3.6 Flood Hydrology

This section focuses on potential changes to flood hydrology due to the Proposed Project. Historical and current surface water hydrology in the Klamath Basin are complex; however, only elements of the hydrology related to the Proposed Project's potential to impact floodplain inundation extent and flood risk to people and/or structures are described in this section. The potential for changes in flood hydrology and/or floodplain inundation extent to impact aquatic resources is discussed in Section 3.3; the potential to impact terrestrial resources is discussed in Section 3.5. Other sections of this EIR discuss water quality (Section 3.2), groundwater (Section 3.7), and water supply/water rights (Section 3.8).

Many comments were received during the NOP public scoping process relating to flood hydrology (Appendix A). These comments were primarily concerned with the potential effects of dam and reservoir removal on flood hydrology and impacts to flood inundation areas downstream of the Lower Klamath Project. Examples of specific concerns include the potential for flooding to become more likely and/or flood inundation areas to expand, and concerns about the associated economic impacts, loss of structures, and public safety. See Appendix A for further summary of the flood hydrology comments received during the NOP public scoping process, as well as the individual comments themselves.

3.6.1 Area of Analysis

The Area of Analysis for flood hydrology includes the Klamath River downstream of the California-Oregon border, which lies in portions of three California counties (Siskiyou, Humboldt, and Del Norte). Hydrologic characteristics of features in the Upper Klamath Basin in Oregon are discussed in this section as they pertain to potential impacts to stream flow inputs into California.

The downstream outlet of Upper Klamath Lake in Oregon is the Link River Dam which releases water into the Link River. About one mile below the Link River Dam, the Link River flows into Keno Reservoir/Lake Ewauna. The Keno Reservoir/Lake Ewauna is controlled by the Keno Dam near Keno, Oregon. The Klamath River begins at the historical outfall of Lake Ewauna, which is upstream of Keno Dam. Water impounded by Keno Dam floods the historical Lake Ewauna outfall. The Klamath River flows approximately 250 miles from the historical outfall of Lake Ewauna, through Keno Dam, through the Lower Klamath Project, and to the Pacific Ocean near Klamath, California (see Figure 3.6-1).

The Upper Klamath Basin upstream of Iron Gate Dam includes Upper Klamath Lake and its tributaries, Link River, the Keno Reservoir/Lake Ewauna, and the Hydroelectric Reach (from J.C. Boyle Dam to Iron Gate Dam). Facilities that are part of the Klamath Hydroelectric Project and USBR's Klamath Irrigation Project control surface water distribution in the Upper Klamath Basin via diversions from the Upper Klamath River (FERC 2007) (see also Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*). The Mid Klamath Basin includes the areas of the Klamath Basin from Iron Gate Dam downstream to the Trinity River confluence. Tributaries to the Mid Klamath Basin include the Shasta, Scott, and Salmon Rivers. The Lower Klamath Basin extends from the Trinity River confluence to the Pacific Ocean and includes the Klamath River Estuary and mouth, which are on the northern California coast approximately 50 miles south of the Oregon border.

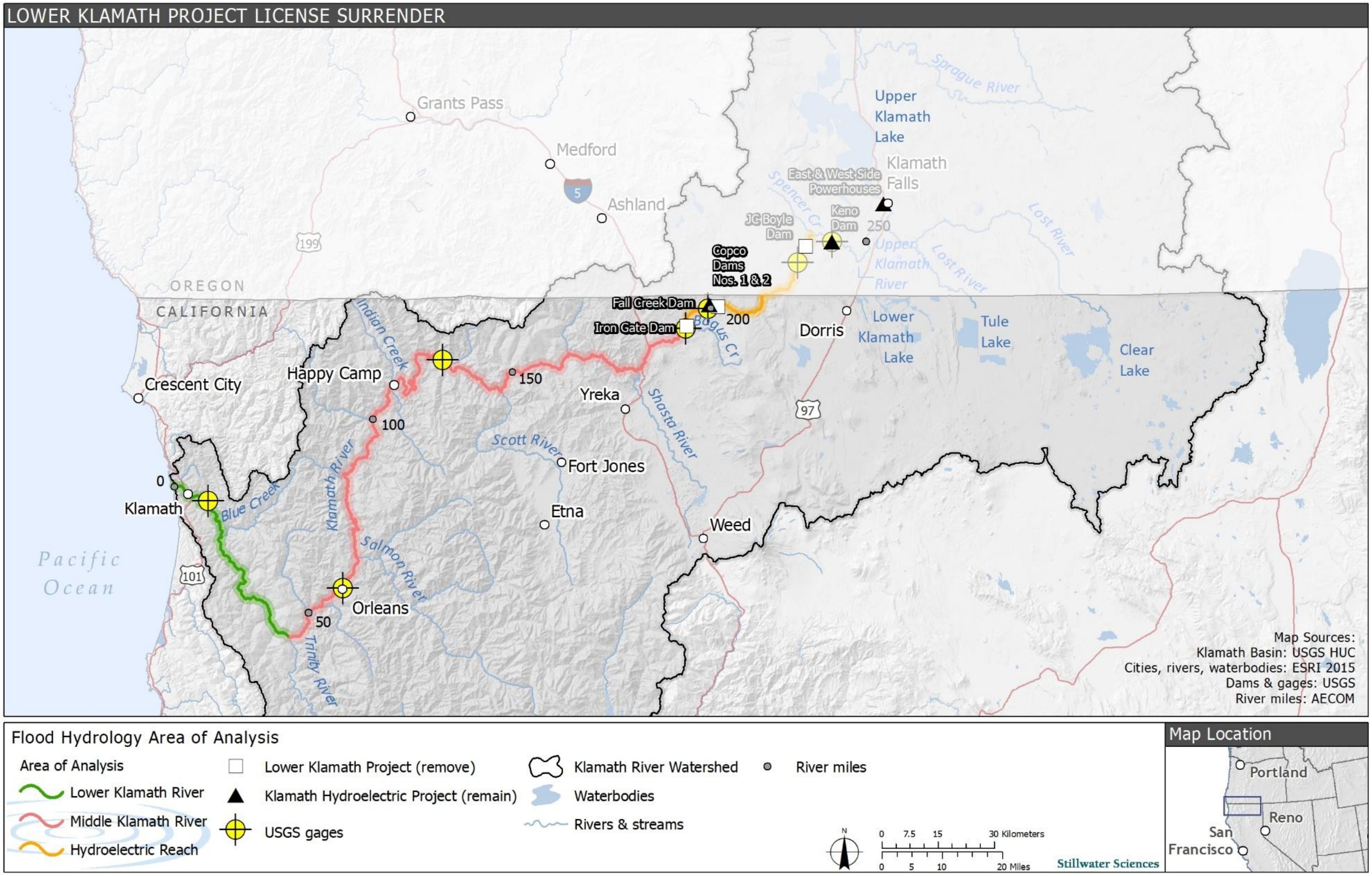

Figure 3.6-1. Flood Hydrology Area of Analysis.

3.6.2 Environmental Setting

This section describes the hydrologic conditions of surface waters in the Klamath Basin. Figure 3.6-1 shows the Area of Analysis. This section includes a description of basin hydrology including precipitation; reservoirs; major rivers and tributaries; lakes; springs and seeps providing measurable flow; historical stream flows; and flood hydrology. Existing average daily and monthly river flows and their relationship to USBR's Klamath Irrigation Project and PacifiCorp's Klamath Hydroelectric Project are also described throughout this section.

3.6.2.1 Historical Hydrologic Conditions

Pre-Dams and Pre-Klamath Irrigation Project Hydrology

Several studies have been conducted to determine the natural flow conditions of the Klamath Basin (USBR 2005); however, these studies are limited by a lack of flow data. Prior to development of dams and implementation of USBR's Klamath Irrigation Project, the Upper Klamath Basin contained lakes and large areas of marshes and wetlands. Upper Klamath Lake was not much larger than its current size; however, Tule Lake and Lower Klamath Lake were much larger. Tule Lake was approximately 7 times larger and Lower Klamath Lake was as much as 35 times larger (Dicken and Dicken 1985). Springs, snowmelt, and groundwater-dominated rivers carrying water from the Cascades and other highlands in the Upper Basin contributed greatly to Upper Klamath Lake, the Klamath River, and the wetlands and marshes in that area (Akins 1970). The elevation of Upper Klamath Lake was originally bedrock-controlled at its outlet. Water then flowed 1.3 miles down the Link River to Lake Ewauna. Lake Ewauna developed because of another natural bedrock control point near Keno, Oregon. Before construction of dams and other water control structures, the Klamath River began at the outfall of this bedrock control forming Lake Ewauna.

During high flow events out of Upper Klamath Lake, some water would flow down the Lost River Slough and into Tule Lake, another natural sump and wetland area. Water that flowed into the Klamath River reached another split near Keno (Akins 1970).

During flood conditions, water would also back up from the Keno bedrock control point and flow into the Klamath Straits and down to Lower Klamath Lake. The Lower Klamath Lake and Tule Lake areas once contained large areas of wetlands and marshes. The Lost River flowed from Clear Lake to Tule Lake. A diversion currently provides water from the Lost River to the Klamath River (Akins 1970).

The presence of both historical Tule and Lower Klamath lakes influenced flows in the Klamath River. Lower Klamath Lake (approximately 47 square miles of open water and 86 square miles of marsh) was connected to the Klamath River through the Klamath Straits. The historical Tule and Lower Klamath lakes saw increased flood inundation and lake surface area during spring snowmelt and subsequent draining of the inundated areas during the late summer and fall. Lower Klamath Lake provided some short-term storage by reducing the total volume of water leaving the upper watershed as well as delaying the peak flow. Tule Lake received overflow during high flow periods from the Klamath River near Klamath Falls, Oregon. Tule Lake was a terminal lake system; the overflow through the Lost River Slough reduced peak flows in the Klamath River in late winter and spring (Abney 1964).

Historical Land Uses Affecting River Flows

Prior to the discovery of gold in California in 1848, which prompted a dramatic influx of European immigrants to California and the Klamath Basin, the region had been inhabited for millennia by native peoples belonging to the Klamath Tribes, Shasta, Karuk, Hoopa, and Yurok. Euro-American settlement in the Klamath River watershed continued throughout the 19th Century. Sustained logging enterprises appeared in the 1880's, and the first hydroelectric development in the Klamath Basin was established in 1891 in the Shasta River Canyon below Yreka Creek.

Additional hydrologic changes to the mainstem of the Klamath Basin were triggered by the passage of the Reclamation Act of 1902 (Reclamation Act) by the U.S. Congress and the subsequent authorization of USBR's Klamath Irrigation Project in 1905. The Reclamation Act supported development in the "arid West" by allowing the Federal Government to fund irrigation projects (USBR 2010). In 1905, the Oregon and California legislatures and the U.S. Congress passed the Cession Act for all necessary legislation to begin USBR's Klamath Irrigation Project (USBR 2011). Afterwards, USBR began building the Klamath Irrigation Project, which led to the construction of the Link River Dam, hundreds of miles of irrigation ditches and large canals and pumping plants to divert water from the Klamath River watershed for agricultural use (FERC 2007). This infrastructure supported the agricultural community which was already well established in the Upper Klamath Basin and allowed for reclamation of additional wetlands for agricultural use (FERC 2007).

Development of hydroelectric plants in the Klamath Basin began as early as 1891 in the Shasta River Canyon to provide electricity for the City of Yreka. In 1895, another facility was constructed on the east side of the Link River to supply power to Klamath Falls, Oregon. Additional power suppliers developed facilities in the area on Fall Creek and the West Side plant on the Link River (FERC 2007).

3.6.2.2 Basin Hydrology

This section begins with an historical description of changes to Klamath River hydrology that have occurred associated with development of water management features in the past century and longer. The section then summarizes basin precipitation and stream flows before describing reservoirs, rivers, and creeks in the affected environment. Various springs and seeps occur in the vicinity of Iron Gate, Copco No. 1, Copco No.2, and J.C. Boyle dams and contribute flows to surface waters. Springs around Upper Klamath Lake provide inflow to many of the streams feeding the lake and also provide stability for area wetlands (Akins 1970). Section 3.7.2.1 *Regional Groundwater Conditions* describes the locations of springs and seeps in more detail. Some measurable inflows from springs and seeps to various surface waters are described below. Figure 3.6-1 shows the major rivers, dams, and reservoirs in the Klamath Basin, as well as USGS gaging locations.

Historical Water Management Changes to Klamath River Hydrology

The following provides a brief description of changes to Klamath River hydrology that have occurred through development of water management features related to irrigation, power generation, and environmental requirements over the past century and longer. The major hydrologic time periods discussed include a description of: 1) natural hydrology prior to development of major reclamation or hydroelectric facilities (pre-1903; 2) major hydrologic alterations caused by development of power peaking facilities (1903 to 1962); and 3) hydrology following construction of Iron Gate Dam in 1962 through 2000, when ESA flow requirements began to influence water releases downstream from Iron Gate (for more detail see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*).

Owing to the long history and early development of water resources within the basin, little hydrologic data exist to describe the natural flow patterns that existed prior to construction of USBR’s Klamath Irrigation Project. The first streamflow records on the Klamath River began on June 1, 1904, when the USGS began operating a flow gage on the Klamath River at Keno (USGS Gage No.11509500). River flow data for the USGS gage at Keno are available for water years 1905 through 1912, after which the gage was discontinued until 1930. The Lost River Diversion Dam was completed in 1912, which affects Klamath River hydrology (Hecht and Kamman 1996). Therefore, flow data collected at Keno from 1905 through 1912 provide the best record of unaltered hydrologic conditions prior to construction of major irrigation facilities in the upper basin. Although the 1905 through 1912 period is known to be slightly wetter than normal, the general flow conditions are still useful for understanding the general timing, magnitude, and duration of flow throughout the year under near natural conditions. Over this eight-year period the total annual discharge at Keno ranged from a low of 1,345,000 acre-feet to a high of 1,952,000 acre-feet and averaged about 1,558,000 acre-feet. Examination of three different water years, representing conditions that range from dry to wet, provide a sense of the natural flow variation that existed under natural conditions (Figure 3.6-2). Average daily flows for the 1905–1912 water years therefore provide the most reasonable set of data to assess hydrologic changes in the Klamath Basin through time as various irrigation and hydropower generation facilities were constructed. For the purposes of the following discussion, the term “natural” applies to the period prior to construction of either the hydroelectric or irrigation systems in the Klamath Basin, with river flows best represented by the 1905–1912 data.

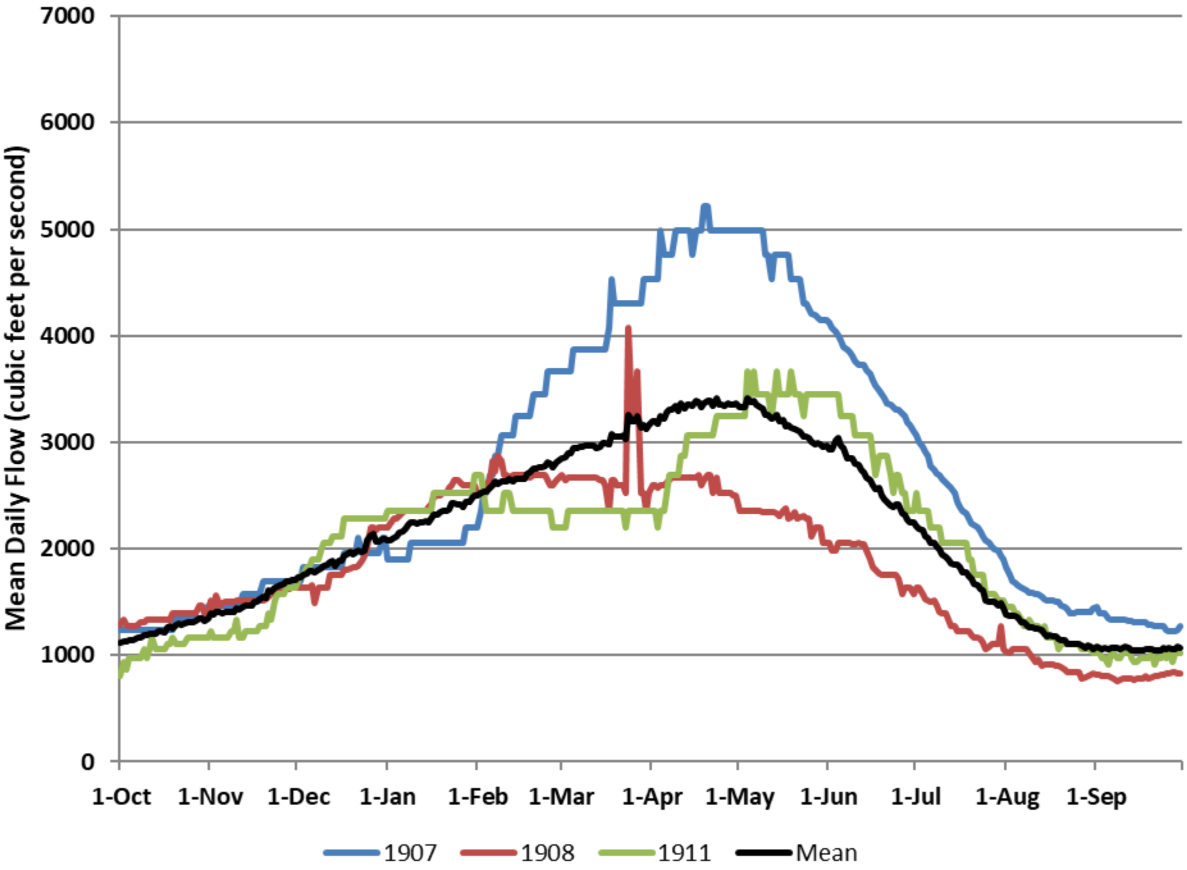

Figure 3.6-2. Mean Daily Flows (cubic feet per second) for the Klamath River at the USGS Gage at Keno for three Different Water Years, Generally Representing Drier (1908), More Normal (1911), and Wetter (1907) Conditions. Mean daily flows for water years 1905 through 1912 are also displayed to illustrate the natural flow regime that existed prior to development of major reclamation or hydroelectric projects.

Although there are no empirical river discharge data downstream from Keno prior to implementation of USBR's Klamath Irrigation Project, modeling results of flows near Iron Gate Dam without USBR's Klamath Irrigation Project show similar patterns to the natural discharge downstream of Keno (USBR 2005). Spring peaks from snowmelt in tributary basins reliably provided an increase in discharge, typically near the end of April (NRC 2004), with base flows subsequently declining to a minimum in the beginning of September.

