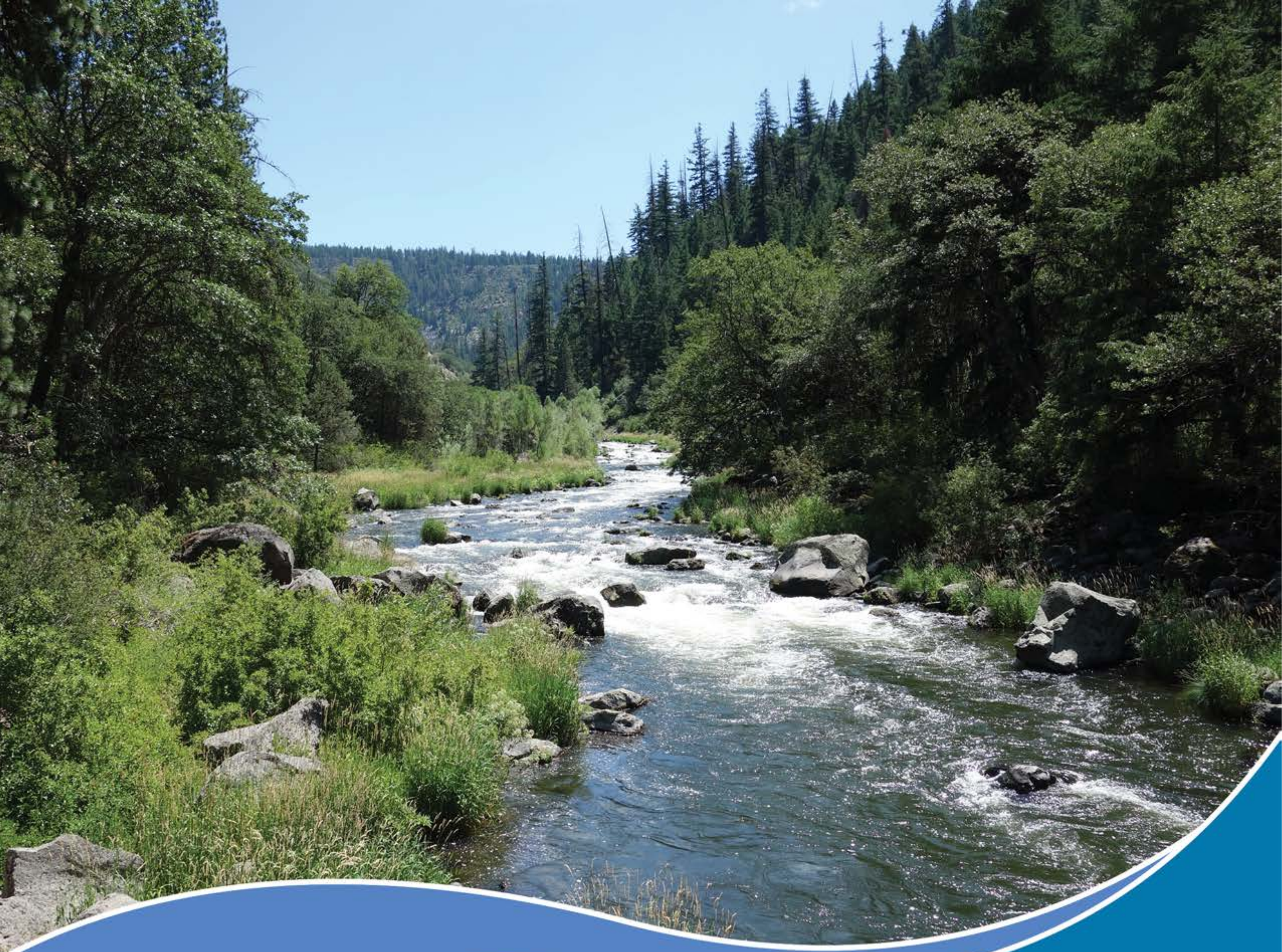
Bridge Name	Dam	Road	Bridge No.	As-Builts	Year Built	Haul or Access	Deck Width	Lane 1 Width	Lane 2 Width	Span	Notes	Recommended Improvements	Temporary Traffic Control (Y/N)
Spencer bridge	J.C. Boyle	Green Springs Hwy (OR66), Oregon	19789	Yes	2005	Haul	42.54'	12'	12'	3 spans @ 557.74' total	Reinforced 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	No construction access improvement. Private bridge. Demolish post-construction.	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	Drawdown and post-project flows have potential to cause erosion at the abutments or central pier. Further evaluation during the detailed design phase. Erosion protection may be required at the abutments or pier.	Y (during construction of improvements)
Daggett Road bridge	Copco 2	Daggett Rd		Partial	1983	Haul	14'	12'		42', 72', 58' 61'	Timber deck on steel girders	Construction access improvements on private road. Existing structure will be replaced by a bridge of similar length and width as 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.	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.	Construction access improvement on County Road. Structure will be replaced by a single span bridge of similar length and width as the existing structure.	Y (Staging involves constructing half of bridge, using half of existing bridge for one-way reversible traffic control in Stage 1. Move traffic with one-way reversible traffic control on new half of bridge while constructing final half in Stage 2.)
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	Construction access improvements on County Road. Structure will be replaced for construction access. The new bridge will be similar in length and width and constructed on a revised alignment adjacent to the existing bridge.	Y (traffic control during pavement conform work at approach roadways)
Camp Creek Bridge (replace existing culvert)	Iron Gate	Copco Road	n/a	No	n/a	Haul	n/a	n/a	n/a	n/a	Existing 10' Arched CMP pipe culvert to be replaced by a bridge.	Permanent long term improvement. Due to difficulty in knowing when erosion would occur, it is expected that replacement of the culvert with a bridge will be necessary. A temporary structure and detour road upstream of the culvert would be constructed to maintain traffic during the works.	Y
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	Permanent long term improvement. 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 on the upstream side of the existing structure, on a modified alignment, to preclude damage to the structure after drawdown.	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	Construction access improvement on County Road. Temporary bridge for construction duration and associated traffic. Existing bridge to remain as is.	Y
Pedestrian bridge - private	Klamath River	None		No		n/a					Deteriorated, not in use. Should be removed.	Demolish. The bridge spans the Klamath River just upstream of the 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 removal of the dams.	N
Campground Pedestrian bridge	Klamath River	None		No		n/a					Well maintained. In flood plain	Demolish. The bottom chord of the bridge is not high enough to pass the anticipated 100-year flood following 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.	N

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)**
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. Needs for these improvements will be confirmed following drawdown and associated monitoring.	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. Need for these minor improvements would be confirmed following drawdown.	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 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. Improvements to be confirmed following drawdown of Copco Lake and associated monitoring.	Y (during erosion protection installation)
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 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. Improvements to be confirmed following drawdown of Copco Lake and associated monitoring.	Y (during erosion protection installation)
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 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. Improvements to be confirmed following drawdown of Copco Lake and associated monitoring.	Y (during erosion protection installation)
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 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. Improvements to be confirmed following drawdown of Copco Lake and associated monitoring.	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 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. Improvements to be confirmed following drawdown of Copco Lake and associated monitoring.	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 reservoir level so no impact is anticipated and no improvement required.	N

Culvert Field Observations

Description	Dam	Road	No. of Pipes	Culvert Size(s)	Type of Pipe	Notes	Recommended Improvements	Temporary Traffic Control (Y/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 reservoir level 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	10ft	CMP	10ft pipe visually seen but not able to access due to heavy vegetation. Road width at culvert is 22ft.	Some erosion is anticipated in the vicinity of the culvert following drawdown of the reservoir due to incision into reservoir sediments. Culvert will likely need to be replaced and provided with a 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 replacement.	Y
Copco Road 200' east of Scotch Creek drainage	Iron Gate	Copco Rd	2	18", 12"	CMP		Assessment of the condition of these pipes would be performed after completion of dam removals and hauling to assess whether any damage occurred during construction. Rehabilitation or replacement would be performed if necessary.	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 - replace culvert with bridge - see structures table	Iron Gate	Copco Rd	1	10'	CMP arched	Water in culvert.	Significant erosion is anticipated in this area following drawdown of the reservoir due to incision into reservoir sediments. Due to difficulty in knowing exactly when the erosion would occur, it is expected that replacement of the culvert with a bridge will be necessary. Replace with a single span bridge along existing alignment. Provide temporary detour road upstream during replacement.	Y (during replacement)



Definite Plan for the Lower Klamath Project

Appendix L - Cultural Resources Plan

KLAMATH RIVER RENEWAL CORPORATION

June 2018

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Prepared for:

Klamath River Renewal Corporation

Prepared by:

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Acronyms and Abbreviations

ACHP Advisory Council on Historic Preservation
ADI Areas of Direct Impacts
AIR Additional Information Request
APE Area of Potential Effects
BCE Before the Common Era
BLM Bureau of Land Management
BMF Bedrock Milling Features
CA California
CDFG California Department of Fish and Game
CEQA California Environmental Quality Act
CRWG Cultural Resource Working Group
CRHR California Register of Historical Resources

EIS/R	Environmental Impact Statement/Report
ETH	Ethnographic
FIC	Field Inventory Corridor
HABS	Historic American Building Survey
HAER	Historic American Engineering Record
HPMP	Historic Properties Management Plan
HIS	Historic
KHHD	Klamath Hydroelectric Historic District
KRRC	Klamath River Renewal Corporation
MUL	Multiple
NAGPRA	Native American Graves Protection and Repatriation Act
NAHC	Native American Heritage Commission
NEPA	National Environmental Policy Act
NRHP	National Register of Historic Places
NHPA	National Historic Preservation Act
OARRA	Oregon Archaeological Records Remote Access
OR	Oregon
PA	Programmatic Agreement
PRE	Prehistoric
RM	River mile
SCR	Sensitive Cultural Resources
SHPO	State Historic Preservation Officers
SOHS	Southern Oregon Historical Society
SWRCB	State Water Resource Control Board
TCP	Traditional Cultural Property
TCR	Tribal Cultural Resources
TCRe	traditional cultural riverscape
THPO	Tribal Historic Preservation Officers
UNK	Unknown
USACE	United States Army Corps of Engineers
USFS	United States Forest Service
USGS	United States Geologic Survey

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Chapter 1: Introduction

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1. INTRODUCTION

Klamath River Renewal Corporation (KRRC) is preparing the necessary documentation of compliance with all local, state, federal and tribal laws, including those for cultural and tribal resources. This Cultural Resources Plan (Plan) provide the Federal Energy Regulatory Commission (FERC) with a framework for understanding the cultural resources studies that KRRC has completed, those that are currently ongoing, and others that are anticipated to achieve regulatory requirements under Section 106 of the National Historic Preservation Act of 1966 (NHPA) as codified in 36 CFR Part 800. As requested in FERC's July 2017 Additional Information Request (AIR), the Plan also provides the status of informal consultation completed to date by KRRC and PacifiCorp, acting as FERC's non-federal representative under 36 CFR § 800.2(c)(4), in an effort to identify and evaluate cultural resources and develop measures to avoid, minimize, or mitigate potential adverse effects to historic properties (AIR #28). This consultation effort includes affected federally recognized and non-federally recognized tribes with regard to the identification and National Register of Historic Places evaluation of Traditional Cultural Properties; the Klamath Riverscape as a cultural landscape and/or Traditional Cultural Property (TCP); and the management, disposition, and treatment of human remains (AIR #29). The Plan also lays out how KRRC intends to coordinate Section 106 compliance with the cultural resource requirements of the California Environmental Quality Act (CEQA) and the California State Water Resources Control Board's (SWRCB) tribal consultations required under California Assembly Bill (AB) 52. AB 52 compliance is a requirement for the SWRCB's consideration of KRRC's application for a water quality certification under Section 401 of the Clean Water Act.

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Chapter 2: Plan Overview

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2. PLAN OVERVIEW

KRRC developed this Cultural Resources Plan to guide the multifaceted phases of cultural resources compliance actions planned for the Lower Klamath Project (Project). Foremost among these tasks is identification of historic properties in the Project's Area of Potential Effects (APE). Historic properties are cultural resources listed or eligible for listing in the National Register of Historic Places (NRHP). The Advisory Council on Historic Preservation (ACHP) regulations define the APE as the geographic area or areas within which an undertaking may directly or indirectly cause changes in the character or use of historic properties, if any such properties exist. The scale and nature of an undertaking influences the geographic scale of an APE, which may be different for different kinds of effects caused by the undertaking (36 CFR § 800.16(d)). Once defined, the APE will become the primary focus of the Project's cultural and tribal resources studies.

Additional resource identification efforts, effects determinations, and potential mitigation measures also are needed to meet Section 106 requirements, including an assessment of the completeness of previous cultural resource inventories conducted within the APE and particularly in the Areas of Direct Impacts (ADI) from dam removal. Anticipated effects to cultural and tribal resources include, but are not limited to, removal of historic project facilities, including the four dams; disturbances associated with road construction, disposal sites and staging activities; erosion and exposure associated with reservoir drawdown and enhanced river flows; and potential vandalism and theft to re-exposed sites. Cultural resources identification efforts for the Project, including pre-drawdown surveys for portions of the ADI not previously inventoried are underway. Planning efforts are also occurring for drawdown, dam removal, and post-drawdown events. These include developing field inventory and site monitoring procedures to ensure the consideration of effects on anticipated (based on the historic record) and unanticipated cultural and tribal resources.

Previous cultural resources surveys conducted by PacifiCorp in the early 2000s for the Klamath Hydroelectric Project (FERC License No. 2082) relicensing encompassed existing developments on the main stem Klamath River, including the four developments that will be removed by the Project. The PacifiCorp cultural resources study (PacifiCorp 2004) documented hundreds of cultural resources sites within a then-defined Field Inventory Corridor (FIC), although not all identified cultural resources have official NRHP eligibility determinations. The eligibility of many cultural resources within the ADI for the Project requires reevaluation because their eligibility under the Klamath Hydroelectric Project relicensing was never formalized through consultation with the California and Oregon State Historic Preservation Officers (SHPOs), or because other components of the sites were not considered in the original evaluations. New cultural and tribal resources sites identified through ongoing and future survey efforts will also require NRHP evaluation determinations, particularly for those resources within the ADI. Following evaluation and effects assessment, the Project anticipates developing mitigation measures for historic properties that will be adversely affected by the Project.

PacifiCorp completed a NRHP evaluation report of the Klamath Hydroelectric Project, comprised of seven generation facilities and their related resources located along the Klamath River and its tributaries in

Klamath County, Oregon, and Siskiyou County, California. That report included the four developments planned for removal (J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate) as part of the Project. The Fall Creek powerhouse, located on a tributary of the Klamath River, just north of Copco No. 2 was also evaluated at that time. A historic context statement (Kramer 2003a) and Determination of Eligibility Report (Kramer 2003b) were developed for the Klamath River Hydroelectric Project District (P-47-004015), noting its NRHP eligibility under Criterion A for its association with the industrial and economic development of southern Oregon and northern California (Kramer 2003b). The California and Oregon SHPOs have not concurred with this eligibility recommendation. Updating these recommended evaluations and achieving their formal eligibility determinations remains an important element to be completed as part of this Cultural Resource Plan.

As part of the 2004 relicensing effort, PacifiCorp sponsored tribal ethnographic studies, prepared by the Klamath, Shasta, Karuk, and Yurok Tribes, which combined ethnography with extensive oral interviews to identify traditional cultural properties/sensitive cultural resources (TCPs/SCRs). PacifiCorp also provided for an investigation of the feasibility of nominating Klamath River corridor as a traditional cultural riverscape/traditional cultural property (TCRe/TCP). The NRHP evaluation of the TCPs, SCRs, and the TCRe was not formalized through consultation with the California and Oregon SHPOs and the associated federal agencies and remains a task for implementation under the Project.

KRRC will prepare a draft Historic Properties Management Plan (HPMP) for the Project which will include management, treatment, protection, and mitigation measures for historic properties, as described in greater detail in Section 8 below and consistent with FERC's "Guidelines for the Development of Historic Properties Management Plans for FERC Hydroelectric Projects" (2002). The HPMP will include an Inadvertent Discovery Plan, which will outline protocols regarding unanticipated finds, as well as a Monitoring Plan to provide general protocols for monitoring historic properties and other select areas that will benefit from monitoring during and following dam removal. Measures to manage, treat, protect, and mitigate historic properties developed under the Section 106 consultation process will be coordinated with the applicable measures developed under the SWRCB's AB 52 consultations.

Finally, both Native American and European American human burial sites have been previously identified in the Project's limit of work. These include individual graves, burials in prehistoric village sites, and prehistoric and historic-period cemeteries along the Klamath River corridor. Adverse effects to human burial sites have been identified as a key concern of tribes, and possible downstream erosion and enhanced river flows may cause degradation of soil and exposure of human burials. Before dam removal occurs, a Plan of Action and protocols for treatment of human burials will be developed by KRRC.

Since the Project meets many of the requirements of 36 CFR § 800.14, a Programmatic Agreement (PA) will be completed during the Section 106 process. The PA will be developed in consultation with the Cultural Resources Working Group (CRWG) and FERC.

Chapter 3: Ongoing Consultations

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3. ONGOING CONSULTATIONS

3.1 Informal Consultation (NHPA)

FERC designated KRRC as its designated non-federal representative, pursuant to Section 106 of the NHPA (54 U.S.C § 300101 et seq.) and the ACHP's regulations at 36 C.F.R. § 800.2(c)(4). In January 2018, KRRC initiated informal consultation with affected tribes and other tribal organizations as FERC's designated non-federal representative, pursuant to Section 106 of the NHPA (54 U.S.C § 300101 et seq.) and the ACHP regulations at 36 C.F.R. § 800.2(c)(4). Twenty-five federally and non-federally recognized Tribes located in northern California and southern Oregon received invitation letters to participate in the informal consultation process and included tribes previously identified by FERC during its tribal consultation efforts as well as by the California Native American Heritage Commission (NAHC) List and Oregon Commission on Indian Services. The invitation was extended to federally recognized tribes consistent with 36 CFR 800.2(c)(2) and non-federally recognized tribes pursuant to 36 CFR 800.2(c)(5). Currently eight tribes have accepted participation in the ongoing informal consultation with KRRC: Karuk Tribe, Klamath Tribes, Modoc Tribe of Oklahoma, Quartz Valley Indian Reservation, Shasta Indian Nation, Shasta Nation, Cher'Ae Heights of the Trinidad Rancheria, and the Yurok Tribe. KRRC held a project introduction meeting with the participant Tribes on April 6, 2018 in Yreka, California. This meeting provided a project overview, reviewed the previous cultural resource studies, discussed the informal consultation process, and provided an overview and invitation to the tribes to participate in the CRWG (see below). Additional meetings and consultation efforts pursuant to Section 106 with tribes and other interested parties will continue.

Among the topics requiring tribal consultation are the delineation of the APE, the identification and evaluation of TCPs, the proposed Klamath Cultural Riverscape, and the management and disposition of cultural and human remains. KRRC is preparing a cultural resources work plan to guide the Section 106 process through the course of the Project. This work plan includes the written definition of a preliminary APE; a discussion of the integration of the proposed Klamath Cultural Riverscape into the APE; draft protocols for inadvertent discoveries; and an outline for a Plan of Action and appropriate treatment of human remains, funerary objects, sacred objects, and objects of cultural patrimony.

3.2 California Consultations

KRRC is participating in related tribal cultural resources consultation efforts being conducted by the SWRCB for the Project. SWRCB is conducting their consultation as part of CEQA review for KRRC's application for a Water Quality Certification for the Project pursuant to Assembly Bill 52 (AB 52). AB 52 requires California state and local agencies to consider a proposed action's impacts to Tribal Cultural Resources (TCRs) as part of the agency's review of the proposed action under the CEQA. A TCR is defined as a site, feature, place, cultural landscape, sacred place, or object with cultural value to a California Native American tribe. California Native American tribes are those tribes registered with the California NAHC, regardless of whether the tribes are federally-recognized. KRRC's tribal resources lead has participated in meetings and teleconferences held between the SWRCB and the tribes engaged in the AB 52 consultation. As this California AB 52 tribal consultation process will overlap in part with the Section 106 consultation, KRRC will make efforts to coordinate and integrate the two processes to the extent feasible and as appropriate.

Chapter 4: Cultural Resources Working Group

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4. CULTURAL RESOURCES WORKING GROUP

KRRC has established a CRWG to provide a collaborative and interactive process for data sharing, participation, and discussion among the applicants, tribes, and resource agencies during the Section 106 consultation process. The CRWG is comprised of representatives from federal agencies with administered lands in the project APE (U.S. Forest Service and Bureau of Land Management; Figure 4-1), as well as California and Oregon SHPOs and tribes (Table 4-1). Other invited parties include the Bureau of Reclamation and United States Army Corps of Engineers (USACE) who have currently elected not to participate. KRRC expects membership of the CRWG to expand as consultation proceeds.

The goals of the CRWG include: (1) definition of the project APE; (2) preparation of a Programmatic Agreement and other guidance documents; (3) overall guidance on the scope and level of effort required for inventory and evaluation of historic, archaeological, and tribal resources; (4) assessment of effects to Historic Properties; (5) identification and implementation of mitigation measures. In addition, KRRC will consult with the CRWG in the development of a HPMP.

The CRWG held an initial meeting on September 5, 2017, the purpose of which was to provide working group members with background information on the Project, status of cultural resources inventory and evaluation efforts, and allow for the identification and discussion of the CRWG's goals and objectives. Subsequent to that meeting, KRRC developed a preliminary APE for the Project.

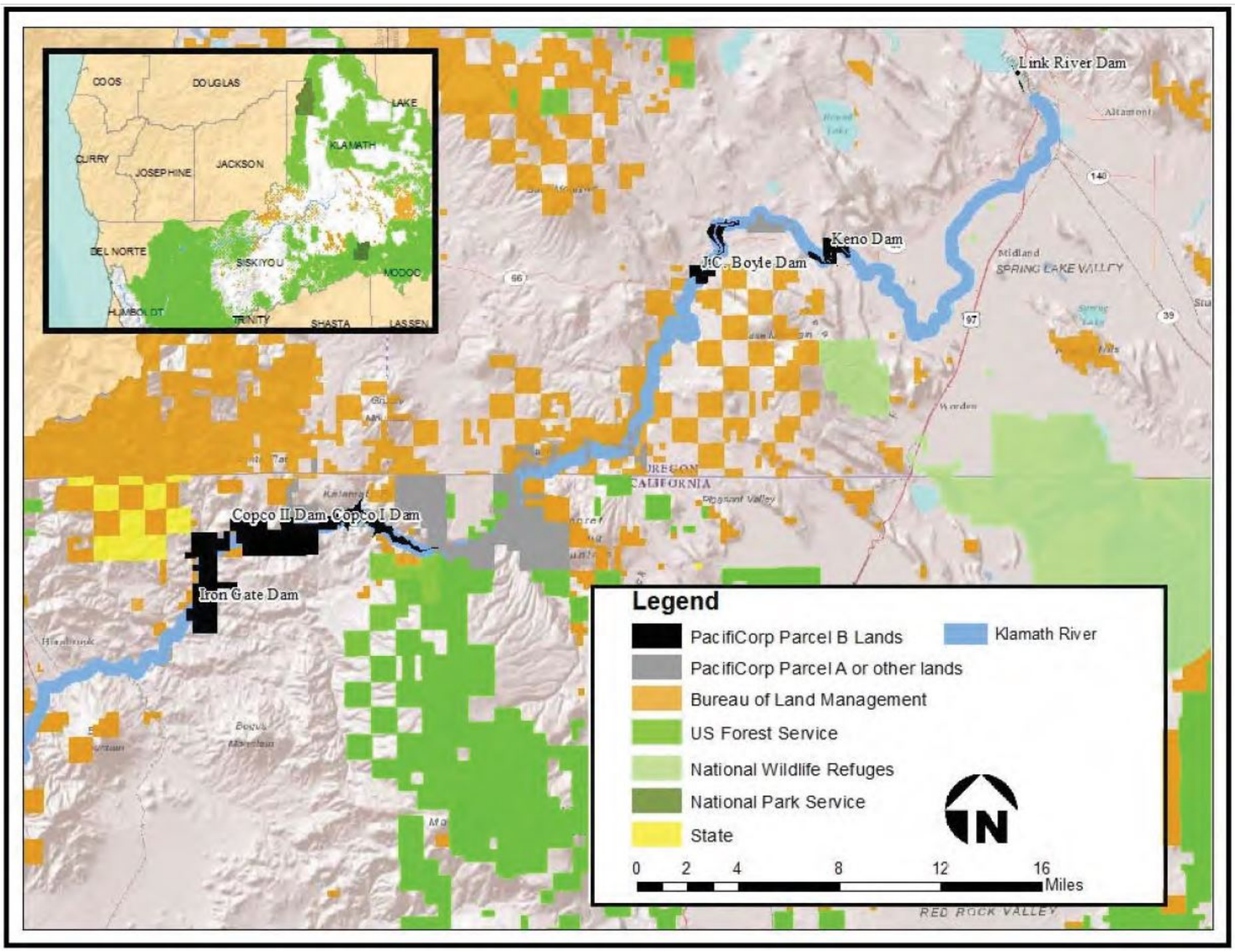
KRRC hosted a second meeting on December 14, 2017 to review the KRRC's draft APE. A third CRWG meeting occurred on March 15, 2018 to provide an update on Section 106 consultation, the project schedule, anticipated field work dates, next steps in SHPO consultation, and outlining the process for developing the Section 106 agreement document. KRRC plans to hold the next CRWG meeting in August 2018.

