UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

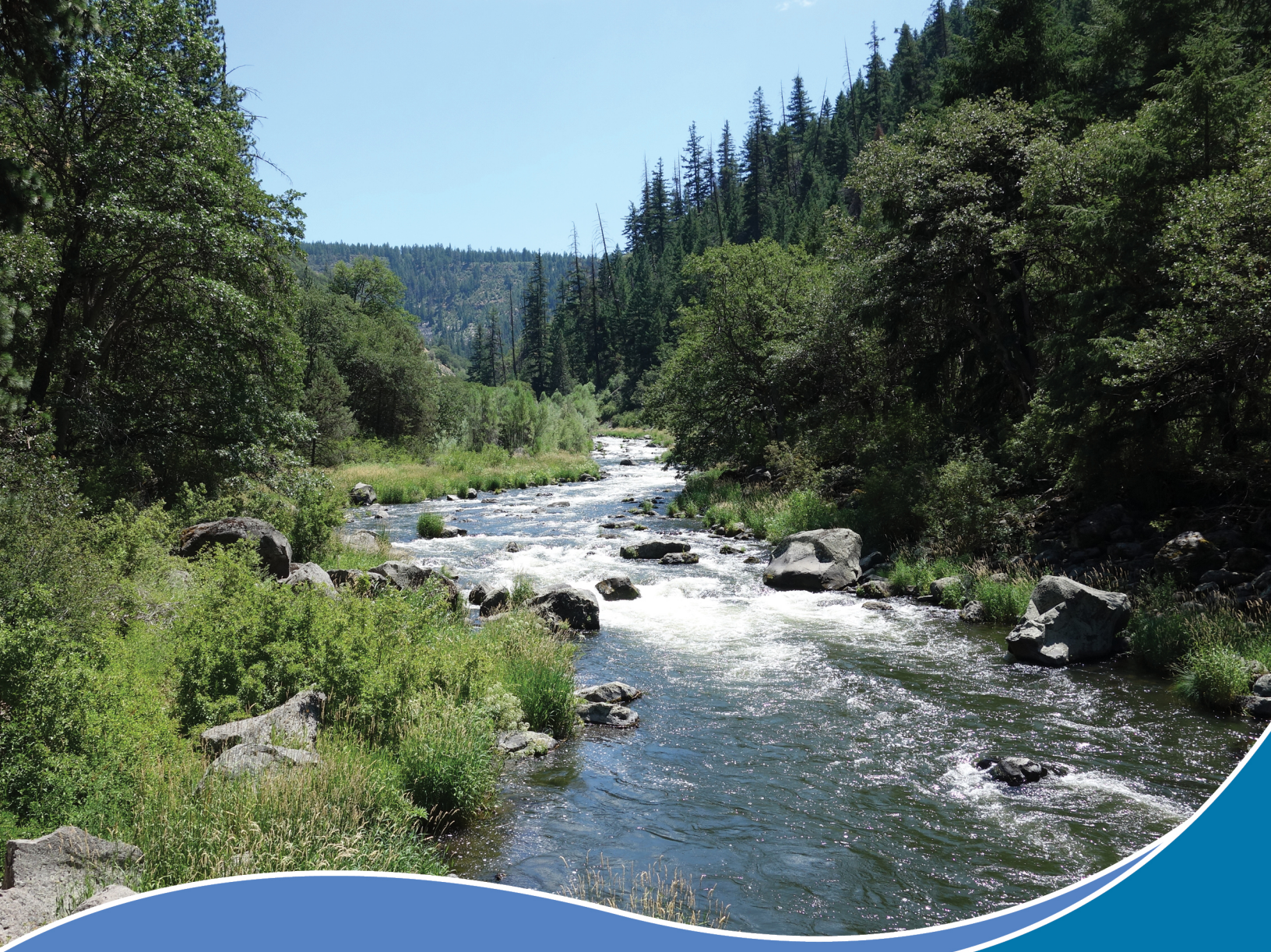
Klamath River Renewal Corporation **Project Nos. 14803-001;**
PacifiCorp **2082-063**

AMENDED APPLICATION FOR SURRENDER OF LICENSE FOR MAJOR PROJECT AND REMOVAL OF PROJECT WORKS

Attachment A-9

Lower Klamath Project Biological Assessment

Appendix H
(Suspended Sediment Effects on Coho Salmon Populations)



Biological Assessment

Appendix H – Suspended Sediment Effects on Coho Salmon Populations

KLAMATH
RIVER RENEWAL
CORPORATION

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Prepared for:

Klamath River Renewal Corporation

Prepared by:

Renewal Corporation Technical Representatives:

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

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

River Design Group
311 SW Jefferson Avenue
Corvallis, Oregon 97333

H. SUSPENDED SEDIMENT EFFECTS ON COHO SALMON POPULATIONS

This appendix presents the predicted effects of suspended sediment concentrations (SSCs) on each coho salmon life history stage and cohort (referenced by spawning year) to evaluate the likely effects of the Proposed Action on coho salmon populations in the Action Area. The approach for evaluating the effects of SSCs on coho salmon is described in Section 5.1.1.1 of the BA. The suspended sediment effects analyses completed by the Renewal Corporation are based on updated sediment modeling output provided by USBR using a previously developed SRH-1D sediment transport model (2011b). The updated modeling results represents a revised drawdown scenario proposed by the Renewal Corporation as described in Appendix I of the BA. References cited in this appendix are listed in Chapter 8 of the BA.

The effects of suspended sediment on coho salmon in the Klamath River are presented using the historical population structure of Southern Oregon Northern California Coast (SONCC) coho salmon presented in Williams et al. (2006). As described in Williams et al. (2006), nine coho populations are in the Klamath River Basin, including the Upper Klamath River, Shasta River, Scott River, Salmon River, Mid- Klamath River, Lower Klamath River, and three population units in the Trinity River watershed (Upper Trinity River, Lower Trinity River, and South Fork Trinity River population units). SSC effects on distinct population units are differentiated where appropriate (see Table 5-5 of the BA).

As described in Section 5.1.1.1 of the BA, suspended sediment modeling results were reported for four USGS gaging stations, including Iron Gate, Seiad Valley, Orleans, and Klamath (see Figure 5-1 in Appendix A of the BA). The Renewal Corporation used an SSC exposure–duration analysis to predict the potential impacts that may occur on coho salmon as a result of high SSCs in the Klamath River due to the Proposed Action for each year within the 48-year hydroperiod. Two representative years within the 48-year record were used for more detailed analysis: the calculated median impact year and the most severe impact year. For coho salmon, the median impact year is represented by the 1991 water year hydrology and the severe impact year is represented by the 1970 water year hydrology.

The wide distribution and use of tributaries by both juvenile and adult coho salmon will likely protect the population from the worst effects of SSCs from the Proposed Action. However, the Renewal Corporation anticipates some direct mortality of redds and/or juveniles from all Klamath coho salmon populations during the winter and spring of the drawdown year (Year 1) under the Proposed Action drawdown scenario (2020). The following sections present the Renewal Corporation's anticipated effects for coho salmon by life stage and time of year when the respective life stages will be exposed to elevated SSCs due to drawdown of the reservoirs.