As described below in the Keno Reservoir/Lake Ewauna section, bedrock originally controlled the elevation of Upper Klamath Lake and river flows downstream to the Link River. The Link River is only 1.3 miles long and ends at the upper extent of Lake Ewauna and the Keno Reservoir. Though a range is not identified, historical accounts describe the occurrence of extremely low flows in Link River during prolonged dry spells. These extremely low flow conditions were most likely caused by strong south winds (i.e., blowing upstream) forming seiches[135] (within Upper Klamath Lake which greatly diminished flows to the Link River for brief periods of time (Dicken and Dicken 1985). Inputs from tributary streams and natural springs downstream from Keno would have maintained flow in the Klamath River and prevented it from drying completely farther downstream near the current location of Iron Gate Dam.

In the Lower and Mid Klamath basins, the hydrologic pattern of the Klamath River was primarily dominated by rainfall events in the fall, winter and spring. In the middle and lower portions of the Klamath River, discharge responds rapidly to rainfall due to the relatively short length of lower tributary sub-basins (e.g., Salmon River). The natural Klamath River hydrology was diverse, with a range of hydraulic conditions affected by both the Upper Klamath Basin patterns previously described (e.g., Figure 3.6-2) and lower basin tributary inputs (see *Precipitation and Stream Flows* subsection, below).

Copco No. 1 and Copco No. 2 facilities were constructed to generate hydroelectric power and their operation greatly altered flow patterns downstream. The USGS gage on the Klamath River near Fall Creek, downstream from Copco No. 1 and Copco No. 2 dams, began recording flows at this location in October 1923 (USGS Gage No. 11512500). Flow data are available from USGS Gage No. 11512500 until 1962 when construction of Iron Gate Dam inundated the river at this location. Hydroelectric power peaking operations at Copco No. 1 and Copco No. 2 caused major changes to the hydrograph downstream from the Copco No. 2 powerhouse (Figure 3.6-3). Rapid changes in flow associated with hydropower generation, commonly referred to as power peaking, created both hazardous conditions for recreational fishermen and inhospitable conditions for aquatic species downstream. Mean daily flows fell below 100 cfs at USGS Gage No. 11512500 on 50 occasions between water years 1931 and 1937. Thus, hydropower peaking between 1918 and the construction of Iron Gate Dam to re-regulate flows in 1962 may explain some anecdotal accounts of the occurrence of low flows in the Klamath River in the past that were submitted by citizens during public scoping of the 2012 KHSA EIS/EIR (USBR and CDFG 2012) and the Lower Klamath Project EIR (see Appendix A).

Iron Gate Dam was completed in 1962 to re-regulate peaking flow releases from the Copco facilities upstream. At that time minimum flow releases downstream were stipulated by FERC under Article 52 of the FERC License for operation of Project No. 2082. Article 52 required the following minimum flows downstream from Iron Gate Dam: 1,300 cfs from September 1 through April 30; 1,000 cfs from May 1 through May 31; 710 cfs from June 1 through July 31; and 1,000 cfs from August 1 through August 31. These flow requirements provided more stable flow conditions downstream; however, they also altered the timing of base flows and did not attempt to restore or simulate the natural hydrograph. Fall flows were slightly increased while spring and summer flows were substantially reduced compared to natural flows. Figure 3.6-4 illustrates this alteration.

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[135] A seiche is a standing wave oscillating in an enclosed, or partially enclosed, body of water (NOAA 2018). Seiches are typically caused when atmospheric (i.e., wind or pressure) or seismic forces push water from one end of the body of water to the other. Eventually, the water rebounds to the other side of the body of water and then continues to oscillate back and forth for hours or even days.

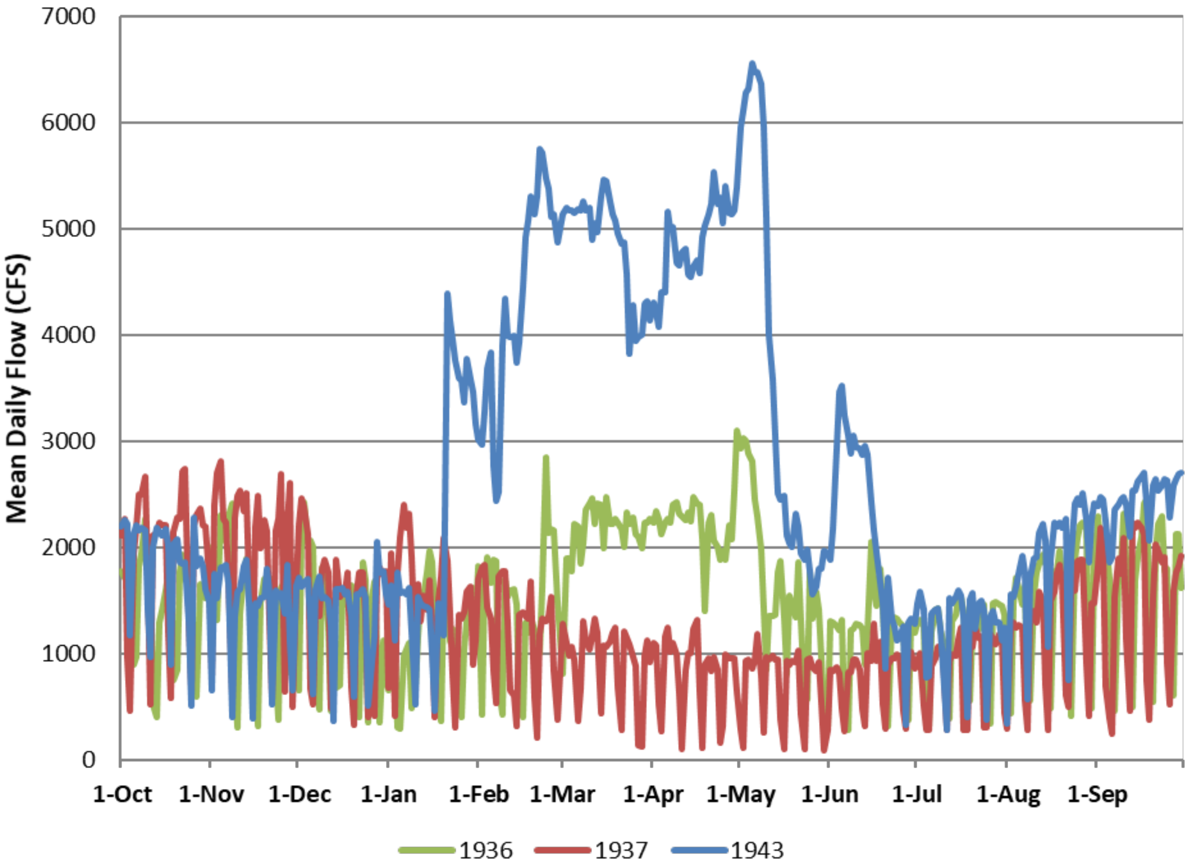

Figure 3.6-3. Mean Daily Flows (cubic feet per second) for the Klamath River at the USGS Gage Near Fall Creek (Gage No. 11512500) for Three Different Water Years, Generally Representing Drier (1937), Normal (1936), and Wetter (1943) Conditions.

Hecht and Kamman (1996) analyzed the hydrologic records for similar water years (pre- and post-Project) at several locations along the Klamath River. The authors concluded that the timing of peak and base flows changed significantly after construction of USBR's Klamath Irrigation Project (KIP), and that the operation of the KIP increases flows in October and November and decreases flows in the late spring and summer as measured at Keno, Seiad, and Klamath USGS gage sites. Comparison of mean daily flows recorded at Keno (USGS Gage No. 11509500) from 1905 to 1912 with mean daily flows recorded at Keno and Iron Gate (USGS Gage No. 11516430) in more recent years (1961–2000) illustrate these findings (Figure 3.6-4).

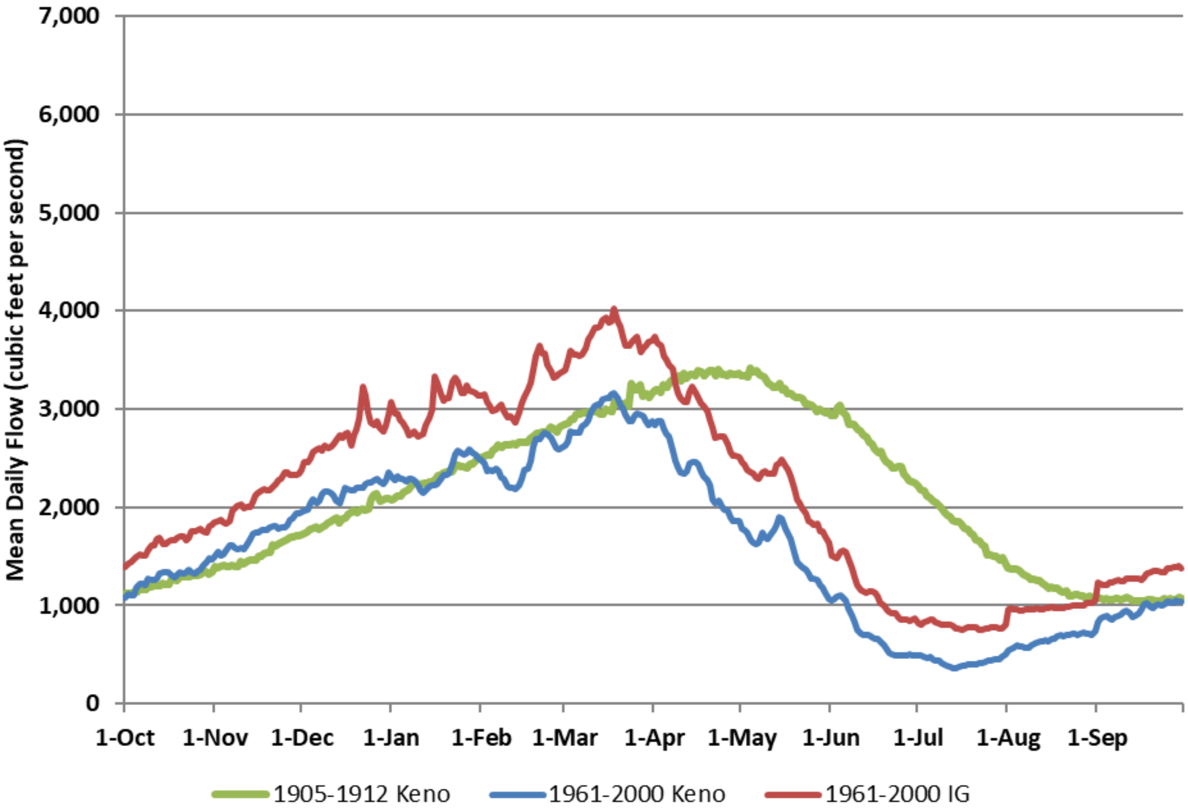

Figure 3.6-4. Comparison of Mean Daily Flows Recorded at Keno (USGS Gage No. 11509500) Historically (1905–1912) with More Recent Conditions (1961–2000). Mean daily flows recorded at Iron Gate (USGS Gage No. 11516530) are shown to depict both the mean daily accretions and similarities that exist in the hydrograph between Keno and Iron Gate.

During the period from 1961 through 2000, the timing and magnitude of average flows in the Klamath River at Keno changed relative to the natural flow regime (Figure 3.6-4). USBR's Klamath Irrigation Project water diversions from the Klamath River in the spring and summer significantly reduced flow volumes in the Klamath River from approximately April until September. The extraction of water significantly accelerated the decline of flow rates during the spring runoff and had the effect of moving the spring runoff peak from the end of April and beginning of May to the middle of March, a shift of more than one month. Although most of the diverted water remained within the basin, a combined total of about 30,400 acre-feet of water was diverted annually from Jenny Creek (tributary to the Klamath River at Iron Gate Reservoir) and Fourmile Lake (tributary to Upper Klamath Lake) to the Rogue River Valley for irrigation and hydropower production. Under natural conditions, river discharge did not reach base (minimum) flow, until September. Operation of USBR's Klamath Irrigation Project caused a shift in the onset of minimum base flow levels by about two months earlier in the summer from September to July. Tributary inflows and spring flow accretions, the most prominent being Big Springs (about 250 cfs) in the J.C. Boyle Bypass Reach, accounts for the difference in mean daily flow between Keno and Iron Gate.

Minimum flow requirements, based on consideration of ESA species, at Iron Gate Dam have gone through multiple iterations (e.g., 2002 Biological Opinion, 2008 Biological Opinion, KBRA/2010 Biological Opinion) and are currently operated under the 2013 Joint Biological Opinion (BiOp) and court-ordered flushing flows (for more detail see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project,* and the *Iron Gate Reservoir* subsection below) (NMFS and USFWS 2012, U.S. District Court 2017).

Precipitation and Stream Flows

The Upper Klamath Basin receives rain at all elevations and snow at elevations above 4,000 feet (above mean sea level [amsl]) during the late fall, winter, and spring. Snow is the primary form of precipitation in the upper watershed. Depending on the elevation and location, the amount of precipitation ranges from approximately 10 to more than 50 inches per year. From 1907 through 1997 the average annual precipitation at Klamath Falls was 13.4 inches and from 1959 to 2009 it was 20 inches at Copco No. 1 Dam (USBR 2010). Peak stream flows generally occur during snowmelt runoff from March through May. After the runoff has stopped, flows drop to low levels in the late summer or early fall. Fall storms may increase flows compared with the lower summer flows. Generally, conditions in the Upper Klamath Lake area are drier than the area where the Klamath River reaches the ocean (Figure 3.6-5). The reaches downstream from the confluence of the Klamath and Shasta rivers receive higher levels of precipitation than other reaches in the Klamath Basin (FERC 2007). Average annual precipitation is 49 inches at Happy Camp from 1914 to 2010 and 80 inches at Klamath between 1948 and 2006 (Desert Research Institute 2011).

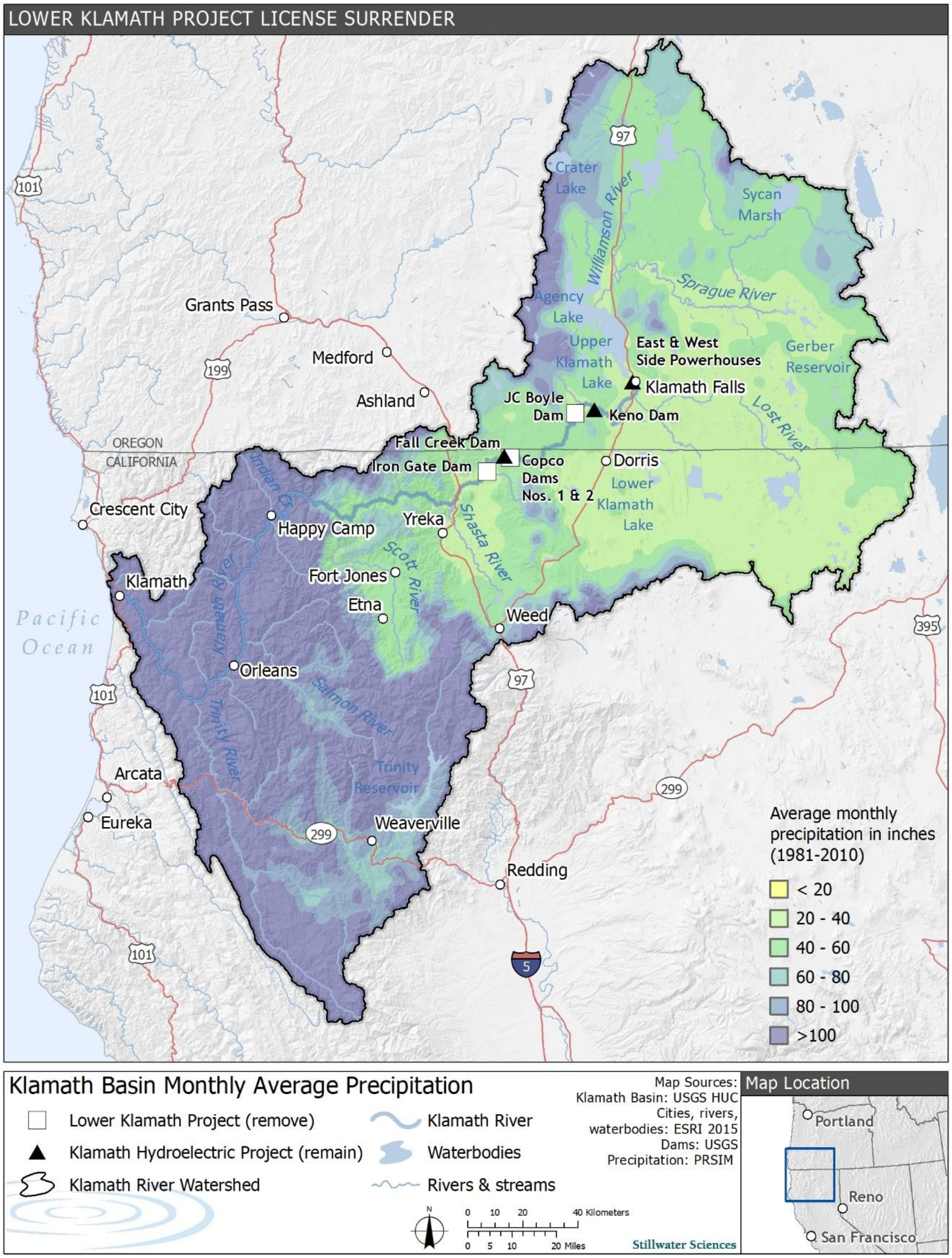

Figure 3.6-5. Mean monthly precipitation across the Klamath River watershed (1981–2010).

The following graphs and tables provide more detail regarding precipitation and streamflow from the upper to the lower watershed, as well as information on the range of hydrologic conditions. The USGS stream gages on the Klamath River are summarized in Table 3.6-1 and Figure 3.6-1. Summer and early fall periods (July through October) generally have much lower flows than during spring runoff. Tributaries downstream from Iron Gate Dam contribute substantial amounts of flow. Figure 3.6-6 shows historical daily average stream flows at several locations on the river using USGS monitoring data from 1961 to 2009 (USGS 2011). Flows are substantially higher during wet years; Table 3.6-2 shows historical average monthly flows during wetter years (represented by flows exceeded 10 percent of the time) using the same USGS data (USGS 2011). Table 3.6-3 shows the daily average flows at the four primary hydroelectric dams. The column indicating "Percent of time equaled or exceeded" indicates the hydrologic conditions, with 99 percent being extremely dry conditions and 1 percent being extremely wet conditions.