Table 4-1 Current Participants - Cultural Resources Working Group

Agency/Entity	Status
KRRC	Applicant
PacifiCorp	Applicant
AECOM	Technical Representative
CDM Smith	Technical Representative
USDA Forest Service, Klamath National Forest	Federal
Bureau of Land Management, Klamath Falls, Oregon and Redding, California Field Offices	Federal
California Office of Historic Preservation	State of California

Agency/Entity	Status
Oregon State Historic Preservation Office	State of Oregon
Cher'Ae Heights of Trinidad Rancheria	Tribe
Karuk Tribe	Tribe
Klamath Tribes	Tribe
Modoc Tribe of Oklahoma	Tribe
Quartz Valley Indian Reservation	Tribe
Shasta Indian Nation	Tribe
Shasta Nation	Tribe
Yurok Tribe	Tribe

KRRC also anticipates outreach to local municipalities, museums and historical societies, and other entities that may have an interest in the consideration and treatment of historic properties. KRRC will send letters to these parties to seek and consider their views concerning the identification, evaluation, and treatment of historic properties.



Source: 2012 EIS/R (USBR and CDFW 2012)

Figure 4-1 Land ownership in the project vicinity

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Chapter 5: Definition of the Area of Potential Effects

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5. DEFINITION OF THE AREA OF POTENTIAL EFFECTS

Implementing regulations of the NHPA require federal undertakings to determine the scope of identification efforts (36 CFR § 800.4(a)). This is accomplished in part by determining and documenting the APE (36 CFR § 800.4(a)(1)). The APE means the "geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist." Furthermore, the APE "is influenced by the scale and nature of an undertaking and may be different for different kinds of effects caused by the undertaking" (36 CFR § 800.16(d)). Inclusion of land within an APE does not mean that an undertaking would affect any or all cultural resources in that area. Defining an APE provides both the lead federal agency and consulting parties with a basis for understanding the geographic extent of anticipated impacts of a proposed project, which is necessary to determine whether the project may adversely affect historic properties.

As the lead federal agency for the Project, FERC defines the APE, in consultation with other federal agencies, tribes, SHPOs, THPOs, KRRC, PacifiCorp, and other consulting parties. KRRC and PacifiCorp, in collaboration with the CRWG members and tribes are in the process of developing a preliminary APE and will continue to refine the APE as a part of the Section 106 process. The KRRC is currently receiving comments from the participants in the Section 106 process and will engage in additional consultation to address agency/entity concerns.

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Chapter 6: Resource Identification

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6. RESOURCE IDENTIFICATION

6.1 Records Search Update

As part of the Klamath Hydroelectric Relicensing (FERC 2007) and Klamath River Dam Removal (USBR 2012) studies, PacifiCorp (2004) and Cardno ENTRIX (2012) completed cultural resources records searches to collect information of previous archaeological research and historical information. These earlier record searches provided baseline resource data for the respective project areas through 2012. In 2017, KRRC completed an updated records search and literature review for the Project to add information for the intervening 5-year period, or through 2017. The cumulative results of the 2017 KRRC records searches are summarized first, followed by State-specific summaries.

The 2017 KRRC records search area extended from the outlet of the Klamath River at the southern end of Upper Klamath Lake in Klamath County, Oregon (RM 255) downstream to the confluence of Klamath River and Humbug Creek in Siskiyou County (RM 174), for a total of 81 river miles. The section of river below Iron Gate Dam (the downstream-most Project development) was included in the initial records search since this area lies within the altered 100-year floodplain following dam removal, where cultural resources have the potential to be affected. The records search area encompassed a 0.5-mile wide zone, extending on either side of the shorelines of Lake Ewauna, Link River, J.C. Boyle Reservoir, Copco Lake, and Iron Gate Reservoir, or from the center point of the Klamath River in areas where a flowing river exists. The records search identified 502 previously recorded cultural resources, comprised of a broad range of archaeological sites, built environment resources, isolated finds, and a few locations of an undetermined resource type (Table 6-1).

In response to the delineation of a preliminary APE, KRRC initiated an expanded records search in 2018 for an area encompassing a 0.5-mile wide zone on either side of the Klamath River from below Humbug Creek to the mouth of the river at the Pacific Ocean, in California. KRRC will incorporate results of the 2018 expanded records search for California into future reports and are not reflected in the discussion and tables provided below.

The 2017 records search identified 290 previously recorded archaeological sites, including 170 sites in Oregon and 120 sites in California. Collectively, these sites consist of 162 prehistoric resources, 19 of which have documented ethnographic associations or uses. Also recorded are 83 historic-period archaeological sites and 44 sites with both prehistoric and historic-period components. These latter sites, termed multiple component sites, include at least eight locations that have documented ethnographic use. The final archaeological site consists of a resource of unknown temporal association.

Table 6-1 Summary of Previously Recorded Cultural Resources for Oregon and California (2017 Records Search).

Resource Type	Component Type					
	Prehistoric	Historic	Multiple	Ethnographic Only	Unknown	Total
Archaeological Site	162	83	44	–	1	290
Ethnographic	–	–	–	1	–	1
Built Environment	–	24	3	–	–	27
Isolated Find	158	17	–	–	1	176
Undetermined	–	–	–	–	8	8
Total	320	124	47	1	10	502

One resource has been recorded as an ethnographic location that figures prominently in an important legend in Shasta Indian oral history.

A group of 27 built environment resources, comprised of manufactured structures, features, and facilities, have been previously recorded, including 15 in Oregon and 12 in California. The built environment resources include intact structures, such as log cabins and sheds; power facilities, including powerhouses; bridges; boardwalks; cemeteries; a lumberyard; a commercial sawmill; and other constructed features.

Eight resources of undetermined resource type or age have been reported in California. While the physical location for these sites has been recorded, other information such as the types of artifacts and/or features present is unavailable.

The final resource type consists of a group of 176 isolated finds, which typically represent locations with five or fewer artifacts or single features. These finds include 108 isolates in Oregon and 68 isolates in California. The isolated finds encompass 158 prehistoric resources, 17 historic-period isolates, and 1 feature of unknown age.

6.1.1 Oregon Records Search

Within the State of Oregon, the 2017 records search area included the length of the Klamath River from its outlet at Upper Klamath Lake at Link River Nature Trailhead (RM 255) south to the Oregon/California Stateline (RM 214), for a total length of roughly 41 river miles. This river stretch also included the Link River and Lake Ewauna. The records search area encompassed a 0.5-mile wide zone, extending on either side of the shorelines of Lake Ewauna, Link River, and J.C. Boyle Reservoir, or from the center point of the Klamath River in areas where the river remains free flowing.

In April 2017, KRRC reviewed records on file at the Oregon SHPO to determine the extent of previously recorded cultural resources and past investigations within Oregon records search area. This records search was conducted using the Oregon Archaeological Records Remote Access (OARRA) GIS database maintained by the Oregon SHPO. This database contains all cultural resources reports and resource forms approved by SHPO and provides information on the location of previously recorded archaeological sites, cultural resource surveys, National Register properties, and cemeteries. In addition, KRRC also reviewed the separate Oregon SHPO online Oregon Historic Sites Database to collect information regarding built environment resources located within the records search area.

In July 2017, KRRC conducted a records search at the BLM Klamath Falls Resource Area office in Klamath Falls, Oregon. KRRC examined cultural resources files for government lands in Klamath County, Oregon, for recent project reports and copies were made of relevant reports and resource records. In October 2017, KRRC visited the Southern Oregon Historical Society (SOHS) Library in Medford, Oregon to examine the John C. Boyle papers, maps, and photograph collection pertaining to the Klamath River area.

In addition to these office visits, KRRC researched online newspaper archives, 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. KRRC also reviewed copies of the Klamath County Historical Society Klamath Echoes for relevant site and historic context information.

In May 2017, 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).

Previous Cultural Resources Studies

The 2017 Oregon records search and literature review identified 119 previous cultural resources investigations as having been conducted within the records search area, with five of these studies (Kramer 2003a, 2003b; Cardno ENTRIX 2012; PacifiCorp 2004; Daniels 2006) completed specifically for the Project. Collectively, these reports provide a broad range of reference materials derived from pedestrian surveys, archaeological testing and evaluation, prehistoric and historic-period context documents, and professional studies. Most reports (n=79) detail the results of cultural resources surveys or survey/excavation work conducted across the records search area. Twenty-three reports consist of archaeological, ethnographic, or historical overviews that include the Klamath River area. An additional 10 reports describe archaeological excavations and one report focuses on an archaeological survey and provides a cultural overview. Also included are two archaeological research designs, one scope of work, one Ph.D. dissertation, and two professional papers.

Previously Recorded Cultural Resources

The 2017 Oregon records search identified 296 previously recorded cultural resources, consisting of 170 archaeological sites, 18 built environment resources, and 108 isolated finds (Tables 6-2). By component type, these resources include 206 prehistoric, 65 historic-period, 24 multiple (prehistoric and historic-period), and 1 resource of unknown temporal association.

Table 6-2 Oregon - Previously Recorded Resources by Resource Type and Component

Resource Type	Component Type				
	Prehistoric	Historic	Multiple	Unknown	Total
Archaeological Site	113	35	21	1	170
Built Environment	–	15	3	–	18
Isolated Find	93	15	–	–	108
Total	206	65	24	1	296

Archaeological Sites

Archaeological sites represent roughly 57 percent of the previously recorded resources in Oregon. The sites consist of 113 prehistoric, 35 historic-period, 21 multiple components, and 1 unknown component property. The prehistoric component sites include housepit villages; lithic scatters; bedrock milling features (BRMs); lithic scatters with associated cultural features; one toolstone quarry; peeled trees; village sites and lithic scatters with human burials; a rockshelter with human burials; a cremation site; and rock art sites.

The historic-period archaeological sites include late-nineteenth or early-twentieth century properties associated with the development of agriculture including abandoned ditches or other features such as homesteads; logging; public works (hydroelectric); transportation (railroad berms); and recreation. Agricultural-related sites include settlements (homesteads) with or without features, irrigation ditches, rock walls, cairns, and artifact scatters. Logging-related sites include a portable sawmill location and artifact scatters. Homesteads include the remains of Hoover’s 41 Ranch and artifact scatters. The former locations of a dam and powerhouse near Keno represent public works sites. Transportation-related sites consist of an abandoned segment of the Weyerhaeuser Railroad grade and other railroad berms. Also related to transportation is Robber’s Rock, a large boulder, historically used as a hiding spot for stagecoach thieves.

The multiple component sites comprise both prehistoric and historic-period archaeological components. Prehistoric components associated with these sites include housepit villages, a housepit village with a documented historic-period boat landing, lithic scatters, and a rock art panels with both prehistoric and historic elements. Historic-period components comprise historic homesteads or ranches and artifact scatters, and water conveyance ditches.

One peeled tree represents an unknown component of either prehistoric or historic-period use.

Information regarding the NRHP eligibility of the archaeological sites is based on recommendations provided by Cardno ENTRIX (2012), or by eligibility information noted on site records that were updated since preparation of the Cardno ENTRIX study. Overall, 38 archaeological sites are considered NRHP-eligible, 53 sites are potentially eligible for listing, 8 sites are not eligible, and 71 sites are either unevaluated or have undetermined NRHP eligibility status.

Built Environment Resources

The Oregon records search identified 18 properties with built environment resources, including 15 historic-period and 3 multiple component locations. Collectively, the built environment resources are associated with the historic themes of commerce, settlement, transportation, public works, and recreation or tourism.

The commerce-themed resources include the Weyerhaeuser Company Mill Complex, a water tower, and a lumberyard. Settlement-related sites include a log cabin, a shed, a split rail fence, the Frain Ditch, the Way Ranch Complex, the Topsy/Frain School, Way Cemetery, Spencer Cemetery, and grave and structural remains at Hoover's 41 Ranch. Transportation-related resources include a bridge and an associated boat dock. Public works resources include two hydroelectric powerhouses, comprised of the westside and eastside plants at Klamath Falls. Recreation or tourism is represented by a group of boardwalks for wildlife viewing. The final built environment resource consists of a New Age rock medicine wheel.

NRHP eligibility information for these resources indicates that eight are NRHP-eligible properties, including the Way Station/Ranch Complex, Topsy/Frain School, Frain Ranch, the westside and eastside powerhouses, a lumberyard with nine features near Lake Ewauna, Hoover's 41 Ranch, and the Weyerhaeuser Company Mill Site. Three built environment resources have been assessed as not eligible, including a bridge and dock, a water tower, and boardwalks associated with wildlife viewing. Four built environment resources are unevaluated and three other resources are classified as undetermined concerning NRHP eligibility.

Isolated Finds

The Oregon records search identified 108 isolated finds, consisting of 93 prehistoric and 15 historic-period resources. Prehistoric isolates include 5 ground stone tools, 1 ground stone tool with debitage, 1 exposure of multiple ground stone tools, 27 single flakes, 36 locations with multiple flakes, 18 flaked stone tools, 4 flaked stone tools with debitage, and 1 flaked stone tool with a battered stone tool. The ground stone tools include pestles, a mano, a metate fragment, bowl mortar fragments, and unspecified objects. The flaked stone tools include chert cores, flake tool, and scrVCrs; obsidian projectile points and fragments, bifaces and fragments, and a flake tool; and one uniface of unspecified material. Debitage comprises obsidian, chert, and basalt flakes.

The historic-period isolates consist of one metal watering can, two bottle glass fragments, one automobile body, one blazed tree, one dump of oyster shell, seven debris scatters or dumps, and two areas containing multiple dumps possibly associated with logging.

6.1.2 California Records Search Results

Within the State of California, the 2017 KRRC records search area included the length of the Klamath River from the Oregon/California Stateline (RM 214), downstream to Humbug Creek (RM 174), for a total length of roughly 40 river miles. The section of river below Iron Gate Dam (the downstream-most project development) was included in the records search since this 18-mile-long area lies within the altered 100-year floodplain following dam removal, where the Project has the potential to affect cultural resources. The records search area included a 0.5-mile wide zone, extending on either side of the shorelines of Copco Lake and Iron Gate Reservoir, or from the center point of the Klamath River in areas where the river remains free flowing.

In 2017, KRRC completed two records searches for the Project in California. In April 2017, 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, NRHP, California Register of Historical Resources (CRHR), and California Points of Historical Interest, California Inventory of Historic Resources, and the California State Historic Resources Inventory. Also in April 2017, KRRC visited the Klamath National Forest office and the Siskiyou County Museum, both in Yreka, California. Klamath National Forest Heritage Program Manager Jeanne Goetz conducted a search of records for Forest Service lands within or near the records search area and provided appropriate archaeological site record forms.

In addition to these office visits, KRRC searched online newspaper archives, 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.

KRRC contacted the 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 tribes with traditional lands or cultural places located within the boundaries of Del Norte, Humboldt, and Siskiyou counties.

Previous Cultural Resources Studies

The 2017 California records search and literature review identified that 58 previous cultural resources investigations have been conducted within the records search area, with 5 of these studies (Kramer 2003a, 2003b; Cardno ENTRIX 2012; Durio 2003; PacifiCorp 2004) completed specifically for the Project. Fourteen of these studies are archaeological, ethnographic, or historical overviews, while eight reports describe archaeological excavations. Two studies involved cultural resources monitoring, while the remaining 34 projects involved archaeological survey or inventory. Overall, an estimated 8,189 acres of federal, state, and/or private land have been surveyed within the records search area, although survey acreage information was not available for all projects covered in the reports.

Previously Recorded Cultural Resources

The 2017 California record searches identified 206 previously recorded cultural resources, consisting of 120 archaeological sites, 1 ethnographic property, 9 built environment resources, 68 isolated finds, and 8 resources of an undetermined resource type (Tables 6-3). By component type, these resources include 114 prehistoric, 59 historic-period, 23 multiple (prehistoric and historic-period), 1 ethnographic property, and 9 resources whose temporal association is unknown.

Table 6-3 California - Previously Recorded Resources by Resource Type and Component

Resource Type	Component Type					
	Prehistoric	Historic	Multiple	Ethnographic	Unknown	Total
Archaeological Site	49	48	23	0	–	120
Ethnographic	–	–	–	1	–	1
Built Environment	–	9	–	–	–	9
Isolate	65	2	–	–	1	68
Undetermined	–	–	–	–	8	8
Total	114	59	23	1	9	206

Archaeological Sites

Archaeological sites represent roughly 60 percent of the previously recorded resources. The sites consist of 49 prehistoric, 48 historic-period, and 23 multiple components. Identified prehistoric period sites include housepit villages; campsites; lithic scatters; lithic scatters with associated cultural features; toolstone quarries; a possible vision quest site with multiple features; and a human burial site.

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

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

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

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

Information regarding the National Register eligibility of the archaeological sites is based on recommendations provided by Cardno ENTRIX (2012), or by eligibility information noted on new or updated site records that were not part of the Cardno ENTRIX study. Of the 120 archaeological sites, one property is listed in the National Register as a contributor to a district, one site is determined individually eligible, three sites are contributors to a district determined eligible, 29 sites appear eligible for listing, two sites might become eligible for listing when more historical research is performed; four sites have been found ineligible; and the remaining 80 sites have not been evaluated for NRHP eligibility.

Ethnographic Resource

The records search identified one resource that figures prominently in an important legend in Shasta Indian oral history. This resource appears eligible for listing in the National Register.

Built Environment Resources

The 2017 California records search identified nine historic-period built environment resources associated with the historic themes of commerce, settlement, transportation, and public works. The single commerce-themed resource includes a former service station converted to residence (Klamath Kamp). Two settlement-related sites have been recorded, consisting of a post-1930s duplex residence with associated structures and the Frank Wood cabin, a late 1890s to 1950s era homesite. Transportation-related sites consist of a one-lane, wooden and steel beam truss bridge over the Klamath River (Ash Creek Bridge), and a two-lane, concrete, T-beam Bridge over the Klamath River (Bridge 02-0015). Public works sites include four recorded elements of the Klamath Hydroelectric Project, including Copco No. 1 hydroelectric powerhouse and dam; Copco No. 2 hydroelectric powerhouse; Fall Creek hydroelectric powerhouse; and the Copco No. 2 wooden stave penstock. The Fall Creek Powerhouse coincides with the reported location of an ethnographic Shasta Indian village; however, this component of the site has not been archaeologically recorded.

Besides these nine built environment resources, standing historic-period structures have been identified at several archaeological sites, including a ranch house and bunkhouse at the Beswick Hotel site (CA-SIS-513-H) and a shed at Copco II Ranch (CA-SIS-2239-H). The historic Spannaus Barn was noted at prehistoric/ethnographic site CA-SIS-2574, but was not recorded as an element of the site.

NHRP eligibility information for these nine sites indicates that the two Klamath River bridges have been determined eligible for listing. The four hydroelectric-related sites were noted by Cardno ENTRIX (2012) as appearing eligible for separate listing, but these sites have also been documented as contributing elements to the Klamath Hydroelectric Historic District (Kramer 2003b), which has yet to be concurred upon by the California and Oregon SHPOs. Also recommended as NRHP-eligible is the Frank Wood cabin. The final two resources, composed of a residence and a former service station, have been noted as not eligible for the NRHP.

Isolated Finds

The 2017 California records search identified 68 isolated finds, including 65 prehistoric resources, 2 historic-period isolates, and 1 isolated feature of unknown age. 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.

6.1.3 Archaeological Districts

FERC Relicensing Study Proposed Archaeological Districts, California and Oregon

As part of the Klamath Hydroelectric Project relicensing study (FERC 2007), five areas of multiple prehistoric sites were identified along the same section of the Klamath River that was considered as a potential National Register District (PacifiCorp 2004:3-198-199; FERC 2007:3-544). This district included four groups of multiple sites in Oregon located at the head of Link River and the mouth of Upper Klamath Lake, Teeter's Landing, Spencer Creek/mouth of upper Klamath River Canyon, and near Frain Ranch. In California, a cluster of three villages near Fall Creek, in the Copco Lake area, comprised the fifth potential district group (Table 6-4). The National Register eligibility of these districts has not been finalized.

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

Table 6-4 FERC Relicensing Study Proposed Archaeological Districts

District Type	Area
Prehistoric	Link River area and mouth of Upper Klamath Lake, OR
	Teeter's Landing, OR
	Spencer Creek/mouth of upper Klamath River Canyon, OR
	Near Frain Ranch, OR
	Fall Creek Villages, near Copco Lake, CA
Historic	Frain Ranch, OR

Upper Klamath River Stateline Archaeological District, California

The newly designated Upper Klamath River Stateline Archaeological District (Bureau of Land Management 2016) is located along the upper Klamath River, in California. 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 1,000 years Before the Common Era (BCE) or earlier to possibly as late as 1840 BCE (BLM 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.

Klamath River Canyon Archaeological District, Oregon

An archaeological study conducted in the upper reaches of the Klamath River Canyon in 2008 by Central Washington University (McCutcheon and Dabling 2008) examined the NRHP eligibility of 19 prehistoric and historic-period sites located along the river corridor between the California/Oregon Stateline and J.C. Boyle Dam. NRHP eligibility recommendations were provided using information gathered during field visits, preparation of updated site records, and the assessment of a site's research potential and integrity; no new subsurface testing was conducted, although previous excavations had been conducted at some of the sites. Thirteen of the 19 sites were recommended NRHP eligible under Criterion D, while the remaining six sites were assessed as unevaluated resources, requiring additional data to make a determination. Recommendations included consideration of an Archaeological District nomination for the NRHP-eligible resources as a way to provide a broader context to evaluate the archaeological record of the Klamath River Canyon (McCutcheon and Dabling 2008). Documentation and nomination of such a district has not been completed.

Klamath River Hydroelectric Project District

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

The proposed Klamath River Hydroelectric Project District (P-47-004015) includes the hydroelectric facilities and various diversion dams; support structures; linear elements such as flumes, canals, and tunnels; and other related buildings and structures. A historic context statement (Kramer 2003a) and Determination of Eligibility (Kramer 2003b) developed for the Klamath Hydroelectric Project notes its eligibility to the National Register as a District under Criterion A for its association with the industrial and economic development of southern Oregon and northern California (Kramer 2003b). The California and Oregon SHPOs have not concurred with this eligibility recommendation. Table 6-5 identifies key features of the hydroelectric complexes located in Oregon and California that are part of the Klamath River Renewal Project and their National Register eligibility recommendation.