It should be noted that locally elevated SSCs would also be expected due to pre- and post-drawdown activities at Iron Gate Dam, including construction of access roads, modifications to the Iron Gate Dam

tunnel, removal of sediment and debris from upstream of the tunnel intake structure to provide a clear approach for effective flow passage during and after drawdown, installation of tunnel outlet erosion protection measures, potential construction and removal of the Lakeview Road temporary bridge, and tailrace backfilling. The effects of pre- and post-drawdown construction activities at Iron Gate Dam are described in Section 5.1.2.1 of the BA.

H.1 Adult Migration (September 1st – January 1st)

Upstream migration of adult coho salmon in the Klamath River occurs between September and January. Because this is the only period when adults are present in the mainstem Klamath River, this is the only period when adults will be exposed to elevated suspended sediment in the mainstem. Adult coho salmon enter the lower Klamath River between late September and mid-December, with peak upstream migration occurring between late October and mid-November. Based on adult migration observations in Scott River (2007–2009), Shasta River (2007–2009), and Bogus Creek (2003–2009), on average, only around 4 percent of adult coho salmon remain in the mainstem after January 1st (CDFW, unpublished data). In most years, all adult coho salmon are observed entering tributaries prior to December 15, although in some years (e.g., Scott River in 2009) most fish are observed between December 15th and January 1st. The anticipated effects of SSCs on migrating adult coho salmon from the various populations residing in the Klamath Basin is differentiated by SSC model result station based on the spawning locations of those populations.

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

H.1.1 Upper Klamath River and Shasta River Populations

The Renewal Corporation evaluated the potential effects to upstream migrating adult coho salmon from the Upper Klamath River and Shasta River populations using SSC modeling results from the Iron Gate station.

Table H-1 presents the SSCs, the Newcombe and Jensen (1996) severity (SEV) of effects, and the predicted responses of adult coho salmon under the median impact year and severe impact year for the background condition and the Proposed Action based on modeling results at the Iron Gate Station. Adult coho salmon

from the Upper Klamath River and Shasta River populations will experience sublethal effects in Year 1 and Year 2. The Proposed Action median and severe impact year conditions will result in similar SEV values.

Table H-1: SSC, SEV Score, and Adult Coho Migration Response Scenarios at the USGS Iron Gate Station.

Scenario	Year 1 (Drawdown)			Year 2[1]		
	14- day Median SSC Range (mg/L)	SEV	Response	14- day Median SSC Range (mg/L)	SEV	Response
Background Median Impact Year	0 to 1	0 to 2	No effect or minor changes in behavior	0 to 1	0 to 1	No effect or minor changes in behavior
Background Severe Impact Year	0 to 6	1 to 6	Sublethal effects, including moderate stress	0 to 1	1 to 2	No effect or minor changes in behavior
Proposed Action Median Impact Year	52 to 194	7 to 8	Sublethal effects, including major stress and impaired homing	14 to 14	6 to 6	Sublethal effects, including moderate stress
Proposed Action Severe Impact Year	38 to 123	7 to 8	Sublethal effects, including major stress and impaired homing	2 to 2	5 to 5	Sublethal effects, including minor stress

1. Year 2 data end on September 30 and do not encompass the entire adult migration period.

H.1.2 Middle Klamath River and Scott River Populations

The Renewal Corporation evaluated the potential effects to upstream migrating adult coho salmon from the Middle Klamath River and Scott River populations using SSC modeling results from the Seiad Valley station. Table H-2 presents the SSCs, SEV scores, and the predicted responses of adult coho salmon under the median impact year and severe impact year for the background condition and the Proposed Action based on modeling results at the Seiad Valley Station. Adult coho salmon from the Middle Klamath River and Scott River populations will experience sublethal effects in Year 1 and Year 2. The Proposed Action median and severe impact year conditions will result in similar SEV values.

Table H-2: SSC, SEV Score, and Adult Coho Salmon Migration Response Scenarios at the USGS Seiad Valley Station.

Scenario	Year 1 (Drawdown)			Year 2[1]		
	14- day Median SSC Range (mg/L)	SEV	Response	14- day Median SSC Range (mg/L)	SEV	Response
Background Median Impact Year	0 to 6	3 to 6	Sublethal effects, including moderate stress	0 to 1	2 to 3	Behavioral response, including avoidance
Background Severe Impact Year	0 to 145	4 to 8	Sublethal effects, including major stress and impaired homing	1 to 2	5 to 5	Sublethal effects, including minor stress
Proposed Action Median Impact Year	30 to 170	7 to 8	Sublethal effects, including major stress and impaired homing	8 to 9	6 to 6	Sublethal effects, including moderate stress
Proposed Action Severe Impact Year	20 to 100	7 to 8	Sublethal effects, including major stress and impaired homing	2 to 2	5 to 5	Sublethal effects, including minor stress

1. Year 2 data end on September 30 and do not encompass the entire adult migration period.

H.1.3 Lower Klamath River, Salmon River, and Trinity River Populations

The Renewal Corporation evaluated the potential effects to upstream migrating adult coho salmon from the Lower Klamath River, Salmon River, and the three Trinity River populations (Lower Trinity, Upper Trinity, and South Fork Trinity) using SSC modeling results from the Orleans station.

Table H-3 presents the SSCs, SEV scores, and the predicted responses of adult coho salmon under the median impact year and severe impact year for the background condition and the Proposed Action based on modeling results at the Orleans Station. Adult coho salmon from the Lower Klamath River, Salmon River, and the Trinity River populations will experience sublethal effects in Year 1 and Year 2. The Proposed Action median and severe impact year conditions will result in similar SEV values.

Table H-3: SSC, SEV Score, and Adult Coho Salmon Migration Response Scenarios at the USGS Orleans Station.

Scenario	Year 1 (Drawdown)			Year 2[1]		
	14- day Median SSC Range (mg/L)	SEV	Response	14- day Median SSC Range (mg/L)	SEV	Response
Background Median Impact Year	0 to 5	3 to 6	Sublethal effects, including moderate stress	0 to 1	3 to 3	Behavioral response, including avoidance
Background Severe Impact Year	1 to 119	4 to 8	Sublethal effects, including major stress and impaired homing	1 to 2	5 to 5	Sublethal effects, including minor stress
Proposed Action Median Impact Year	18 to 133	7 to 8	Sublethal effects, including major stress and impaired homing	7 to 7	6 to 6	Sublethal effects, including moderate stress
Proposed Action Severe Impact Year	15 to 76	7 to 8	Sublethal effects, including major stress and impaired homing	2 to 2	5 to 5	Sublethal effects, including moderate stress

1. Year 2 data end on September 30 and do not encompass the entire adult migration period.

In summary, it is anticipated that most adult coho will already be in tributaries in January of the drawdown year. The effects of the Proposed Action on migrating adults in Year 1 from all population units are anticipated to be higher than those experienced under background conditions. In Year 2, the Renewal Corporation expects that SSCs in the Klamath River will be similar to background levels, and that adult coho salmon will experience project benefits that include access to previously inaccessible historical tributary and mainstem spawning habitats, cooler fall water temperatures during migration, and reduced disease impacts.