Table 3.6-1. USGS Gages on the Klamath River.

USGS Gaging Station	Station Name	Drainage Area (miles^2)	Latitude	Longitude	Gage Elevation (feet amsl)	Period of Record (Water Years)
11509500	Klamath River at Keno, OR	3,920	42°08'00"	121°57'40"	3,961	1905–1913 1930–2016
11510700	Klamath River below J.C. Boyle Power Plant near Keno, OR	4,080	42°05'05"	122°04'20"	3,275	1959–2016
11512500	Klamath River below Fall Creek near Copco, CA	4,370	41°58'20"	122°22'05"	2,310	1924–1961
11516530	Klamath River below Iron Gate Dam, CA	4,630	41°55'41"	122°26'35"	2,162	1961–2016
11520500	Klamath River near Seiad Valley, CA	6,940	41°51'14"	123°13'52"	1,320	1913–1925 1952–2016
11523000	Klamath River at Orleans, CA	8,475	41°18'13"	123°32'00"	356	1927–2016
11530500	Klamath River near Klamath, CA	12,100	41°30'40"	123°58'42"	5.6	1911–1927 1932–1994, 1996, 1998–2016

Source: USBR 2012.

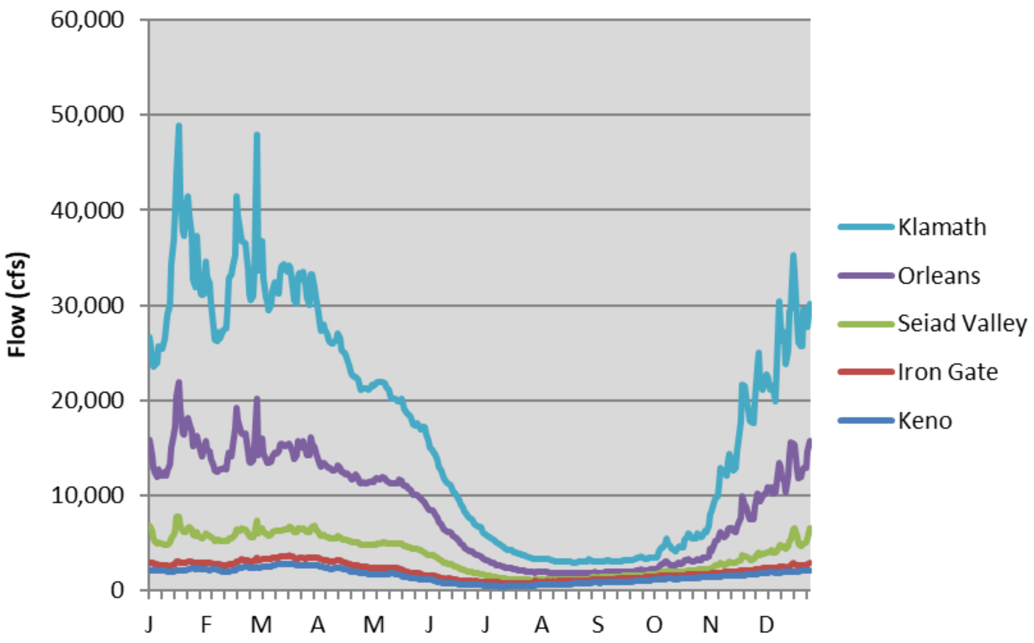

Figure 3.6-6. Daily Average Flows at Five USGS Stream Gages on the Klamath River. Source: USGS 2011.

Table 3.6-2. Historical Monthly Average Flows (cfs) in Wetter Years (10 Percent Exceedance Level) during Water Years 1961–2009 on the Klamath River.

	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**
Keno Dam	2,053	2,625	3,304	3,645	4,703	5,691	4,543	3,046	1,525	755	788	1,225
J.C. Boyle Dam	2,271	2,824	3,449	3,720	4,727	5,741	4,766	3,346	1,823	1,010	1,035	1,441
Iron Gate Dam	2,447	3,047	3,994	4,544	5,567	6,429	5,487	3,918	2,003	1,059	1,094	1,582
Seiad Valley	3,070	4,606	9,372	11,866	11,129	11,658	9,516	8,077	5,262	1,985	1,461	1,903
Orleans	4,031	11,635	28,185	33,198	23,710	25,697	2,0345	18,408	11,277	4,060	2,343	2,418

Source: USGS 2011

Table 3.6-3. Annual and Seasonal Daily Flows.

Percent of Time Equaled or Exceeded	Discharge (cfs)							
	Annual				Seasonal (July 1–Nov 31)			
	Keno	Boyle	Copco	Iron Gate	Keno	Boyle	Copco	Iron Gate
99	152	331	290	528	147	325	294	441
95	297	522	529	716	292	473	524	701
90	431	635	643	741	417	592	604	725
80	645	802	882	955	621	725	823	846
70	821	962	1,088	1,040	737	856	973	1,000
60	990	1,130	1,269	1,320	901	960	1,150	1,030
50	1,180	1,260	1,483	1,360	1,020	1,060	1,273	1,130
40	1,440	1,480	1,730	1,700	1,180	1,180	1,470	1,320
30	1,800	1,810	2,104	1,977	1,390	1,280	1,670	1,350
20	2,390	2,660	2,640	2,980	1,580	1,490	1,905	1,510
10	3,120	3,200	3,350	3,870	1,960	1,890	2,300	1,840
5	4,320	4,530	4,486	5,500	2,450	2,710	2,720	2,920
1	6,875	7,660	7,295	9,167	3,300	3,970	3,536	4,350

Source: USBR 2012

Upper Klamath Basin

Upper Klamath Lake and Link River Dam

Link River Dam was constructed in 1921 at the natural outlet of Upper Klamath Lake by California Oregon Power Company (now PacifiCorp). The dam, deeded to the United States, is operated and maintained by PacifiCorp under the direction of USBR. Upper Klamath Lake has active total storage capacity of approximately 629,780 acre-feet including areas restored by levee and dike breaches at Tulana Farms and Goose Bay and pumped storage at Agency Lake and Barnes Ranches (Table 3.6-4) (FERC 2007). Currently, USBR manages Upper Klamath Lake for irrigation delivery and in accordance with USFWS and NOAA Fisheries Service biological opinions regarding lake levels and downstream flows, based on current and expected hydrologic conditions (USBR 2010).

Table 3.6-4. Klamath River Reservoir Information.

Reservoir	Surface Area (acres)	Average Yearly Inflow [a] (cfs)	Average Depth [a] (feet amsl)	Maximum Depth [a] (feet amsl)	Active Storage (acre-feet)	Total Storage (acre-feet)	Retention Time (days)
Upper Klamath Lake	67,000[a]	1,450	9	60	486,830[a, b]	629,780[a, b]	219[a]
Keno	2,475[a]	1,575	7.5	20	495[a, b]	18,500[a, b]	5.9[a]
J.C. Boyle	350[c]	1,575	8.3	40	1,724[a, b]	2,267[c]	1.1[a]
Copco No. 1	972[c]	1,585	47	108	6,235[a, d]	33,724 [c]	10.7[a]
Copco No. 2	N/A[c]	1,585	[e]	[e]	0[a, b]	70[c]	0[a]
Iron Gate	942[c]	1,733	62	167	3,790[a, d]	50,941 [c]	14.8[a]

Notes:

[a] Source: FERC (2007).

[b] Storage volumes are from Table A2.1-1 of PacifiCorp's Exhibit A, as cited in FERC (2007).

[c] Source: AECOM et al. (2017). Data have been adjusted from those reported in FERC 2007 and USBR 2012a based on available data (e.g., as-built drawings, aerial photographs, topographic information).

[d] Storage for Copco No. 1 Reservoir between the normal maximum water level and the invert of the penstock intakes is approximately 20,000 acre-feet. Storage for Iron Gate Reservoir between the normal maximum water level and invert of the penstock intake is approximately 24,000 acre-feet, as reported in FERC (2007).

[e] Very small reservoir, no information on depth provided.

Outlets from Upper Klamath Lake include the Reclamation A Canal, PacifiCorp's East Side and West Side development canals and the Link River Dam. Water that passes through the East Side and West Side development canals re-enters the Link River downstream from the dam where it eventually enters Keno Reservoir/Lake Ewauna (FERC 2007).

USBR's Klamath Irrigation Project (KIP)

Operation of USBR's Klamath Irrigation Project affects Klamath River flows and Upper Klamath Lake water surface elevations. Link River Dam is the primary structure controlling the level of Upper Klamath Lake and releases of water to the Klamath River. Upper Klamath Lake water level fluctuation is approximately four to five feet annually, reaching a maximum (about 4,143 feet amsl, USBR datum) near the beginning of the irrigation season in April, and often dropping below 4,139 feet amsl, USBR datum, at the end of the irrigation season in October. The range of water levels in Upper Klamath Lake depends on many factors, including hydrologic conditions, flood risk management, agricultural demands for irrigation deliveries, and ESA requirements to protect listed fish.

Section 3.8 *Water Supply/Water Rights*, describes the scope of USBR's Klamath Irrigation Project in more detail, including the water supply diversions and amount of water diverted. As a federal agency, USBR is required to comply with the ESA. To meet ESA requirements, USBR operates the Klamath Irrigation Project in compliance with the most recent biological opinion. To comply with ESA, USBR operates the Klamath Irrigation Project to maintain: (1) water surface elevations in UKL for ESA-listed sucker fish; (2) minimum flows in the Klamath River below Iron Gate Dam for threatened Coho salmon. Though Iron Gate Dam is owned and operated by PacifiCorp, PacifiCorp makes releases from Iron Gate Dam for USBR's flow requirements as a result of PacifiCorp's requirements under a habitat conservation plan for coho salmon. Refer to Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* and the *Iron Gate Reservoir* subsection below for additional information on biological opinion flow requirements.

Keno Reservoir/Lake Ewauna and Keno Reach

Lake Ewauna existed before the construction of Keno Dam due to a natural bedrock control point or "reef" as described by others (e.g., Akins 1970). In 1931, Needle Dam was built on the Klamath River near Keno, Oregon and, in 1967, Keno Dam was built to replace Needle Dam. With construction of Keno Dam, the waterbody of Keno Reservoir/Lake Ewauna became a long and narrow lake that begins where the Link River ends, 1.3 miles downstream from the Link River Dam, and ends at Keno Dam. The Keno Dam is owned and operated by PacifiCorp as part of the Klamath Hydroelectric Project. The operations are coordinated with the operations of Link River Dam. Before Keno Dam, the river meandered through swamps for approximately 20 miles. It took two to four days for water released at Link River Dam to reach Copco No. 1 Dam. With the construction of Keno Dam, and dikes along the shores of Keno Reservoir/Lake Ewauna, this travel time has been reduced to 12 hours. The currently normal water surface elevation is 4,085 feet amsl in Keno Reservoir/Lake Ewauna (USGS 2009).

On an annual basis, the majority of the water entering Keno Reservoir/Lake Ewauna comes from Upper Klamath Lake through the Link River. Several notable federal and private facilities upstream of Keno Dam transport water to or from the river including: Lost River Diversion Channel, Klamath Straits Drain, and Ady Canal. The surface elevation of Keno Reservoir/Lake Ewauna is maintained to facilitate the operations of these facilities (FERC 2007).

Historical daily mean discharge for the Klamath River at Keno Dam for the period of record from water years 1961–2015 are shown in Figure 3.6-7.

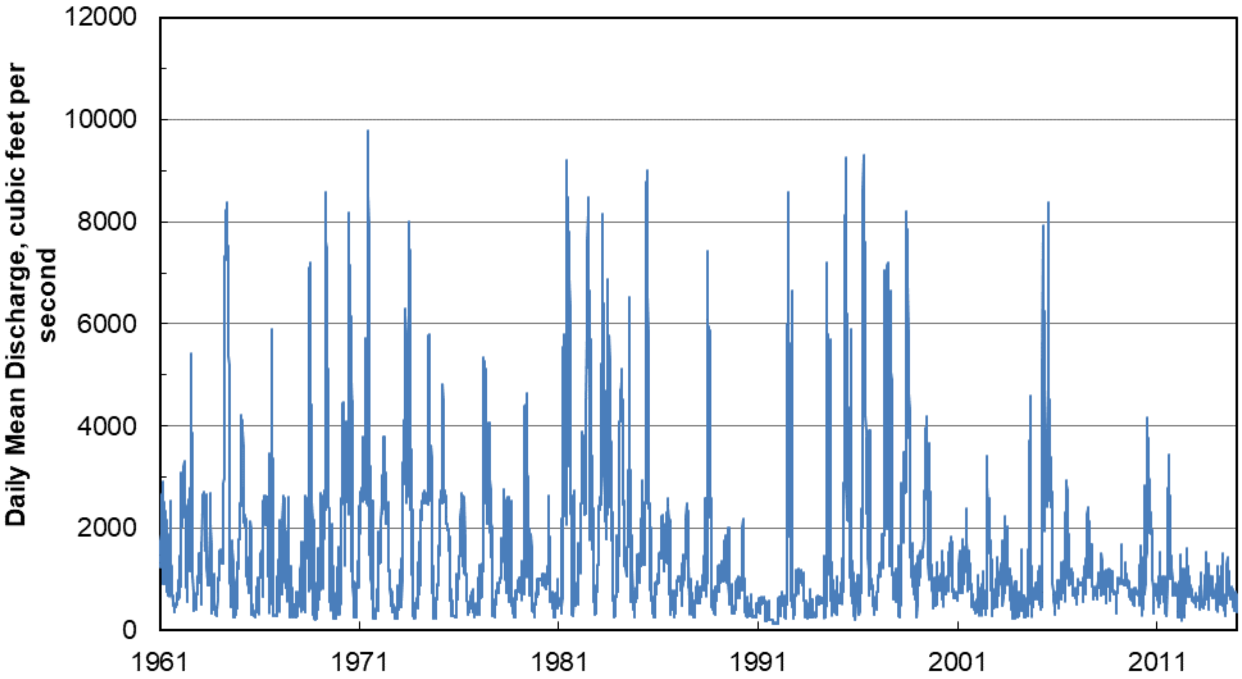

Figure 3.6-7. Discharge for the Klamath River at Keno Dam, 1961–2015. Source: USGS 2016.

J.C. Boyle Reservoir

J.C. Boyle Reservoir is approximately five miles downstream from Keno Dam. PacifiCorp operates J.C. Boyle Reservoir to produce hydroelectric power. Current operations of the reservoir follow Interim Measures from the Interim Conservation Plan effective as of February 2010. Water is spilled from the dam during high flow months of January through May and when inflow exceeds the capacity of the J.C. Boyle powerhouse and low flow requirements (see Table 3.6-5) (FERC 2007).

Table 3.6-5. Average Spillage at J.C. Boyle, Copco No. 1, and Iron Gate Dams from January 2, 1990 through December 5, 2004.

	J.C. Boyle			**Copco No. 1**			**Iron Gate**		
	Average # of days	**Average[a] (cfs)**	**Average Monthly Spill [b] (acre-feet)**	**Average # of days**	**Average[a] (cfs)**	**Average Monthly Spill [b] (acre-feet)**	**Average # of days**	**Average[a] (cfs)**	**Average Monthly Spill [b] (acre-feet)**
October	1.8	553	2,271	0.0	-	-	1.9	132	552
November	0.0	-	-	0.4	756	772	2.4	523	2,911
December	0.2	1,215	552	1.8	1,783	7,488	5.1	1,395	18,046
January	4.3	2,803	28,235	5.2	3,682	44,378	11.0	1,379	35,539
February	7.1	2,368	37,812	8.4	2,672	50,957	12.1	2,934	79,987
March	7.8	1,738	41,677	7.4	2,774	46,219	17.3	2,297	89,676
April	5.8	1,728	22,750	5.9	2,026	27,205	15.7	1,595	56,608
May	4.7	2,207	21,483	5.3	2,031	24,122	15.0	1,643	66,979
June	1.8	801	3,148	1.1	1,136	2,732	6.1	790	10,930
July	0.1	266	61	0.0	-	-	2.1	56	246
August	0.0	-	-	0.3	96	61	0.2	656	307
September	0.9	456	950	0.0	-	-	0.0	-	-
Yearly	35	2,032	161,272	36	2,506	206,834	89	1,726	352,196

Notes:

Most of water year 1993 is missing for this data set.

[a] Average flow during spill events.

[b] Includes non-spill events

Source: FERC 2007

J.C. Boyle Bypass Reach

The J.C. Boyle Bypass Reach is a moderately steep (approximately 1.7 percent grade), 4.6-mile reach of the Klamath River between the J.C. Boyle Dam and Powerhouse. One-half mile downstream from the dam, flows are increased by groundwater entering the bypass reach. There is currently a 100 cfs minimum required release from J.C. Boyle Reservoir into the J.C. Boyle Bypass Reach (NOAA 2010). The average accretion due to groundwater inflow/spring inflow is an additional 220 to 250 cfs and varies seasonally and from year to year (FERC 2007).

J.C. Boyle Peaking Reach

The J.C. Boyle Peaking Reach is downstream from the J.C. Boyle Powerhouse, so flows vary based on releases from the powerhouse. Typically, the reach has high flows during the day as a result of powerhouse flows used to provide peak energy demand. The powerhouse flows may be reduced to zero at night when J.C. Boyle Reservoir is refilled. The powerhouse ramps up flow for either a one-unit operation (up to 1,500 cfs) or a two-unit operation (up to 3,000 cfs). Normal daily average flows in the peaking reach during periods with no power generation range from 320 to 350 cfs, which includes 80 cfs from the fish ladder and 20 cfs from the juvenile fish bypass system. Additional water enters the reach from springs. Figure 3.6-8 shows historical flows for the Klamath River below J.C. Boyle Powerhouse (USGS Gage No. 11510700) for the period of record from January 1, 1959, through the end of water year 2015. This gage is located at RM 224.5, about 0.7 mile downstream from the powerhouse.

Commercial whitewater rafting and boating occurs during the same months as peak power demands, May through October (see also Section 3.20 *Recreation*). Under PacifiCorp's current annual FERC license, upramping and downramping flows occur at a rate of 9 inches per hour (FERC 2007).