Table 6-5 Summary of National Register Eligibility Recommendations for the Klamath Hydroelectric District Facilities/Components

Facility/Description	Date	National Register Eligibility Recommendation and Reference	
		Kramer 2003b	EIS/R 2012
J.C. Boyle Complex			
Dam	1956-1958	Historic Contributing	Historic Contributing
Communications Building	Ca. 1995	Non-Contributing	Non-Contributing
Fire Protection Building	Ca. 1995	Non-Contributing	Non-Contributing
Red Barn	Ca. 1958, altered 1978	Non-Contributing	Non-Contributing
Maintenance Shop	1991	Non-Contributing	Non-Contributing
Residence 1	Ca. 1985	Non-Contributing	-
Residence 2	Ca. 1985	Non-Contributing	-
Water Conveyance Features	1958		Potentially Contributing
Steel Pipe	1958	Historic Contributing	Historic Contributing
Flume Headgate	2002	Non-Contributing	Non-Contributing
Open flume/Concrete	1958	Historic Contributing	Historic Contributing
Headgate Structure	1958	Historic Contributing	Historic Contributing
Forebay/spillgates	1958	Historic Contributing	Historic Contributing
Spillway House	Ca. 1958	Historic Contributing	Historic Contributing
Tunnel	1958	Historic Contributing	Historic Contributing
Surge Tank	1958	Historic Contributing	-

Facility/Description	Date	National Register Eligibility Recommendation and Reference	
		Kramer 2003b	EIS/R 2012
Penstocks	1958	Historic Contributing	Historic Contributing
Powerhouse	1958	Historic Contributing	Historic Contributing
Substation	1958	Historic Contributing	Historic Contributing
Residential Site	Ca. 1950/1995	Non-Contributing	-
Armco Warehouse	1957	Historic Contributing	Historic Contributing
Copco No. 1 Complex			
Dam	1912-1918, 1921-1922	Historic Contributing	Historic Contributing
Gatehouse 1	1918	Historic Contributing	Historic Contributing
Gatehouse 2	1922	Historic Contributing	Historic Contributing
Gate Hoist System/Rails	1918	Historic Contributing	Historic Contributing
Single and Double Penstocks	1912-1918	Historic Contributing	Historic Contributing
Powerhouse	1918	Historic Contributing	Historic Contributing
Copco Guesthouse (remains)	1917, 1980s	Historic Contributing	-
House/Garage 1	ca.1922	Historic Contributing	-
House/Garage 2 (21600 Copco Rd)	ca.1922	Historic Contributing	-
Garage/Warehouse	ca.1922	Historic Contributing	-
Copco No. 2 Complex			
Dam	1925	Historic Contributing	Historic Contributing
Water Conveyance Features	1925	Historic Contributing	Historic Contributing
Headgate	1925 (rebuilt)	Historic Contributing–	Historic Contributing
Tunnel Intake	1925	Historic Contributing	Historic Contributing
Concrete-lined Tunnel	1925	Historic Contributing	Historic Contributing
Wood Stave Pipeline	1925	Historic Contributing	Historic Contributing
Concrete Tunnel	1925	Historic Contributing	Historic Contributing
Steel Penstocks	1925	Historic Contributing	Historic Contributing
Timber Cribbing	1925	Historic Contributing	Historic Contributing
Coffer Dam	1925	Historic Contributing	Historic Contributing
Powerhouse	1925, 1996	Historic Contributing	Historic Contributing
Control Center/Office	ca. 1980	Non-Contributing	-
Maintenance Building	1991	Non-Contributing	-
Oil and Gas Shed		Historic Contributing	-

Facility/Description	Date	National Register Eligibility Recommendation and Reference	
		Kramer 2003b	EIS/R 2012
Cookhouse/Bunkhouse	ca. 1925	Historic Contributing	-
Modern Bunkhouse	ca. 1960	Non-Contributing	-
Garage/Accessory Building	ca. 1960	Non-Contributing	-
Ranch Housing	ca. 1965		
Ranch House 1	ca. 1965	Non-Contributing	-
Ranch House 2	ca. 1965	Non-Contributing	-
Ranch House 3	ca. 1965	Non-Contributing	-
Bungalow Housing	ca. 1925		
Bungalow/Garage 1	ca. 1925	Historic Contributing	-
Bungalow/Garage 2	ca. 1925	Historic Contributing	-
Bungalow/Garage 3	ca. 1925	Historic Contributing	-
Modular Residences	1985		
Modular 1	1985	Non-Contributing	-
Modular 2	1985	Non-Contributing	-
Modular 3	1985	Non-Contributing	-
School House/Comm.Center	1965	Non-Contributing	-
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		

Facility/Description	Date	National Register Eligibility Recommendation and Reference	
		Kramer 2003b	EIS/R 2012
Hatchery Building	1962	Non-Contributing	
Warehouse	1962	Non-Contributing	
Office	1962	Non-Contributing	
Workers Housing 1	1962	Non-Contributing	
Workers Housing 2	1962	Non-Contributing	
Workers Housing 3	1962	Non-Contributing	
Workers Housing 4	1962	Non-Contributing	
Fish Rearing Ponds	1962	Non-Contributing	
Fish Ladder	1962	Non-Contributing	
Visitors Center	1962	Non-Contributing	

6.1.4 Ethnographic Information and TCPs

KRRC's review of ethnographic information for the Project identified TCPs and other culturally sensitive areas along and near the Klamath River based on ethnographic inventory reports prepared by the Klamath Tribes (Deur 2003), Shasta Nation (Daniels 2003, 2006), Karuk Tribe (Salter 2003), and Yurok Tribe (Sloan 2003) for the FERC 2007 Relicensing FEIS.

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

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

In response to AIR #29, Section 106 consultation with federally recognized and non-federally recognized tribes occurred beginning in January 2018, after FERC's tribal outreach effort. The KRRC will continue to consult with tribes. KRRC's Section 106 informal tribal consultation efforts will focus on tribal input regarding identification and NRHP evaluation of TCPs, the proposed Klamath Cultural Riverscape (discussed below), and the management , disposition, and treatment of human remains (discussed in Section 8.4.2 below).

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 Cultural 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 Cultural Riverscape as eligible for the National Register based on its association with broad patterns of tribal environmental stewardship, spiritual life, and relationships between humans and the non-human world. The riverscape and/or ethnographic reports and eligibility determination have not been submitted by a Federal agency to the Oregon and California SHPOs for National Register eligibility concurrence (USBR and California Department of Fish and Game (CDFG)[1] 2012: Vol. 1, 3.13-29).

Further research and consultations to define and update the riverscape cultural landscape as a historic property is identified as a Cultural Resources mitigation measure for the Project. The Klamath Cultural Riverscape is an ongoing topic of discussion for the CRWG and informal Section 106 tribal consultation efforts.

6.1.5 Historical Landscape Analysis

As part of the 2017 records search, KRRC conducted a historical landscape analysis to identify locations where post 1850s era settlement and resource developments occurred within the records search area. The materials for this study included the review of the General Land Office (GLO) records, including California plat maps (1856, 1876, 1880, and 1881) and surveyor's notes; Oregon plat maps (1858, 1874, 1881, 1900, and 1917) and surveyor's notes; a variety of published and manuscript resources (Beckham 2006; Boyle 1976; Kramer 2003a, b; PacifiCorp 2004; USDI 1989); and USGS maps available at http://historicalmaps.arcgis.com/usgs. Other map searches included the David Rumsey collection, Northwestern California map collection at Humboldt State University, Library of Congress digital collections, and Online Archive of California. Historical landscape information was digitized into a GIS format.

KRRC is currently completing the review of the J.C. Boyle Collection (MI 165306) housed at the Southern Oregon Historical Society in Medford, Oregon. This archive contains photo albums, newspaper clippings, maps, manuscripts, financial records, and Copco annual reports belonging to Copco Engineer J. C. Boyle, and pertaining predominately to construction of Copco No. 1 dam and reservoir. This archive is a valuable source of information concerning the pre-inundation historical landscape of the Copco No. 1 area and will provide important information regarding cultural and historical resources that may be anticipated during reservoir drawdown. In addition, archival and historical landscape research is currently underway at local

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

County repositories and historical societies to provide information regarding cultural and historical resources that may be anticipated during reservoir drawdown.

6.1.6 Data Gap Analysis

Subsequent to the completion of the combined record searches, KRRC will examine compiled data and assess it to identify missing information such as gaps in survey coverage, resource recordation, and the status of NRHP eligibility determinations for cultural resources potentially subject to effects during project implementation activities.

6.2 Resource Identification

6.2.1 Pre-Removal Resource Inventory

In response to AIR #28, beginning in July 2017, KRRC initiated cultural resources identification efforts focused on areas within the limits of work that were not subject to previous pedestrian inventory for cultural and historical resources. To date, this new inventory has included three local waste disposal sites currently planned to accommodate concrete rubble and loose earth materials associated with dam removal. The disposal sites include one area for J.C. Boyle Dam (see Figure 5.2-1(C), Sheet 1 in Appendix C), a combined site for Copco No. 1 and Copco No. 2 Dams (see Figure 5.3-1 (C), Sheet 1 in Appendix C), and one area for Iron Gate Dam (see Figure 5.5-1(C), Sheet 2 in Appendix C).

6.2.2 Disposal Site Inventories

J.C. Boyle Disposal Site

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

Copco No. 1 and Copco No. 2 Disposal Site

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

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

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

Iron Gate Disposal Site

The Iron Gate disposal site encompasses an approximately 36-acre area located approximately 750-feet east of Iron Gate Dam, within a small basin that overlooks Iron Gate Reservoir to the northwest (Figure 5.5-1 (C), Sheet 2 in Appendix C of Definite Plan). 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, KRRC conducted a cultural resources inventory of the remaining acres. KRRC conducted the inventory 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).

Other Areas

In addition to the Disposal Site inventories conducted in July 2017, KRRC is currently undertaking a data gap analysis to identify other land-based areas within the limits of work (e.g. haul routes), which includes areas where soils are most likely to be disturbed during construction, that were not previously inventoried for cultural resources, including archaeological, historical, and built environment resources. Such areas will be subject to pedestrian survey to provide 100 percent coverage of direct impact areas associated with the limits of work.

The CRWG may identify additional survey areas located outside the limits of work for pedestrian survey as part of its ongoing efforts to define the Project APE, as well as based on recommendations derived during informal consultation with tribes and consulting parties. The limits of work will continue to be refined during the Section 106 consultation process and as project planning continues.

6.2.3 During and Post-Removal Resource Inventory

Measures to resolve adverse effects to cultural and historical resources developed for the 2012 EIS/R will likely be integrated into the PA as a conclusion to the Section 106 process. In addition cultural resources surveys in the reservoir drawdown zones to identify historic and significant properties, will need to be completed after project approvals are received. In consultation with the CRWG and the approval of FERC, the PA will create a consultation process for considering these surveys. KRRC is in the process of developing a proposed program for implementation during dam removal, which includes cultural resources surveys based on archival research, historical landscape analyses, and tribal consultation. In addition, KRRC will conduct post-demolition surveys of areas outside of the reservoir footprints (i.e., hydropower infrastructure areas, former recreation areas) where revegetation will occur.

6.2.4 General Inventory and Resource Recordation Methods

Archaeological Inventory

Any archaeological inventory to be conducted for the Project will include 100 percent, intensive-level survey of designated areas. The inventory will employ a standard systematic pedestrian survey following the appropriate Oregon and California survey and reporting standards, tailored if appropriate to meet any specific federal land management agency guidelines. Inventory of parcels will employ standard transect spacing of 15 m (65 ft.) or less. The survey convention for elements such as staging areas, borrow areas, substations, and other facilities will include a buffer of 46 m (150 ft.) around the footprint of the proposed activity.

KRRC will conduct surveys in accordance with the Guidelines for Conducting Field Archaeology in Oregon, published by the Oregon State Historic Preservation Office (SHPO 2007), and, in California, by the guidelines provided by the California Department of Historic Preservation. KRRC will complete all inventory efforts on federal lands under the supervision of field supervisors authorized under agency-specific cultural resources permits. All inventory methods will follow those prescribed by United States Forest Service (USFS) and Bureau of Land Management (BLM) protocols, dependent upon the lands being surveyed, and will be conducted by field supervisors and archaeological technicians that fully meet qualifications and standards dependent upon appropriate land management agency permitting requirements

KRRC expects that two categories of cultural resources will be identified: archaeological sites and isolated finds. An archaeological site in Oregon is defined as 10 or more artifacts (including lithic debitage) or a feature likely to have been generated by patterned cultural activity within a surface area reasonable to that activity (a form of density measure). An isolated find in Oregon is defined as one (1) to nine (9) artifacts discovered in a location that appears to reflect a single event, loci, or activity. The presence of any feature advances the find into a site status. KRRC will follow similar guidelines in California, where a strict written policy is not provided. Alternatively, on lands managed by federal agencies, KRRC will follow the policies of those agencies.

Previously recorded sites present within the areas to be inventoried will be relocated, if possible, and re-recorded, as necessary. KRRC will give newly identified sites a temporary field number and plot them onto a USGS field map; UTM coordinates will be recorded using a GPS instrument. KRRC will not permanently flag identified resources or otherwise mark them in the field, unless requested by land management agencies.

All above-ground resources, such as buildings, within or adjacent to (within 100 feet of) the survey areas that are 50 years of age or older, or of indeterminate age, will be noted, and their location and information provided to the Built Environment study team for documentation on an appropriate site record. KRRC will consider visual effects to above-ground resources beyond the pedestrian survey area in a separate study.

Built Environment Inventory

Fieldwork methodology will consist of two phases of identification and evaluation, and will focus on two distinct resource categories – hydroelectric (Phase I) and non-hydroelectric (Phase II) facilities. A reconnaissance level effort will make a preliminary evaluation of all historic-era resources and determine whether they meet the NRHP criteria for evaluation, retain integrity, whether they were constructed over 45 years ago (before 1973), and if they meet any NRHP criteria considerations. KRRC chose the 45-year criterion to take into account that effects that could be present during the full course of project activities.

KRRC will typically conduct fieldwork with teams of two architectural historians, who will drive publicly accessible rights-of-way and record resources in a systematic manner. For those resources that would clearly not have views of the Project due to vegetation, landform, or surrounding development, KRRC will collect only location information, as the resource will be considered outside the APE. For those resources inventoried in the APE, KRRC will collect specific information, at least two or more photographs taken, and each resource noted on a field map with recorded by GPS. For those properties that clearly lack historic integrity, or that is a type of resource that is not indicative of broad patterns of history or related to historical events (Criterion A), not associated with significant person or people (Criterion B), and/or is of a common type, style, or method of construction that does not exhibit high artistic values or represent a significant and distinguishable entity whose components may lack individual distinction (Criterion C), no additional information will be collected and a “not eligible” recommendation will be made. In order to apply the criteria, KRRC will use information collected during fieldwork to revise the historic context for the APE and provide an initial basis from which to evaluate the relative importance of identified resources. KRRC will also conduct additional secondary and archival research on common resource types so that a more comprehensive historic context of these resources within the APE can be developed and used for a comparative analysis and an assessment of significance. This assessment will consider whether the resource retains significance at the local, state, or national levels. Further, the analysis will take into account the relative rarity of a resource type and likewise adjust considerations related to that resource’s historical integrity. For those resources that retain integrity, are 45 years old or older, and may be eligible under any of the NRHP criteria for evaluation, the resource will be listed as “unevaluated” and subject to Phase II analysis. This analysis will include detailed recordation and full evaluation.

In addition to field recordation, KRRC will undertake research to better understand the resource’s history. This will include SHPO/USFS/BLM files, historic maps (such as GLO, Metsker’s, and Sanborn, newspapers, and other applicable resources such as census records, genealogical records, biographical encyclopedias, city directories, and family histories. After taking into account the overall integrity and historical significance of the resource, KRRC will make a final recommendation concerning a resource's NRHP eligibility.

Built Environment HABS/HAER/HALS Recordation

KRRC anticipates that mitigation for impacts on the hydroelectric facility buildings and structures will involve some level of Historic American Building Survey (HABS) and Historic American Engineering Record (HAER), documentation. HABS/HAER recordation has been previously determined to be an important mitigation measure in compliance with NHPA Section 106 provisions.

Chapter 7: Resource Evaluation

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7. RESOURCE EVALUATION

7.1 Archaeological Evaluation

To date, the evaluation of cultural resources identified within the limits of work (and subject to potential direct effects) has occurred based on survey-level data or from subsurface testing work (Phase II investigations) conducted by other parties (not KRRC). The 2004 PacifiCorp report identified three levels of NRHP eligibility for identified sites: eligible, potentially eligible, and not eligible. Eligible sites include those resources that were designated as historic properties on the basis of sufficient existing information about them to draw that conclusion. Potentially eligible sites include those that require more intensive, subsurface investigations to obtain information necessary to determine if they are or are not eligible for the NRHP under Criterion D. Those sites identified as not eligible lack attributes necessary for their inclusion in the NRHP. Neither the California nor Oregon SHPOs has concurred with the NRHP evaluations offered in the previous Klamath River cultural resources reports (Cardno ENTRIX 2012; PacifiCorp 2004). KRRC, working through the CRWG, is facilitating SHPO review of the previous eligibility recommendations to reach NRHP eligibility determinations under the Section 106 process. Once eligibility concurrence is reached, the list of potentially eligible and any yet unevaluated properties will be screened against areas of direct impacts to develop an inventory of affected sites that require evaluation through Phase II testing. Because most individual sites have not yet been identified for evaluation, site-specific methods will be developed later.

The TCPs identified in the tribal ethnographic reports (Section 6.1.4 above) may or may not have archaeological components with information potential and have been evaluated as NHRP-eligible based on other cultural values including associations under Criterion A. Section 106 consultation performed by the FERC, as supported by KRRC, will assist in verifying the NRHP eligibility of TCPs and how TCPs will be integrated into project planning and compliance.

TCRs identified by Tribes as a part of the AB52 consultation process may be disclosed to the SWRBC. If this information is shared with the KRRC, the KRRC will coordinate the evaluation of TCRs for the NRHP with the CRWG and FERC as a part of the Section 106 consultation process.

7.2 Evaluation of Historic Built Environment Resources

The evaluation of historic built environment resources will include an update to the Klamath Hydroelectric Project Request for Determination of Eligibility to include Iron Gate Dam as a historic property and to identify contributing elements to the Klamath Hydroelectric Historic District (KHHD). In addition, an estimated 50 non-hydroelectric historic structures (including buildings, bridges, and other built environment facilities) identified during inventory efforts will require evaluation for eligibility to the NRHP. KRRC will perform built environment evaluation studies to Oregon and California standards. Two historical resources reports for both hydroelectric and non-hydroelectric resources, will be prepared that include information on the resources located in the respective states. The reports will identify the APE, apply the NRHP Criteria for Evaluation, assess project effects, and make recommendations to avoid and minimize effects and mitigate adverse effects. This task will also include a reassessment of those built environment resources that were not 50 years old at time of previous evaluation; and a complete analysis of cultural resources within 100-year flood plain below Iron Gate Dam to Humbug Creek.

Chapter 8: Management Plans and Agreement Documents

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8. MANAGEMENT PLANS AND AGREEMENT DOCUMENTS

KRRC will produce a number of management plans and agreements to support the Project's Section 106, CEQA, and AB 52's compliance efforts. The documents currently planned include a HPMP, Programmatic Agreement, Inadvertent Discovery Plan, Plan of Action for the treatment of human remains, and a Cultural Resources Monitoring Plan. KRRC may add other plans based on recommendations made by the CRWG and Tribes.

8.1 Historic Properties Management Plan and Programmatic Agreement

FERC, with the assistance of KRRC, will prepare and implement a PA for the Project. KRRC will prepare HPMP to assure compliance with the federal and state laws and regulations that govern historic, cultural, and tribal resources. In preparing the PA and HPMP, KRRC will consult, as appropriate, with FERC and the CRWG. KRRC will continue to consult with FERC and the CRWG as appropriate through the Project's implementation until the expiration of the PA.

On the federal level, the relevant statutes include: (1) Section 106 of the NHPA; (2) National Environmental Policy Act (NEPA); and (3) the Native American Graves Protection and Repatriation Act (NAGPRA). Section 106 requires federal agencies to take into account the effects of their undertakings on historic properties, engage consulting parties, and to provide the ACHP with reasonable opportunity to comment. A "historic property" is "any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in the NRHP. This term includes artifacts, records, and remains that are related to and located within such properties" (36 CFR § 800.16(l)). The term also includes "properties of traditional religious and cultural importance to an Indian tribe . . . and that meet the National Register criteria" (Ibid). Section 106 also requires consultation with relevant SHPOs, THPOs, Indian Tribes, representatives of local governments, individuals and organizations with a demonstrated interest in the Project, and the public (36 CFR § 800.2(c)).

NEPA requires federal agencies to determine whether an action may "significantly affect the quality of the human environment." Among other things, agencies must consider the "unique characteristics of the geographic area such as proximity to historic or cultural resources (40 CFR § 1508.27(b)(8)." NEPA also encourages agencies to the fullest extent possible, prepare environmental documents concurrently with and integrated with environmental impact analyses and related surveys and studies required by the NHPA (40 CFR § 1502.25(a)).

NAGPRA establishes the ownership of cultural items excavated or discovered on federal or tribal land lies with the lineal descendants and culturally affiliated Indian tribes and Native Hawaiian organizations and, among other things, establishes procedures for the inadvertent discovery or planned excavation of Native American cultural items on federal or tribal lands.

As discussed above, KRRC and PacifiCorp have initiated informal Section 106 consultation consistent with FERC's direction and convened a CRWG that includes FERC, other federal agencies, SHPOs, THPOs, Indian Tribes, as well as other consulting parties that will consider the identification and evaluation of cultural resources as well as the avoidance, minimization, and resolution of adverse effects to historic properties. This informal consultation will establish the groundwork for a PA that KRRC will submit for FERC's approval. The PA and HPMP will be completed prior to FERC's Surrender Order. The HPMP will be appended to the PA, once the agreement is finalized. The PA will be effective for the duration of FERC's jurisdictional authority (i.e. the effective duration of FERC's License Surrender Order) which, if so ordered, is currently estimated to end in 2025.

KRRC will also work with FERC, as well as other federal agencies, SHPOs, Tribes, and consulting parties (which include state-recognized tribes who engage in the State Water Board's AB 52 consultation process) to develop and integrate effect avoidance, minimization, and mitigation measures into the HPMP. KRRC will also implement avoidance, minimization, and mitigation measures developed in the ongoing AB 52 consultation led by the SWRCB. Since these measures are tailored to compliance with California laws and regulations, KRRC may develop comparable measures consistent with Oregon's laws and regulations that govern cultural resources, if applicable. KRRC will work with FERC, other federal agencies, SWRCB, tribes, SHPOs, THPOs, and consulting parties to consider and incorporate these measures into the HPMP and PA as appropriate.

8.2 Programmatic Agreement

As the designated non-federal representative, KRRC will prepare a PA for FERC's consideration that is designed to assist with compliance of Section 106 of the NHPA consistent with 36 CFR § 800.14. The PA will consist of a signed, formal agreement between KRRC, lead and cooperating federal and/or state agencies, the California and Oregon SHPOs, THPOs, Indian Tribes, and consulting parties, and will outline all measures necessary for full compliance with NHPA. These will include but will not be limited to protocols for the identification and evaluation of historic properties, permitting requirements, treatment of historic properties, monitoring requirements, inadvertent discovery protocols, curation, and treatment of human remains. KRRC, in consultation with the federal agencies, SHPOs, THPOs, Indian tribes, and consulting parties will draft a PA suitable for review and consideration by FERC. KRRC will assist with revising the PA following consultation and review by the CRWG and incorporate any necessary revisions to the HPMP (discussed in greater detail in Section 8.2). Finalization of the PA, which includes obtaining necessary signatures for acceptance of the PA, will be the responsibility of FERC. The PA will be effective for the duration of FERC's jurisdiction over the Project.

8.3 Historic Properties Management Plan

KRRC will prepare an HPMP to identify mitigation measures and other protective measures to be implemented before and during drawdown and dam removal activities to protect historic, cultural, and tribal resources during the Project's implementation. KRRC will ask FERC and other applicable federal agencies to approve the HPMP before the commencement of any ground disturbance or reservoir draw down activities. At a minimum, the HPMP will incorporate protocols to address the following: (1) identification and evaluation of historic properties; (2) the avoidance, minimization, and mitigation measures to be implemented;(3) the inadvertent discovery of historic, cultural, and tribal resources; (4) the inadvertent discovery human remains and associated grave artifacts; and (5) the monitoring of cultural resources during KRRC's implementation of the Project. The process to amend the HPMP in the event that additional information is obtained during the Project's implementation will be provided in the PA. Other protocols developed during the Section 106 consultation process will be implemented in the HPMP.

8.3.1 Identification and Evaluation of Historic Properties

The HPMP will address historic properties identified to date within the APE, as well as those historic properties potentially identified during project implementation. The HPMP will include the protocols for the phased identification of (1) resources encountered following dewatering activities; (2) resources on properties (if any) where access is not granted until after permitting, (3) resources (including human remains) found as inadvertent discoveries, and/or (4) resources found during cultural resource monitoring. The HPMP will guide treatment measures to avoid, minimize, and mitigate adverse effects to historic properties through the course of the Project. The HPMP will also identify classes of historic properties, relevant research, and potential data gaps in research for classes of properties present in the APE. The HPMP may include other historic property identification and evaluation considerations developed over the course of the Section 106 consultation process.

8.3.2 Effect Avoidance, Minimization, and Mitigation Measures

KRRC will develop the HPMP, which will include a discussion of measures to avoid, minimize, and/or mitigate adverse effects to historic properties. KRRC will implement feasible mitigation recommendations developed during the SWRCB's AB 52 process. Additional avoidance, minimization, and mitigation measures will be identified through the Section 106 consultation process. These additional measures may include but are not limited to mitigation and monitoring, to address reasonably foreseeable direct, indirect and/or cumulative adverse effects that may result from drawdown and dam removal. Wherever feasible, avoidance and preservation in place will be the preferred treatment for historic properties located within the APE. Avoidance may include design changes and/or use of fencing or barricades to limit access to identified historic properties during dam removal and restoration activities.

In cases where avoidance and minimization are not feasible, resource-specific treatment protocols will be drafted as necessary to resolve adverse effects to historic properties adversely affected by the Project. The process for the development of treatment protocols will be outlined in the HPMP and will be consistent with the Secretary of the Interior's Standards for Archaeological Documentation, Historical Documentation, and Architectural and Engineering Documentation; the ACHP Section 106 Archaeology Guidance; and other guidance from the appropriate SHPOs and/or THPOs, as applicable. Additional standards and guidelines may be identified by FERC and/or the CRWG during the Section 106 process. For effects to archaeological sites that will be mitigated through data recovery, mitigation protocols will include but not be limited to a research design that articulates research questions; data needed to address research questions; methods to be employed to collect data; laboratory methods employed to examine collected materials; and proposed disposition and curation of collected materials and records.

Mitigation protocols for direct effects to historic properties eligible for listing in the NRHP under criteria other than or in addition to criterion D will articulate the context for assessing the properties significance, an assessment of the character-defining features that make the property eligible for listing in the NRHP, and an assessment of how the proposed mitigation measures will resolve the effects to the property. Additional mitigation protocols may be developed during the Section 106 consultation process.

8.4 Inadvertent Discovery Program

KRRC will develop a plan for resolving post-review discoveries. Drawdown of the reservoirs proposed as part of the Project could potentially expose previously recorded and unidentified cultural resources, including archaeological resources and human remains. KRRC will prepare an Inadvertent Discovery Plan that will address the inadvertent discovery of resources protected under federal and state law. KRRC will develop the Inadvertent Discovery Plan during agency and tribal consultations and incorporate feedback from the tribes engaged in such consultations as feasible.