H.2 Spawning, Incubation, and Emergence (November 1 – March 14)

Because coho salmon spawning in the mainstem is uncommon (Magneson and Gough 2006), it is unlikely that dam removal will directly affect egg or alevin development. However, any redds that are constructed in the mainstem Klamath River in the fall of the year before drawdown and in the drawdown year (Year 1) will be negatively affected by suspended sediment released during reservoir drawdown. Coho salmon redds from the Upper Klamath River Population Unit that are built in the mainstem in the fall of the year prior to reservoir drawdown will be expected to suffer up to 100 percent mortality under the Proposed Action scenario. However, even under existing conditions, very high mortality (greater than 80 percent) is expected due to background levels of suspended sediment (in addition to other sources of mortality). Therefore, the effects of suspended sediment resulting from the Proposed Action are within the range of those predicted for background conditions. Mainstem Upper Klamath River coho redd surveys completed between 2001 and 2016 yielded 6 redds per year on average, and no redds in 2009 (USFWS, unpublished data, 2017). A total of 38 mainstem redds were documented between 2001-2005, with two-thirds of those redds found within 12 miles of Iron Gate Dam (NMFS 2010a). Many of the redds anticipated to be affected by the Proposed Action are thought to be from returning hatchery fish (NMFS 2010a). Most natural coho salmon spawning occurs in tributaries of the Klamath River downstream of Weitchpec (Wallace 2004).

The Renewal Corporation predicts that SSCs in the fall and winter of Year 1 could be high enough to result in fine sediment infiltration into redds that are constructed in the mainstem by Upper Klamath River Population Unit adult coho salmon during fall of Year 1. Although no detailed analysis of the amount of infiltration has been conducted, the Renewal Corporation anticipates redd mortality will likely be less severe (40 to 60 percent mortality) than the 100 percent mortality that will be expected to occur in January of Year 1. The Proposed Action-related sediment effects will be greater than the background condition and result in elevated redd mortality. However, in contrast to potential impacts during the previous fall/winter, the Proposed Action will open access to additional tributaries such as Jenny, Shovel, Spencer, Fall, Camp, Scotch, and Dutch creeks, as well as mainstem reaches such as the reach upstream of Copco No. 1 Dam. Therefore, it is likely that fewer redds will be constructed in the mainstem during fall of Year 1 than predicted for the previous year, and therefore the impact on coho redds associated with the Upper Klamath River population will be less than described for the previous year.

H.3 Juvenile Fish Response to SSC

Juvenile salmonids inhabiting the Klamath River during reservoir drawdown and dam removal are expected to employ coping strategies to survive poor conditions. Juveniles may use clear-water tributary junctions, clear-water off-channel ponds and tributaries, and spring seeps, or increase their use of the benthic zone (Bash et al. 2001, Kjelland et al. 2015) or use the upper portion of the water column (Servizi and Martens 1992). The Renewal Corporation expects juvenile fish to actively seek these areas as they move downstream of natal tributaries into the Klamath River. Factors affecting the ability of juvenile salmonids to find clear-water areas include the frequency, and output of clear-water sources, the magnitude of suspended sediment

in the Klamath River, and the developmental stage of juvenile fish (Sedell et al. 1990). Younger fish are generally more susceptible to high SSCs than older fish.

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

The following sections address juvenile stages of coho salmon, including age 0+ summer rearing, age 1+ winter rearing, and age 1+ spring outmigration, and present anticipated effects based on modeled suspended sediment concentrations associated with reservoir drawdown using trap data, run timing, and location information.

H.3.1 Age-0+ Summer Rearing (March 15 – November 14)

Although most age-0+ coho salmon rearing occurs in tributary streams, a portion of age-0+ coho salmon have been observed outmigrating from natal tributaries in spring and early summer. This redistribution behavior is in response to rising water temperatures in natal tributaries. During the spring and summer (March 1 to July 1) of Year 1, as specified in AR-2 – Action 3 (see Section 2.6.1 of the BA), the Renewal Corporation will monitor 13 key tributaries for fish concentrations and behavior, as well as tributary stream temperatures and mainstem SSCs. If Klamath River SSCs remain at elevated levels into the summer rearing/redistribution period, and water temperatures in natal tributary streams become stressful for juvenile coho salmon, AR-2 – Action 3 will be implemented to reduce the impacts of the Proposed Action on redistributing age-0+ and outmigrating age-1+ juvenile coho salmon. The following modelled analysis was conducted for age-0+ coho salmon that remain in the mainstem.

Juvenile coho salmon that redistribute from natal tributaries tend to move downstream and seek refuge in non-natal tributaries, off-channel ponds, or other cool- water habitats (Manhard 2018). During this redistribution period, age-0+ coho salmon may use the mainstem Klamath River as a migratory corridor between their preferred rearing areas in tributaries or off-channel habitats. Based on passive integrated transponder (PIT) tag detections of age-0+ coho salmon at monitoring sites during summer (May 1 to August 31) and winter (November 1 to January 31) as described in Manhard et al. (2018), the Renewal Corporation calculated mainstem travel/residency times for age-0+ coho salmon (Table H-4). Based on median travel times of 11.7 days and 18.9 days in summer and winter, respectively, the Renewal Corporation used a conservative mainstem exposure duration time of 20 days for both summer and winter age-0+ coho salmon.

One PIT-tagged age-0+ coho traveled 175.5 river miles between the Shasta River (RM 179.5) and Waukell Creek (RM 4.0) in 24.5 days during summer, representing a potential maximum residence time in the mainstem. During this migration, there will likely be other tributaries, confluence areas, or off-channel habitats with acceptable water quality for age-0+ coho salmon to migrate into and away from degraded mainstem water quality conditions, limiting the duration of time spent in the mainstem. Soto et al. (2016) concluded that during summer redistribution, age-0+ juveniles typically moved less than 30 miles from their natal tributaries.

Table H-4: Klamath River Mainstem Redistribution Residence by PIT Tagged Juvenile Coho Salmon.

	Summer Redistribution (May 1 – August 31)	Winter Redistribution (November 1 – January 31)
(n)	41	161
Min (days)	2.0	1.8
Max (days)	62.9	53.3
Median (days)	11.7	18.9
Min (distance - miles)	7.3	4.0
Median (distance - miles)	48.0	71.8
Max (distance - miles)	176.4	148.4

Coho salmon from the Scott, Shasta, Salmon, and Trinity river populations would be expected to be rearing in those natal watersheds and not in the Klamath River during summer. However, because of the complex life history of Klamath coho salmon, where fish may redistribute for portions of the year into non-natal watersheds, they are considered in this analysis, because they could potentially occur in the mainstem Klamath River during a portion of the summer rearing period.

Upper Klamath River and Shasta River Populations

The Renewal Corporation evaluated the potential effects to summer rearing and redistributing age-0+ juvenile coho salmon from the Upper Klamath River and Shasta River populations using SSC modeling results from the Iron Gate station.

Table H-5 presents the SSCs, SEV scores, and the predicted responses of age-0+ coho salmon under the median impact year and severe impact year for the background condition and the Proposed Action based on modeling results at the Iron Gate Station. Age-0+ coho salmon from the Upper Klamath River and Shasta River populations will experience major stress in Year 1 under both the Proposed Action median and severe impact year scenarios, with up to 40 percent mortality of fish rearing in the mainstem during the summer rearing period under the Proposed Action severe impact year scenario. In Year 2, age-0+ coho salmon from the Upper Klamath River and Shasta River populations will experience sublethal effects, including major stress, under both scenarios.