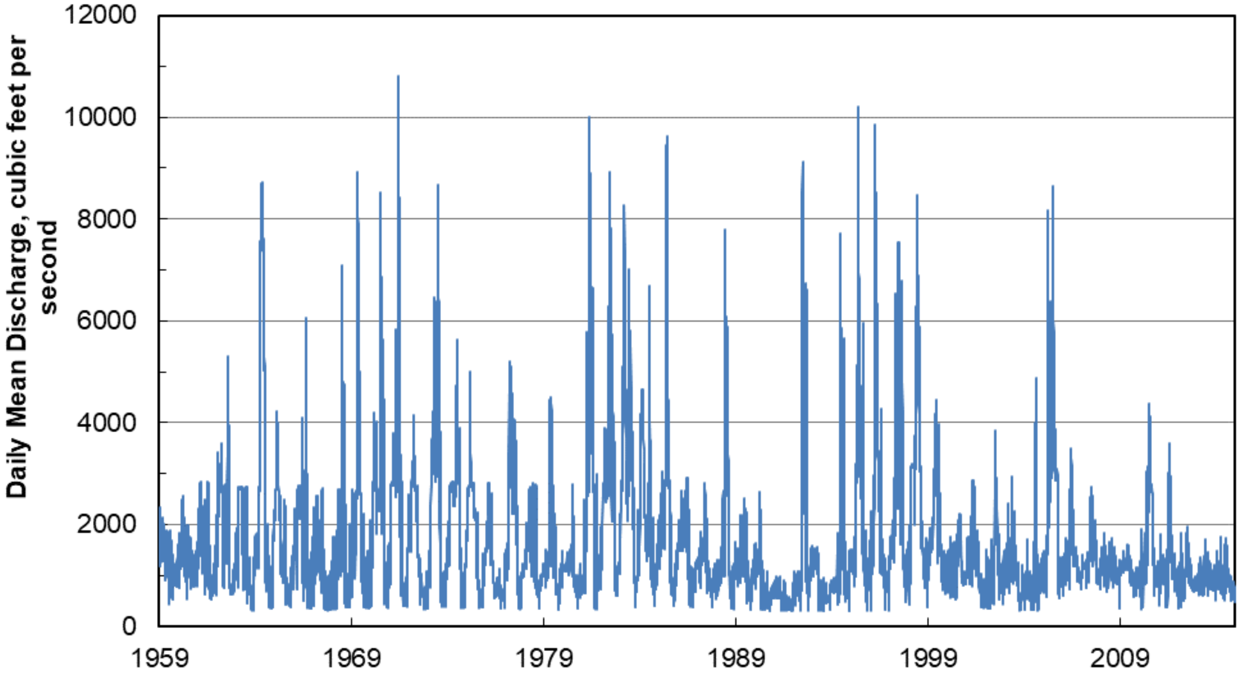

Figure 3.6-8. Discharge for Klamath River Downstream from J.C. Boyle Powerhouse, 1959–2015. Source: USGS 2016.

Copco No. 1 Reservoir
PacifiCorp operates Copco No. 1 Reservoir for hydroelectric power generation through Copco No. 1 Dam. With the most active storage volume of all the Lower Klamath Project reservoirs (6,235 acre-feet for power production), Copco No. 1 Reservoir has a total storage capacity of 46,867 acre-feet (USBR 2012). This reservoir is deeper than both Keno Reservoir/Lake Ewauna and J.C. Boyle Reservoir (FERC 2007).

Copco No. 2 Reservoir and Bypass Reach
Copco No. 2 Reservoir, a small impoundment, receives discharges from Copco No. 1 Reservoir through Copco No. 1 Dam and provides flow to Copco No. 2 Powerhouse through a 1.5-mile conveyance of tunnels and penstocks. The maximum hydraulic capacity is 3,650 cfs, which is the capacity of flow from Copco No. 1 Powerhouse to Copco No. 2 Reservoir. Copco No. 2 Dam controls the flow from the reservoir, and only spills when inflow to the reservoir exceeds storage capacity. Spillage from the dam is rare and typically only happens from November through April. PacifiCorp releases between five to 10 cfs at the bypass reach below Copco No. 2 Dam under normal conditions. Copco No. 2 Powerhouse discharges water to Iron Gate Reservoir (FERC 2007).

Spring, Fall, and Jenny Creeks
Two perennial tributaries, Jenny and Fall creeks, enter Iron Gate Reservoir. Spring Creek is a tributary to Jenny Creek, which flows for 1.2 miles from its source at Shoat Springs before it enters Jenny Creek at RM 5.5. Flow in Jenny Creek is altered by upstream reservoirs that store water during the high runoff season for irrigation as part of the Rogue River Irrigation Project. Approximately 24,200 acre-feet, which is approximately 30 percent of the annual mean runoff of the Jenny Creek watershed, is diverted north into the Rogue River Basin. PacifiCorp estimates that normally between 30 and 500 cfs enters Iron Gate Reservoir from Jenny Creek.

PacifiCorp operates a small diversion dam on Spring Creek that diverts up to 16.5 cfs into Fall Creek, and another dam on Fall Creek that diverts flow into a canal and penstock system leading to the Fall Creek Powerhouse. PacifiCorp states that the Spring Creek diversion was unusable for most of the 1990's, and until 2003, due to a water rights lawsuit with a local landowner, but that the lawsuit was decided in favor of PacifiCorp in 2003. The Spring Creek diversion is located a half mile upstream of its confluence with Jenny Creek, and diverted flow is carried through a 1.3-mile-long canal where it enters Fall Creek, about 1.7 miles upstream of the Fall Creek diversion. PacifiCorp estimates the minimum observed flow in Spring Creek is five cfs. The diversion dam on Fall Creek diverts up to 50 cfs of flow that bypasses 1.5 miles of a steep gradient section (approximately 9 percent) of Fall Creek, leading to the Fall Creek Powerhouse. PacifiCorp's current license requires minimum flows of 0.5 cfs below the Fall Creek diversion and 15 cfs (or natural stream flow, whichever is less) downstream of the powerhouse.

USGS operated Gage No. 11512000 on Fall Creek a short distance downstream of the Fall Creek powerhouse, the fish hatchery, and the City of Yreka intakes during most of the period between 1933 and 1959. From October 1, 2003, until September 30, 2005, Gage No. 11512000 was reactivated, and, during this time, the gage recorded a mean flow of 40 cfs and a minimum flow of 21 cfs. According to data from this gage, flow within Fall Creek does not vary much seasonally due to a reliable baseflow from groundwater springs and typically ranges from 30 to 50 cfs.

The City of Yreka, California, operates a water supply intake downstream of the Fall Creek Powerhouse and withdraws up to 15 cfs (see also Section 2.7.6.2 *Fall Creek Hatchery* of this EIR). Intakes to the currently non-operating Fall Creek rearing facility are downstream from the Yreka water supply intake.

Iron Gate Reservoir

Iron Gate Reservoir is downstream from the Copco No. 2 Dam and also receives water from Jenny and Fall creeks. PacifiCorp operates the Iron Gate Dam complex as a re-regulating facility for peaking operations at the other three hydroelectric power dams. Iron Gate Reservoir is the deepest of the four reservoirs in the Hydroelectric Reach. The total storage at this reservoir is approximately 58,794 acre-feet of which 3,790 acre-feet is available for power production (USBR 2012). Iron Gate Powerhouse, at the base of the dam, has a maximum hydraulic capacity of 1,735 cfs. Cool water is diverted from the reservoir to the Iron Gate Fish Hatchery, downstream from the dam (FERC 2007). USGS Gage No. 11516530 on the Klamath River, downstream from Iron Gate Dam, provides flow monitoring data regarding compliance with biological opinions. Bogus Creek and effluent from the hatchery enter the river upstream of the gage and downstream from the dam (USGS 2009b). Figure 3.6-9 shows Klamath River flows downstream from Iron Gate Dam for water years 1963 to 2015. Data for the same period are summarized in Table 3.6-6. The Lower Klamath Project's effect on peak flow events is discussed in sections 3.6.2.3 *Flood Hydrology* and 3.6.5 *[Flood Hydrology] Potential Impacts and Mitigation*. Recent flows for water years 2009 through 2015 are highlighted in Figure 3.6-10. The earlier highlighted years represent flows under the 2008 and 2010 BiOps. The graph also shows actual flows released in accordance with the current 2013 BiOp, as well as the recent drought years.

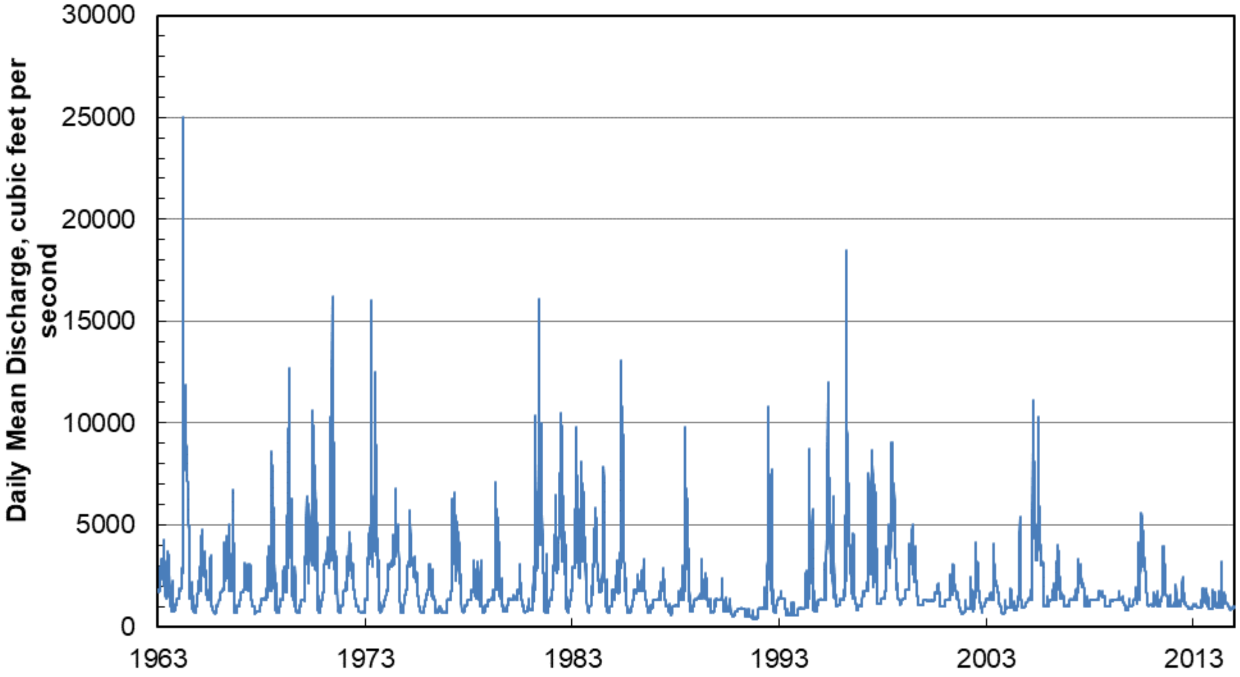

Figure 3.6-9. Discharges for Klamath River Downstream from Iron Gate Dam, 1963–2015. Source: USGS 2016.

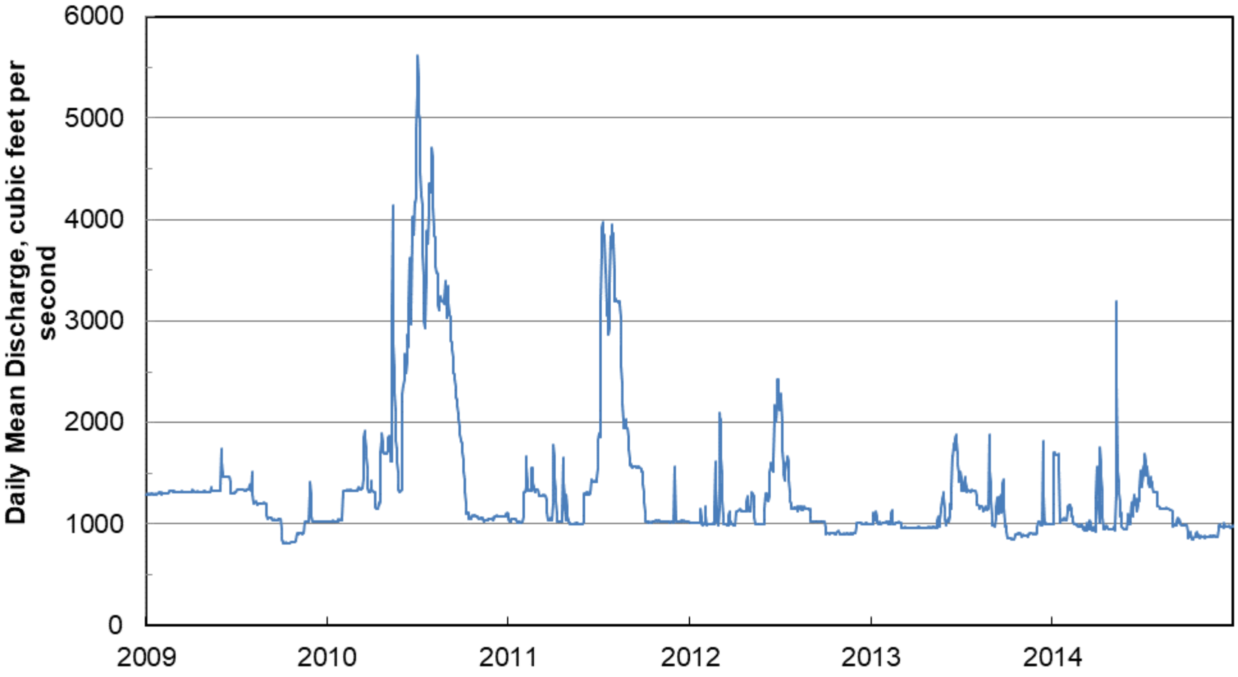

Figure 3.6-10. Discharges for Klamath River Downstream from Iron Gate Dam, 2009–2015. Source: USGS 2016.

Table 3.6-6. Monthly Discharge Statistics for Klamath River gages.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Yearly
Klamath River at Keno, OR, USGS Gage No. 11509500 (water years 1963 to 2015). Drainage area 3,920 sq. miles, excluding Lost River.													
Mean	1,150	1,465	1,793	2,022	2,104	2,539	2,187	1,551	829	494	649	876	1,468
Median	1,010	1,040	1,310	1,380	1,490	1,940	1,580	1,060	557	444	685	840	954
Max	4,210	5,210	8,160	9,310	9,250	9,780	8,380	6,640	6,640	2,750	1,350	2,240	9,780
Min	253	292	215	248	184	200	203	201	147	131	144	145	131
10 Percent Exceed	1,960	2,640	3,316	4,030	4,484	6,010	4,690	3,322	1,659	782	865	1,310	2,920
90 Percent Exceed	590	620	599	587	449	514	604	448	280	253	332	473	389
Klamath River below J.C. Boyle Powerhouse, USGS Gage No. 11510700 (water years 1963 to 2004). Drainage area 4,080 sq. miles, excluding Lost River													
Mean	1,383	1,678	2,010	2,243	2,327	2,776	2,446	1,836	1,089	738	889	1,113	1,708
Median	1,260	1,290	1,530	1,620	1,760	2,200	1,920	1,370	813	700	938	1,090	1,210
Max	4,170	5,100	8,260	9,860	10,200	10,800	8,660	6,790	6,740	3,070	1,650	2,600	10,800
Min	320	346	342	318	316	313	306	317	321	309	302	309	302
10 Percent Exceed	2,186	2,810	3,526	3,964	4,502	6,080	4,860	3,590	1,920	1,050	1,140	1,560	3,180
90 Percent Exceed	812	840	814	801	666	754.4	857	694	520	407	556	704	633
Fall Creek near Copco, CA, USGS Gage No. 11512000 (water years 1933 to 1959). Drainage area 15 sq. miles													
Mean	35	37	43	46	51	49	45	38	35	34	33	34	40
Median	34	36	37	40	45	46	44	36	33	33	32	33	36
Max	77	137	474	249	200	130	187	65	58	52	47	52	474
Min	27	26	28	28	27	29	28	25	24	24	24	24	24
10 Percent Exceed	44	45	57	65	75	69	61	49	44	42	43	44	55
90 Percent Exceed	28	30	30	30	31	32	31	29	28	28	27	28	29
Klamath River below Iron Gate Dam, CA, USGS Gage No. 11516530 (water years 1963 to 2015). Drainage area 4,630 sq. miles, excluding Lost River													
Mean	1,512	1,861	2,354	2,684	2,791	3,295	2,894	2,153	1,244	837	973	1,221	1,981
Median	1,340	1,370	1,750	1,820	1,950	2,580	2,220	1,670	960	743	1,020	1,310	1,340
Max	4,550	5,830	25,000	18,500	16,100	16,200	12,500	6,950	7,710	3,570	1,650	2,500	25,000
Min	846	848	865	598	508	495	508	484	402	406	389	408	389
10 Percent Exceed	1,900	3,120	4,236	5,052	5,452	7,050	5,689	4,210	2,090	1,060	1,070	1,589	3,780
90 Percent Exceed	949	941	964	1,020	934	999	1,290	1,010	715	690	719	893	746

Note:
All data are shown in cubic feet per second.
Source: USGS 2016

Table 3.6-7 shows the ramping rate criteria for Iron Gate established in the 1961 FERC license amendment and the 2013 BiOp (NMFS and USFWS 2013).

Table 3.6-7. Ramping Rate Requirements for Iron Gate Dam.

Flow Range	Maximum Decrease	Source
General	250 cfs per hour or 3 inches per hour whichever is less	FERC 1961 license amendment
Greater than 3,000 cfs	Follows a 3-day moving average of net inflow into UKL and accretions between Link River Dam and Iron Gate Dam	NMFS & USFW 2013
Above 1,750 cfs and less than or equal to 3,000 cfs	not more than 125 cfs per 4-hour period and not exceeding 300 cfs per 24 hours	NMFS & USFW 2013
1,750 cfs or less	not more than 50 cfs per 2-hour period and not exceeding 150 cfs per 24-hour period	NMFS & USFW 2013

Source: NMFS and USFWS 2013

Flows downstream from Iron Gate Dam are the result of the Link River Dam releases from Upper Klamath Lake, Link River Dam to Iron Gate Dam flow accretions, and management of the Klamath Hydroelectric Project by PacifiCorp. Since approximately 1997, Iron Gate Dam minimum flow releases have been stipulated by various BiOps, which was discussed in detail in the 2007 FEIS as well as the 2008 and 2010 BiOps (FERC 2007).