The Inadvertent Discovery Plan will include measures that will be implemented in and downstream of the reservoirs if archaeological materials, human remains, or other cultural resources are discovered during drawdown activities. The Inadvertent Discovery Plan will comply with applicable federal and state laws and regulations regarding cultural resources and human remains. The Inadvertent Discovery Plan will address such situations occurring once reservoir drawdown has commenced and throughout the dam removal and restoration process. The discussion below provides a basis and framework for KRRC's Inadvertent Discovery Plan for the Project and may be adjusted and/or supplemented during the Section 106 consultation process.

8.4.1 Inadvertent Discovery of Cultural Resources

KRRC will develop and implement procedures for its personnel and contractors if historic properties are discovered or unanticipated effects on historic properties occur in conjunction with the drawdown of the reservoirs. KRRC will develop these procedures prior to the initiation of dam removal in accordance with 36 CFR § 800.13(a)(2)(b) (Post-review Discoveries).

As noted above, KRRC will provide instruction to environmental monitors regarding the historic, cultural, and tribal resources that could be discovered during project activities. In addition, all KRRC personnel involved in project field activities will be instructed on site discovery, avoidance, and protection measures that will be triggered in the event of an inadvertent discovery, including information on the federal and state statutes and regulations protecting cultural and tribal resources.

KRRC will develop and implement procedures that address situations where unanticipated cultural resources are encountered on private, non-federal public, or federal lands. The procedures will also include the appropriate agency and tribal contacts and consultations in the event of an inadvertent discovery. Applicable federal, tribal, and state laws may govern the procedures.

If previously unidentified cultural resources are discovered during the implementation of the Project, KRRC will immediately implement the Inadvertent Discovery Plan.

8.4.2 Inadvertent Discovery of Human Remains

KRRC will prepare written protocols that will be incorporated into the Inadvertent Discovery Plan specifically for the discovery of human remains in coordination with the CRWG and with Native American tribes (both the tribes engaged in the Section 106 process and the tribes that engaged in the State Water Board's AB 52 consultation process). The protocol will require signature by FERC as the Federal agency official for purposes of Section 106, and a copy of the protocol will be provided to the consulting tribes.

The protocol for the treatment of human remains will include: (1) planned treatment, care, and handling of human remains, funerary objects, sacred objects, and objects of cultural patrimony; (2) information on the kinds of objects that are considered to be funerary objects, sacred objects, and objects of cultural patrimony; (3) specific information used to determine custody/ownership of the remains; (4) the methods to be used for archaeological recording, analysis, and reporting of human remains, funerary objects, sacred objects, and objects of cultural patrimony; (5) the steps to be followed to contact relevant Native American tribal officials at the time of excavation or inadvertent discovery of human remains, funerary objects, sacred objects, and objects of cultural patrimony; (6) the kind of traditional treatment, if any, to be used for human remains, funerary objects, sacred objects, objects of cultural patrimony; and (7) the planned disposition of human remains, funerary objects, sacred objects, and objects of cultural patrimony.

KRRC will utilize the following as a basis and framework to develop the protocol:

- Human remains and associated grave goods may be discovered during various phases of project's planning and implementation. In all cases, human remains encountered during project activities will be treated in a respectful manner and in accordance with the protocol.
- If human remains and/or associated grave goods are discovered as a result of project activities, project activities near the find will cease to the extent feasible. Project activities will be not be allowed within 200 feet of the discovery until authorization is provided through implementation of the approved treatment protocols unless such a restriction is not feasible (e.g., the infeasibility of

halting reservoir drawdown). One exception to this general principle is the conduct of controlled archaeological investigations, which will be subject to specific requirements outlined in the protocol.

- Human remains and/or associated grave goods will be secured and protected to the extent feasible until appropriate disposition has been determined, in accordance with the protocol and applicable federal, state, and local statutes and regulations. Specific procedures to be followed in the event of a discovery will depend on the ownership status of the lands where the human remains and associated grave goods are discovered.
- The provisions of the NAGPRA will govern inadvertent discoveries of Native American human remains on federal or tribal lands. The federal land management agency, in consultation with FERC, as the lead agency, will be responsible for compliance with the NAGPRA and its implementing regulations for all NAGPRA-related inadvertent discoveries and discovery situations on federal or tribal lands. FERC and any relevant land management agency (e.g., BLM) will consult with the relevant Native American tribe(s) or other ethnic groups related to the human remains identified to determine the treatment and disposition measures consistent with the applicable federal laws, regulations, and policies.
- 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 federal, state laws, regulations, or policies, as determined through consultation with the appropriate SHPO, federally- or state-recognized Native American tribe, or other ethnic groups related to the human remains.
- In California, treatment of human burials found on State or private lands are covered under the Public Resources Code, Division 5, Parks and Monuments (Division 5 added by Stats. 1939, Ch. 94.), Chapter 1.75. Native American Historical, Cultural, and Sacred Sites, and the California Native American Graves Protection and Repatriation Act of 2001 (Chapter 5 of Part 2 of Division 7 of the Health and Safety Code).
- In Oregon, treatment of human burials found on State or private lands are covered under Oregon Revised Statute (ORS) 97.745. If human remains are encountered, the state police, Oregon SHPO, the Commission on Indian Services, and the appropriate Native American tribe(s) (which are determined by the Commission on Indian Services) need to be immediately contacted.

8.5 Cultural Resources Monitoring Plan

KRRC will develop a Cultural Resources Monitoring Plan as part of the HPMP for implementation during drawdown and dam removal efforts proposed as part of the Project. The Cultural Resource Monitoring Plan will establish general protocols for monitoring when ground disturbing work is occurring in close proximity to historic properties or where work is occurring in areas where there is a high probability of encountering cultural resources. The Cultural Resources Monitoring Plan may include other areas that will benefit from monitoring, including known archaeological sites and those areas determined to show a high probability for buried cultural deposits. Monitoring will, as appropriate, include field inspection by personnel under the direct supervision of a person meeting the Secretary of the Interior's Professional Qualifications standards and will consult with federally- and state-recognized tribes for tribal monitors, as appropriate. The Cultural Resources Monitoring Plan will address the management and protection of historic properties in the APE to avoid Project-related effects from drawdown, dam removal, and restoration activities. Cultural resources, human remains, or funerary objects discovered during the monitoring of project activities will be treated in accordance with the protocols described in the Inadvertent Discovery Plan.

8.6 Looting and Vandalism Prevention Plan

KRRC will develop a Looting and Vandalism Prevention Plan to reduce the risk of looting or vandalism during the implementation of the Project to the extent that the Project's implementation creates additional risk of looting or vandalism. If looting and vandalism occur to sites in California, KRRC will consult with federal agencies, SHPOs, THPOs, tribes engaged in the Section 106 process and tribes participating in the AB 52 consultation with SWRCB.

The Looting and Vandalism Prevention Plan will include training of KRRC monitors and personnel about looting and vandalism of tribal, cultural, and historic resources. It will also include an established communications protocol and reporting process to law enforcement and other relevant federal, state, and local agencies upon discovery of evidence that looting or vandalism is or has occurred. Public access to the reservoirs will be restricted during drawdown for safety reasons, as well as protecting against the potential looting and vandalism of protected tribal, cultural, or historic resources.

KRRC will also include in the Looting and Vandalism Plan other protective measures, including appropriate restrictions to public access to known or inadvertently discovered historic, tribal, or cultural resources as appropriate and feasible on a case by case basis. Specific measures that will be considered include fencing, posting of signs, strategic plantings, strategic routing of roads, boating access points and trails, or other means that are feasible and necessary to protect unauthorized looting or vandalism of resources protected under federal and state law. Additional measures may be identified during the Section 106 consultation process with FERC and the CRWG.

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Chapter 9: References

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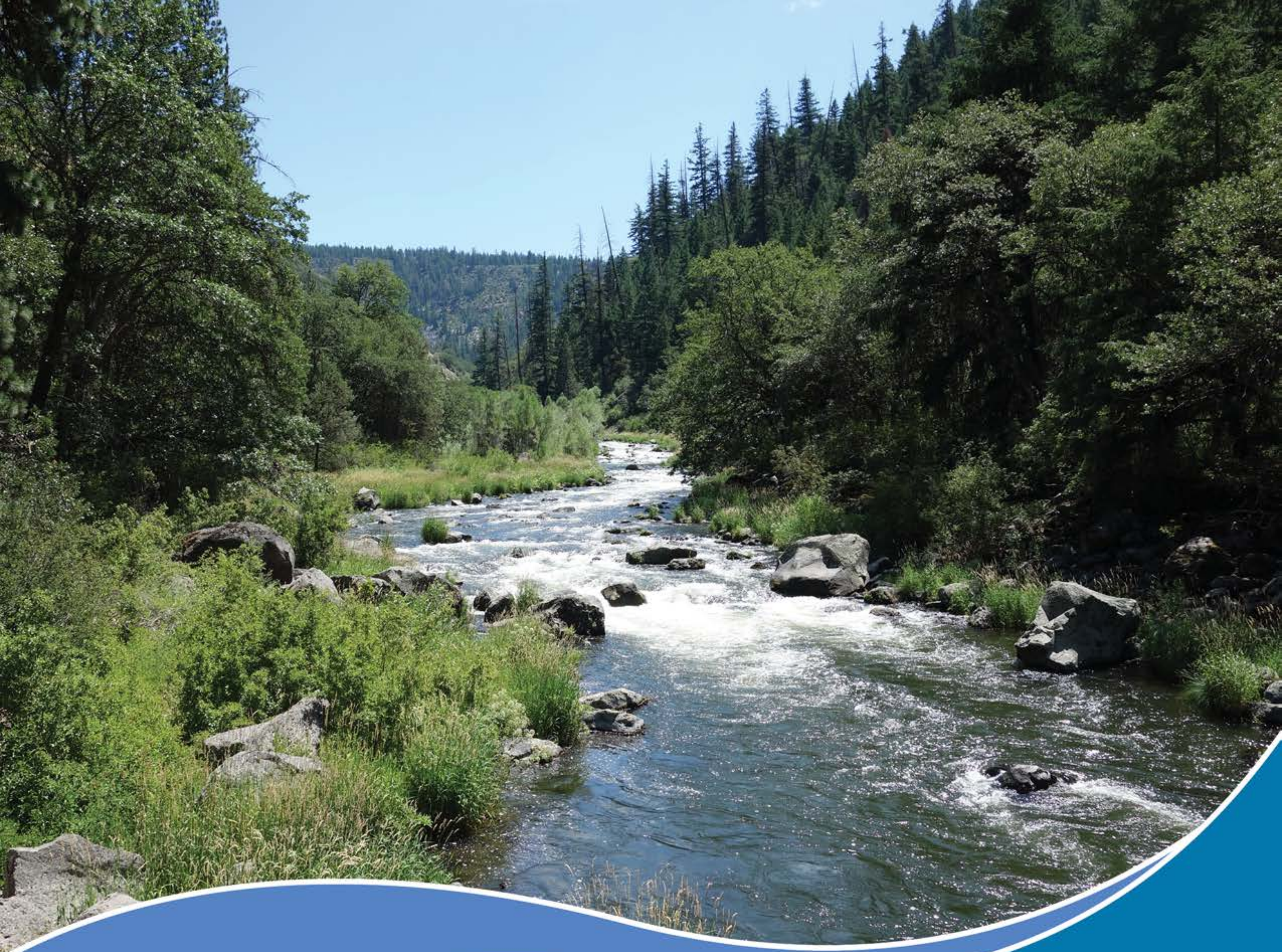
www.klamathrenewal.org



Definite Plan for the Lower Klamath Project

Appendix M - Water Quality Monitoring Plan

KLAMATH RIVER RENEWAL CORPORATION

June 2018

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Acronyms

COD chemical oxygen demand
DO dissolved oxygen
EIS/R Environmental Impact Statement/Environmental Impact Report

EPA	U.S. Environmental Protection Agency
IMs	Interim Measures
IM-15	Interim Measure 15 - Water Quality Monitoring
KBMP	Klamath Basin Monitoring Program
mg/L	milligrams per liter
NTUs	Nephelometric Turbidity Units
ODEQ	Oregon Department of Environmental Quality
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
SEF	Sediment Evaluation Framework
SLs	screening levels
SLVs	Screening Level Values
SSC	suspended sediment concentrations
SWAMP	Surface Water Ambient Monitoring Program
WQ Plan	Water Quality Monitoring Plan
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USGS	US Geological Services

Chapter 1: Introduction

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1. INTRODUCTION

This Water Quality Monitoring Plan (WQ Plan) describes the proposed water quality monitoring activities prior to, during, and following completion of the Project. In general, the monitoring plan covers the following elements:

- Assessment of Klamath River water quality parameters (e.g. dissolved oxygen, temperature, turbidity, conductivity, suspended sediment, nutrients) collected prior to, during, and following dam removal.
- Sampling and analysis for the presence of blue-green algae related toxins (microcystin) 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 WQ 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 before, during, and after dam decommissioning, and the KRRC's approach to sampling and analyzing the river and estuary waters and sediments.

KRRC will revise this draft document to be consistent with the water quality monitoring requirements in the final Clean Water Act Section 401 Water Quality Certifications from California and Oregon. Draft 401 Water Quality Certifications from both states are currently under public review and public comments are expected through mid-July 2018. The information collected under this WQ 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 of the Definite Plan).

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Chapter 2: Background

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2. BACKGROUND

2.1 Klamath Interim Measure 15 Water Quality Monitoring

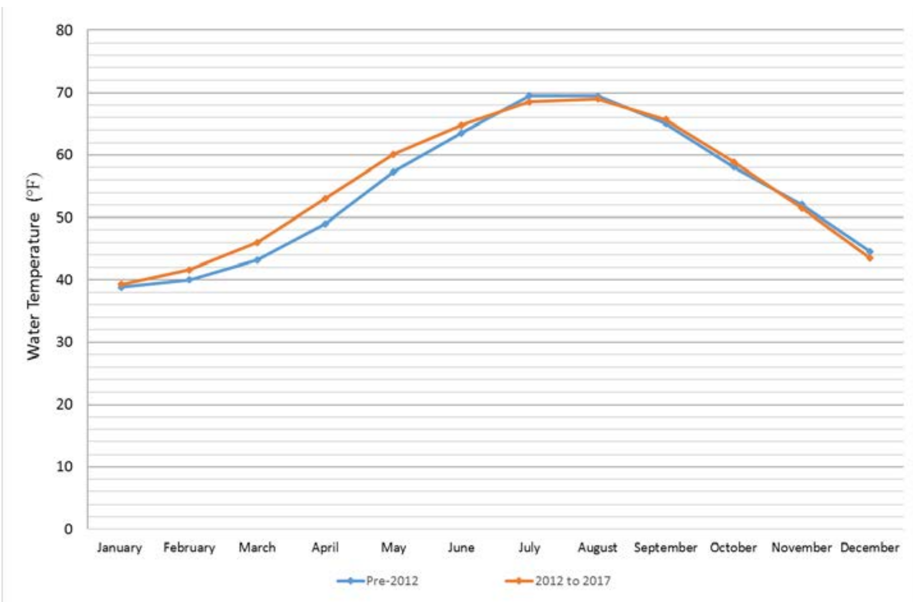
The amended KHSA includes provisions for the interim operation of the Lower Klamath Project (FERC Project 14803) by PacifiCorp prior to decommissioning and included several Interim Measures (IMs) to mitigate conditions created by the dams and to collect baseline information prior to the beginning of dam removal drawdown Activities. The KHSA includes IM-15 that requires PacifiCorp to fund 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 tenth year in 2018 and PacifiCorp has an obligation to continue IM-15 monitoring until the dam decommissioning phase of the Project 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.
- 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) 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 (USBR), PacifiCorp, and the Yurok and Karuk tribes and is funded by 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. KRRC intends to utilize the existing KBMP data set, augmented by new data collected before, during, and after dam decommissioning, as the WQ Plan data set.

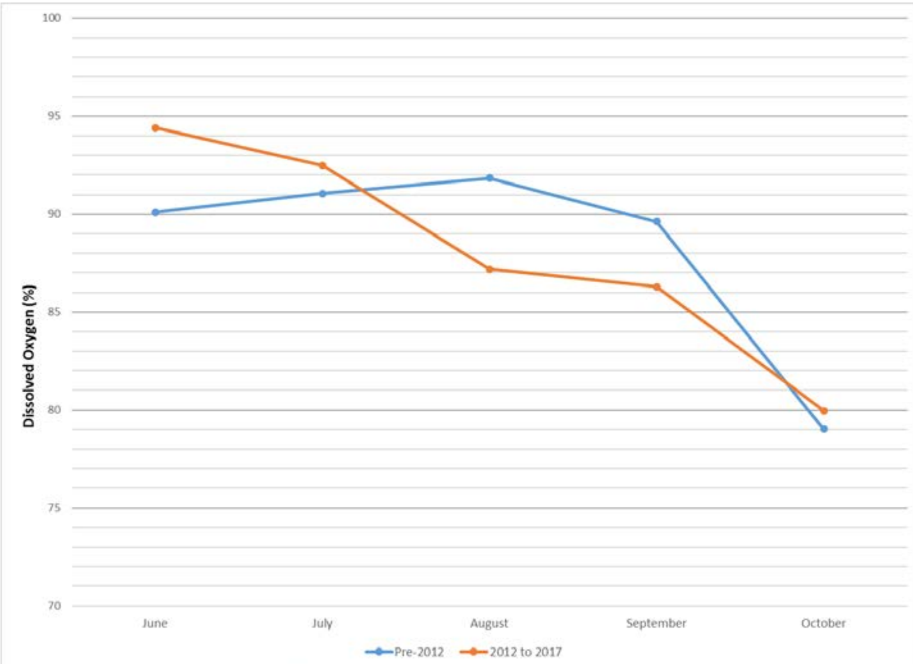
2.1.1 Water Quality Trends

Water quality monitoring in the Klamath Basin has continued since the publication of the Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report, 2012 (2012 EIS/R). Data compiled from real-time continuous monitoring of parameters such as water temperature, dissolved oxygen (DO), pH, conductivity, and turbidity at a point on the Klamath River just below Iron Gate Dam was analyzed for trends, some of which is presented below. This location provides an overview of water quality in the river as it exits the last dam of the Lower Klamath Project. Water quality in the area generally continues to follow the trends evaluated in the 2012 EIS/R. Figure 2-1 shows the average monthly water temperature in the Klamath River below Iron Gate Dam from 2006 to 2011 and 2012 to 2017, where data was available. In general, water temperature below Iron Gate Dam is warmer in spring months (March through May) than it was in the past, differing by up to 4 percent in April. Figure 2-2 presents the average DO recorded from 2006 to 2017 for the months of June through October, when available. Typically, during the summer and early fall, water temperature in the river is higher and issues with DO occur. During these months, DO was recorded higher in June, July, and October, but lower in August and September compared to previous years. The average monthly pH from 2012 onward was recorded at higher values than those between 2006 and 2011; though similar from May to October, see Figure 2-3. This information suggests that there would be no changes to the conclusion made in the 2012 EIS/R.



Source: Karuk Tribe 2017

Figure 2-1 Monthly Average Water Temperature in the Klamath River below Iron Gate Dam



Source: Karuk Tribe 2017

Figure 2-2 Average Percent DO in the Klamath River below Iron Gate Dam between June and October

Source: Karuk Tribe 2017

Figure 2-3 Monthly pH in the Klamath River below Iron Gate Dam

2.1.2 Contaminants in Sediment

In 2011, an evaluation of the sediments from each reservoir was completed to assess the risk of contamination in biota and humans from the release of reservoir sediments. Results of this evaluation were compared to the 2009 U.S. Army Corps of Engineers (USACE) Sediment Evaluation Framework (SEF) for the Pacific Northwest and U.S. Environmental Protection Agency (EPA) screening levels (SLs). Freshwater contaminant screening levels were updated and finalized in the 2016 SEF and are typically less protective than standards set forth by EPA SLs and Oregon Department of Environmental Quality (ODEQ) Bioaccumulation Screening Level Values (SLVs) for fish consumption. The marine SLs are relatively unmodified from the 2009 SEF. KRRC reviewed the results from the 2011 evaluation under the 2016 SEF SLs and compliance with a level 2B evaluation (see Section 4.7.5 of the Definite Plan for a full discussion). This reevaluation confirmed the conclusions presented in the 2012 EIS/R that the reservoir sediments in each reservoir are suitable for unconfined, aquatic disposal and that contamination risks from reservoir sediment are unlikely and/or are either lower than with the dams still in place and/or lower than background levels.

2.1.3 Algae in the Klamath Hydroelectric Reach

There are two dominant algal communities within the Hydroelectric Reach in the Klamath Basin, phytoplankton and periphyton. Blue-green algae and cyanobacteria are the predominant phytoplankton in Copco 1 and Iron Gate reservoirs and frequently reach nuisance levels in the summer and fall, often producing toxins (i.e. microcystin) at levels that are potentially harmful to humans and animals. Phytoplankton accumulation from the reservoirs occurs in portions of the Klamath River below Iron Gate Dam and can contribute to nuisance levels of blue-green algae, under certain conditions. Cyanobacteria and green algae are the dominate periphyton (i.e., attached algae) in the riverine portions of the Klamath River. The growth and prevalence of nuisance algal blooms of blue-green algae and other species are generally determined by the nutrient concentration, primarily nitrogen and phosphorus, and water temperature within the river. Continued monitoring of nutrients, algae, and algal toxins show the continuation of trends observed and presented in the 2012 EIS/R. A study published in 2015 (Otten et al. 2015) used a variety of genetic approaches to track the source of toxic algae found in the Klamath River below Iron Gate Dam, in addition to 15 other sampling locations throughout the Klamath River. The study concluded that microcystin producing algal populations originate within Copco 1 and Iron Gate reservoirs rather than imported from upstream sources (e.g. Upper Klamath Lake). The relative significance of contributions of the reservoirs and upstream sources is complex and disputed. The KRRC does not state a position on the relationship or relative significance of such sources. To the extent that these reservoirs are a source, the Project will remove the source.

In 2016, the Oregon Heath Authority released the updated Public Health Advisory Guidelines for Harmful Algae Blooms in Freshwater Bodies. This updated the criteria for issuing and lifting a public health advisory. Criteria for issuing a public health advisory is dependent on visible scum (photos and water testing), cell counts (greater than or equal to 100,000 cells per milliliter [cells/mL] for combined species or 40,000 cells/mL for microcystin), and/or toxicity levels (greater than or equal to 10 micrograms per liter for microcystin). Public health advisories can be lifted only after the initial cell count or toxin results are reported below the threshold. The Yurok Tribe also updated their advisory threshold guidelines after the 2012 EIS/R. These updated Level 1 thresholds are equal to those issued by the Oregon Health Advisory for combined species (100,000 cells/mL) but are much lower for microcystin cell count (1,000 cells/mL) and microcystin toxin concentrations (0.8 micrograms per liter). Despite the changes to the guidelines for posting public health advisories for toxic algae blooms, the most recent monitoring data shows that health advisory postings remain common place at Copco 1 and Iron Gate reservoirs and on the Klamath River below Iron Gate Dam.

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Chapter 3: Water Quality Monitoring Plan

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3. WATER QUALITY MONITORING PLAN

3.1 Rationale for Water Quality Monitoring Plan

KRRC anticipates impacts from the Project on aquatic resources in the lower Klamath River through the release of reservoir sediment. The 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 (SSC) 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. KRRC plans to conduct pre-, concurrent, and post-dam removal water quality monitoring (one year before and three years following dam removal) 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 samples at Keno Dam upstream from the Project to assess baseline river conditions.

3.2 Monitoring Locations

Table 3-1 and Figure 3-1 present the locations and characteristics of the project water quality monitoring stations that will operate 12 months of the year at least one year prior to dam removal and up to three years following dam removal. Each monitoring location is also an existing IM-15 monitoring site, thus enabling KRRC to augment previously collected data. KRRC will collect water quality and discharge data at each site, as discussed in the next section.

KRRC was informed by the IM-15 monitoring entities that all locations require strengthening of the sonde holding mechanism to withstand winter conditions (currently, IM-15 data collection activities are ceased from approximately November through April). KRRC is working with the Karuk tribe, Yurok tribe and US Geological Services (USGS) to complete the necessary improvements prior to the beginning of pre-drawdown monitoring activities. KRRC will augment the IM-15 monitoring during the pre-drawdown monitoring period by upgrading and operating the stations during the winter months. Once drawdown is initiated, KRRC will operate the monitoring stations year-round and IM-15 monitoring will cease.

KRRC removed the Walker Bridge site along the Klamath River at River Mile 156.3 from the list due to access approval issues. If access issues are resolved, KRRC may add the site back into the list of monitoring sites.

The Klamath River site above Shovel Creek is located approximately 3 river miles downstream from the California/Oregon stateline and KRRC is considering it as a possible location for a stateline monitoring station. The site is currently monitored under IM-15. The final location of the stateline monitoring location may change including moving this monitoring to the JC Boyle Powerplant location at RM 219.7. The stateline monitoring location, specifics and duration of operation will be defined in consultation with will ODEQ and California SWRCB.