Table H-5: SSC, SEV Score, and Age-0+ Juvenile Coho Salmon Summer Rearing Response Scenarios at the USGS Iron Gate Station.

Scenario	Year 1 (Drawdown)			Year 2[1]		
	20- day Median SSC Range (mg/L)	SEV	Response	20- day Median SSC Range (mg/L)	SEV	Response
Background Median Impact Year	0 to 1	1 to 5	Sublethal effects, including avoidance short–term reductions in feeding, and minor stress for fish rearing in the mainstem	0 to 1	0 to 5	Sublethal effects, including avoidance short–term reductions in feeding, and minor stress for fish rearing in the mainstem
Background Severe Impact Year	0 to 2	2 to 5	Sublethal effects, including avoidance short–term reductions in feeding, and minor stress for fish rearing in the mainstem	0 to 3	3 to 6	Sublethal effects, including avoidance short–term reductions in feeding, and moderate stress for fish rearing in the mainstem
Proposed Action Median Impact Year	51 to 1165	8 to 10	Major stress, reduced growth, and 0 - 20% mortality of fish rearing in the mainstem for 15% of the summer rearing period.	5 to 36	6 to 8	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Proposed Action Severe Impact Year	39 to 2111	8 to 11	Major stress, reduced growth, 0 - 20% mortality of fish rearing in the mainstem for 31% of the summer rearing period and 20 - 40% mortality of fish rearing in the mainstem for 8% of the summer rearing period	2 to 60	5 to 8	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem

1. Year 2 data end on September 30 and do not encompass the entire adult migration period.

Middle Klamath River and Scott River Populations

The Renewal Corporation evaluated potential effects to summer rearing and redistributing age-0+ juvenile coho salmon from the Middle Klamath River and Scott River populations using SSC modeling results from the Seiad Valley station.

Table H-6 presents the SSCs, SEV scores, and the predicted responses of age-0+ coho salmon under the median impact year and severe impact year for the background condition and the Proposed Action based on modeling results at the Seiad Valley Station. Age-0+ coho salmon from the Middle Klamath River and Scott River populations will experience major stress in Year 1, with up to 20 percent mortality of fish rearing in the mainstem during the summer rearing period under the Proposed Action median and severe impact year scenarios. In Year 2, age-0+ coho salmon from the Middle Klamath River and Scott River populations will experience sublethal effects under both scenarios (and major stress for the severe impact year).

Table H-6: SSC, SEV Score, and Age-0+ Juvenile Coho Salmon Summer Rearing Response Scenarios at the USGS Seiad Valley Station.

Scenario	Year 1 (Drawdown)			Year 2[1]		
	20- day Median SSC Range (mg/L)	SEV	Response	20- day Median SSC Range (mg/L)	SEV	Response
Background Median Impact Year	0 to 47	3 to 8	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	0 to 29	2 to 7	Sublethal effects, including reductions in feeding and moderate stress for fish rearing in the mainstem
Background Severe Impact Year	0 to 72	5 to 8	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	1 to 160	5 to 9	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Proposed Action Median Impact Year	32 to 858	8 to 10	Major stress, reduced growth, and 0 - 20% mortality of fish rearing in the mainstem for 8% of the summer rearing period	4 to 19	6 to 7	Sublethal effects, including reductions in feeding and moderate stress for fish rearing in the mainstem
Proposed Action Severe Impact Year	23 to 1510	7 to 10	Major stress, reduced growth, and 0 - 20% mortality of fish rearing in the mainstem for 38% of the summer rearing period	2 to 45	5 to 8	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem

1. Year 2 data end on September 30 and do not encompass the entire adult migration period.

Lower Klamath River, Salmon River, and Trinity River Populations

The Renewal Corporation evaluated the potential effects to summer rearing and redistributing age-0+ juvenile coho salmon from the Lower Klamath, Salmon, and three Trinity river populations using SSC modeling results from the Orleans station.

Table H-7 presents the SSCs, SEV scores, and the predicted responses of age-0+ coho salmon under the median impact year and severe impact year for the background condition and the Proposed Action based on modeling results at the Seiad Valley Station. Age-0+ coho salmon from the Lower Klamath River, Salmon River, and the Trinity River populations will experience sublethal effects in Year 1 (under the Proposed Action median impact year scenario) or major stress (under the Proposed Action severe impact year scenario), with up to 20 percent mortality of fish rearing in the mainstem during the summer rearing period under the Proposed Action severe impact year scenario. In Year 2, age-0+ coho salmon from the Lower Klamath River, Salmon River, and the Trinity River populations will experience sublethal effects, including major stress, under both scenarios.

Table H-7: SSC, SEV Score, and Age-0+ Juvenile Coho Salmon Summer Rearing Response Scenarios at the USGS Orleans Station.

Scenario	Year 1 (Drawdown)			Year 2[1]		
	20- day Median SSC Range (mg/L)	SEV	Response	20- day Median SSC Range (mg/L)	SEV	Response
Background Median Impact Year	0 to 28	4 to 7	Sublethal effects, including short – term reductions in feeding and moderate stress for fish rearing in the mainstem	0 to 23	4 to 7	Sublethal effects, including short – term reductions in feeding and moderate stress for fish rearing in the mainstem
Background Severe Impact Year	1 to 47	5 to 8	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	1 to 126	5 to 9	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Proposed Action Median Impact Year	19 to 454	8 to 9	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	4 to 38	6 to 8	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Proposed Action Severe Impact Year	18 to 679	7 to 10	Major stress, reduced growth, and 0 - 20% mortality of fish rearing in the mainstem for 15% of the summer rearing period	2 to 39	5 to 8	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem

1. Year 2 data end on September 30 and do not encompass the entire adult migration period.

H.3.2 Age-1+ Winter Rearing (November 15 – February 14)

Rearing has previously been observed in tributary confluence pools in the mainstem Klamath River (T. Shaw, USFWS, 2002, unpublished data; as cited in NRC 2004). Although the number of juveniles that rear in the mainstem during winter is unknown, the Renewal Corporation anticipates only a small proportion (less than 1 percent) of any of the coho salmon populations rear in the mainstem (USBR and CDFW 2012). Many juveniles in the mainstem Klamath River appear to migrate to the lower river to rear and may avoid adverse conditions in the mainstem by using tributary or off-channel habitats during winter, thereby reducing their exposure and potential mortality (Hillemeier et al. 2009, Soto et al. 2008). This expectation is consistent with the observation that juvenile salmonids avoid turbid conditions (Sigler et al. 1984, Servizi and Martens 1992).

This strategy may be even more pronounced under the Proposed Action. Although low numbers of yearling coho salmon (less than 500) are expected to be encountered in the mainstem, these fish will be particularly vulnerable to the effects of elevated SSCs from reservoir drawdown. These fish represent a small, but important, life history strategy in the ESA-listed coho salmon population. As a component of AR-2 – Action 1 (see Section 2.6.1 of the BA), a reconnaissance effort will be conducted in the winter two years before drawdown to better determine the abundance and distribution of overwintering/redistributing juvenile coho salmon in the mainstem Klamath River. Based on the results of the reconnaissance effort, a targeted

salvage and relocation effort will be conducted in December of the year prior to the drawdown of Iron Gate Reservoir to reduce the number of juvenile coho remaining in Klamath River when lethal concentrations of SSC are expected to be encountered between Iron Gate Dam and Orleans. The following analysis was conducted for age-1+ coho salmon that remain in the mainstem.