In 2008, the USFWS issued a BiOp to USBR on the operation and maintenance of USBR's Klamath Irrigation Project. This BiOp outlined measures to improve the habitat for the Lost River sucker and shortnose sucker, affected by USBR's Klamath Irrigation Project operations. Among other measures to protect the suckers, the BiOp required that specific surface elevations of Upper Klamath Lake be maintained.

In 2010, NMFS also issued a BiOp to USBR, requiring releases from USBR's Klamath Irrigation Project to release specified rates of flow for the Klamath River downstream from Iron Gate Dam, based on the habitat needs of coho salmon. Target flow rates in the Klamath River downstream from Iron Gate Dam varied by month and were dependent in part on the amount of water entering Upper Klamath Lake.

Currently, flow releases at Iron Gate Dam are dictated by the 2013 BiOp and court-ordered flushing flows, which were designed to protect federally listed coho salmon, Lost River sucker, and shortnose sucker (NMFS and USFWS 2013, U.S. District Court 2017c). The court-ordered flushing flows became effective in February 2017, after the Notice of Preparation (NOP) was filed by the State Water Board in December 2016, and are therefore not part of the Existing Conditions for the Proposed Project. This section notes, and as appropriate discusses, the potential differences to the Existing Conditions and the impact analysis based on the newer flow requirements. The current flow regime does not result in any changes to the findings of significance and does not result in any changes regarding mitigation measures.

USBR uses the monthly 50 percent exceedance inflow forecasts from the Natural Resources Conservation Service (NRCS) as the basis for Klamath Irrigation Project operations to manage Upper Klamath Lake and the Klamath River during the spring-summer irrigation season (March 1 through September 30). To estimate the water supply available from Upper Klamath Lake and the Klamath River, USBR relies on actual inflows to Upper Klamath Lake and NRCS inflow forecasts for Upper Klamath Lake to determine three key operational values: (1) the volume of water to be reserved in Upper Klamath Lake to maintain lake elevations analyzed in the BiOp; (2) the volume of water designated for the Klamath River, referred to as the environmental water account (EWA); and (3) the volume of water available for delivery for irrigation purposes to the Klamath Irrigation Project (USBR 2016).

USBR makes a preliminary calculation of these three operational values on March 1; however, those estimates are subject to change, based on actual Upper Klamath Lake inflows after March 1 and subsequent NRCS inflow forecasts. USBR recalculates these values on April 1, based on actual Upper Klamath Lake inflows observed in March and NRCS Upper Klamath Lake inflow forecast for April 1 to September 30. This April 1 calculation establishes the initial volume of water available for irrigation from the Upper Klamath Lake and the Klamath River during the spring-summer irrigation season.

The 2013 BiOp established average daily minimum target flows below Iron Gate Dam. Maximum target flows are established for July, August, and September, and are based on the EWA volumes. These target flows are summarized in Table 3.6-8.

In addition, increases to the target flows in Table 3.6-8 can occur in late August or early September to support the Yurok Tribal Boat Dance Ceremony. To ensure adequate flow for the Yurok Tribal Boat Dance Ceremony, which occurs during even calendar years, flow releases at Iron Gate Dam can be increased. The volume of water required for the ceremony is estimated to be between 2,000 and 4,000 acre-feet depending on real-time hydrologic conditions (NMFW and USFWS 2013). Deviations to the flow targets in Table 3.6-8 can also occur based on other circumstances, such as large fish disease events or flood hazard risks.

Table 3.6-8. Iron Gate Dam Target Flow Release Criteria According to the 2013 Biological Opinion.

Month	NMFS & USFWS 2013 Biological Opinions Iron Gate Target Flows (cfs)[2]	
	Average Daily Minimum	Average Daily Maximum[3]
April	1,325	--
May	1,175	--
June	1,025	--
July	900	1,000 cfs @ EWA = 320,000 acre-feet 1,500 cfs @ EWA ≥ 1,500,000 acre-feet
August	900	1,050 cfs @ EWA = 320,000 acre-feet 1,250 cfs @ EWA ≥ 1,500,000 acre-feet
September	1,000	1,100 cfs @ EWA = 320,000 acre-feet 1,350 cfs @ EWA ≥ 1,500,000 acre-feet
October	1,000	--
November	1,000	--
December	950	--
January	950	--
February	950	--
March	1,000	--

Notes:

"--" none specified, but regulated per ramping rates shown in Table 3.6-7.

cfs = cubic feet per second; EWA = Environmental Water Account

[1] Source: FERC 2007

[2] Source: NMFS and USFWS 2013a

[3] In late August/early September during even calendar years, flow releases at Iron Gate Dam may be increased to support the Yurok Tribal Boat Dance Ceremony. The volume of water required is estimated to be 2,000–4,000 acre-feet depending on real-time hydrologic conditions.

Source: NMFS and USFWS 2013

Mid Klamath Basin

The Middle Klamath Basin includes the area downstream from Iron Gate Dam to the confluence of the Trinity River, which includes 150 miles of river. The major tributaries entering the Klamath River along these reaches include the Shasta, Scott, and Salmon rivers. The Klamath Basin is heavily influenced by these three rivers because they provide 44 percent of the average annual runoff (FERC 2007). Below are brief descriptions of these three rivers and other reaches along the Middle Klamath River.

Shasta River

The Shasta River enters the Klamath River at RM 179.5, 13.5 miles downstream from Iron Gate Dam. The Shasta River watershed includes the glaciated slopes of Mount Shasta but is largely rangeland with substantial amounts of irrigated pastureland and agricultural area. The average precipitation in the watershed varies greatly with exposure and elevation but is about 15 inches per year due to the rain shadow effects of the mountains to the west of the watershed.

The hydrograph for the Shasta River near the confluence with the Klamath River shows a peak in the winter and minimum median flows under 40 cfs during July and August (see Table 3.6-9). The current hydrology of the Shasta River is affected by surface-water diversions, alluvial pumping, and the Dwinnell Dam which creates Lake Shastina. Historically, springs and seeps dominated the hydrograph of the Shasta River resulting in a cool and stable river flow. Dwinnell Dam, about 25 miles upstream from the Klamath River at a location that controls 15 percent of the total drainage area of the Shasta River, was constructed in 1928 and has a normal storage capacity of 50,000 acre-feet.

The majority of the water in Lake Shastina is retained during the winter and early spring and then used for irrigation during the later spring and summer. A 2013 settlement between the Karuk Tribe and the Montague Water Conservation District mandates a flow release of 2,250 to 3,000 acre-feet per year from Lake Shastina to support endangered coho salmon. Farther downstream, there are seven major diversion dams and numerous smaller dams or weirs on the Shasta River and its tributaries. When these diversions are in operation during the irrigation season, they substantially and rapidly reduce flows in the mainstem causing complete dewatering of the main channel in some reaches of the river during the late summer of dry years.

Scott River

The Scott River enters the Klamath River at RM 145.1, 47.1 miles downstream from Iron Gate Dam. The Scott River watershed includes the heavily forested and relatively wet Salmon Mountains on its western divide, but these mountains create a rain shadow for the rest of the watershed. Similar to the Shasta River Valley, many areas in the Scott River Valley have been extensively altered for grazing and agriculture. Although the Scott River watershed is almost the same size as the Shasta River watershed, the hydrograph for the Scott River near the confluence with the Klamath River has four to five times higher median monthly flows in the winter and spring months (see Table 3.6-6). Somewhat similar to the Shasta River, the minimum monthly median flows near 50 cfs occur during August and September.

Klamath River at Seiad Valley

A USGS flow gage is on the Klamath River at Seiad Valley, downstream from its confluence with the Scott River. During the low flow months of August through November, approximately 75 percent of the water flowing past this gage is attributed to Iron Gate Dam releases. During the months of April through June approximately 50 percent of the water flowing past this gage is attributable to Iron Gate Dam releases (FERC 2007). Figure 3.6-11 shows daily flow at the Klamath River at Seiad Valley from water years 1963 to 2015.

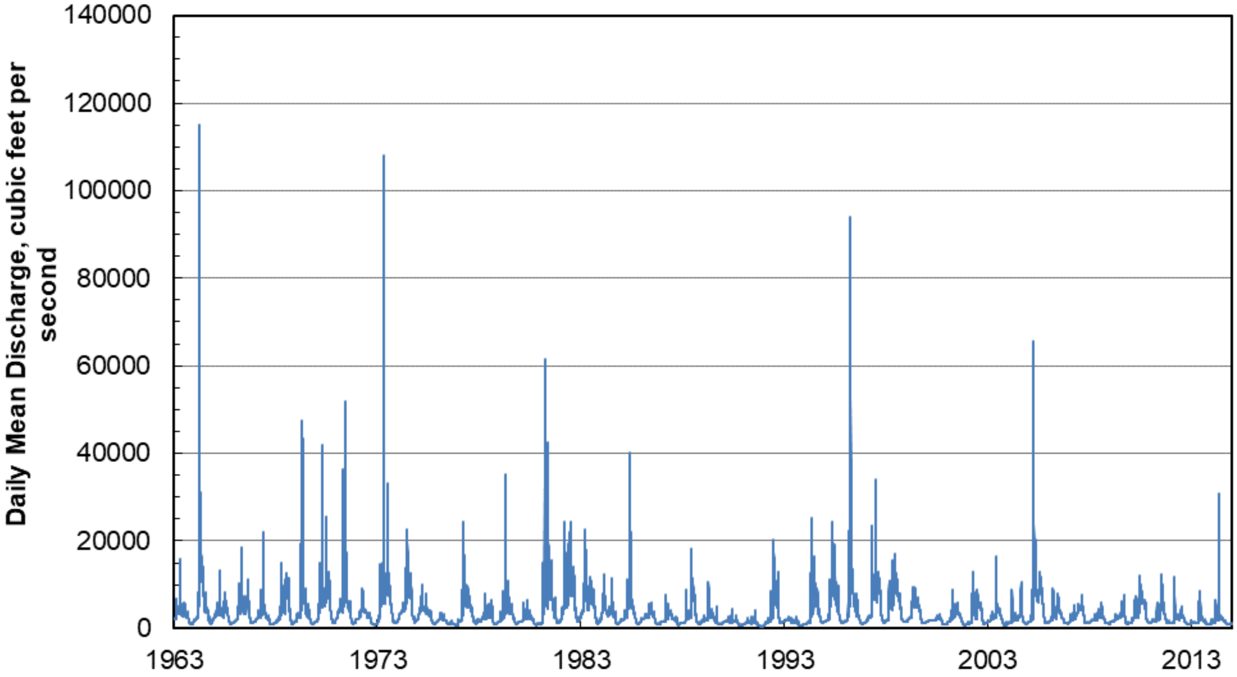

Figure 3.6-11. Discharge for Klamath River at Seiad Valley, 1963–2015. Source: USGS 2016.

Salmon River

Approximately 77 miles downstream from the Scott and Klamath rivers confluence, the Salmon River enters the Klamath River at RM 66.3. The Salmon River flows through the Klamath National Forest and many designated wilderness areas. The region surrounding the Salmon River is mainly forested with some agricultural activity. High monthly average flows (3,375 cfs) occur in January, which is the winter peak for flooding as rain and rain-on-snow events occur (see Table 3.6-6). In April and May, the Salmon River has a high monthly average flow (2,660 and 2,630 cfs, respectively) from snowmelt at higher elevations. The Salmon River has its lowest monthly average flow at about 200 cfs in September, which is later than for other tributaries upstream including the Shasta River where lowest monthly average flow occurs in July (FERC 2007).

Klamath River at Orleans

USGS Gage No. 11523000 is at Orleans, downstream from the confluence of the Salmon and Klamath rivers and other smaller tributaries within the Middle Klamath Basin. This area receives a high amount of precipitation compared to other reaches upstream of the Shasta River; therefore, higher flows than in upstream reaches occur here in the winter and spring months. Iron Gate Dam releases account for approximately 20 percent of the flow during these high flow periods and over 50 percent of the flow during the late summer and fall (FERC 2007). Figure 3.6-12 shows daily flow at USGS Gage No. 11523000 from water years 1963 to 2015, the same period of record summarized for this gage in Table 3.6-6.

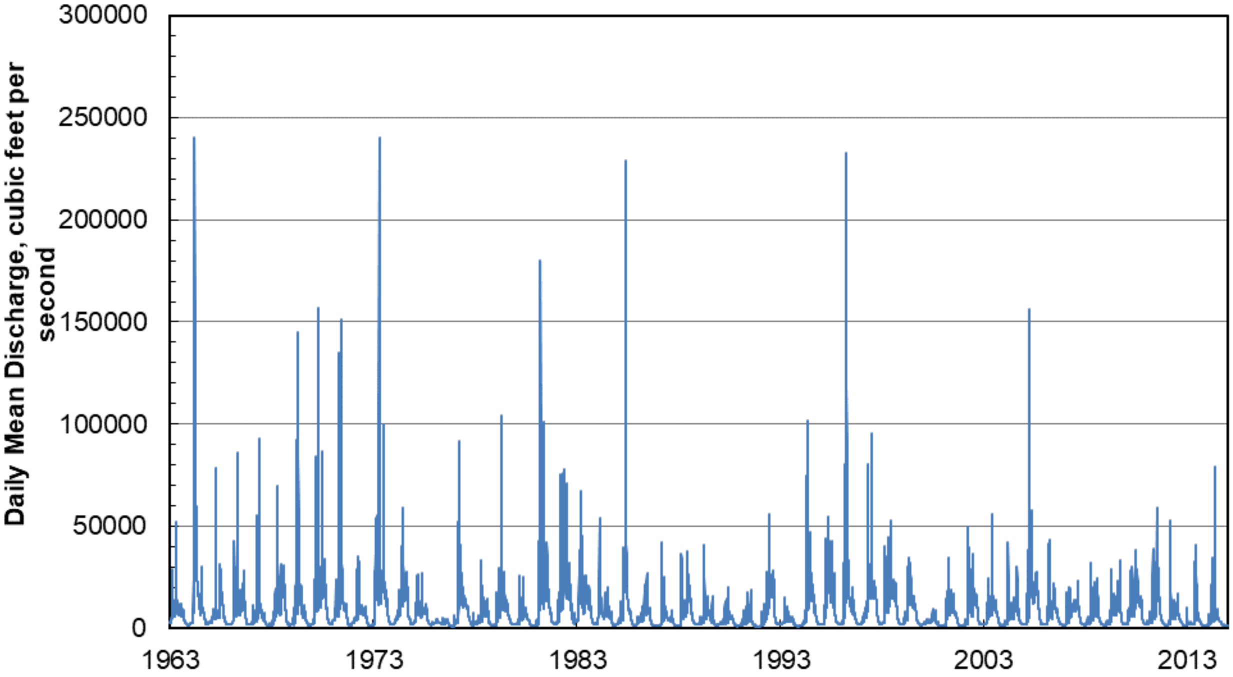

Figure 3.6-12. Discharge for Klamath River at Orleans, 1963–2015. Source: USGS 2016.

Table 3.6-9. Monthly Discharge Statistics for USGS Gages along the Lower Klamath River and for the Shasta, Scott, Salmon, and Trinity Rivers.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Yearly
Shasta River near Yreka, CA, USGS Gage No. 11517500 (water years 1963 through 2015) Gage data prorated by 1.0485 to the confluence with the Klamath. Shasta River drainage area 800 square miles.													
Mean	158	207	295	366	334	326	206	150	104	49	40	71	192
Median	153	191	212	237	252	248	159	115	79	35	31	63	161
Max	1,311	910	10,904	8,828	3,796	2,726	2,768	1,143	969	285	245	475	10,904
Min	34	125	138	146	148	48	18	13	6	2	2	5	2
10 Percent Exceedance	208	262	421	639	564	550	403	287	195	101	74	126	354
90 Percent Exceedance	107	151	163	170	178	158	56	47	26	15	15	24	28
Scott River at Fort Jones, CA, USGS Gage No. 11519500 (water years 1963 through 2015). Gage data prorated by 1.2557 to the confluence of the Klamath River. Scott River drainage area 820 square miles.													
Mean	110	377	1,018	1,319	1,307	1,332	1,210	1,365	832	205	58	52	763
Median	73	143	416	635	856	997	1,087	1,182	600	116	43	46	357
Max	8,514	8,062	49,600	38,801	16,952	16,324	8,212	6,065	5,776	1,771	701	556	49,600
Min	5	6	16	68	92	80	63	88	12	8	5	4	4
10 Percent Exceedance	147	867	2,373	2,788	2,662	2,386	2,135	2,562	1,920	526	116	92	1,871
90 Percent Exceedance	20	60	108	154	297	471	412	389	117	25	9	9	30
Klamath River at Seiad Valley, CA, USGS Gage No. 11520500 (water years 1963 to 2015). Drainage area 6,940 square miles, does not include Lost River.													
Mean	1,889	2,727	4,470	5,599	5,490	6,101	5,355	4,628	2,780	1,336	1,178	1,425	3,573
Median	1,670	2,070	2,970	3,580	3,940	4,730	4,655	3,950	2,230	1,160	1,210	1,460	2,250
Max	14,900	15,000	115,000	108,000	42,400	51,900	31,600	14,100	12,900	7,200	2,650	2,710	115,000
Min	963	1,080	1,180	1,210	1,070	1,020	1,070	954	603	552	398	464	398
10 Percent Exceedance	2,662	4,919	7,846	11,500	10,700	12,300	9,569	8,460	5,170	2,010	1,456	1,940	7,520
90 Percent Exceedance	1,220	1,350	1,668	1,824	1,860	2,124	2,141	1,734	1,190	880	816	986	1,120
Salmon River at Somes Bar, CA, USGS Gage No. 11522500 (water years 1963 to 2015). Drainage area of the gage and the Salmon River 751 square miles.													
Mean	346	1,112	2,523	3,222	2,902	3,075	2,874	2,941	1,785	613	269	208	1,818
Median	208	464	1,330	1,910	2,100	2,360	2,670	2,690	1,380	474	246	192	1,050
Max	12,300	22,000	10,0000	64,400	31,200	43,600	15,200	11,000	12,000	4,160	3,950	3,440	100,000
Min	83	119	179	182	182	281	399	546	224	107	72	60	60
10 Percent Exceedance	544	2,639	5,916	6,380	5,392	5,216	4,710	5,020	3,649	1,180	417	275	4,150
90 Percent Exceedance	126	205	331	543	910	1,160	1,231	1,040	502	225	138	119	185