Table 3-1 Monitoring Locations

Location	River Mile	Current Monitoring Entity	Existing Sonde	USGS Gage Station
Klamath River below Keno Dam	233.4	USBR and PacifiCorp	n	y
Klamath River below J.C. Boyle Powerplant	219.7	PacifiCorp	n	y
Klamath River above Shovel Creek (near Stateline)*	206.42	PacifiCorp	n	n
Klamath River below Iron Gate Dam	189.7	PacifiCorp	y	y
Klamath River below Seiad	128.5	Karuk Tribe	y	y
Klamath River at Orleans (USGS)	59.1	Karuk Tribe	y	y
Klamath River near Klamath	6.0	Yurok Tribe	y	y

3.3 Water Quality Monitoring Parameters and Frequency

Table 3-2 lists the water quality parameters KRRC will monitor at each of the monitoring locations. KRRC will collect time-series water quality and stream discharge data, in accordance with the Water Quality Certifications, to assess water quality impacts of the Project. Discrete water quality samples will also be collected to support the suspended sediment load quantification, characterize constituent concentrations that cannot be measured using sondes, and to validate the sonde time-series data.

Table 3-2 Water Quality Monitoring Parameters

Constituent	Frequency	Type of Data
Temperature	Hourly, 12 months per year	Time-Series
Dissolved Oxygen	Hourly, 12 months per year	Time-Series
pH	Hourly, 12 months per year	Time-Series
Conductivity	Hourly, 12 months per year	Time-Series
Turbidity	Hourly, 12 months per year	Time-Series
SSC	Up to 24 samples pre-drawdown; weekly during drawdown, monthly following drawdown for 36 months or until TSS equals background at Keno	Discrete (Auto-Sampler)

Constituent	Frequency	Type of Data
SSC	4 storm events pre-drawdown; every two weeks during and after drawdown or until TSS equals background at Keno	Depth-width integrated sample
Chemical Oxygen Demand	Monthly, daily during drawdown	Discrete
Total Nitrogen	Monthly	Discrete
Total Phosphorous	Monthly	Discrete
Microcystin Cell Count	Monthly	Discrete

KRRC will collect sonde turbidity data as Nephelometric Turbidity Units (NTUs). However, impacts to aquatic resources from reservoir sediments have been quantified in milligrams per liter (mg/L) of SSC. The KRRC collected reservoir sediment samples in 2017 and plans to have the USGS conduct a series of laboratory tests to develop a SSC 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. KRRC will develop a laboratory protocol for the SSC/turbidity relationship analysis that identifies the accuracy and reliability of this relationship along with any uncertainties and specific field verification testing during dam decommissioning.

KRRC will characterize chemical Oxygen Demand and nutrient concentrations to assess the impacts of reservoir sediment decomposition, and other biological activities, on the dissolved oxygen concentrations in the river.

KRRC will quantify cell counts of microcystin producing blue-green algae to determine attainment of existing heath related water quality standards.

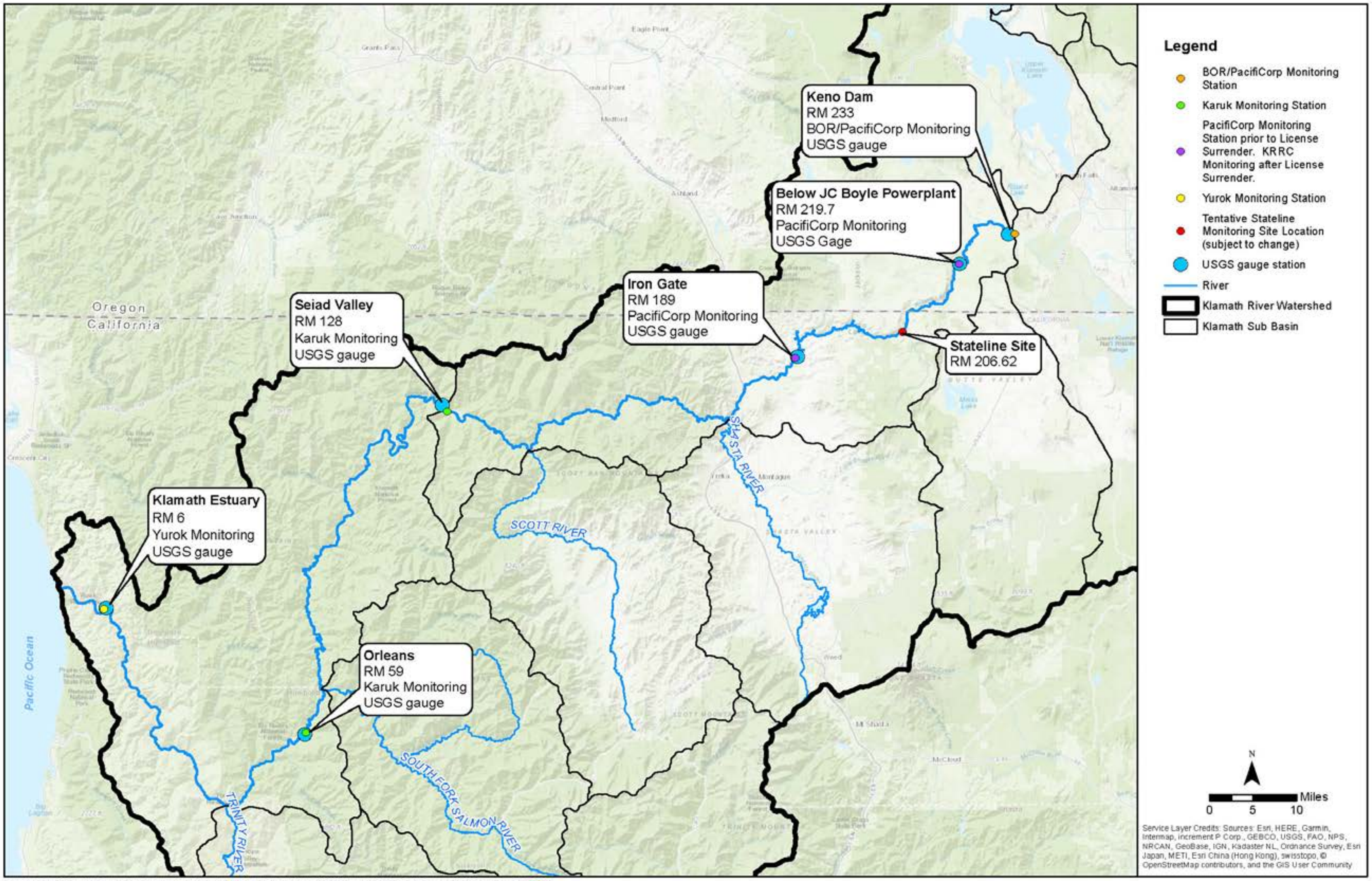

Figure 3-1 Water Quality Monitoring Locations

3.4 Riverbed Sediment Sampling and Analysis

During the Secretarial Determination process, USBR collected 75 five sediment cores in 2009 from the three reservoirs that will be removed as part of the Project 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 during dam decommissioning to the freshwater or marine environment were identified for human or aquatic biota exposure (USBR 2012d).

The above finding aside, the draft California Section 401 Water Quality Certification requires characterization of sediment quality in reservoir and riverbed sediments upstream and downstream of the project reservoirs, and in the Klamath estuary. KRRC will develop a sediment characterization plan in consultation with Oregon and California regulatory agencies to satisfy the requirements of the Section 401 Water Quality Certifications for both states with consistent sampling and testing protocols and procedures.

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).

3.5 Plan Implementation and Schedule

The KRRC will implement this Plan in accordance with the sampling schedules and frequencies defined herein and for up to three years following dam removal. Monitoring activities will continue until the State Water agencies are satisfied that attainment of Basin Plan water quality standards occurs, or after the specified time period (3 years) expires for post-construction monitoring stated within the California and Oregon 401 Water Quality Certifications, whichever occurs first.

KRRC will implement the WQ Plan in accordance with the State Water Resources Control Board’s Surface Water Ambient Monitoring Program (SWAMP). KRRC will develop a project-specific Quality Assurance Project Plan (QAPP) to describe the monitoring protocols and will include detailed mapping and figures depicting site locations, characteristics and equipment configurations. The QAPP will define:

- Monitoring entities (i.e. Yurok and Karuk tribes, USGS, USBR) and their specific roles and responsibilities
- Monitoring program design details and data collection protocols
- Data management activities and data storage
- Data quality objectives and quality assurance/quality control (QA/QC)
- Regulatory, stakeholder, and public reporting of the collected data.

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Chapter 4: References

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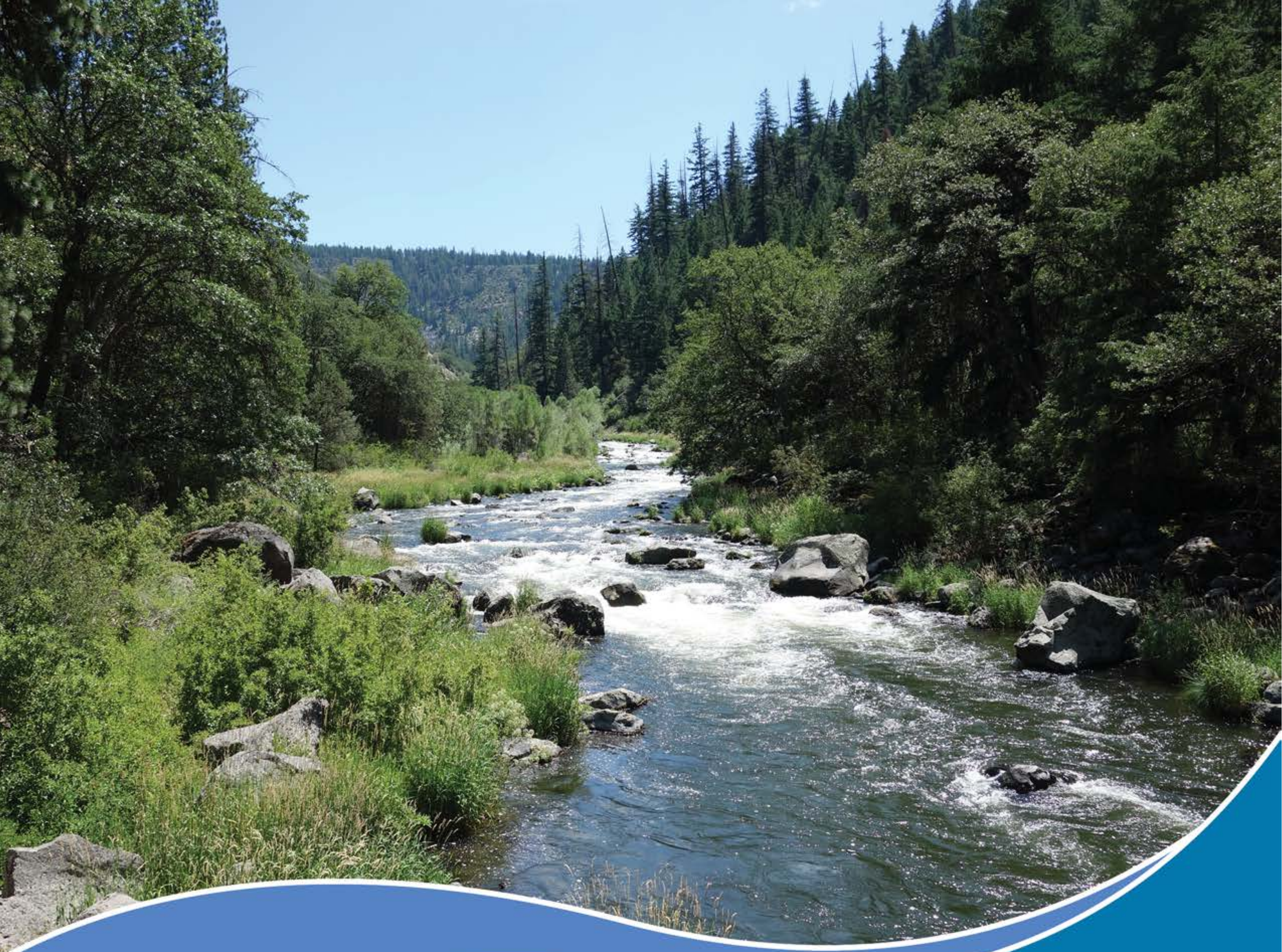

Definite Plan for the Lower Klamath Project

Appendix N – Groundwater Well Management Plan

KLAMATH RIVER RENEWAL CORPORATION

June 2018

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Acronyms and Abbreviations

CDFW California Department of Fish and Wildlife
DWR California Department of Water Resources
OWRD Oregon Water Resources Department
USBR United States Bureau of Reclamation

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Chapter 1: Introduction and Purpose

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1. INTRODUCTION

The Project may impact groundwater levels in the immediate vicinity of the reservoirs. The United States Bureau of Reclamation (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 Final Environmental Impact Statement/Environmental Impact Report for dam decommissioning (USBR and CDFW 2012). 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.

This Groundwater Well Management Plan identifies groundwater wells that the Project may adversely impact.   If the Project adversely impacts groundwater wells, KRRC will take steps (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. Proposed actions to improve production rate

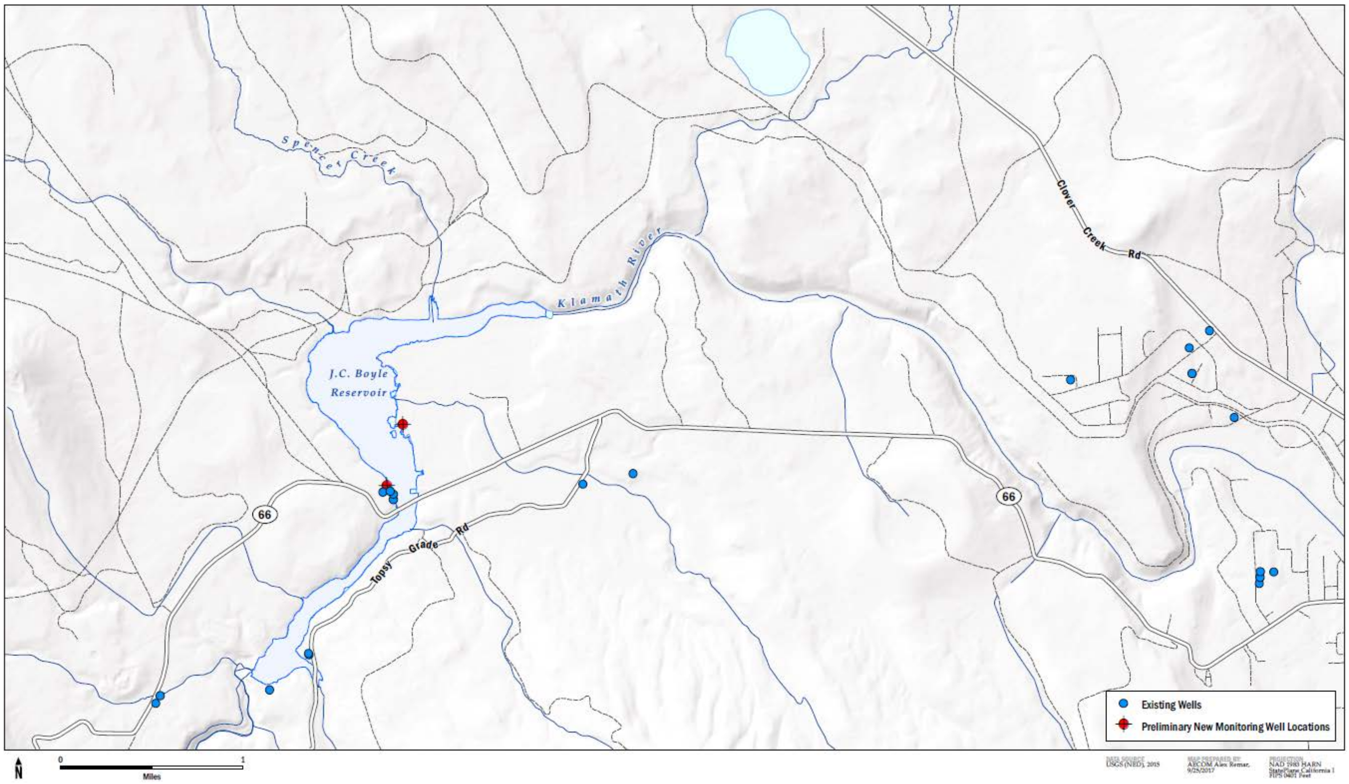

Figure 1 Identified Groundwater Wells within 2.5 Miles of J.C. Boyle Reservoir

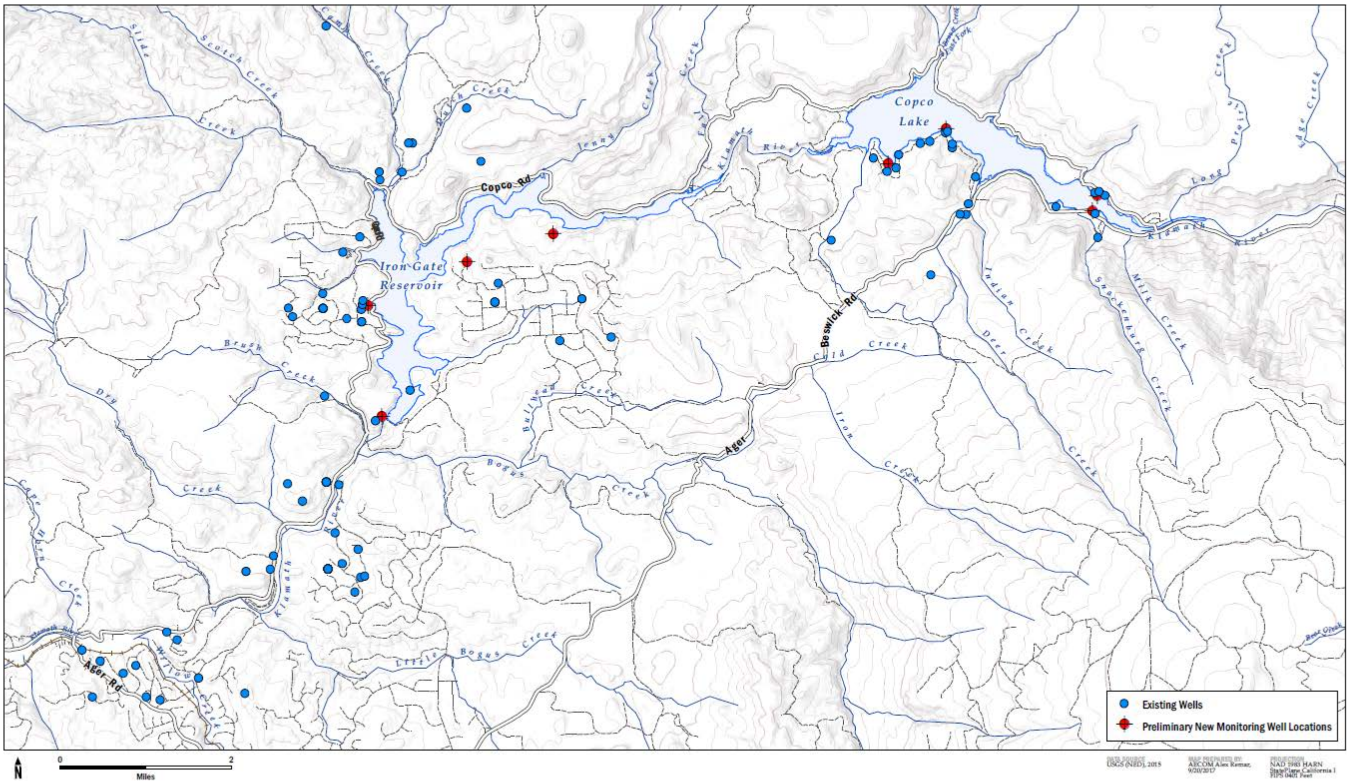

Figure 2 Identified Groundwater Wells within 2.5 Miles of Copco Lake and Iron Gate Reservoir

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Chapter 2: Management Plan

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2. MANAGEMENT PLAN

The following sections summarize the 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. Proposed actions to improve production rate

2.1 Database Search and Agency Coordination

The KRRC reviewed USBR's database that identifies 124 existing wells located within a 2.5-mile radius of the project reservoirs. The KRRC attempted to verify the location of these wells and identified any new wells within this radius installed since 2012. 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 did not 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[1], so KRRC 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). .

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 KRRC identified and downloaded using the OWRD database search, only one provided a specific location..

Given the gaps in information discernable from these data bases,, the KRRC has proposed a broad land owner outreach program as described below.

[1] KRRC has since learned from residents that there is a shared spring water supply near Copco Lake that supplies a portion of the residences there.

2.2 Outreach to Land Owners and Residents

KRRC retained the locations reported by USBR in 2012 for further analysis. To fully understand and update this information, the KRRC will undertake an outreach effort in 2018-2019 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 project reservoir in 2018. 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 proposal to identify wells for monitoring within 2.5 miles of the reservoirs. The KRRC will identify as many well owners as possible that are willing to participate in the monitoring program. Initial information requested by the questionnaire will include:

- Description of the well monitoring program
- Request to participate in the well monitoring program
- Specific information requests:
  - 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)

2.3 Installation of Groundwater Monitoring Wells

The KRRC will 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 preferred, as the groundwater recharge effect from the reservoir decreases with distance from the reservoir. If an insufficient number of well owners agree to participate in the groundwater monitoring activity, the KRRC will install a minimum of 10 sentinel monitoring wells around the three reservoirs. KRRC will install the monitoring wells between residents and the reservoirs on PacifiCorp land. KRRC proposes to install up to four monitoring wells each at Iron Gate Reservoir and Copco Lake and two wells at J.C. Boyle Reservoir. Figures 1 and 2 show proposed monitoring well locations.

2.4 Groundwater Monitoring

KRRC will monitor sentinel wells belonging to participating landowners including any monitoring wells installed by the KRRC pre- and post-dam decommissioning to identify seasonal fluctuations in groundwater levels and any groundwater level changes that may be attributable to reservoir removal. KRRC will also monitor sentinel wells 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, KRRC will conduct groundwater monitoring monthly for up to one year or until such time that post-project groundwater levels and general water quality parameters have been determined (no discernable water level declines or changes in quality over a four-month period) or they mirror baseline conditions.

During the drawdown period, KRRC will install data loggers in the sentinel wells to continuously record groundwater levels and pH and conductivity. If KRRC identifies changes attributable to reservoir removal to water levels or quality that might indicate potential supply problems, the KRRC proposes to take the actions described in Section 2.6 to restore temporary and/or long-term water supplies.

2.5 Post-Dam Removal Outreach/ Notification of Findings

The KRRC will compile and summarize in writing the groundwater data collected prior to, during, and following dam decommissioning. KRRC will use these data to identify any trends or changes in groundwater water levels and quality that may be attributable to reservoir removal. The KRRC will prepare a report of findings and identify any areas where groundwater wells are determined to be vulnerable to groundwater levels or water quality 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 to determine if there are changes in groundwater water levels and quality attributable to reservoir removal.

2.6 Proposed Actions

If the data collected during or following dam decommissioning indicates a loss of supply or adverse water quality to any potable or irrigation well, and that these circumstances are attributable to reservoir removal, then the KRRC will provide temporary water supplies until long-term measures such as motor replacement, well deepening, or full well replacement are identified and implemented as needed to return the production rate of any affected domestic or irrigation groundwater supply well to conditions prior to dam decommissioning .

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Chapter 3: References

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3. REFERENCES

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*. December.