Fish that may remain in the mainstem after December 31 of the year before drawdown will be especially susceptible to effects from high concentrations of SSC from drawdown-related activities. Coho salmon from the Scott, Shasta, Salmon, and Trinity river populations would be expected to be rearing in those watersheds and not in the Klamath River during winter. However, because of the complex life history of Klamath coho salmon, where fish may redistribute for portions of the year into non natal watersheds, they are considered in this analysis because they could potentially occur in the mainstem Klamath River.

Upper Klamath River and Shasta River Populations

The Renewal Corporation evaluated the potential effects to winter rearing and late redistributing juvenile coho salmon from the Upper Klamath and Shasta river populations using SSC modeling results from the Iron Gate station.

Table H-8 presents the SSCs, SEV scores, and the predicted responses of juvenile coho salmon under the median impact year and severe impact year for the background condition and the Proposed Action based on modeling results at the Iron Gate Station. Age-1+ coho salmon from the Upper Klamath River and Shasta River populations that rear in the mainstem Klamath River during winter will experience effects including major stress, reduced growth, and up to 40 percent mortality in Year 1 (under the Proposed Action median impact year scenario) or sublethal effects including major stress and reduced growth (under the Proposed Action severe impact year scenario). In Year 2, age-1+ coho salmon from the Upper Klamath River and Shasta River populations will experience sublethal effects, including major stress, under both scenarios.

Table H-8: SSC, SEV Score, and Age-1+ Juvenile Coho Salmon Winter Rearing Response Scenarios at the USGS Iron Gate Station.

Scenario	Year 1 (Drawdown)			Year 2		
	20- day Median SSC Range (mg/L)	SEV	Response	20- day Median SSC Range (mg/L)	SEV	Response
Background Median Impact Year	0 to 1	3 to 4	Sublethal effects, including avoidance, and short-term reductions in feeding for fish rearing in the mainstem	0 to 1	3 to 5	Sublethal effects, including avoidance, and short-term reductions in feeding, and minor stress for fish rearing in the mainstem
Background Severe Impact Year	0 to 12	3 to 7	Sublethal effects, including avoidance, short-term reductions in feeding, and moderate stress for fish rearing in the mainstem	1 to 17	5 to 7	Sublethal effects, including avoidance, short-term reductions in feeding, and moderate stress for fish rearing in the mainstem
Proposed Action Median Impact Year	33 to 2319	8 to 11	Major stress, reduced growth, 0 - 20% mortality of fish rearing in the mainstem for 20% of the winter rearing period and 0 - 40% mortality of fish rearing in the mainstem for 20% of the winter rearing period	16 to 111	7 to 8	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Proposed Action Severe Impact Year	27 to 264	7 to 9	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	39 to 354	8 to 9	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem

Middle Klamath River and Scott River Populations

The Renewal Corporation evaluated the potential effects to winter rearing and late redistributing juvenile coho salmon from the Middle Klamath and Scott river populations using SSC modeling results from the Seiad Valley station.

Table H-9 presents the SSCs, SEV scores, and the predicted responses of juvenile coho salmon under the median impact year and severe impact year for the background condition and the Proposed Action based on modeling results at the Seiad Valley Station. Age-1+ coho salmon from the Middle Klamath River and Scott River populations that rear in the mainstem Klamath River during winter will experience effects including major stress, reduced growth, and up to 20 percent mortality in Year 1 (under the Proposed Action median impact year scenario) or sublethal effects including major stress and reduced growth (under the Proposed Action severe impact year scenario). In Year 2, age-1+ coho salmon from the Middle Klamath River and Scott River populations will experience sublethal effects, including major stress, under both scenarios.

Table H-9: SSC, SEV Score, and Age-1+ Juvenile Coho Salmon Winter Rearing Response Scenarios at the USGS Seiad Valley Station.

Scenario	Year 1 (Drawdown)			Year 2		
	20- day Median SSC Range (mg/L)	SEV	Response	20- day Median SSC Range (mg/L)	SEV	Response
Background Median Impact Year	2 to 7	6 to 6	Sublethal effects, including avoidance, short-term reductions in feeding, and moderate stress for fish rearing in the mainstem	3 to 18	6 to 7	Sublethal effects, including avoidance, short-term reductions in feeding, and moderate stress for fish rearing in the mainstem
Background Severe Impact Year	9 to 292	7 to 9	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	26 to 355	7 to 9	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Proposed Action Median Impact Year	25 to 1739	7 to 10	Major stress, reduced growth, and 0 - 20% mortality of fish rearing in the mainstem for 40% of the winter rearing period	13 to 49	7 to 8	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Proposed Action Severe Impact Year	31 to 198	8 to 9	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	31 to 102	8 to 8	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem

Lower Klamath River, Salmon River, and Trinity River Populations

The Renewal Corporation evaluated the potential effects to winter rearing and late redistributing juvenile coho salmon from the Lower Klamath, Salmon, and the three Trinity river populations (Lower Trinity, Upper Trinity, and South Fork Trinity) using SSC modeling results from the Orleans station.

Table H-10 presents the SSCs, SEV scores, and the predicted responses of juvenile coho salmon under the median impact year and severe impact year for the background condition and the Proposed Action based on modeling results at the Orleans Station. Age-1+ coho salmon from the Lower Klamath River, Salmon River, and the Trinity River populations that rear in the mainstem Klamath River during winter will experience effects including major stress, reduced growth, and up to 20 percent mortality in Year 1 (under the Proposed Action median impact year scenario) or sublethal effects including major stress and reduced growth (under the Proposed Action severe impact year scenario). In Year 2, age-1+ coho salmon from the Lower Klamath River, Salmon River, and the Trinity River populations will experience sublethal effects, including major stress, under both scenarios.

Table H-10: SSC, SEV Score, and Age-1+ Juvenile Coho Salmon Winter Rearing Response Scenarios at the USGS Orleans Station.

Scenario	Year 1 (Drawdown)			Year 2		
	20- day Median SSC Range (mg/L)	SEV	Response	20- day Median SSC Range (mg/L)	SEV	Response
Background Median Impact Year	2 to 11	6 to 7	Sublethal effects, including short – term reductions in feeding and moderate stress for fish rearing in the mainstem	3 to 22	6 to 7	Sublethal effects, including short – term reductions in feeding and moderate stress for fish rearing in the mainstem
Background Severe Impact Year	8 to 355	7 to 9	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	53 to 265	8 to 9	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Proposed Action Median Impact Year	17 to 992	7 to 10	Major stress, reduced growth, and 0 - 20% mortality of fish rearing in the mainstem for 20% of the winter rearing period	12 to 34	7 to 8	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Proposed Action Severe Impact Year	25 to 124	7 to 9	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	26 to 74	7 to 8	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem

Renewal Corporation expects that a majority of juvenile coho salmon will be in tributary streams prior to the beginning of reservoir drawdown on January 1, and therefore will be unaffected by the Proposed Action prior to outmigration. In addition, the implementation of AR-2 Action 1 in the December prior to reservoir drawdown will likely reduce the anticipated impacts to small numbers of juvenile coho salmon remaining in the mainstem Klamath River during winter of Year 1.