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Yearly
Klamath River at Orleans, CA, USGS Gage No. 11523000 (water years 1963 to 2015). Drainage area 8,475 square miles does not include Lost River.													
Mean	2,721	5,801	11,669	14,832	14,059	14,491	12,491	10,791	6,175	2,591	1,832	1,940	8,257
Median	2,220	3,490	6,700	8,920	10,200	11,700	11,100	9,410	4,820	2,240	1,840	1,940	4,710
Max	33,400	83,900	240,000	240,000	229,000	151,000	72,900	34,000	33,400	12,200	10,400	10,400	240,000
Min	1,110	1,510	1,820	1,770	1,980	2,240	2,330	1,930	1380	824	652	652	652
10 Percent Exceedance	4,042	12,700	25,060	30,100	25,900	25,660	21,500	18,900	11,990	4,256	2,390	2,459	18,500
90 Percent Exceedance	1,570	2,160	2,660	3,408	4,476	5,294	5,012	3,760	2,301	1,434	1,240	1,280	1,710
Trinity River at Hoopa, CA, USGS Gage No. 11530000 (water years 1963 to 2015. Gage data prorated by 1.01647 to the confluence with the Klamath River. Trinity River drainage area 2,900 square miles. Post-Trinity River diversion.													
Mean	926	2,674	6,987	10,019	9,622	9,598	7,041	5,619	3,121	1,379	815	739	4,859
Median	719	1,118	3,415	5,794	6,577	6,973	5,428	4,472	2,287	1,108	743	684	2,287
Max	23,074	36,491	17,0767	11,9943	99,919	86,603	45,843	29,173	15,755	5,855	6,170	3,802	170,767
Min	311	498	511	555	630	1,047	986	1,027	422	275	248	292	248
10 Percent Exceedance	1,256	6,404	16,629	23,176	20,960	18,601	13,011	10,876	6,057	2,507	1,220	1,037	11,384
90 Percent Exceedance	514	693	905	1,407	2,476	2,972	2,491	2,155	1,170	686	502	460	639
Klamath River near Klamath, CA, USGS Gage No. 11530500 (water years 1963 to 2015). Drainage area 12,100 square miles, does not include Lost River.													
Mean	4,593	12,357	25,188	32,056	30,769	31,741	25,257	19,709	11,256	4,754	3,130	3,171	16,914
Median	3,600	6,280	14,600	20,000	22,650	24,600	20,800	16,800	8,880	4,000	2,980	3,000	9,440
Max	79,000	140,000	420,000	397,000	404,000	317,000	173,000	71,500	63,100	25,100	20,900	20,100	420,000
Min	1,910	2,320	3,070	2,840	3,300	5,030	4,410	4,680	2,100	1,440	1,340	1,310	1,310
10 Percent Exceedance	6,429	28,000	5,7200	6,8600	6,1800	5,9200	4,3390	3,5380	2,0500	7,900	4,268	4,150	38,000
90 Percent Exceedance	2,630	3,520	4,656	6,892	9,902	12,100	10,100	8,180	4,431	2,580	2,070	2,100	2,830

Notes:

For water years 1963 to 2015; data for December 31, 1994 to January 6, 1995 and October 30, 1995 to September 30, 1997 are missing.

Source: USGS 2016

Lower Klamath Basin

Trinity River

The Trinity River enters the Klamath River at RM 43.3, 150 miles downstream of Iron Gate Dam. The Trinity River is the largest tributary to the Klamath River. The Trinity River watershed is generally wet, steep, forested, and largely federally owned within several national forest and wilderness areas. As shown in Table 3.6-9, the Trinity River hydrograph at the confluence with the Klamath River has peak median monthly flows in February and March near 7,000 cfs, gradually declining to about 600 cfs in September.

A main feature of the Trinity River watershed is Trinity Lake. This reservoir has a storage capacity of 2.4 million acre-feet and is located 119 miles upstream from the Klamath River along the main branch of the Trinity River. Both Trinity Lake and the much smaller downstream Lewiston Reservoir were constructed in the early 1960's as part of the Central Valley Project's Trinity River Division (TRD). For the first 10 years of full operation, an average of nearly 90 percent or 1.2 million acre-feet of the annual river flow at the Lewiston Reservoir (drainage area of 692 square miles) was diverted via the Clear Creek Tunnel to Whiskeytown Lake and then to the Sacramento River system (FERC 2007). The California Department of Water Resources estimates that about 1.1 million acre-feet per year were diverted during 1964 to 1986 and 0.73 million acre-feet during 1987 to 2000.

The current flow release program from Lewiston Dam to the Trinity River is based on the Trinity River Mainstem Fishery Restoration EIS, completed in October 2000. In December 2000, USBR issued the Record of Decision (Trinity ROD) for the Trinity River Mainstem Fishery Restoration, but these flows did not go into full effect until November 2004.

Figure 3.6-13 shows the daily flow from the Trinity River at the confluence with the Klamath River for water years 1963 to 2015. Data for this same period that represents post-TRD operations are summarized in Table 3.6-9.

The Trinity ROD directed for approximately 50 percent of the Trinity River's flow to remain in the river (i.e., would not be diverted to the Central Valley) and for the Trinity River Restoration Program (2016) to recommend how water was to be released for restoration of the river and its fisheries.

Restoration flows are intended to: clean spawning gravels, build gravel/cobble bars; scour sand out of pools, provide adequate temperature and habitat conditions for fish and wildlife at different life stages, control riparian vegetation, and perform many other ecological functions. To mimic some of the inter-annual variation that is naturally found within the Trinity Basin, the Trinity ROD defines five water year types along with a minimum volume of water to be released into the Trinity River for each year type, as summarized in Table 3.6-10.

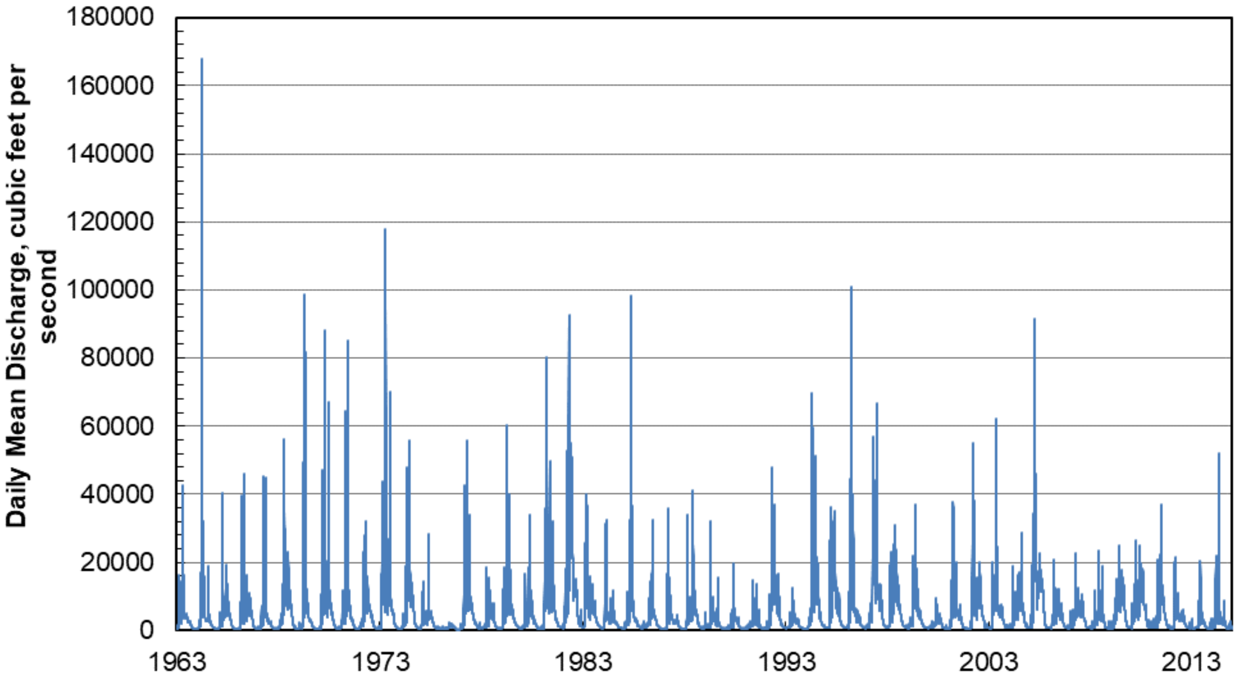

Figure 3.6-13. Daily Inflow from the Trinity River at the Confluence with the Klamath River, 1963–2015. Source: USGS 2016.

Table 3.6-10. Minimum Releases for Trinity River Restoration.

Water Year Type	Minimum Release Volume (acre-feet)
Critically Dry	369,000
Dry	453,000
Normal	647,000
Wet	701,000
Extremely Wet	815,000

Source: Trinity River Restoration Program 2016

Typical flow releases for each month of the five water year types are determined based on forecasted inflows to Trinity Reservoir on April 1. Each year, the water not allocated to the river for restoration purposes is available for export to the Central Valley Project for water supply and power generation.

During the recent drought from 2012 to 2016, USBR's drought plans included flow augmentation for the lower Klamath River from the Trinity Reservoir in addition to curtailing deliveries to Klamath Irrigation Project contracts. Abnormally dry hydrologic conditions led to very low Klamath River accretion forecasts, prompting concerns of a disease outbreak. Tribes, sport-fishermen groups, and other fishery advocates formally requested that USBR take action. Chinook in-river run size projections were at all-time highs in 2012, 2013, and 2014 (USBR 2015). Flow augmentation during these three drought years was as follows:

- **2012**: Ultimately 39,000 acre-feet was released for preventative purposes and no emergency releases were required. No substantial disease outbreak was noted by any tribes or fishery resource agencies during the return period. The fall Chinook return, post-season estimate was 292,000 adults.

- **2013**: Flows were augmented to a rate of 2,800 cfs in the lower Klamath River from August 15 through September 21. Ultimately 17,500 acre-feet was released for preventative purposes in 2013, and no emergency releases were required. No substantial disease outbreak occurred, although the Yurok Tribe reported that several fish had died from Columnaris. The post-season run size estimate was 165,100 adults.
- **2014**: Outbreaks of Ich drove the need for two emergency releases from Lewiston Dam. The volume of water initially released under the emergency criteria (from August 23 through September 16) totaled approximately 22,700 acre-feet, while the emergency flow doubling that (from September 17 through September 24), excluding ramping, totaled 41,300 acre-feet, for a grand total of 64,000 acre-feet. The fall Chinook return, post-season estimate was 160,000 adults.

USBR reported that the average volume released from Trinity Reservoir for augmentation in previous and recent dry periods (i.e., 2003, 2004, 2012, 2013, and 2014) was 38,963 acre-feet. USBR anticipates that a similar quantity will be sufficient in the majority of years when augmentation is required. However, as demonstrated by conditions experienced in 2014, the volume of release may exceed 40,000 acre-feet in any given year (USBR 2015).

Klamath River at Klamath

USGS Gage No. 11530500 is near the mouth of the Klamath River where it meets the estuary within the Lower Klamath watershed (see Table 3.6-9). During the September to October low flow periods, the releases from Iron Gate Dam account for approximately 40 percent of flow. However, the area surrounding the Klamath River reach downstream from its confluence with the Trinity River receives a heavy amount of precipitation, and during the winter months approximately 85 percent of the flow comes from other sources than Iron Gate Dam releases (FERC 2007).

Figure 3.6-14 shows daily flow from water years 1963 to 2015. Flows for July 2014 in the Lower Klamath River tied with 1994 for the second lowest on record (period of record from 1963 to 2015, with 1992 also similar). However, releases from Iron Gate Dam on the Klamath River were 300 cfs lower in July 1994, compared to 2014 (with Lewiston Dam releases on the Trinity River being equivalent), meaning that accretions were approximately 300 cfs lower in July 2014, compared to the exceptionally dry year of 1994. The extreme drought year of 1977 had the driest July and September on record, yet flows increased on September 20 of that year, to over 3,200 cfs from precipitation. In 1994, flows also increased in September (on September 1) to approximately 2,000 cfs (Strange 2014).

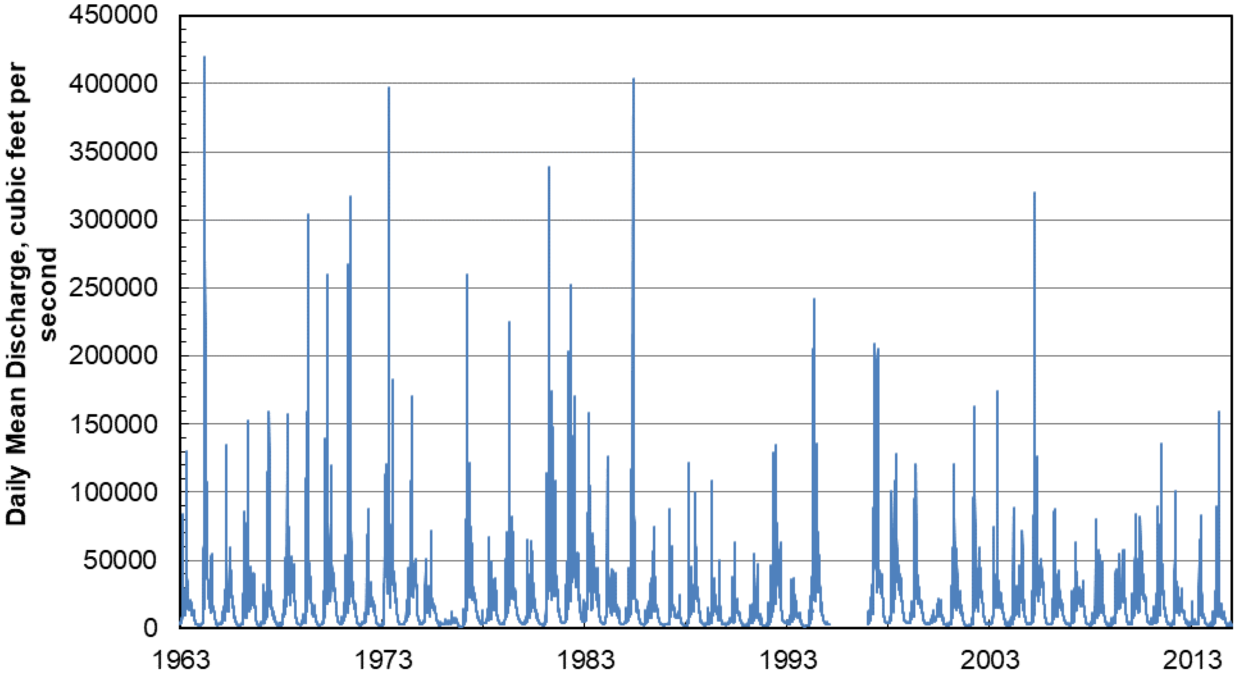

Figure 3.6-14. Discharge for Klamath River at Klamath, 1963–2015. Source: USGS 2016.

Klamath River Estuary

The Klamath River Estuary spans approximately four to five miles upstream of the mouth. The tidal influence normally extends approximately four miles upstream of the mouth during high tides greater than six feet upstream of the U.S. Highway 101 bridge. Past studies have observed the formation of a sill at the river mouth in late summer or early fall causing a standing water backup up to six miles upstream. During high tides saltwater was observed in the summer and early fall from the mouth upstream ranging approximately 2.5 to four miles depending on the time period samples were taken. The saltwater recedes during low tides (Wallace 1998).

3.6.2.3 Flood Hydrology

The active storage capacity at Upper Klamath Lake is approximately 579,200 acre-feet and includes areas restored by levee and dike breaches at Agency Lake, Barnes Ranch, Tulana Farms, and Goose Bay (USBR 2012). Active storage at Keno, J.C. Boyle, Copco No. 1, Copco No. 2 and Iron Gate reservoirs totals approximately 12,244 acre-feet (FERC 2007). Approximately 98 percent of the active surface water storage along the Klamath River is provided by Upper Klamath Lake behind Link River Dam. Keno, J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams provide approximately two percent of the active storage on the river.

Flood frequency analyses for 10-year to 100-year events were performed for seven USGS gages along the Klamath River. The analysis used a Log-Pearson III distribution and methods consistent with USGS Bulletin 17B (Table 3.6-11) (USGS 1982). The flows at Keno, J.C. Boyle, and Copco gages are highly regulated by impoundments and diversions upstream of the Keno gage. To better model those effects and improve the fit of the frequency curve to the data, a gage base discharge was applied to censor the data. This was done based on the assumption that the peak discharges above the gage base discharge represent what would be expected during unregulated conditions. The analyses do not include peaks below the gage base discharge to estimate the frequency curve statistics because they are regulated and cannot be modeled using the same distribution. Following the procedures of USBR (2012) the gage base discharges used for Keno, J.C. Boyle, and Copco were 4,000 cfs, 4,000 cfs, and 5,400 cfs, respectively. The Iron Gate, Seiad Valley, Orleans, and Klamath gages are not significantly impacted by the regulation upstream of Keno and therefore the data from these gages were not censored for the flood frequency analyses.

To create a common period of record, the gage records at J.C. Boyle and Copco were extended based on correlation to Keno. The gage data at Keno was correlated to the J.C. Boyle and Copco data for the overlapping years of record when the peak discharges at both gages were from the same flood event. The Iron Gate, Seiad Valley, Orleans, and Klamath gage records do not correlate well with the Keno record and thus they were not extended.

Table 3.6-11. Annual Flood Frequency Analysis on Klamath River for 10-Year to 100-Year Flood Events.