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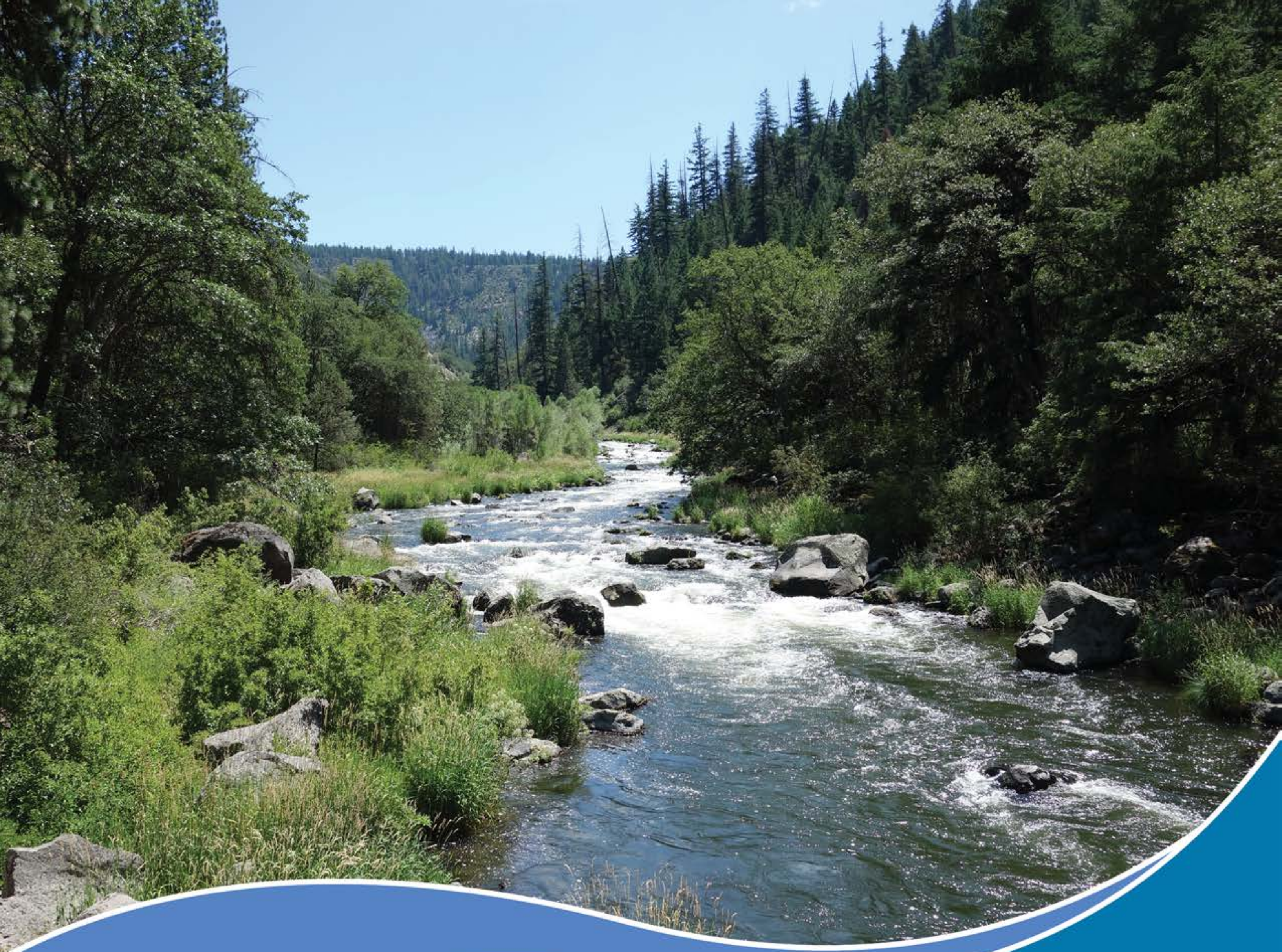

Definite Plan for Decommissioning

Appendix O1 – Fire Management Plan

KLAMATH RIVER RENEWAL CORPORATION

June 2018

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Acronyms

BLM	U.S. Bureau of Land Management
Cal Fire SU	Cal Fire Siskiyou Unit
CCR	California Code of Regulations
CFR	Code of Federal Regulations
FDL	Fire Danger Level
FMP	Fire Management Plan
FPD	Fire Protection District
KLD	Klamath-Lake District
KRRC	Klamath River Renewal Corporation
LIFC	Lakeview Interagency Fire Center
ODF	Oregon Department of Forestry
OAR	Oregon Administrative Rules
ORS	Oregon Revised Statutes
PALs	Predicted (or Designated) Activity Levels
PDM	Power-Driven Machinery
PRC	California Public Resources Code
SCOFMP	South Central Oregon Fire Management Partnership
USFS	U.S. Forest Service

Chapter 1: Need for Fire Management

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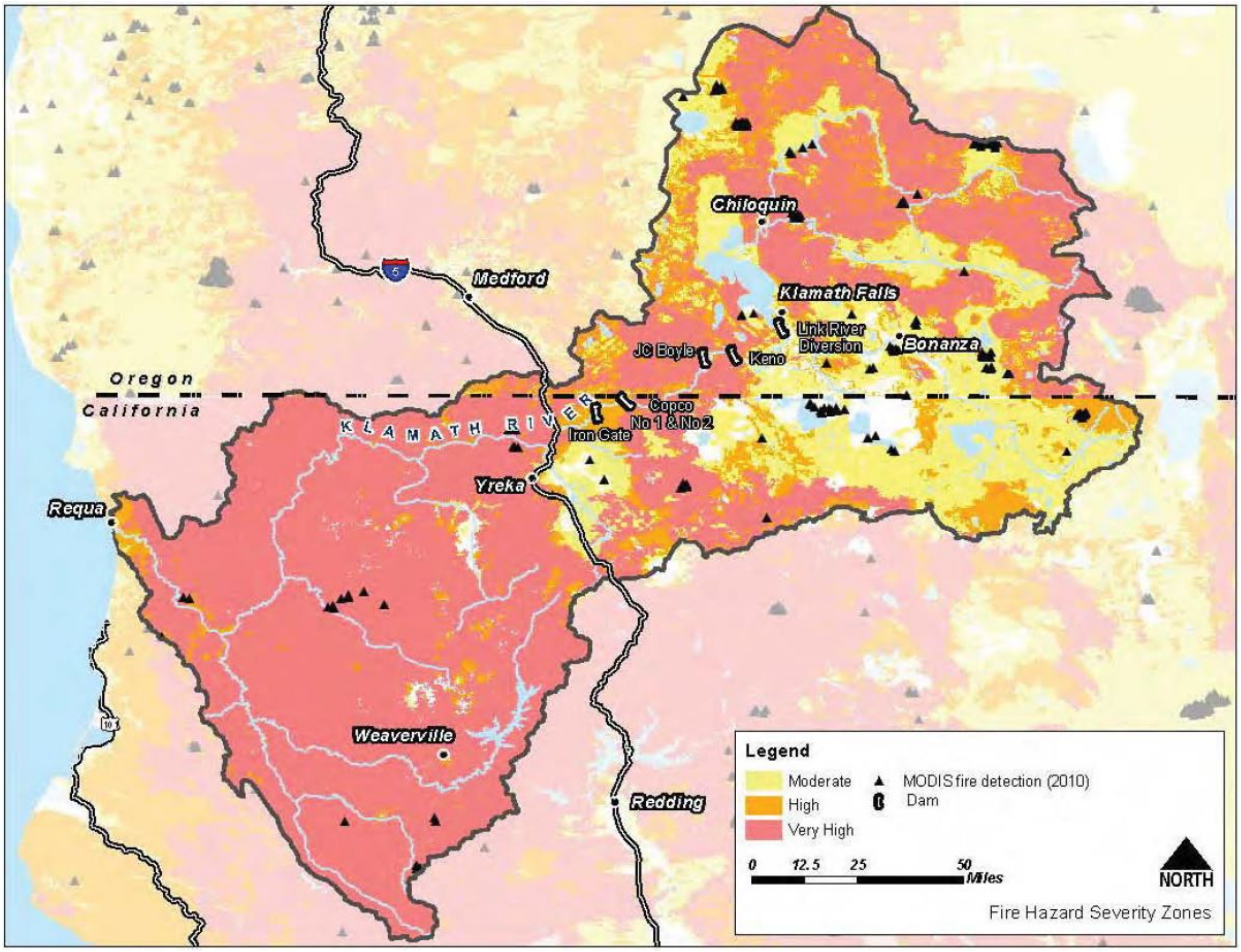
1. NEED FOR FIRE MANAGEMENT

KRRC developed this Fire Management Plan (FMP) to address fire prevention and response methods including fire precaution, pre-suppression, and suppression measures to support implementation of the Definite Plan for the Lower Klamath Project (Definite Plan) proposed by the Klamath River Renewal Corporation (KRRC) for physical removal of four dam developments (Iron Gate, Copco No. 1, Copco No. 2, and J.C. Boyle), hereinafter the Project. The FMP requires that areas of construction and deconstruction work involving activities that could result in open sparks or flame be cleared of dried vegetation or wetted-down to prevent wildfires. The FMP also requires fire suppression equipment be on-site at all times and emergency contact numbers be posted, in case of a fire. With the removal of the reservoirs as a source of water for fighting wildfires, the Fire Management Plan also provides measures for potential alternative sources of water for firefighting.

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 such as this FMP to prevent and respond to fires. California Department of Forestry and Fire Protection (Cal Fire) categorizes the fire threat in the region 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 1-1), and Klamath County has identified Wildland Urban Interfaces (WUI), where fire damage hazards are high (Wildland Fire Technologies, 2016). There is a ranking system associated with WUIs and J.C. Boyle Dam, which is partially located in the Keno WUI Community, has a WUI rating of High, the highest value in Klamath County.

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, 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 region have developed regulations and management methods to combat the increased risk of fire associated with construction activities. KRRC developed the FMP 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 Project.



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.

Chapter 2: Fire Suppression Agencies

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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 (KLD), Cal Fire - Siskiyou Unit (Cal Fire SU), 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 vicinity

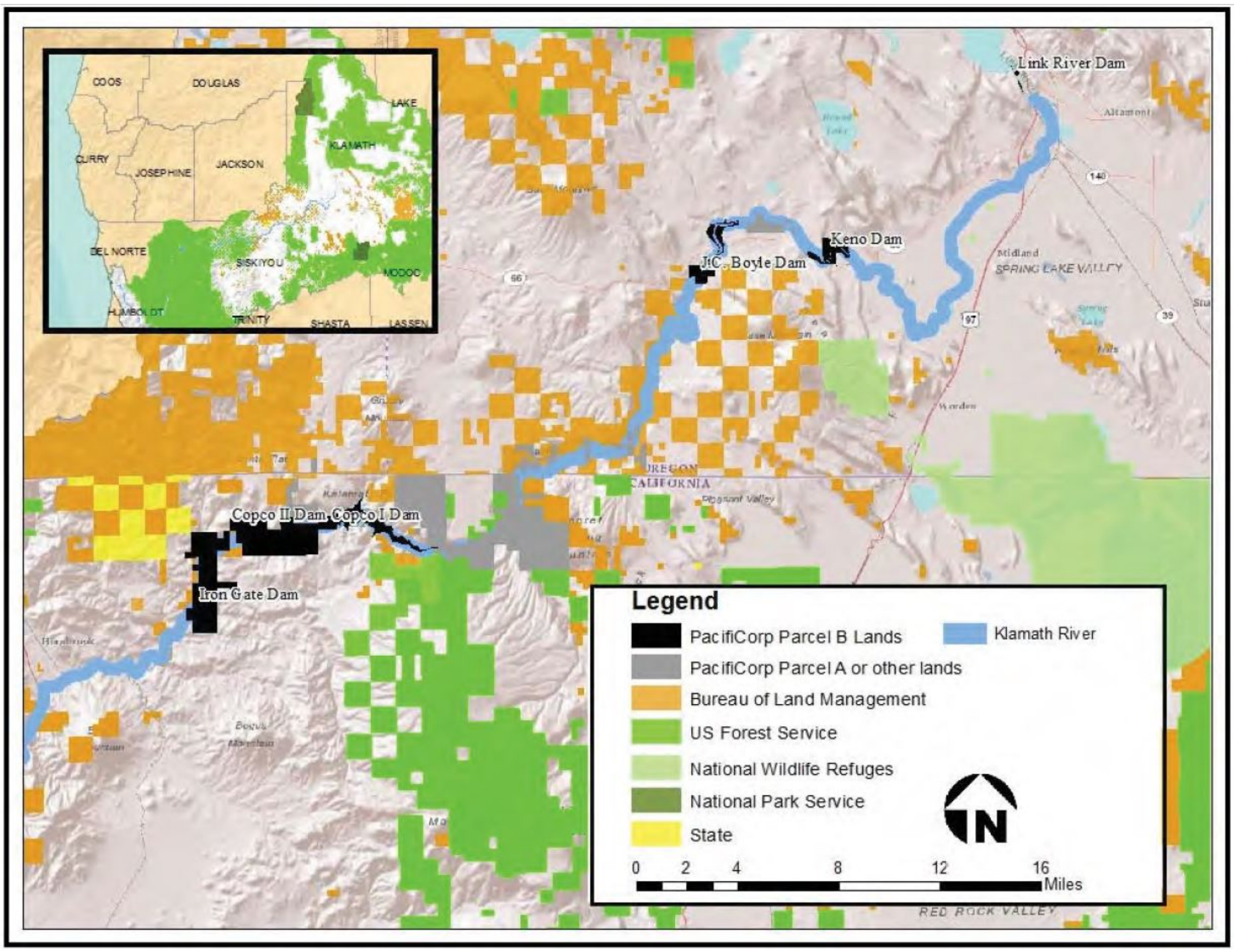
Agency	Type	Jurisdiction
USDA Forest Service	Federal	National Forests, federally managed land
Bureau of Land Management	Federal	BLM lands, federally managed land
Cal Fire	State of California	State Resource Lands, California
Oregon Department of Forestry	State of Oregon	State Resource Lands, Oregon, BLM 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 limit of work is primarily limited to several BLM parcels along the Klamath River downstream of J.C. Boyle Dam and along Iron Gate and Copco reservoirs (Figure 2-1). BLM land near the Project limit of work in Oregon, including the Klamath River Canyon, is managed for fire by ODF 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 limit of work. 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 SU. The Iron Gate and Copco developments are located within the Siskiyou County Unit Shasta Valley Battalion 2 area, and the Klamath River flows through Battalion 3. Cal Fire stations in the project vicinity include the City of Yreka and Hornbrook, which is located 10 miles west of Iron Gate Dam. The J.C. Boyle development 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 region include the Yreka and Mount Shasta Fire Departments in California. Many county fire stations are present throughout the project vicinity, and are associated with Klamath and Jackson counties in Oregon and Siskiyou County in California (Table 2-1).



Source: USBR and CDFW 2012

Figure 2-1 Land ownership in the project vicinity. Figure from EIS/R (2012).

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Chapter 3: Regulations and Requirements

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3. REGULATIONS AND REQUIREMENTS

KRRC developed this FMP to meet the regulations and requirements set forth by the fire suppression agencies in the Project vicinity (Figure 2-1). 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 those regulations only need to be met for construction taking place on federal land. There are several BLM parcels along the Klamath River adjacent to and in the Project limits of work. In Oregon, ODF KLD manages the BLM lands east of the Cascades crest and west of Hwy 97 and regulates them 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 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. In Oregon, fire season is declared by each ODF district and is typically between early June and mid- to late-October. Table 3-1 lists the laws and requirements for all ODF districts.

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 KLD. Construction operations must follow the regulations in Table 3-1 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 required by Oregon law ORS 477.625, KRRC's contractor will obtain a permit for Power-Driven Machinery (PDM) from the ODF state forester for construction activities that involve heavy machinery. Fire prevention requirements under the PDM permit are dependent on the Fire Danger Level (FDL) and requirements for fire prevention and suppression preparedness relate to the type of machinery and fire hazard. The PDM permit 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 ((ORS 477.625(1a), OAR 629-043-0026(5)). The Project will use tracked equipment and, if a PDM permit is required, such use will 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 KRRC’s contractor will renew a PDM as necessary.

The ODF forester can grant waivers from the fire prevention and suppression requirements, including the PDM permit, in some instances. Waivers may be granted 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

Category	Reference	Requirement
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. 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. The following shall be immediately available for prevention and suppression of fire: • One gallon of water or pressurized container of fire suppressant of at least eight ounce capacity • One round pointed shovel at least 8 inches wide with a handle at least 26 inches long • 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: • One round pointed shovel at least 8 inches wide, with a handle at least 26 inches long • One axe or Pulaski with 26 inch handle or longer • One fire extinguisher rated not less than 2A:10BC (5 pound).

Category	Reference	Requirement
Spark Arresters and Mufflers	ORS 477.645, OAR 629-043-0015	All non-turbo charged engines must meet Spark Arrester Guide specifications except: • Fully turbo charged engines. • Engines in motor vehicles operating on improved roads equipped with an adequate muffler and exhaust system. • Engines in light trucks (26,000 GVW or less) that are equipped with an adequate muffler and an exhaust system. • Engines in heavy trucks (greater than 26,000 GVW) that are equipped with an adequate muffler and exhaust system. • 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. • Water pumping equipment used exclusively for fighting fire. • Engines of 50 cubic inch displacement or less, except ATV's and motorcycles, shall be equipped with an adequate muffler and an exhaust system. • 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. • 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. • 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. • 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.) • One water supply is adequate as long as the operator can deliver water to the fire within 10 minutes • 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. • Water supply, pump, and at least 250' of hose with nozzle must be maintained as a connected, operating unit ready for immediate use.

Category	Reference	Requirement
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 KLD has specific fire watch duration prescriptions based on Fire Danger Level adjective class. • Low = 1 hr fire watch • Moderate = 2 hrs • High to Extreme = 3 hrs Fire watch shall: • Be physically capable and experienced to operate firefighting equipment. • Have facilities for transportation and communications to summon assistance. • Observe all portions of the operation on which activity occurred during the day. 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. • Avoid line-rub on rock or woody material, which may result in sparks or sufficient heat to cause ignition of a fire. • 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 3-2) 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 no associated permits are 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 Field Guide (1999).

Table 3-2 California Public Resources Code Fire precautionary measures*

Category	Reference	Requirement
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: a. First clearing away all flammable material, including snags, from the area around such operation for a distance of 10 feet. 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 during the operation. 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. 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. 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. 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.

Category	Reference	Requirement
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. • Tools shall be included shovels, axes, saws, backpack pumps, and scraping tools. • One serviceable headlight adaptable for attachment to at least one-half of the tractor-bulldozers used on the operation. • 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 • 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. • 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. • If two steam-operated engines or steam equipment are customarily operated within 100 feet of each other, only one engine or piece of 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. 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 shall be specified in regulations issued by the Director of Forestry and Fire Protection. 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.

Category	Reference	Requirement
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. 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. 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. d. Engines used to provide motor 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. e. Turbocharged engines are not subject to this section if all exhaust 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.*

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Chapter 4: Contacts

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4. CONTACTS

KRRC's contractor will be in frequent contact with the pertinent fire suppression agencies during construction to discuss fire hazards, prevention, suppression, and contingency plans. KRRC's contractor and a designated Safety Officer will identify the nearest local fire stations to the current operation areas and ensure the emergency contact information for each agency is posted at the project site and available to fire watch personnel and on-site workers.

In Oregon, the primary contact agency is ODF KLD. KRRC's contractor will contact the ODF KLD Unit Forester and Stewardship Forester during development of detailed, site-specific fire management plans to identify fire management resources in the Project vicinity. ODF KLD will be the first agency contacted in the event of a fire on the Oregon portion of the Project.

In California, the primary contact agency is Cal Fire SU. KRRC's contractor will contact the Cal Fire SU Prevention Specialist during development of detailed, site-specific fire management plans to identify resources in the Project vicinity. Cal Fire SU will be the first agency contacted in the event of a fire on the California portion of the Project.

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Chapter 5: Fire Management Plan

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5. FIRE MANAGEMENT PLAN

5.1 Responsibilities

KRRC's contractor 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 at the project site. 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 for 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. KRRC's contractor will clearly post a table of emergency contact agencies, their jurisdictions, and phone numbers at each project site. 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 Cal Fire SU in California and subsequently any other pertinent fire suppression agencies and the Federal Energy Regulatory Commission local office as appropriate. The Safety Officer will then initiate fire suppression protocols 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 the Project without sacrificing the safety of workers. If the Safety Officer judges equipment on-site incapable of suppressing the fire, the Safety Officer will initiate an evacuation of the project site.

KRRC's contractor and Safety Officer will work with ODF KLD and Cal Fire SU foresters to develop broad scale contingency plans for fire containment within their respective jurisdictions in the Project areas. KRRC's contractor will meet regularly with ODF KLD and Cal Fire SU foresters to discuss Project progress and updates as they pertain to fire prevention and suppression. The Safety Officer will continuously evaluate the location, condition, and importance of existing fuel breaks and will alert the relevant fire suppression agencies if fuel breaks need to be modified. KRRC's contractor and Safety Officer will identify the location of water resources for fire suppression, and KRRC's contractor will inform the ODF KLD and Cal Fire SU 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

This FMP includes fire prevention and response methods that are consistent with the policies and standards of the various local, county, state, and federal jurisdictions. KRRC's contractor will take precautionary, pre-suppression, and suppression measures to ensure public safety in the Project vicinity and comply with the fire season regulations and requirements set forth by ODF (Table 3-1) and Cal Fire (Table 3-2). KRRC's contractor will work closely with the ODF KLD Unit Forester and Stewardship Forester and the Cal Fire SU 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 for the duration of the Project.

If required by ORS 477.625, KRRC's contractor will obtain an ODF PDM permit. Operation hours of tracked machinery are limited by the PDM permit during extreme fire danger, and KRRC's contractor will suspend operation of these machines between the hours of 1 pm to 8 pm when required. KRRC's contractor will take additional measures to keep machinery and the work area clear of excess flammable material. If acquired, KRRC's contractor will renew the PDM permit 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 Project limit of work for fire. The Safety Officer will train the fire watchman in the appropriate responses in the event of a 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 this FMP is preparedness for fire prevention and response in compliance with Oregon and California state regulations (Table 3-1 and Table 3-2, 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 vehicles and machinery will be equipped with functional spark arresters and/or mufflers, where applicable, and KRRC's contractor will routinely clean spark arrester ports. Gas powered saws, if operated at the Project, will maintain the fire suppression equipment 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. The Safety Officer will develop best management practices for smoking in accordance with ORS and CCR regulations.

KRRC's contractor and Safety Officer will conduct work using best management practices in addition to compliance with all federal, state, and local laws. KRRC's contractor will establish communication lines to the various fire suppression agencies, particularly ODF KLD and Cal Fire SU. KRRC's contractor will maintain all equipment to the working standards of the manufacturer and keep them 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. KRRC's contractor will clear work areas 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. KRRC's contractor will consult with ODF KLD and Cal Fire SU 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 KLD foresters granting waivers of certain fire prevention and suppression requirements.

KRRC's 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 vicinity

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. 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 provided by Colestin Rural Fire Protection District and Greensprings Rural Fire District.

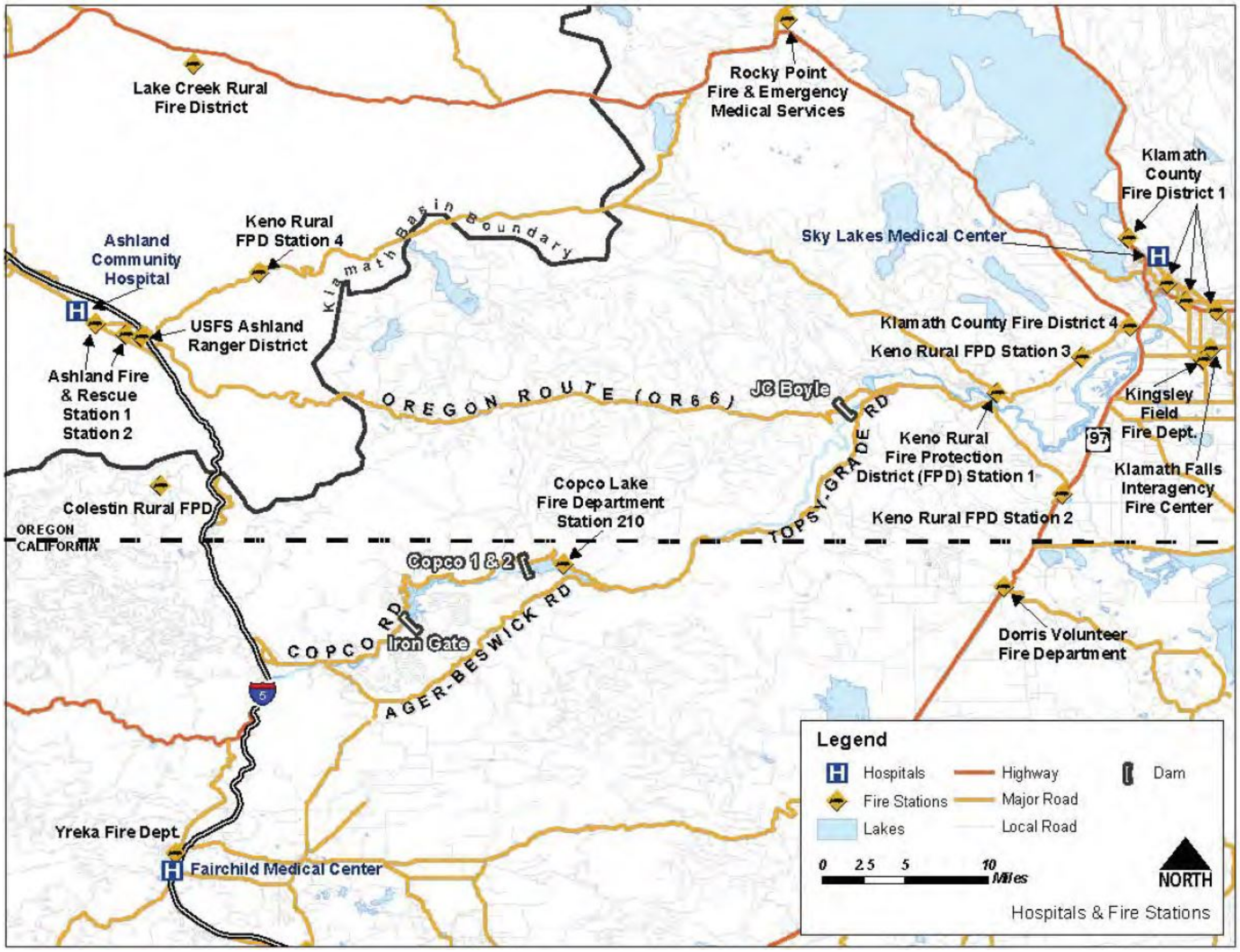
5.4 Fire Suppression Resources

KRRC's contractor will work 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 SU has a Unit Strategic Fire Plan that describes fire prevention goals and resources and guides fire management and fire suppression tactics (Siskiyou County, 2016).