H.3.3 Age-1+ Spring Outmigration (February 15 – June 30)

Coho salmon smolts are expected to outmigrate to the ocean beginning in late February of Year 1, although most natural origin smolts typically outmigrate to the mainstem Klamath during April and May (Wallace 2004). To assess the potential impacts on oumigrating coho smolts, including juvenile salmonid outmigration timing and relative abundance, the Renewal Corporation reviewed and summarized available screw trap data for the Klamath River and its tributaries (Table H-11). Reported data include both juvenile outmigration population estimates and trap catch numbers.

Figure 5-6 (Appendix A of the BA) includes a map with highlighted trap and water and suspended sediment modeling stations.

Table H-11: Juvenile Outmigration Trap Data for the Klamath River and Tributaries.

Reach	Trap Location	Trap Type	Acquiring Entity	Years Summarized
Upper Klamath River	Mainstem downstream of Bogus Creek (RM 191.2)	Net frame	USFWS	2008 – 2018
	Mainstem at I-5 (RM 182.1)	RST*	USFWS	2008 – 2018
	Shasta River (Confluence at RM 179.3)	RST	CDFW	2009 – 2017
	Mainstem at Kinsman Creek (RM 147.6)	RST	USFWS	2008 – 2018
	Scott River (Confluence at RM 145.1)	RST	CDFW	2008 – 2016
Middle Klamath River	Salmon River (Confluence at RM 66.4)	RST	Karuk Tribe	-
	Mainstem at Big Bar (RM 49.7)	RST	Karuk Tribe	1996 – 2016
	Trinity River (Confluence at RM 43.4)	RST	USFWS	-
Lower Klamath River	Blue Creek (Confluence at RM 16.0)	RST	Yurok Tribe	2008 – 2015

* RST = rotary screw trap

To better predict the potential effects of elevated SSCs on outmigrating juvenile salmonids, the Renewal Corporation reviewed past studies and analyzed age-1+ coho salmon outmigration rates and timing. Past Klamath River studies found age-1+ coho salmon outmigration rates are influenced by tributary and Klamath River water temperatures, smolt growth rates, and other environmental cues. Wallace (2004) reported coho salmon smolts in the Klamath River estuary peaked in May, the same month as peak outmigration from the tributaries (Stillwater Sciences 2010). Radio telemetry studies conducted on wild and hatchery coho salmon smolts in the Klamath River between 2006 and 2009 found a wide range of travel times for coho salmon smolts outmigrating from Iron Gate Dam to the gaging station near the Klamath estuary (Beeman et al. 2012). The minimum and maximum travel times were 3.8 and 54.4 days, respectively, with median values over the 4-year study ranging between 15.1 and 25.9 days. However, the longest residence time for any single reach was from the Iron Gate Dam release site to the Shasta River, because tagged fish remained near the release site until they were ready to begin the downstream migration to the Klamath estuary.

Once fish passed the Shasta River, travel times in any individual reach were less than 2 days, and coho salmon smolts usually took less than 1 week to complete the migration to the estuary (Beeman et al. 2012). Courter et al. (2008) assumed that all fish from a given cohort would migrate to the estuary in 2 weeks, and this assumption is also consistent with travel rates documented by Stutzer et al. (2006). Based on the literature review, the Renewal Corporation anticipates a 2-week outmigration period is a conservative time period for juvenile salmonid exposure to elevated SSCs in the Kamath River. The Renewal Corporation also anticipates that outmigrating salmonids will have access to and will choose to use clean water locations, such as clear-water tributary confluences, off-channel ponds and tributaries, and spring seeps during their outmigration, reducing exposure times. Additionally, as fish move downstream, SSCs will be substantially diluted by tributary inputs, including the Trinity River.

The Renewal Corporation reviewed smolt trapping data collected by USFWS and CDFW on the upper mainstem Klamath River (2008 to 2018), on the Scott River (2008 to 2016), and on the Shasta River (2009 to 2017) to determine the typical outmigration timing for age-1+ coho salmon smolts. The Renewal Corporation also reviewed travel time data to see how quickly juvenile fish typically outmigrate in the spring to avoid long exposure to background SSC effects.

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

To assess the effects to outmigrating age-1+ coho salmon from the various listed populations, the Renewal Corporation calculated the 14-day outmigration period median SSCs at the Iron Gate, Seiad Valley, and Orleans stations for the median and severe impact year scenarios for the background condition and the Proposed Action for each 2-week period of the outmigration window (February 15 to June 30). The Renewal Corporation then determined the associated Newcombe and Jensen SEVs for each of the outmigration periods. The resulting SEVs were overlaid with the proportion of age-1+ coho salmon expected to outmigrate during each period based on weekly catch or population estimates from the screw trap data to determine the anticipated effects to outmigrating juvenile coho in both Year 1 and Year 2.

Upper Klamath River Populations

The Renewal Corporation evaluated the potential effects to outmigrating age-1+ coho salmon from the Upper Klamath River population using SSC modeling results from the Iron Gate station.

Table H-12 presents the SSCs, SEV scores, and the predicted responses of outmigrating juvenile coho salmon under the median impact year and severe impact year for the background condition and the Proposed Action based on modeling results at the Iron Gate Station. Age-1+ outmigrating coho salmon from the Upper Klamath River population will experience major stress under both the Proposed Action median and severe impact year scenarios, with up to 20 percent mortality of fish rearing in the mainstem in Year 1. In Year 2, age-1+ coho salmon from the Upper Klamath River population will experience sublethal effects, including major stress, under both scenarios.

Table H-12: SSC, SEV Score, and Juvenile Coho Salmon Outmigration Response Scenarios at the USGS Iron Gate Station.

Scenario	Year 1 (Drawdown)			Year 2		
	14- day Median SSC Range (mg/L)	SEV	Response	14- day Median SSC Range (mg/L)	SEV	Response
Background Median Impact Year	0 to 1	3 to 5	Sublethal effects, including avoidance, and short-term reductions in feeding, and minor stress	0 to 1	2 to 5	Sublethal effects, including avoidance, and short-term reductions in feeding, and minor stress
Background Severe Impact Year	0 to 1	4 to 5	Sublethal effects, including avoidance, and short-term reductions in feeding, and minor stress	1 to 3	4 to 6	Sublethal effects, including avoidance, and short-term reductions in feeding, and moderate stress
Proposed Action Median Impact Year	72 to 2433	8 to 10	Major stress, reduced growth, and up to 20% mortality for approximately 30% of the outmigration period	13 to 38	7 to 7	Sublethal effects, including reductions in feeding and moderate stress
Proposed Action Severe Impact Year	250 to 2844	9 to 10	Major stress, reduced growth, and up to 20% mortality for approximately 60% of the outmigration period	6 to 165	6 to 8	Sublethal effects, including major stress and reduced growth