Gaging Station	**Drainage Area (miles^2)**	**Gage Base[1] (cfs)**	**Peak Flood Discharge (cfs)**			
			10-Year	**25-Year**	**50-Year**	**100-Year**
United State Geologic Service (USGS) Gage No. 11509500, Klamath River at Keno, OR	3,920	4,000	9,729	11,071	12,010	12,907
USGS Gage No. 11510700, Klamath River below J.C. Boyle Power Plant, OR	4,080	4,000	10,362	12,063	13,301	14,518
USGS Gage No. 11512500, Klamath River below Fall Creek near Copco, CA	4,370	5,400	11,910	13,543	14,702	15,821
USGS Gage No. 11516530, Klamath River below Iron Gate Dam, CA	4,630	N/A	14,854	20,867	25,985	31,648
USGS Gage No. 11520500, Klamath River near Seiad Valley, CA	6,940	N/A	53,300	85,784	118,058	158,619
USGS Gage No. 11523000, Klamath River at Orleans, CA	8,475	N/A	157,938	221,107	274,019	331,731

Gaging Station	**Drainage Area (miles^2)**	**Gage Base[1] (cfs)**	**Peak Flood Discharge (cfs)**			
			10-Year	**25-Year**	**50-Year**	**100-Year**
USGS Gage No. 11530500, Klamath River near Klamath, CA	12,100	N/A	302,484	401,814	481,078	564,372

Data Source: USGS 2017
Notes:
[1] Gage base is a threshold above which peak discharges represent what would be expected during unregulated conditions. Peak discharges below the gage base are influenced by regulation and are omitted from the analysis.
Periods of record (gaged and correlated) (water years):
Keno 1905–1913, 1930–2016
J.C. Boyle 1959–2016. 1905–1913 and 1930–1958 correlated based on Keno gage.
Copco, 1924–1961. 1905–1913 and 1962–2016 correlated based on Keno gage.
Iron Gate 1961–2016
Seiad Valley 1913–1925, 1952–2016
Orleans 1927–2016
Klamath 1911–1927, 1932–1994, 1996–2016

The flood frequency analyses use the most recently published USGS streamflow data (Table 3.6-11) to provide an update to USBR (2012), which conducted comparable flood frequency analyses to support the hydrologic and hydraulic modeling of 100-year floodplain inundation (presented in Appendix K). USBR (2012) states that under the Proposed Project during a 100-year event the largest water surface elevation increases would be approximately 1.5 feet downstream of Iron Gate Dam, and that the error in computed water surface elevations is one to two feet at most modeled cross sections. USBR (2012) acknowledges their computed water surface elevation increases are conservative overestimates. The 100-year peak flow estimate for Iron Gate Dam (the flow used in model calculations to compare the Proposed Project with existing conditions) presented in Table 3.6-11 differs from that given in USBR (2012) by less than one percent.

Results of the flood frequency analyses indicate that peak flows at Iron Gate Dam are substantially greater than peak flows at J.C. Boyle Dam (Table 3.6-11). This is because of flows from the tributaries that enter the Klamath River between the two dams. In particular, Jenny Creek contributes a large amount to the peak flow during the winter and spring months. The watershed area of Jenny Creek is 210 square miles, and it is the largest single tributary to the Klamath River between Keno Dam and Iron Gate Dam (USBR 2012).

During extremely wet years, surface water elevations rise in Upper Klamath Lake. Agency Lake, Barnes Ranch, and the Nature Conservancy-owned lands provide over 108,000 acre-feet of storage around and near Upper Klamath Lake due to recent breaching of local dikes and levees, which can help to reduce flooding downstream. In contrast, there is minimal surplus storage in the Lower Klamath Project to help control flooding downstream of Iron Gate Dam. During wet years, decreased irrigation demands in the upper basin may allow for more water to remain in Upper Klamath Lake for use later in the year. The amount of water retained in Upper Klamath Lake is determined under the 2013 BiOp and depends on decisions related to ESA-listed suckers and the magnitude of spring flushing flows and fall migration flows downstream of Iron Gate Dam (NMFS and USFWS 2013) (see also Section 3.1.6.1 Klamath River Flows under the

Klamath Irrigation Project's 2013 BiOp Flows). The 2013 BiOp also includes provisions for average and wet years that increase minimum flow requirements at Iron Gate Dam and surface water elevations in Upper Klamath Lake to more closely mimic natural flow and lake-level conditions and provide storage for surplus water (NMFS and USFWS 2013).

3.6.2.4 Risks of Dam Failure

Dams are man-made structures and do include some risk of failure that could result in flooding downstream. According to the Association of State Dam Safety Officials (ASDSO), dams fail due to one of five reasons (ASDSO 2011):

1. Overtopping caused by water spilling over the top of dam;
2. Structure failure of materials used in dam construction;
3. Cracking caused by movements like the natural settling of dam;
4. Inadequate maintenance and upkeep; or
5. Piping—when seepage through a dam is not properly filtered and soil particles continue to erode, and form sink holes in the dam or its foundation.

In California, weighted point systems are used during inspections to classify both the hazard or damage potential and condition of the dam. Once classified, the frequency of inspections and return period for hydrology studies are selected. The classifications used for damage potential are extreme, high, moderate and low and refer to the possibility of loss of life and property downstream from the dam if it were to fail. The classifications of the condition of the dam are poor, fair, good, and excellent and are determined based on the age, general condition, and geologic and seismic setting. Dams may be reclassified after improvements or other changes have occurred (ASDSO 2000).

Siskiyou County recently developed a Multi-Jurisdictional Hazard Mitigation Plan which addressed, among other issues, flood and dam failure hazards. Maps are currently available that describe dam inundation areas based on potential failure of J.C. Boyle and Iron Gate dams as well as a domino effect, depicting the inundation area if multiple dams were to fail at the same time (Siskiyou County 2011). FERC staff have conducted safety inspections of the dam structures as part of the licensing program over the past 50 years. Every five years J.C. Boyle, Copco No. 1 and Iron Gate dams are inspected and evaluated by an independent consultant and reports documenting the evaluation are submitted to FERC for review (FERC 2007).

3.6.3 Significance Criteria

Criteria for determining significant impacts on flood hydrology was informed by Appendix G of the CEQA Guidelines (California Code of Regulations title 14, section 15000 et seq.) and based on professional judgment. Effects on flood hydrology are considered significant if the Proposed Project would result in exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding, where substantial risk is associated with structures located within the FEMA 100-year floodplain inundation extent. These impacts are broadly divided into short-term flood risks that could occur during reservoir drawdown and long-term, permanent changes to the downstream floodplain elevations (i.e., permanent changes to the FEMA 100-year floodplain) as a result of dam removal.

The potential for changes in flood hydrology and/or in the extent of floodplain inundation to impact aquatic and terrestrial resources are discussed in Sections 3.3 *Aquatic Resources* and 3.5 *Terrestrial Resources*, respectively.

3.6.4 Impacts Analysis Approach

The assessment of the environmental impacts on flood hydrology that would result from implementation of the Proposed Project and its alternatives determines whether changes in stream flows would cause flooding within the Area of Analysis. The impact assessment is based on the USBR's hydrologic and hydraulic modeling, which covers the Proposed Project and the No Project Alternative. USBR used a one-dimensional HEC-RAS model that assessed hydrologic conditions for these two alternatives and analyzed modeling output to determine how frequently the current FEMA floodplain is inundated and how the floodplain could change under the Proposed Project. This information was presented in the *Hydrology, Hydraulics, and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration* (USBR 2012). The model results under the Proposed Project and No Project Alternatives provide adequate information to estimate the relative effects of the other alternatives not modeled.

USBR used KBRA flows as the hydrologic input for modeling floodplain inundation (USBR 2012). The 2013 BiOp changed the likely flow regime under which dam removal would occur in 2020 (i.e., no longer using KBRA flows). However, the differences in hydrology between KBRA and 2013 BiOp flows are minor (see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* for further details regarding KBRA and 2013 BiOp flows).

The model results include predictions of the river flows that would occur if the four dams in the Lower Klamath Project were removed. The modeling effort provided useful information for assessing the impacts on flood hydrology in the long term but provides limited information about the construction period. Flood risks associated with dam removal activities are described qualitatively and quantitatively using the HEC-RAS and SRH-1D modeling results completed by USBR, and the analysis includes the measures incorporated to reduce these risks (USBR 2012).

The following sources were assessed to determine the scope of existing local plans and policies relevant to the Proposed Project:

- Del Norte County General Plan (Mintier & Associates et al. 2003):
  - Section 2 Safety and Noise
    - General Policies: 2.A.1, 2.A.2
    - Flood Hazards Policies: 2.D.1, 2.D.4, 2.D.6
    - Disaster Planning Policies: 2.G.1
- Humboldt County General Plan for Areas Outside of the Coastal Zone (Humboldt County 2017):
  - Chapter 14 Safety Element
    - General Policies: S-P1, S-P4
    - Flooding Policies: S-P12, S-P13, S-P14, S-P15

    - Flood Management Standards: S-S5, S-S6, S-S8
- Siskiyou County General Plan (Siskiyou County 1980)
  - Chapter 3 Land Use Policies
    - Flood Hazard Policies: 21, 22, 23, 24, 26
    - Surface Hydrology Policies: 27

Most of the aforementioned policies and standards are stated in generalized terms, consistent with their overall intent to address flood hydrology impacts. By focusing on the potential for impacts to specific flood hydrology issues within the flood hydrology Area of Analysis, consideration of the more general local policies listed above is inherently addressed by the specific, individual analyses presented in Section 3.6.5 *[Flood Hydrology] Potential Impacts and Mitigation;* and the more general local policies are not discussed further.

3.6.5 Potential Impacts and Mitigation

3.6.5.1 Flood Hydrology

Potential Impact 3.6-1 Reservoir drawdown and dam removal could result in short-term increases in downstream surface water flows and result in exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding.

Reservoir drawdown activities would begin on November 1 of the year prior to drawdown at Copco No. 1 Dam, and on January 1 of the drawdown year at J.C. Boyle, Copco No. 1, and Iron Gate dams (see also Table 2.7-1 and Section 2.7.2 *Reservoir Drawdown*). The KRRC would control the releases that would vary by reservoir depending on the type of dam, discharge capacity, water year type, and the volume of water and sediment within the reservoir. The resultant reservoir water surface elevation after the initial drawdown would be generally higher in a wetter year than in a drier year at all the dams (see also Section 2.7.2 *Reservoir Drawdown*).

Reservoir drawdown in the Proposed Project includes considerations for minimizing potential flood risks. These considerations include carefully drawing down the Lower Klamath Project reservoirs using controlled flow releases (see Section 2.7.2 *Reservoir Drawdown*) and the increased storage availability in J.C. Boyle, Copco No. 1, and Iron Gate reservoirs once drawdown has begun. If a flood event occurred during drawdown, the KRRC proposes to retain flood flows using the newly available storage capacity and continue drawdown after flood risks have ended. Existing conditions do not allow these reservoirs to assist in flood prevention in this manner.

At J.C. Boyle Dam, the KRRC would begin reservoir drawdown activities in January of the drawdown year (see also Table 2.7-1), while stream flows are still high. Controlled releases would initially be through the gated spillway and power intake, with drawdown increases to the existing river flow ranging from a minimum of 19 cfs (on average) to a maximum of 138 cfs (on average), assuming a continuous 5 feet per day drawdown (Appendix B: *Definite Plan*).

Because J.C. Boyle Reservoir has very little storage capacity, release flows would fluctuate throughout the drawdown period due to changes in reservoir inflow rate. Occasional periods of rapid increases in release flows would occur, with a total maximum drawdown release flow of approximately 3,000 cfs occurring for approximately 2-3 hours, then dropping back to near inflow values over a total of 6-8 hours (S. Leonard, AECOM as KRRC Technical Representative, pers. comm., September 2018). The maximum capacity of the power intake is approximately 2,800 cfs. Therefore, flows above approximately 2,800 cfs would go over the spillway. Storm inflows large enough to cause refilling of the reservoir would also pass over the spillway. The reservoir drawdown is planned be completed by January 31 of the drawdown year, to minimize potential impacts at the downstream dam removal sites. The potential formation of reservoir ice in January at J.C. Boyle would not affect reservoir drawdown substantially during this period because reservoir releases at the dam would be maintained below ice cover (Appendix B: *Definite Plan*). Drawdown would proceed through the spillway and penstock, which would access the liquid portion of the reservoir. As the water level drops, surface ice would lower and start to crack. Broken ice on the reservoir surface would provide some amount of roughness that slows the flowing water in the canyon portion of the reservoir as well as reduces the entrainment of reservoir sediment. As a flowing condition is restored, surface ice would melt and be reduced because moving water mixes temperatures between the air and ground, the latter of which does not get cold enough in the Area of Analysis to freeze. The J.C. Boyle powerhouse successfully operates throughout the winter even with lake ice present (S. Leonard, AECOM as KRRC Technical Representative, pers. comm., November 2018).

The additional controlled releases that would occur for the purposes of drawing down J.C. Boyle Reservoir would be unlikely to increase flood risks downstream of the California-Oregon state line because releases from the dam would be within the range of historical flows and so would not be a change from existing conditions. The 2-year and 5-year flow events downstream of J.C. Boyle Dam are 4,736 cfs and 7,719 cfs, respectively. A 10-year flow at J.C. Boyle results in an estimated flow of 10,362 cfs (see Table 3.6-11), and the maximum daily winter flow (January through March) is in excess of 8,000 cfs (USGS 2011). The average monthly flow below J.C. Boyle Dam for the period 1961−2009 was approximately 2,380 cfs in January, 2,450 cfs in February, and 2,890 cfs in March. Therefore, temporarily increasing the flow to approximately 3,000 cfs during reservoir drawdown would not result in exposing people or structures to substantial flood risks downstream of the California-Oregon state line.

Removal of the J.C. Boyle Dam embankment would occur in late June, July, and August of the drawdown year (see also Table 2.8-1) and would initially (June 15 to June 30) progress to no lower than elevation 3,778 feet amsl to provide sufficient elevation above a 150-year flood plus approximately 5 feet of freeboard. In July and August, the upstream cofferdam crest would not go below 3775 feet amsl to endure a 150-year flood plus approximately 5 feet of freeboard, and in September the cofferdam elevation would not go below 3771 feet amsl to endure a 100-year flood plus 0 feet of freeboard (S. Leonard, AECOM as KRRC Technical Representative, pers. comm., September 2018). This drawdown scenario would involve flows up to approximately 3,500 cfs through the left abutment. The upstream cofferdam would be armored with rockfill to allow a controlled breach to fully drain the reservoir prior to September 30 of the drawdown year. Reservoir releases would temporarily exceed inflow by up to approximately 5,000 cfs, depending upon the rate of breach development, but would remain below the downstream channel capacity of 6,957 cfs (S. Leonard, AECOM as KRRC Technical Representative, pers. comm., September 2018). Although the breach flow would quickly attenuate as it moved downstream due to the very small reservoir volume, the Iron Gate cofferdam would be breached before breaching the J.C. Boyle cofferdam as a precaution against the potential increased inflow to the Iron Gate impoundment (Appendix B: *Definite Plan*).

Although a limited drawdown (i.e., two feet per day) of Copco No. 1 Reservoir would begin on November 1 of the year prior to drawdown to allow early removal of the spillway gates and crest structure using a barge mounted crane, the primary drawdown and sediment release of Copco No. 1 Reservoir would begin January 15 of the drawdown year. Increased drawdown rates of five feet per day are delayed two weeks after drawdown releases begin at Iron Gate Dam (i.e., January 1) to create additional reservoir capacity at Iron Gate, which would better handle drawdown releases from Copco No. 1 Reservoir and help attenuate outflows from Iron Gate Reservoir due to storms. Drawdown would be limited to five feet per day to maintain reservoir rim slope stability and control drawdown releases from both reservoirs upstream of Iron Gate Reservoir. Maximum additional discharge downstream of Copco No. 1 Dam due to drawdown activities is anticipated to be about 6,000 cfs when the gate is opened on January 15. During other times the flow 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 2,597 feet amsl is about 12,000 cfs. If water levels increase above the spillway crest, the gate would be closed down to limit the total discharge to 13,000 cfs to avoid high water levels that would interfere with power production at Copco No. 2 Powerhouse. For reference, the 10-year, 20-year, 50-year, and 100-year flow events downstream of Copco No. 1 are 11,910 cfs, 13,543 cfs, 14,702 cfs, and 15,821 cfs, respectively. Storm inflows large enough to cause refilling of the reservoir would pass through the spillway.

Beginning January 15 of the drawdown year, as the Copco No. 1 Reservoir is drawn down through the new large gate structure at the downstream end of the diversion tunnel, penstocks, abutment gate houses, and above ground powerhouse equipment would be removed. After April 15 of the drawdown year Copco No. 1 Dam would be excavated in 12-foot lifts. Concrete rubble from the dam and powerhouse would be removed by truck. Temporary cofferdams in the river channel would be constructed as required for removal of the powerhouse and diversion tunnel control structures. The cofferdams would be removed once no longer needed and the upstream and downstream diversion tunnel portals would be plugged with concrete (Appendix B: *Definite Plan*).

Copco No. 2 Dam does not provide any meaningful storage, and the reservoir is very small compared to the other reservoirs, with little or no impounded sediment. Dam removal would begin on about May 1 of the drawdown year. No additional releases would be made from the upstream reservoirs during this time as they would have already been mostly drained. The KRRC would use cofferdams to isolate areas of the small concrete dam during demolition and would remove them once they were no longer needed (Appendix B: *Definite Plan*).

Reservoir drawdown at Iron Gate Reservoir would begin from normal operating elevation of 2,331.3 feet amsl on January 1 of the drawdown year by making controlled releases through the modified diversion tunnel. Reservoir drawdown would be limited to a maximum of five feet per day to maintain reservoir rim slope stability. Maximum additional discharge downstream of the dam due to drawdown activities would be approximately 4,000 cfs. Total discharge capacity of the modified diversion tunnel with the reservoir at spillway crest elevation of 2,331.3 feet amsl is about 10,000 cfs

(Appendix B: *Definite Plan*). For reference, the 10-year flow event downstream of Iron Gate Dam is 14,854 cfs.

Results from reservoir drawdown modeling (USBR 2012) indicate that during representative drier water years, Iron Gate Reservoir would be drawn down by early February of the drawdown year, and it would not refill after that point. During wetter water years the reservoir would be completely drawn down by March 1, but it could partially refill during storms later in the drawdown year. The majority of the accumulated sediment would mobilize during the initial drawdown, and subsequent reservoir filling and drawdown would be expected to cause only moderate increases in suspended sediment relative to background (USBR 2012). During the wettest water years, the reservoir would be completely drawn down by early March (Appendix B: *Definite Plan*).