KRRC's contractor and Safety Officer will provide the location of nearby fire stations, hospitals, access roads, evacuation routes, and water sources (Figure 5-1) 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. KRRC's contractor will identify the location of and access to the closest water sources in the event 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 vicinity, Cal Fire SU provides fire suppression resources and coordinates with additional local fires suppression entities (Table 5-1). 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 Cal Fire SU is divided into 4 battalions, and the Project limit of work 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 are the Copco Lake Fire Department Station 210, which services the area surrounding the Copco 1 reservoir, and the 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 vicinity, ODF KDL is primarily responsible for organizing fire prevention and suppression; and stations and districts that service Oregon are in Table 5-1. ODF KLD operates within the SCOFMP and shares resources and responsibilities with the other agencies therein. LIFC handles dispatch responsibilities for SCOFMP. 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.



Source: USBR 2012

Figure 5-1 Map of hospitals, fire stations, and major fire routes near the Klamath Dams

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Chapter 6: Water Supply Assessment Post-Dam Removal

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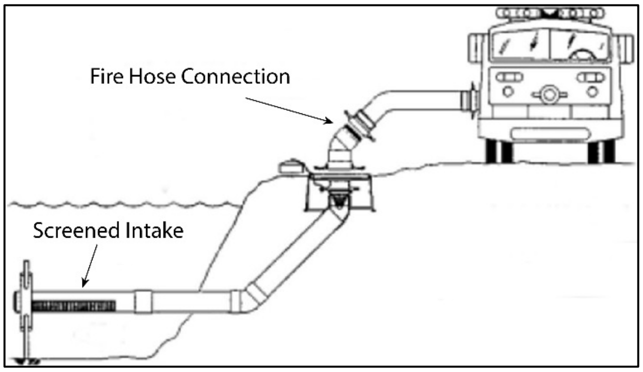
6. WATER SUPPLY ASSESSMENT POST-DAM REMOVAL

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 will be 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 (USBR and CDFW 2012). However, most helicopter water tanks require 3 feet of water depth to be filled, so helicopters will be able to use only certain portions of the Klamath River. Response and travel times between water tank fills for helicopter crews are expected to increase following reservoir drawdown (USBR and CDFW 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 will be a maximum of 15 minutes after 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 also expected to be 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, KRRC will develop additional water supplies and access points for fire suppression following the removal of the dams. Flows in the Klamath River and tributaries will not 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 FMP 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 6-1). 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.

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.



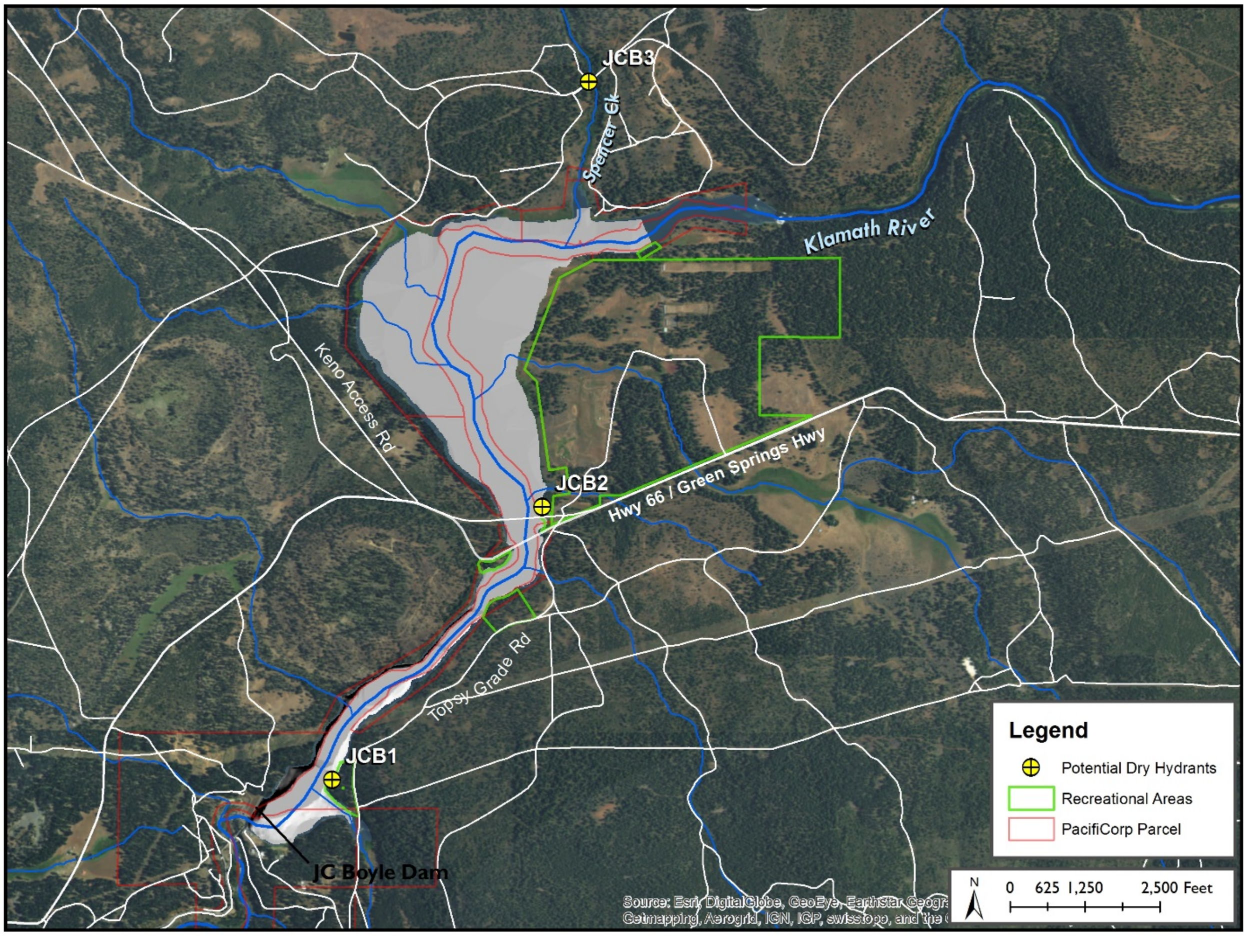
Adapted from ettfire.com

Figure 6-1 Diagram of dry hydrant system

At J.C. Boyle, three potential dry hydrant locations were identified (Figure 6-2). 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.

At Copco and the reach of the Klamath River upstream of Copco Lake, eight potential dry hydrant sites were identified (Figure 6-3). 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, and the mainstem will likely be either far from existing roads or difficult to access because of steep, high relief bluffs particularly near the Copco No. 1 Dam site.

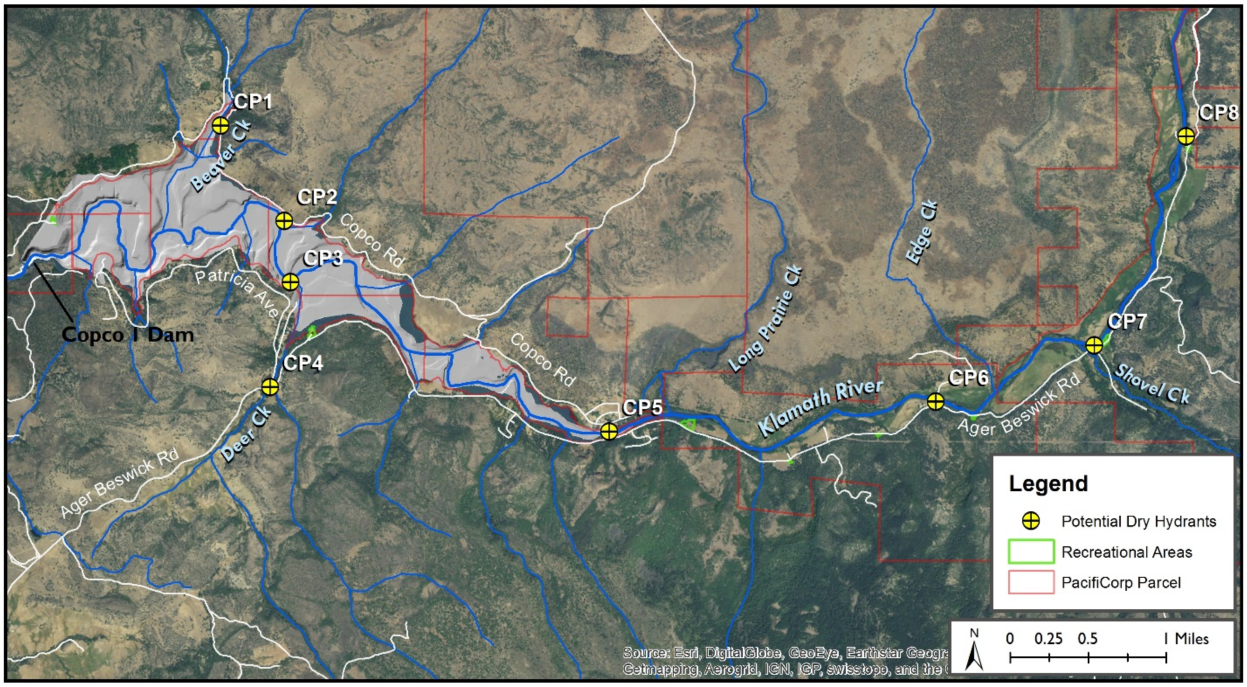
CP1 is located along Copco Road adjacent to where Beaver Creek is expected to run post-removal, but, if flow is sufficient, could be moved to where Copco Road crosses Beaver Creek upstream of the confluence with East Beaver Creek. CP2 is along the historical Klamath River and Copco Road downstream of 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 Beswick Road. CP7 is located on a small bridge over the Klamath River off Ager Beswick Road and immediately upstream of the Shovel Creek confluence. CP8 is located at a fishing access area off Ager Beswick 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.

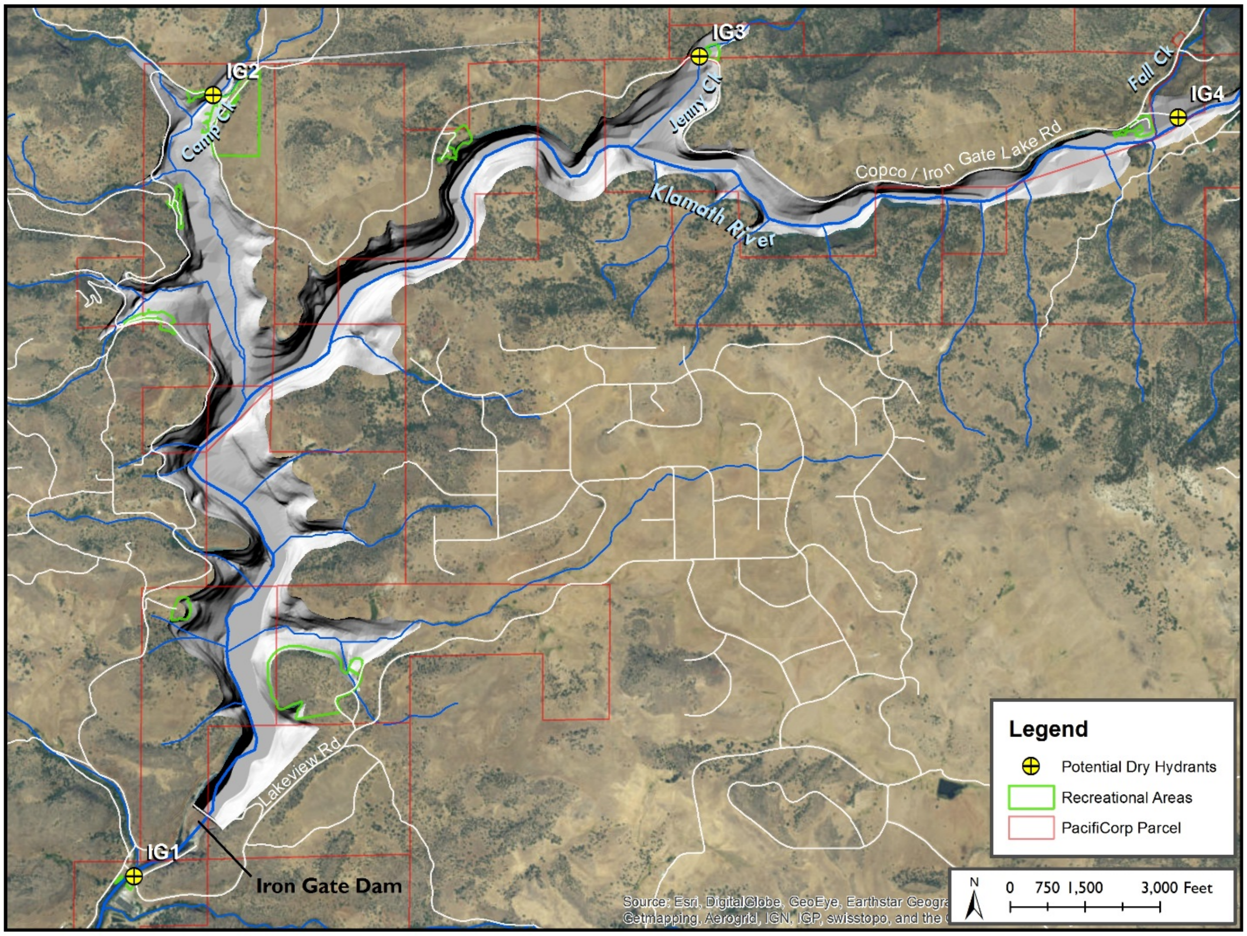
Figure 6-2 Locations of potential dry hydrants for J.C. Boyle Reservoir

At Iron Gate, four potential dry hydrant locations were identified (Figure 6-4). 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 Road crosses Camp Creek. IG3 is located at the bridge where Copco 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 Road.



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



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

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Chapter 7: References

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7. REFERENCES

Cal Fire 2007. Fire and Resource Assessment Program. 2007. Fire Hazard Severity Zones [computer file]. Sacramento, CA.

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Siskiyou County 2016. Unit Strategic Fire Plan: Siskiyou Unit. Yreka, CA.

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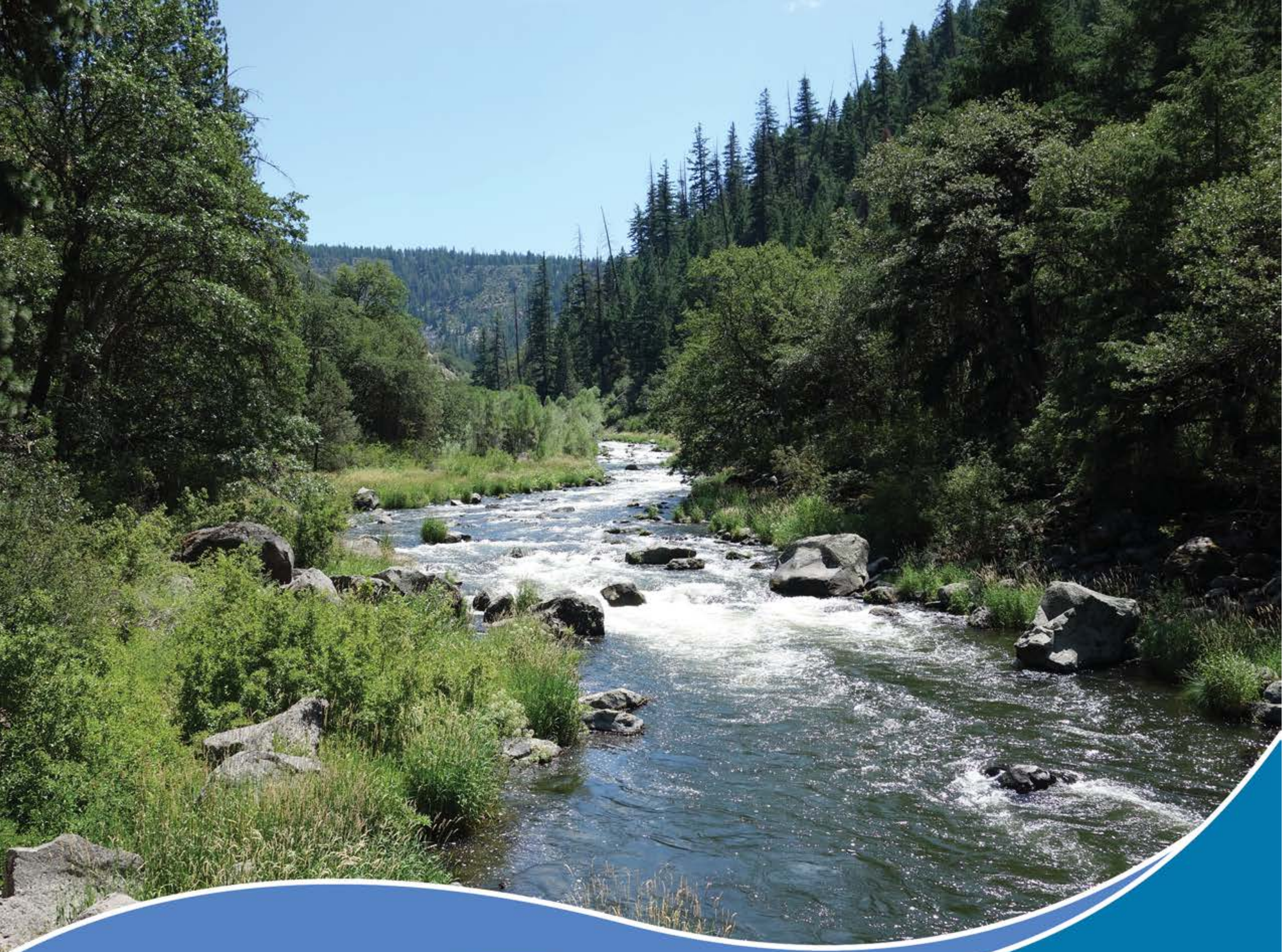

Definite Plan for Decommissioning

Appendix O2 – Traffic Management Plan

KLAMATH RIVER RENEWAL CORPORATION

June 2018

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Prepared for:

Klamath River Renewal Corporation

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List of Tables

Acronyms

Caltrans	California Department of Transportation
CHP	California Highway Patrol
KRRC	Klamath River Renewal Corporation
ODOT	Oregon Department of Transportation
OR	Oregon Route
TMP	Traffic Management Plan

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Chapter 1: Need for Traffic Management Plan

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1. NEED FOR TRAFFIC MANAGEMENT PLAN

KRRC prepared this Traffic Management Plan (TMP) for the implementation of the Definite Plan for the Lower Klamath Project (Definite Plan) proposed by the Klamath River Renewal Corporation (KRRC) for physical removal of the four dam developments (Iron Gate, Copco No. 1. Copco No. 2, and J.C. Boyle) (the Project). The TMP is a specialized program tailored to minimize impacts 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 covered by activities in the Definite Plan and to provide public awareness of potential impacts to traffic on both haul routes and access roads to the four dam developments.

Construction activities can create additional traffic delays and safety concerns on the affected highways and roadways. Planning work activities and balancing traffic demand with highway capacity is more critical during construction or maintenance. To prevent unreasonable traffic delays resulting from planned work during implementation of the Definite Plan, KRRC developed this TMP, and KRRC's contractor will implement it, to maintain acceptable levels of service, traffic circulation and safety on the state and county highway and roadway system.

This TMP outlines the structure and key requirements that will be incorporated by the KRRC's contractor into a final traffic management plan. The final traffic management plan will be informed by KRRC's contractor's specific means and methods for construction, which could refine the approach to access and traffic management. The final traffic management plan will meet applicable regulatory permit requirements, as well as applicable state and local ordinances, as appropriate. In developing the final traffic management plan, the Contractor will coordinate with the following agencies:

- Oregon Department of Transportation (ODOT)
- California Department of Transportation (Caltrans)
- Klamath and Siskiyou Counties
- Oregon State Police
- California Highway Patrol (CHP)

1.1 Access Summary

Throughout the construction and demolition contemplated in the Definite Plan, various roads in the vicinity of the four developments will experience some changes to traffic conditions, with the potential to impact other road users. The KRRC anticipates changes to traffic conditions 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 development are summarized in Table 1.1-1, and generally shown in Definite Plan Figure 1.2-2(C). Definite Plan Section 5 (Dam Removal Approach) and Section 7.4 (Road Improvements) provide additional details concerning access and associated road improvements.

Table 1.1-1 Primary Access Route Summary

Development	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

1.2 Management Strategies

This section describes strategies KRRC proposes to minimize construction-related traffic delays and maintain safe movement of vehicles during implementation of the Definite Plan. These strategies are of a general nature and are intended to reduce the overall level of congestion. KRRC's contractor will include more detailed techniques for management of potential traffic impacts in the final traffic management plan. The proposed management strategies are grouped into the following four broad categories: (1) public information; (2) motorist information; (3) incident management; and (4) construction strategies. The numbered list below summarizes each category of management strategy and associated details.

1. **Public Information:** KRRC's contractor will adopt various methods 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:** KRRC's contractor will develop a motorist information system to provide advance notice to motorists of potential traffic delays throughout the project sites and associated access routes. Proposed methods will include portable changeable message signs, stationary mounted signs, and highway advisory radio.

3. **Incident Management:** KRRC's contractor will devise an incident management procedure to outline traffic procedures to be adopted in the case of an incident on a road or highway. The procedure will be developed in collaboration with local and state agencies (listed above), and in accordance with local and state requirements.
4. **Construction Strategies:** KRRC's contractor will incorporate the following construction strategies into the final traffic management plan:

   a) **Roadway Closures**: During construction, some longer-term (more than a day) road closures will occur, though only on minor dam access roads where no public interruption would occur. Some short duration road closures will occur on more frequented roads, to enable bridge, culvert and road upgrades or replacements. KRRC's contractor will consider road users when these closures are scheduled and appropriate public and motorist information regarding detours will be issued in due course.
   b) **Traffic Handling and Stage Construction**: During construction, KRRC's contractor will provide signage and traffic control where Project generated traffic will impact road users. KRRC's contractor will determine the extent of signage and traffic control through consideration of the changes to road conditions caused by the activities and the amount of public traffic using the roads. KRRC's contractor will develop more detailed signage and traffic control plans as part of the final traffic management plan.
   c) **Construction Access to Work Zones**: KRRC's contractor will locate informational signs along the roads directly adjacent or leading to construction work zones, to direct construction traffic and notify other motorists of their presence. Where possible, KRRC's contractor will plan trip schedules to minimize impacts, i.e. avoiding peak traffic times. KRRC's contractor will control ingress and egress of construction trucks 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 developments. The majority of waste volume, the embankment dam fill and concrete, will be disposed of onsite, requiring minimal haulage. KRRC's contractor will haul some materials such as reinforcing steel, mechanical and electrical equipment and other building waste to local recycling facilities or dump sites. KRRC's contractor will schedule haul trips to minimize interruption on the road network, such as by avoiding peak hour times. In addition, KRRC's contractor will use signage to give other motorists notice of truck haulage activities.
   e) **Emergency Detour Plan**: KRRC's contractor will identify emergency service routes within the project area, as appropriate, during detailed design, in coordination with state and local jurisdictions. These emergency detour routes will likely serve hospitals, fire/police stations, emergency shelters, command centers, and other facilities that provide essential services in times of emergencies. The KRRC does not anticipate material impacts on emergency serviced routes, though the potential for minor impacts due to increased traffic will nevertheless be considered.
   f) **Traffic Safety Effects**: The KRRC has identified potential traffic safety hazards from truck hauling, including, the use of blind or sharp corners and turnouts, slow vehicles conflicting with roadway speed limits, and visibility reduction due to dust. KRRC's contractor will manage these by adopting appropriate best practice signage, traffic management systems and dust control

measures. KRRC’s contractor will perform a risk assessment of all intersections and roadways as part of the final traffic management plan.

g) **Pedestrians and Bicycles**: KRRC’s contractor will identify areas where pedestrians and cyclists could potentially share roads with construction vehicles. KRRC’s contractor will install appropriate signage to notify both construction vehicle drivers and non-motorized users of each other's potential presence on the roads. If an unacceptable level of risk to non-motorized users is deemed to persist, KRRC’s contractor will arrange appropriate detours to allow continued movement for such users.