Table H-13 presents the 14-day median SSC, SEV scores, and estimated percent mortality of age-1+ coho salmon entering the mainstem Klamath River at the I-5 RST during the spring outmigration period for the median impact year and severe impact year scenarios. Based on outmigration timing derived from the 2008 – 2018 I-5 trap data, very few coho salmon smolts are expected to migrate through the upper mainstem Klamath River during the two peak suspended sediment events that are anticipated to occur under the median impact year scenario. The first peak is expected to occur in January and February of Year 1 and would occur prior to large numbers of coho salmon outmigrating from tributaries into the mainstem Klamath River. The second peak is expected to occur in mid-June after a majority of coho salmon smolts have migrated downstream to the lower Klamath River, the estuary, or have already entered the Pacific Ocean. During the severe impact year scenario, several events of elevated levels of suspended sediment are expected to occur during the outmigration period that are sufficiently high to cause mortality to a portion of juvenile coho salmon smolts outmigrating from the Upper Klamath River and tributaries in Year 1 (Figure 5-2. Based on suspended sediment modeling output and outmigration timing derived from the I-5 trap, outmigrating coho salmon from the Upper Klamath River population are expected to experience less than 1 percent (0.2 percent) and up to potentially 12 percent mortality under the median and severe impact year scenarios, respectively.

Table H-13: Age-1+ Coho Salmon Outmigrating from the Upper Klamath River at the I-5 RST by 2-week Exposure Period to 14-day Median SSCs at the USGS Iron Gate Station and Associated Predicted Mortality for Year 1.

Exposure Period Year 1				Median Impact Year			Severe Impact Year		
Exposure Period	Start	End	Estimated % Run1	Median SSC	Median SEV	Estimated % Mortality	Median SSC	Median SEV	Estimated % Mortality
1	2/15	2/28	1%	753.3	9.6	20%	249.6	8.8	0%
2	2/29	3/13	1%	292.0	8.9	0%	292.7	8.9	0%
3	3/14	3/27	12%	195.4	8.6	0%	1140.6	9.8	20%
4	3/28	4/10	36%	105.7	8.1	0%	557.0	9.3	0%
5	4/11	4/24	21%	80.4	8.0	0%	2843.7	10.5	20%
6	4/25	5/8	20%	72.4	7.9	0%	984.8	9.7	20%
7	5/9	5/22	7%	387.6	9.1	0%	812.6	9.6	20%
8	5/23	6/5	4%	195.7	8.6	0%	423.1	9.1	0%
9	6/6	6/19	0%	828.5	9.6	20%	1057.0	9.8	20%
10	6/20	7/3	0%	2242.7	10.3	20%	1659.9	10.1	20%
Potential Mortality to Age-1+ Coho Salmon Outmigrants				Median Impact Year			Severe Impact Year		
				0.2%			12.0%		

[1] Estimated proportion of age-1 juvenile coho salmon outmigrants from 2008-2018 at I-5 RST site

Shasta River Population

The Renewal Corporation evaluated the potential effects to outmigrating age-1+ coho salmon from the Shasta River population using SSC modeling results from the Iron Gate station. See Table H-12 for the SSCs, SEVs, and the predicted responses of outmigrating juvenile coho salmon under the median impact year and severe impact year for the background condition and the Proposed Action based on modeling results at the Iron Gate Station.

Table H-14 presents the 14-day median SSC, SEV scores, and estimated percent mortality of age-1+ coho salmon entering the mainstem Klamath River from the Shasta River during the spring outmigration period for the median impact year and severe impact year scenarios. Based on outmigration timing derived from the 2008 – 2018 Shasta River trap data, very few coho salmon smolts are expected to migrate from the Shasta River into the mainstem Klamath River during the two peak suspended sediment events that are anticipated to occur during Year 1 under the median impact year scenario. Under the severe impact year scenario, several events of elevated levels of suspended sediment are expected to occur during the outmigration period that are sufficiently high to cause mortality to a portion of juvenile coho salmon smolts outmigrating from the Shasta River in Year 1. Based on suspended sediment modeling output and outmigration timing derived from the I-5 trap, outmigrating coho salmon from the Upper Klamath River population are expected to experience less than 1 percent (0.1 percent) and up to potentially 15 percent mortality under the median and severe impact year scenarios, respectively.

Table H-14: Age-1+ Coho Salmon Outmigrating from the Shasta River by 2-week Exposure Period to 14-day Median SSCs at the USGS Iron Gate Station and Associated Predicted Mortality for Year 1.

Exposure Period Year 1				Median Impact Year			Severe Impact Year		
Exposure Period	Start	End	Estimated % Run1	Median SSC	Median SEV	Estimated % Mortality	Median SSC	Median SEV	Estimated % Mortality
1	2/15	2/28	<1%	753.3	9.6	20%	249.6	8.8	0%
2	2/29	3/13	<1%	292.0	8.9	0%	292.7	8.9	0%
3	3/14	3/27	33%	195.4	8.6	0%	1140.6	9.8	20%
4	3/28	4/10	20%	105.7	8.1	0%	557.0	9.3	0%
5	4/11	4/24	30%	80.4	8.0	0%	2843.7	10.5	20%
6	4/25	5/8	9%	72.4	7.9	0%	984.8	9.7	20%
7	5/9	5/22	5%	387.6	9.1	0%	812.6	9.6	20%
8	5/23	6/5	1%	195.7	8.6	0%	423.1	9.1	0%
9	6/6	6/19	0%	828.5	9.6	20%	1057.0	9.8	20%
10	6/20	7/3	0%	2242.7	10.3	20%	1659.9	10.1	20%
Potential Mortality to Age-1+ Coho Salmon Outmigrants				**Median Impact Year**			**Severe Impact Year**		
				0.1%			**15.4%**		

[1] Estimated proportion of age-1 juvenile coho salmon outmigrants from 2008-2018 at Shasta River RST site

Scott River Population

The Renewal Corporation evaluated the potential effects to outmigrating age-1+ coho salmon from the Scott River population using SSC modeling results from the Seiad Valley station. Table H-15 presents the SSCs, SEV scores, and the predicted responses of outmigrating juvenile coho salmon under the median impact year and severe impact year for the background condition and the Proposed Action based on modeling results at the Seiad Valley Station. Age-1+ outmigrating coho salmon from the Scott River population will experience major stress under both the Proposed Action median and severe impact year scenarios, with up to 20 percent mortality of fish in the spring outmigration period in Year 1. In Year 2, age-1+ coho salmon from the Scott River population will experience sublethal effects, with moderate stress under the median impact year scenario, and reductions in feeding and major stress under the severe impact year scenario.