Dam removal at Iron Gate Dam would begin following spring runoff on June 1 of the drawdown year and be completed by October 15. The removal plans require that sufficient freeboard be maintained to pass a 100-year flood at all times for those months between the elevation of the excavated embankment surface and any remaining reservoir water surface to reduce to potential for flood flows overtopping the embankment. During dam removal between June 1 and August 31, sufficient embankment elevation would be maintained to endure a 150-year flood event plus approximately 5 feet of freeboard. In September, the upstream cofferdam crest elevation would be maintained to endure a 100-year flood event plus 0 feet of freeboard (S. Leonard, AECOM as KRRC Technical Representative, pers. comm., September 2018). September is the month that the cofferdam would be breached.

Dam excavation would proceed at an estimated 7,500 cubic yards (CY) per day in June, 14,250 CY per day in July, and 16,000 CY per day in August and early September, leaving an upstream cofferdam. Minimum reservoir flood release capacities would be approximately 7,700 cfs in June, 7,000 cfs in July, and 3,000 cfs in August and September, to accommodate the passage of at least a 100-year flood during those times of the year. By late September, the reservoir would be drawn down to the maximum possible extent, minimal streamflow would be occurring, and drawdown releases from upstream reservoirs would have ended. The upstream cofferdam would be armored with rockfill to allow a controlled breach. The cofferdam at Iron Gate Dam would be breached prior to breaching the cofferdam at J.C. Boyle Dam to minimize potential downstream impacts. The breach flow from J.C. Boyle Dam would quickly attenuate as it moved downstream due to the very small reservoir volume.

This analysis uses the reservoir drawdown release rates at Iron Gate Dam to determine the level of significance of adverse impacts downstream because Iron Gate Dam has the largest reservoir, provides the highest amount of discharge, and is the most downstream from all the dams that would be removed. The release rates that would occur during drawdown of the reservoir would be in the range of historical flows during an extremely wet year (one percent exceedance probability or 100-year flood event). While the release rates that would occur during reservoir drawdown would be greater than the flows at the same time under the existing conditions, and in some months above the historical monthly maximum flow (e.g., September), they would be lower than the overall peak flows for extremely wet years recorded during the period of record in each reach. Because the flows would stay below historical peak flows, they would not change the floodplain or flood risks in comparison to the existing conditions. Thus, the short-term increases in downstream flows and changes to flood risks resulting from reservoir drawdown would be less than significant.

Significance
No significant impact

Potential Impact 3.6-2 Under the Proposed Project recreational facilities currently located on the banks of the existing reservoirs would be removed following drawdown and could change flood hydrology.
The existing recreational facilities provide camping and boating access for recreational users of Copco No. 1 and Iron Gate reservoirs. Once the reservoirs are drawn down, most of these facilities would be removed (see also Section 3.20.4.3 *Reservoir-based Recreation*). These facilities would be well above the new river channel, and deconstruction would not place anything in the channel or otherwise impede low or high flows in the Klamath River. Therefore, there would be no impact to flood hydrology from the removal of recreational facilities.

Significance
No significant impact

3.6.5.2 River Floodplain

Potential Impact 3.6-3 The long-term FEMA100-year floodplain inundation extent downstream from Iron Gate Dam could change between river miles 193 and 174, potentially exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding.
Hydrologic and hydraulic modeling of floodplain inundation shows that removal of the Lower Klamath Project dams could alter the 100-year floodplain inundation area downstream of Iron Gate Dam between RM 193 and 174 (i.e., from Iron Gate Dam to Humbug Creek) (USBR 2012). The modeling indicates that the differences between existing conditions and the Proposed Project are minor. Floodplain inundation maps illustrating these model results are presented in Appendix K of this EIR. The mapping includes the effects of the increase in the 100-year flood peak flow rate and the small amounts of sediment deposition in the river channel following removal of the Lower Klamath Project dams.

Modeling of flood flows downstream of Iron Gate Dam indicates that the Lower Klamath Project dams provide a slight attenuation of peak flood flows. USBR (2012) estimated that the discharge of the 100-year peak flood immediately downstream of Iron Gate Dam would increase by up to seven percent following dam removal (Table 3.6-12) and flood peaks would occur about 10 hours earlier. This increased discharge would result in flood elevations that are 1.65 feet higher on average from Iron Gate Dam (RM 193) to Bogus Creek (RM 192.6) and 1.51 feet higher on average from Bogus Creek to Willow Creek (RM 188) (Appendix B: *Definite Plan*). The impact of dam removal on flood peak elevations would decrease with distance downstream of Iron Gate Dam, and USBR (2012) and the KRRC (Appendix B: *Definite Plan*) estimated that there would be no significant effect on flood elevations downstream of Humbug Creek (RM 174) because flow attenuation would occur in the mainstem channel and tributary peak flows would not coincide with the peak flow downstream of RM 193 (i.e., current location of Iron Gate Dam).

Table 3.6-12. Flood Attenuation of Iron Gate and Copco No. 1 Reservoirs on Flows at RM 193.

Flood Event	Peak Flow	Peak Flow - Proposed Project	Percent Reduction With Dams In
Synthetic 100-yr flood	31,460	33,800	6.9
1989	10,200	10,300	1.2
1993	11,100	11,400	2.7
1996	11,200	11,300	1.1
1997	20,500	21,400	4.0
2005	12,400	12,800	3.0

Source: USBR 2012

Changes in flood peak elevations and the extent of floodplain inundation under the Proposed Project could affect properties and structures along the river downstream of Iron Gate Dam during a flood event. The Klamath Basin is currently subject to flooding and FEMA has developed flood insurance risk maps that Siskiyou County has recognized in regulations concerning development along the river.

USBR (2012) estimated the number of residences and structures located along the Klamath River between Iron Gate Dam (RM 193) and Humbug Creek (RM 174) that would potentially be affected should the dams be removed. This estimate was based on photo interpretation and field visits. Structures along the Klamath River were categorized according to whether they are within the existing 100-year floodplain or would be in the altered 100-year floodplain following dam removal. The KRRC revisited the aerial photo analysis using the USBR (2012) floodplain boundaries and determined that a total of 34 legally-established habitable structures are located within the existing 100-year floodplain between Iron Gate Dam (RM 193) and Humbug Creek (RM 174), and an estimated 2 additional legally-established habitable structures would be within the altered 100-year floodplain in the same reach following dam removal, for a total of 36 legally established habitable structures within the altered 100-year floodplain following dam removal (Appendix B: *Definite Plan*). The KRRC defines legally established habitable structures as those that have running water, electricity, appliances, and sanitary service (S. Leonard, AECOM as KRRC Technical Representative, pers. comm., September 2018). This includes residential and commercial structures that are intended for permanent habitation.

Although the original USBR hydrologic and hydraulic modeling was conducted assuming KBRA flows, it is reasonable to conclude that the likely adverse impacts to structures in the 100-year floodplain downstream of Iron Gate Dam and the timing of downstream flood peaks would be similar under the 2013 BiOp flow regime because: (1) the 2013 BiOp and KBRA flows are similar, and (2) there is no change to flood operations under the 2013 BiOp flows versus the KBRA flows (see also Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*).

An estimated three river crossings in this downstream reach could also be affected by the increase in flood depths: two pedestrian bridges and the Central Oregon and Pacific Railroad Bridge (Appendix B: *Definite Plan*). Both pedestrian bridges are below the existing 100-year flood elevation, and there is a potential increase in scour depth at the railroad bridge. Pedestrian Bridge #1 is dilapidated and is not structurally safe. Pedestrian Bridge #2 and the railroad bridge are in good condition. The KRRC proposes to remove Pedestrian Bridge #1, with the owner's permission. The KRRC proposes to consult with the owner of Pedestrian Bridge #2 during the detailed design phase to determine whether this bridge should be removed or replaced, at the KRRC's expense. The KRRC proposes to perform more analysis during the detailed design phase to confirm the effects of scour on the railroad bridge, as it may have sufficient footing and foundation depths to accommodate the increased scour potential but may need additional scour protection. The KRRC would make any needed improvements.

The change to the 100-year floodplain inundation area between Iron Gate Dam (RM 193) and Humbug Creek (RM 174) due to dam removal would result in exposing approximately two additional habitable structures to a substantial risk of damage due to flooding and is considered a significant impact. To address this potential impact, the Proposed Project includes implementation of the Downstream Flood Control Project Component (Project Component), as described in Section 2.7.8.4 *Downstream Flood Control* and in Appendix B: *Definite Plan*. This Project Component replaces Mitigation Measure H-2 from the 2012 KHSA EIS/EIR.

The KRRC proposes to work with willing landowners to implement a plan to address the significant flood risk for the 36 habitable structures (including permanent and temporary residences) located in the altered 100-year floodplain between Iron Gate Dam and Humbug Creek following dam removal. The KRRC would work with the owners to move or elevate the habitable structures in place before dam removal, where feasible, to reduce the risks of exposing people and/or structures to damage, loss, injury, or death due to flooding. However, flood damage and/or loss of structures that are not feasible to move or elevate would be a significant impact. Final determination of the future 100-year floodplain after dam removal would be made by FEMA. The KRRC is coordinating with FEMA to initiate the map revision process (Appendix B: *Definite Plan*). The Project Component would also evaluate the river crossings that could be affected by a substantial risk of damage due to flooding.

When a large flood event is predicted, the National Weather Service (NWS) River Forecast Center provides river stage forecasts and flood warnings for the Klamath River for the USGS gages at Seiad Valley, Orleans, and Klamath. The River Forecast Center is the Federal agency that provides official public warning of floods. They currently do not publish a forecast for river stage at the Iron Gate gage, however, they work with PacifiCorp to issue flood warnings to Siskiyou County.

Under the Proposed Project, the KRRC's Emergency Response Plan would include informing the NWS River Forecast Center of a planned major hydraulic change (i.e., removal of four dams) to the Klamath River that could potentially affect the timing and magnitude of flooding downstream of Iron Gate Dam (Appendix B: *Definite Plan*). The Emergency Response Plan replaces Mitigation Measure H-1 from the 2012 KHSA EIS/EIR. As needed, the River Forecast Center would update their hydrologic and hydraulic modeling of the Klamath River so that changes to the timing and magnitude of flood peaks would be included in their forecasts. The Proposed Project would not affect the River Forecast Center's practice of publicly posting flood forecasts and flood warnings for use by federal, state, county, tribal, and local agencies, as well as the public, so timely decisions regarding evacuation or emergency response can be made.

As described in the Definite Plan (Appendix B), the KRRC would also inform FEMA of the planned major hydraulic change to the Klamath River (i.e., dam removal) that could affect the 100-year floodplain. This would be done through a conditional letter of map revision (CLOMR) report, submitted to FEMA during the detailed design phase. Subsequently, the KRRC would submit a letter of map revision (LOMR) to FEMA to provide recent hydrologic and hydraulic modeling, and updates to the land elevation mapping so FEMA can update its 100-year floodplain maps downstream from Iron Gate Dam, as needed. These updates would provide critical information regarding real-estate disclosures, zoning decisions, and insurance requirements such that short- and long-term flood risks are evaluated and responded to by agencies, the private sector, and the public.

Overseeing development and implementation of the Downstream Flood Control Project Component and the Emergency Response Plan does not fall within the scope of the State Water Board's water quality certification authority. While the KRRC has stated its intention to work with willing landowners to implement a plan to address the significant flood risk and has initiated a process with FEMA to reach enforceable good citizen agreements that will be finalized and implemented, at this time these elements of the Proposed Project are not finalized, and the State Water Board cannot require their implementation. Accordingly, while the State Water Board anticipates that implementation of the Downstream Flood Control Project Component and the Emergency Response Plan, and any modifications developed through the FERC process that provide the same or better level of protection against flood damage, would reduce impacts to less than significant, because the State Water Board cannot ensure their implementation, it is analyzing the impact in this Draft EIR as significant and unavoidable.

Significance

Significant and unavoidable for exposing structures to a substantial risk of damage due to flooding

No significant impact related to exposing people and/or structures to a substantial risk of flooding related to flood forecasting

Potential Impact 3.6-4 The FEMA 100-year floodplain inundation extent downstream from J.C. Boyle Dam could change between the California-Oregon state line and Copco No. 1 Reservoir, potentially exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding.

As part of prior flood-inundation hydrologic and hydraulic modeling conducted for dam removal analyses, USBR (2012) ignored the potential effect of removing J.C. Boyle Dam on floodplain inundation downstream of the Hydroelectric Reach because this dam is approximately 35 miles upstream of Iron Gate Dam and is significantly smaller than either Iron Gate or Copco No. 1 dams. Within the Hydroelectric Reach, USBR (2012) did not conduct 100-yr floodplain mapping; however, FEMA (2016) mapping includes a 100-yr floodplain boundary for existing conditions on the Klamath River, including the Hydroelectric Reach (Appendix K).

Because J.C. Boyle Reservoir provides no storage and the dam typically operates in spill mode at flows above plant capacity (i.e., approximately 6,000 cfs; Table 2-1 in USBR 2012), existing conditions peak flows in the Hydroelectric Reach are not attenuated as a result of J.C. Boyle Dam. More specifically, the estimated spillway capacity of J.C. Boyle Dam at water surface elevation 3,793 feet amsl with all three gates open is 14,850 cfs

(USBR 2012), while the 100-yr estimated peak flow event in the Klamath River downstream of J.C. Boyle Power Plant is slightly lower, at 14,518 cfs (Table 3.6-11).

Therefore, under the Proposed Project the 100-yr flood inundation extent on the Klamath River from the Oregon-California state line downstream to Copco No. 1 Reservoir would not change from existing conditions (see also Appendix K).

Significance
No significant impact

Potential Impact 3.6-5 The release of sediment stored behind the Lower Klamath Project dams and resulting downstream sediment deposition under the Proposed Project could result in potentially exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding.
Depending on hydrologic conditions during drawdown and dam removal, approximately 90,000 to 170,000 U.S. tons of sediment behind J.C. Boyle Dam, 950,000 to 1,590,000 U.S. tons of sediment behind Copco No. 1 Dam, and 420,000 to 550,000 U.S. tons of sediment behind Iron Gate Dam would be eroded and flushed down the Klamath River during dam removal activities (USBR 2012) (see also Section 2.7.3 *Reservoir Sediment Deposits and Erosion During Drawdown*). After dam removal, the remaining sediment would be left in place above the active channel. USBR conducted an analysis of future geomorphology and sediment transport during and after dam removal for dry, average, and wet start year scenarios. Most of the erosion would occur during the drawdown period from January 1 to March 15 of the drawdown year and afterwards the river bed in the reservoir reaches is expected to stabilize. Minor deposition would occur in some of the reaches downstream from dam removal activities, however none is expected downstream of the Shasta River confluence (USBR 2012). The Geology and Soils analysis considers the effects of sediment deposition in more detail (see Section 3.11.5 *[Soils, Geology, and Mineral Resources] Potential Impacts and Mitigation* of this EIR). Sedimentation would occur downstream from the Lower Klamath Project, but the quantity would vary depending on water year type. The magnitude of sediment deposition is relatively small compared to sediment loading from other existing sources along the Klamath River. The only measurable sedimentation would occur in the reach from Bogus Creek to Cottonwood Creek. In the short term (i.e., 2 years following dam removal), there is anticipated to be approximately 1.2 feet of deposition between Bogus Creek (RM 192.6) and Cottonwood Creek (RM 185.1) (Figure 3.11-12). This estimate is based on two successive median water years following dam removal. The predicted bed elevation changes under other modeled scenarios (i.e., two successive wet water year types and two successive dry water year types) are both less than the median water year scenario (USBR 2012). In the long term, average bed elevation is predicted to increase by approximately 1.5 feet in the reach from Bogus to Willow Creek and less than one foot downstream of Willow Creek. Additionally, the sedimentation is anticipated to occur primarily in pools and not in the riffle and bedrock sections that tend to control water surface elevations. Because the sediment deposition would be relatively small in comparison with the existing channel bed and bar sediment conditions, it would not affect stream characteristics in a way that would substantively alter flood inundation or flood risks and would therefore be a less than significant impact. Note that even though the effects of sediment deposition would be less than significant with respect to flooding risk, increases in bed elevations due to sedimentation were included in mapping the 100-year floodplain inundation areas downstream of Iron Gate Dam as described above.

Significance

No significant impact

3.6.5.3 Risks of Dam Failure

Potential Impact 3.6-6 Dam failure could flood areas downstream of the Lower Klamath Project.

Removing the Lower Klamath Project dams could reduce the risks of downstream flooding associated with a dam failure. The Lower Klamath Project dams store over 169,000 acre-feet of water that could inundate a portion of the watershed if the dams failed (Siskiyou County Web Site 2011). The dams are inspected regularly and the probability for failure has been found to be low. Removing the Lower Klamath Project dams would eliminate the potential for dam failure and subsequent flood damages and would therefore be beneficial.

The reservoir drawdown and dam removal processes are specifically designed to reduce the potential for dam failure during dam demolition that could result in downstream flooding. Dam embankment excavation at each site would not take place until after the reservoir was completely drawn down (Appendix B: *Definite Plan*). This approach precludes the possibility of dam demolition activities increasing the risk for failure and subsequent downstream flooding.

Copco No. 1 Dam is a concrete gravity arch structure that would require drilling and blasting during the dam removal phase (Appendix B: *Definite Plan*). Copco No. 1 Dam is thicker and wider at its base, which makes it very strong and less prone to risk of failure as the dam crest is lowered through demolition. With minimal water behind the dam due to reservoir drawdown, there would be little hydrostatic pressure against the remaining sections of the dam that could cause dam failure. Additionally, overtopping flows would not cause dam failure as is evidenced by the lack of deterioration to the stepped face on the downstream side of the dam. High flows have poured over the downstream side of the dam for over 100 years with no scour to the concrete. Seismic loading cannot be controlled by the Proposed Project, but as the dam is lowered, the strength of the remaining gravity structure increases, and therefore, the risk of seismic-induced failure would go down for a given event. Thus, there are no likely failure modes created by the removal process even if water did enter the drained reservoir during a late spring storm, and risk of a failure from the removal process is insignificant (S. Leonard, AECOM as KRRC Technical Representative, pers. comm., November 2018). FERC requires a potential failure modes analysis, and the KRRC will be revisiting this topic in more detail prior to dam removal. FERC dam safety experts would have to approve the final dam removal analysis before a license surrender order could be issued.

See Potential Impact 3.6-1 for further discussion of reservoir drawdown and dam removal details.

Significance

Beneficial following dam removal

No significant impact during reservoir drawdown and dam removal

3.6.6 References

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