Chapter 2: References

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2. REFERENCES

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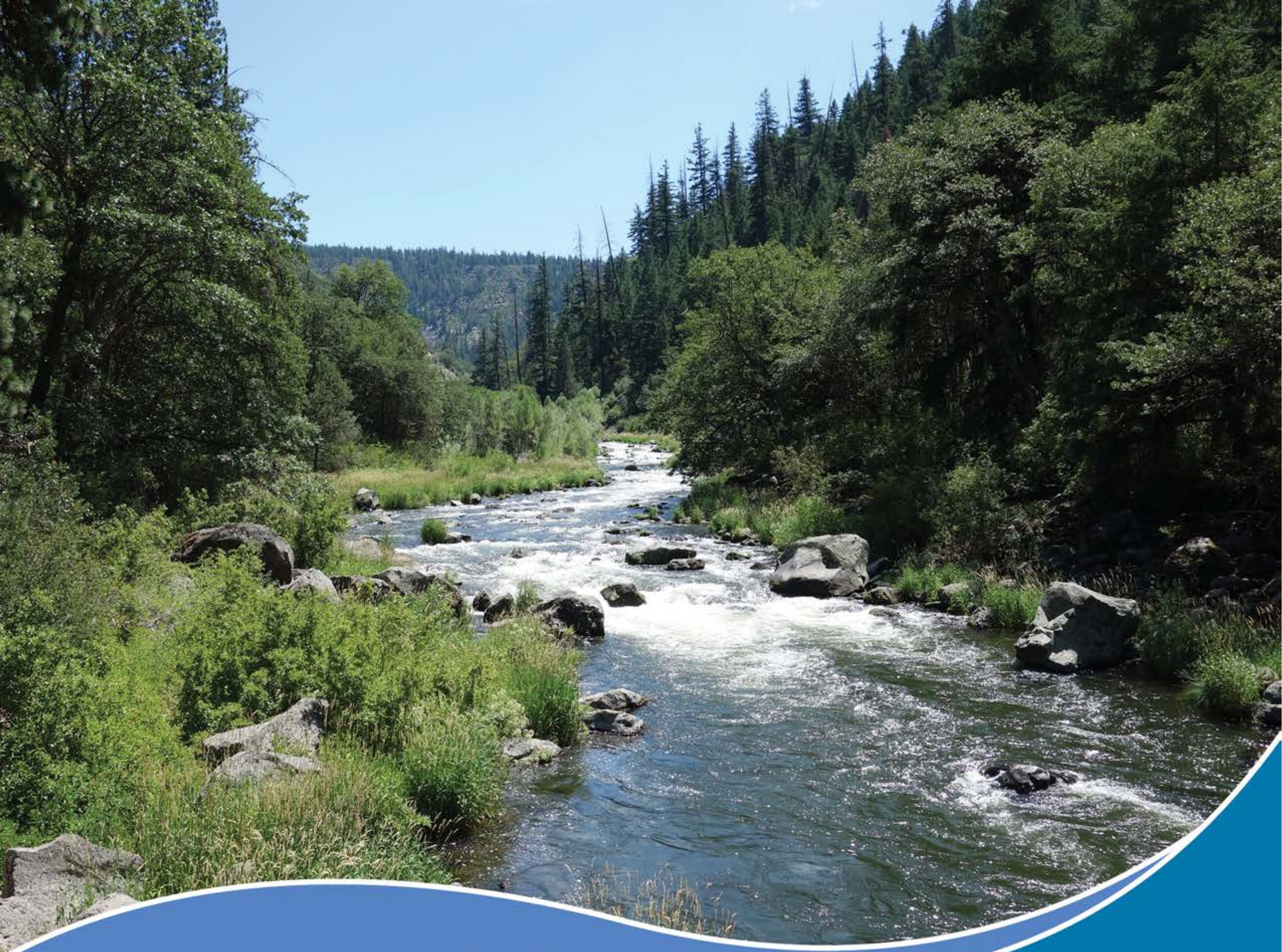

Definite Plan for the Lower Klamath Project

Appendix O3 –Hazardous Materials Management Plan

KLAMATH RIVER RENEWAL CORPORATION

June 2018

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Acronyms

ACM	Asbestos Containing Material
EPA	Environmental Protection Agency
ESA	Environmental Site Assessment
HMMP	Hazardous Materials Management Plan
KRRC	Klamath River Renewal Corporation
LBP	lead based paint
PCBs	polychlorinated biphenyls

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Chapter 1: Hazardous Materials Management Plan

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1. HAZARDOUS MATERIALS MANAGEMENT PLAN

This Hazardous Materials Management Plan (HMMP) was developed to address the management of hazardous materials during implementation of the Definite Plan proposed by the Klamath River Renewal Corporation (KRRC) for physical removal of four developments (Iron Gate, Copco No. 1, Copco No. 2, and J.C. Boyle), hereinafter, the Project. PacifiCorp, EDR, or local agencies provided all data KRRC used to develop this HMMP. KRRC will update the HMMP, as appropriate, following the planned Phase I-Environmental Site Assessment (ESA) visits and interviews and the Phase II Site Investigation, if needed after the Phase I ESA.

The following structures have been reported at each of the four developments.

- 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, a maintenance building, and an 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 years construction activity occurred at each of the four developments. Prior to removal, KRRC or KRRC's contractor will sample and test for ACM, LBP, and PCBs at all structures that are to be removed. KRRC's contractor will handle and dispose of any abated material with asbestos, lead, and or PCBs which exceed hazardous waste criteria levels as hazardous waste at approved hazardous waste facilities in accordance with applicable federal and state regulations. KRRC's contractor will dispose of remaining materials as non-hazardous construction debris.

KRRC's contractor will manage all hazardous materials removed from the developments (i.e., paints, oils, and welding gases) by returning to the vendor, recycling, or managing and disposing of such materials as hazardous waste at an approved hazardous waste facility in accordance with applicable federal and state regulations. If not data exists, KRRC's contractor will test transformer oils for PCBs. Prior to disposal, KRRC's contractor will decontaminate any tanks which contained hazardous materials.

KRRC's contractor will handle universal hazardous waste (i.e., lighting ballasts, mercury switches, and batteries) in accordance with applicable federal and state universal waste regulations.

Table 1 shows the types of hazardous materials that may be present at each development.

Table 1 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
Gas cylinders	X			
Mercury containing fixtures		?	?	
Creosote treated wood			X	

KRRC's contractor will include any additional hazardous materials identified during the Phase I site visits and Phase II investigations, if any, in an updated hazardous materials management plan.

1.1 J.C. Boyle

According to the Detailed Plan (USBR 2012), potential hazardous materials at the 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 will require specialized abatement and disposal. Contaminated soils may exist at the locations of painted exterior equipment and would require remediation. Asbestos may be found in ceiling and floor tiles, roofing materials, and electrical wiring insulation. Although all transformers have tested negative for PCBs, 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 in use within the Red Barn complex of office and maintenance buildings and two residences will be removed. KRRC's contractor will follow applicable federal, state, and local regulations, including those for spill prevention and containment, in the transportation and disposal of all waste materials. Table 2 lists the reported material and quantities for J.C Boyle from the Hazardous Materials Inventories provided by PacifiCorp.

Table 2 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
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

1.2 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 will require specialized abatement and disposal. Contaminated soils may exist at the locations of painted exterior equipment and would 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 tested negative for PCBs, some residual PCBs 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 Copco No. 1 site. KRRC's contractor will follow applicable federal, state, and local regulations, including those for spill prevention and containment for the transportation and disposal of all waste materials. Table 3 lists the reported material and quantities for Copco No. 1 from the Hazardous Materials Inventories provided by PacifiCorp.

Table 3 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

1.3 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 will require specialized abatement and disposal. Contaminated soils may exist at the locations of painted exterior equipment and would 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 tested negative for PCBs, some residual PCBs 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 in use for seven residences near the powerhouse will be removed. KRRC's contractor will follow applicable federal, state, and local regulations, including those for spill prevention and containment for transportation and disposal of all waste materials. Table 4 lists the reported material and quantities for Copco No. 2 from the Hazardous Materials Inventories provided by PacifiCorp.

Table 4 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

1.4 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 will require specialized abatement and disposal. Contaminated soils may exist at the locations of painted exterior equipment and would require remediation. Asbestos may be found in electrical wiring insulation and possibly in other building materials. Although all transformers have tested negative for PCBs, 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 in use for the restroom and two residences near the dam will be removed. KRRC's contractor will follow applicable federal, state, and local regulations, including those for spill prevention and containment, for transportation and disposal of all waste materials. Table 5 lists the reported material and quantities for Iron Gate from the Hazardous Materials Inventories provided by PacifiCorp.

Table 5 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

Chapter 2: References

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2. REFERENCES

USBR 2012. U.S. Bureau of Reclamation. *Detailed Plan for Dam Removal – Klamath River Dams – Klamath Hydroelectric Project – FERC License No. 2082 – Oregon-California*. July 2012.

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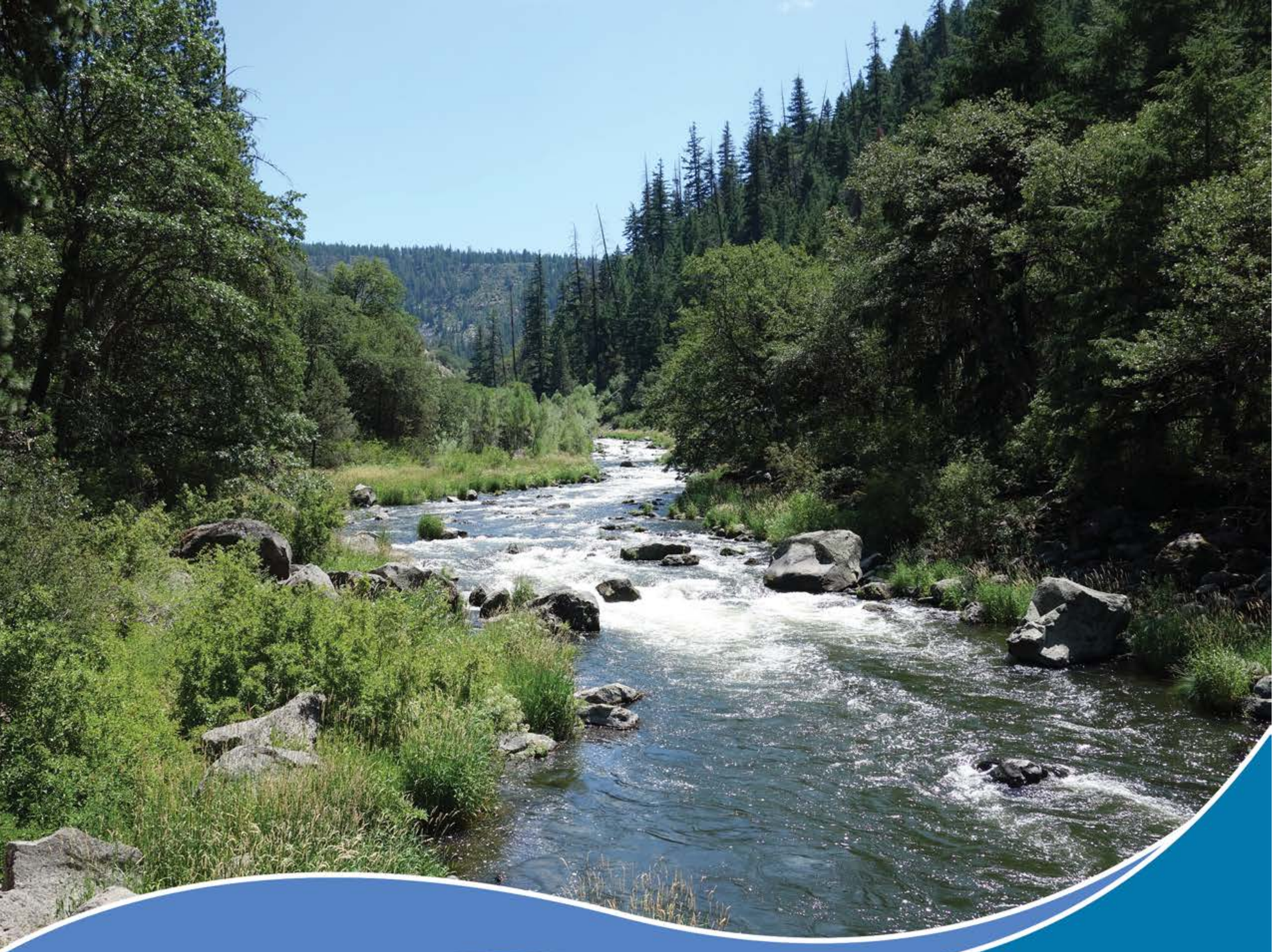

Definite Plan for the Lower Klamath Project

Appendix O4 – Emergency Response Plan

KLAMATH RIVER RENEWAL CORPORATION

June 2018

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Acronyms

CLOMR conditional letter of map revision
DSOD California Division of Safety of Dams
EOP Emergency Operations Plan
ERP Emergency Response Plan
FERC Federal Energy Regulatory Commission
KRRC Klamath River Renewal Corporation
LOMR letter of map revision
MSDS Material Safety Data Sheet
SPCC Spill Prevention Control and Countermeasures

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Chapter 1: Emergency Response Plan

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1. EMERGENCY RESPONSE PLAN

This Emergency Response Plan (ERP) was developed to support implementation of the Definite Plan for the Lower Klamath Project (Definite Plan) proposed by the Klamath River Renewal Corporation (KRRC) for physical removal of the four developments (Iron Gate, Copco No. 1, Copco No. 2, and J.C. Boyle), hereinafter the Project. The Detailed Plan (USBR 2012) had proposed mitigation measure H-1 to develop and implement an Emergency Response Plan to provide adequate notification to agencies and the public of the potential changes in timing and magnitude of flooding below Iron Gate; the KRRC is instead proposing this ERP as part of the Definite Plan.

KRRC's contractor will develop written procedures to help prevent incidents, to assure preparedness in the event incidents occur, and to provide a systematic and orderly response to emergencies. KRRC's contractor will closely coordinate this ERP with the Contractor's Health and Safety Plan, Spill Prevention and Response Plan, Fire Management Plan, and PacifiCorp's Emergency Action Plan for each development.

This ERP applies to all personnel working on the project site. Prior to commencing construction activities, the Contractor's Health and Safety lead will review emergency response procedures with all personnel assigned to the project site, as appropriate.

Applicable emergency scenarios include, but are not limited to, the following:

- Medical, including injury or illness
- Fire
- Traffic incident
- Hazardous material spill
- Downstream hydraulic change planning
- Dam or tunnel failure
- Catastrophic emergency (e.g. earthquake, high wind event, etc.)
- Security threat

The sections below discuss each type of emergency scenario and its associated response plan.

1.1 General Requirements

This ERP includes the following list of general emergency requirements.

1. KRRC's contractor will post emergency service cards in all offices within the project limit of work and in all construction vehicles. KRRC's contractor will post maps to clinics and hospitals by all land-line phones. Emergency service cards will list emergency phone numbers for the local fire department,

ambulance services, life flight medical helicopters, local police department, local medical clinic, nearest hospital, and KRRC contractor's construction manager, onsite supervisor, and Safety Officer.

2. This ERP, as well as the steps to take in an emergency, will be posted and readily accessible at each of the developments within the project limit of work.
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 development on the project 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, the Contractor's on-site 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 the project 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.

1.2 Medical Emergency

In the event of an onsite medical emergency, KRRC contractor's onsite supervisor and the KRRC construction manager shall be notified immediately with details concerning the location, name of injured person(s) and a brief description of the situation. First aid action will be initiated immediately, as necessary, through the use of trained onsite 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. KRRC's contractor will develop written procedures for medical emergencies that include standard reporting forms to document the emergency.

The following hospitals are located within the project vicinity:

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

1.3 Fire Management

Refer to the Fire Management Plan in Appendix O1 - Fire Management Plan for procedures and contacts related to managing fire emergencies.

1.4 Traffic Incident or Emergency

In the event of a traffic incident or emergency onsite, or along construction access routes currently in use by KRRC's contractor, the onsite supervisor and the KRRC construction manager shall be notified immediately with details concerning the location, name of injured person(s), if any, and a brief description of the situation. An incident management procedure will be devised to outline traffic procedures to be adopted in the event of an incident on a road or highway. If medical attention is required, protocols outlined above in 1.2 for "Medical Emergencies" shall be followed. KRRC's contractor onsite supervisor will notify the local authorities of a traffic incident or emergency, as appropriate.

1.5 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, KRRC contractor's onsite supervisor and the 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 a lake, river, stream or other water body shall be checked and maintained daily to prevent leaks of materials. If a leak is discovered, the leak will be stopped and the equipment will be removed from the project site for repair.
4. Required equipment/vehicle maintenance, refueling and lubrication will be performed at a pre-determined, protected location. If this is not possible, the activity will be completed at least 100 feet 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 workers will receive training on the Project Spill Response and Reporting Procedures

In the event of a hazardous materials spill, the MSDS will be referenced to identify safe handling and cleanup procedures. Attempts to handle a hazardous materials spill will only be undertaken if doing so presents no exposure or risk of danger or contamination to personnel. Cleanup of all hazardous material spills will commence as soon as is safely possible following any spill. If a spill requires a hazardous waste cleanup operation and specially trained crew, the Contractor's Health and Safety lead will ensure properly trained personnel conduct the cleanup and remediation. This is not anticipated for cleanup of spills of common construction materials.

1.6 Downstream Hydraulic Change Planning

Prior to dam removal, the KRRC or KRRC's contractor will inform the National Weather Service River Forecast Center of any planned major hydraulic change (removal of one or more of the 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 the 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

During the detailed design phase, the KRRC or KRRC's contractor will submit a conditional letter of map revision (CLOMR) report to FEMA of a planned major hydraulic change to the Klamath River that could affect the 100-year flood plain. Subsequently, the KRRC or KRRC's contractor will submit a letter of map revision (LOMR) to FEMA, to provide recent hydrologic/hydraulic modeling and updates to the land elevation mapping. This information 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.

1.7 Dam or Tunnel Failure

In the event of a tunnel failure during construction activities or drawdown, the immediate area shall be evacuated and the KRRC contractor's onsite supervisor and the KRRC construction manager shall be notified immediately. In the event tunnel failure results in partial or full blockage of flow, KRRC or KRRC's contractor will notify the Federal Energy Regulatory Commission (FERC) and other regulatory agencies, as required,, and the KRRC or KRRC's contractor will develop a plan to mitigate any associated impacts. The plan will be developed within five (5) calendar days of the tunnel failure, and will be sent to the FERC for review and approval and to other regulatory agencies, as required.

In the event of a dam failure, or an imminent dam failure, during construction activities or drawdown, the immediate area shall be evacuated and KRRC contractor's onsite supervisor and the KRRC construction manager shall be notified immediately. KRRC's contractor onsite supervisor shall contact 911, local law enforcement, local fire departments, the Klamath and Siskiyou County emergency services, the FERC local Office of Dam Safety, and the California Division of Safety of Dams (DSOD) immediately.

County Emergency Services, FERC's local Office of Dam Safety 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. FERC Local Office of Dam Safety
   805 SW Broadway
   Fox Tower - Suite 550
   Portland, OR 97205
   503-552-2715
4. DSOD: Specific contact and phone numbers for working and non-working hours shall be coordinated with DSOD prior to finalization of the Emergency Action Plan by the contractor. The current project contact at DSOD is Nekane Hollister at 916-227-4627.

Klamath County, Oregon, has an Emergency Operations Plan 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 therein. Flood inundation maps are available in the office of the Klamath County Emergency Manager. KRRC's contractor will review this document during preparation of the final ERP.

During preparation of the written procedures to implement this ERP, KRRC's contractor shall review PacifiCorp's Emergency Action Plans for each development. These plans will contain useful information on emergency contacts and protocol.

1.8 Catastrophic emergency (e.g., earthquake, extreme weather event, etc.)

In the event of a catastrophic emergency, KRRC contractor's onsite supervisor and the 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 KRRC contractor's written emergency response procedures. 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 not lock doors 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, the KRRC expects the police and other emergency personnel will prevent entrance to the effected site area.
5. When the catastrophic emergency is over, KRRC contractor's project manager or KRRC construction manager, in conjunction with the Safety Officer, will advise employees when it is safe to return to the site.

1.9 Security Threat

Security threats to any facility within the project site will be immediately communicated to KRRC contractor's onsite supervisor and the KRRC construction manager. Based on the information or type of threat received, a response will be initiated by KRRC contractor's onsite 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

Chapter 2: References

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2. REFERENCES

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.

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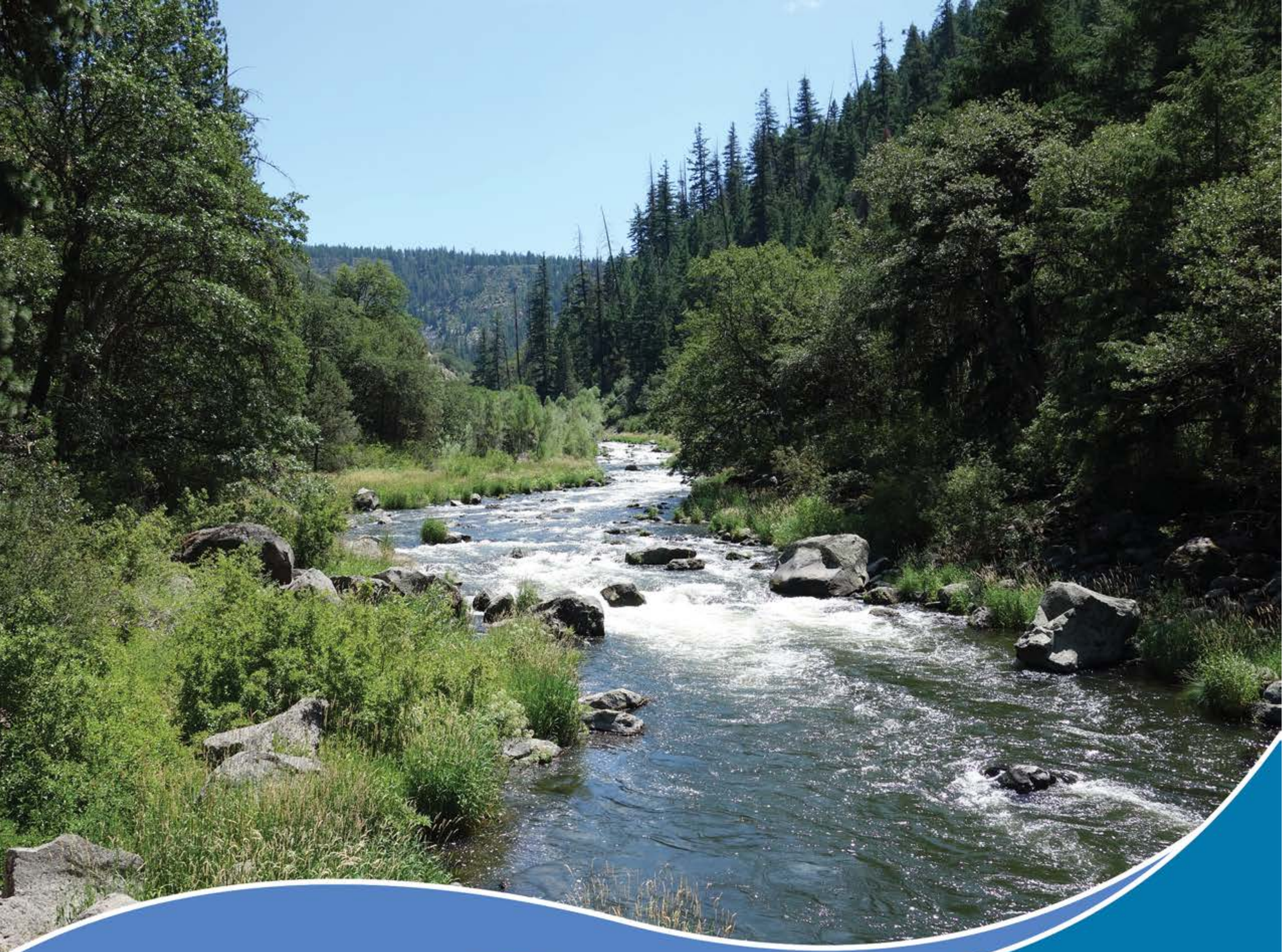

Definite Plan for the Lower Klamath Project

Appendix O5 – Noise and Vibration Control Plan

KLAMATH RIVER RENEWAL CORPORATION

June 2018

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Acronyms

KRRC Klamath River Renewal Corporation
NVCP Noise and Vibration Control Plan

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Chapter 1: Noise and Vibration Control Plan

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1. NOISE AND VIBRATION CONTROL PLAN

The purpose of this Noise and Vibration Control Plan (NVCP) is to address and reduce increases in day and night time noise levels resulting from construction activities during implementation of the Definite Plan for the Lower Klamath Project (Definite Plan) proposed by the Klamath River Renewal Corporation (KRRC) for physical removal of the four dam developments (Iron Gate, Copco No. 1, Copco No. 2, and J.C. Boyle), hereinafter the Project. KRRC's contractor will develop a final NVCP to document the KRRC's noise and vibration objectives based on regulatory and industry guidelines as relevant to specific activities to be completed under the Definite Plan. The final NVCP will address KRRC's contractor staff roles and responsibilities for noise and vibration control, define noise intensive activities and timing, identify sensitive receptors, evaluate construction noise levels, and outline a monitoring program for noise and vibration.

KRRC's contractor will incorporate the following measures into the final NVCP to reduce effects to sensitive receptors associated with noise and vibration. Measures include, but are not limited to, the following:

- KRRC's contractor shall maintain equipment in compliance with federal, state and local noise standards (e.g., exhaust mufflers, acoustically attenuating shields, shrouds, or enclosures)
- KRRC's 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 will not exceed thresholds or durations identified by the appropriate regulatory authorities
- KRRC's 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 will be deployed where construction noise would cause noise levels at sensitive receptor locations to exceed an applicable criteria threshold
- KRRC or KRRC's 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, KRRC or KRRC's contractor will notify all property owners within 1,000 feet of that location that construction activities are about to commence
- KRRC's contractor shall have a complaint hotline for local residents, and shall promptly address noise and vibration complaints

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