Table H-15: SSC, SEV Score, and Juvenile Coho Salmon Outmigration Response Scenarios at the USGS Seiad Valley Station

Scenario	Year 1 (Drawdown)			Year 2		
	14- day Median SSC Range (mg/L)	SEV	Response	14- day Median SSC Range (mg/L)	SEV	Response
Background Median Impact Year	8 to 57	6 to 8	Sublethal effects, including reductions in feeding and major stress	1 to 37	5 to 7	Sublethal effects, including short – term reductions in feeding and moderate stress
Background Severe Impact Year	13 to 113	7 to 8	Sublethal effects, including reductions in feeding and major stress	35 to 191	7 to 9	Sublethal effects, including reductions in feeding and major stress
Proposed Action Median Impact Year	47 to 1598	8 to 10	Major stress, reduced growth, and 0 - 20% mortality of smolts for 10% of the spring outmigration period	8 to 20	6 to 7	Sublethal effects, including short – term reductions in feeding and moderate stress
Proposed Action Severe Impact Year	179 to 1899	9 to 10	Major stress, reduced growth, and 0 - 20% mortality of smolts for 30% of the spring outmigration period	12 to 59	7 to 8	Sublethal effects, including reductions in feeding and major stress

Table H-16 presents the 14-day median SSC, SEV scores, and estimated percent mortality of age-1+ coho salmon entering the mainstem Klamath River from the Scott River during the spring outmigration period for the median impact year and severe impact year scenarios. Juvenile coho salmon from the Scott River will begin entering the mainstem Klamath River by mid-to late-February when SSCs are elevated due to the initial reservoir drawdown. However, based on suspended sediment modeling output at the Seiad Valley station, SSCs are not expected to be high enough at the start of outmigration period to result in any mortality of outmigrating smolts. Under the median impact year scenario, a second suspended sediment peak in mid to late-June is expected to be high enough to cause mortality to a portion of coho salmon smolts outmigrating from the Scott River during Year 1. Under the severe impact year scenario, several events of elevated levels of suspended sediment are expected to occur during the outmigration period that are sufficiently high to cause mortality to a portion of juvenile coho salmon smolts outmigrating from the Scott River during Year 1. Based on suspended sediment modeling output and outmigration timing derived from the Scott River trap, outmigrating coho salmon from the Scott River population are expected to experience less than 1 percent (0.2 percent) and up to potentially 7 percent mortality under the median and severe impact year scenarios, respectively.

Table H-16: Age-1+ Coho Salmon Outmigrating from the Scott River Population by 2-week Exposure Period to 14-day Median SSCs at the USGS Seiad Valley Station and Associated Predicted Mortality for Year 1.

Exposure Period Year 1				Median Impact Year			Severe Impact Year		
Exposure Period	Start	End	Estimated % Run[1]	Median SSC	Median SEV	Estimated % Mortality	Median SSC	Median SEV	Estimated % Mortality
1	2/15	2/28	7%	435.5	9.2	0%	178.9	8.5	0%
2	2/29	3/13	18%	157.6	8.4	0%	188.2	8.6	0%
3	3/14	3/27	17%	106.2	8.2	0%	754.5	9.6	20%
4	3/28	4/10	11%	64.4	7.8	0%	498.8	9.3	0%
5	4/11	4/24	15%	51.2	7.6	0%	1899.3	10.2	20%
6	4/25	5/8	6%	47.1	7.6	0%	655.0	9.5	0%
7	5/9	5/22	11%	178.7	8.5	0%	484.2	9.2	0%
8	5/23	6/5	8%	91.0	8.0	0%	231.3	8.7	0%
9	6/6	6/19	5%	377.6	9.1	0%	531.7	9.3	0%
10	6/20	7/3	1%	1598.3	10.1	20%	1079.7	9.8	20%
Potential Mortality to Age-1+ Coho Salmon Outmigrants				Median Impact Year			Severe Impact Year		
				0.2%			6.7%		

[1] Estimated proportion of age-1 juvenile coho salmon outmigrants from 2008-2018 at Scott River RST site

Middle Klamath River Population

The Renewal Corporation evaluated the potential effects to outmigrating age-1+ coho salmon from the Middle Klamath River population using SSC modeling results from the Seiad Valley station. See Table H-15 for the SSCs, SEVs, and the predicted responses of outmigrating juvenile coho salmon under the median impact year and severe impact year for the background condition and the Proposed Action based on modeling results at the Seiad Valley Station.

Although no screw trap data are available for coho salmon spawning and rearing tributaries in the Middle Klamath River population, spring outmigrating juvenile coho salmon timing of entry to the mainstem Klamath River was assumed to be the same or later than the Upper Klamath River, based on environmental factors such as tributary water temperatures and discharges. Therefore, to assess the impacts of suspended sediment on age-1+ coho salmon outmigrating from the Middle Klamath River population, the Renewal Corporation used screw trap data collected from 2008 to 2016 at the Kinsman site, which is the closest mainstem trap location to tributary streams in the Middle Klamath River population unit (Figure 5-6 in Appendix A of the BA). The Renewal Corporation overlaid the median and severe impact year scenario daily SSCs at the Seiad Valley station (Figure 5-5 in Appendix A of the BA) with average weekly age-1+ coho salmon outmigration population estimates for 2008 through 2018.

Table H-17 presents the 14-day median SSC, SEV scores, and estimated percent mortality of age-1+ coho salmon entering the mainstem Klamath River at the Kinsman RST during the spring outmigration period for the median impact year and severe impact year scenarios. Juvenile coho salmon from middle Klamath River

tributaries will begin entering mainstem Klamath River by late-February when SSCs are elevated due to the initial reservoir drawdown. However, based on suspended sediment modeling output at the Seiad Valley station, SSCs are not expected to be high enough at the start of outmigration period to result in any mortality of outmigrating smolts. Under the median impact year scenario, a second suspended sediment peak in mid to late-June is expected to occur after a majority of coho salmon smolts have migrated downstream to the lower Klamath River, the estuary, or have already entered the Pacific Ocean. Under the severe impact year scenario, several events of elevated levels of suspended sediment are expected to occur during the outmigration period that are sufficiently high to cause mortality to a portion of juvenile coho salmon smolts outmigrating from middle Klamath River tributaries during Year 1. Based on suspended sediment modeling output and outmigration timing derived from the Kinsman trap, outmigrating coho salmon from the Middle Klamath River population are expected to experience less than 1 percent (0.2 percent) and up to potentially 8 percent mortality under the median and severe impact year scenarios, respectively.

Table H-17: Age-1+ Coho Salmon Outmigrating from the Middle Klamath River at the Kinsman RST by 2-week Exposure Period to 14-day Median SSCs at the USGS Seiad Valley Station and Associated Predicted Mortality for Year 1.

Exposure Period Year 1				Median Impact Year			Severe Impact Year		
Exposure Period	Start	End	Estimated % Run[1]	Median SSC	Median SEV	Estimated % Mortality	Median SSC	Median SEV	Estimated % Mortality
1	2/15	2/28	0%	435.5	9.2	0%	178.9	8.5	0%
2	2/29	3/13	9%	157.6	8.4	0%	188.2	8.6	0%
3	3/14	3/27	32%	106.2	8.2	0%	754.5	9.6	20%
4	3/28	4/10	5%	64.4	7.8	0%	498.8	9.3	0%
5	4/11	4/24	6%	51.2	7.6	0%	1899.3	10.2	20%
6	4/25	5/8	24%	47.1	7.6	0%	655.0	9.5	0%
7	5/9	5/22	17%	178.7	8.5	0%	484.2	9.2	0%
8	5/23	6/5	6%	91.0	8.0	0%	231.3	8.7	0%
9	6/6	6/19	0%	377.6	9.1	0%	531.7	9.3	0%
10	6/20	7/3	0%	1598.3	10.1	20%	1079.7	9.8	20%
Potential Mortality to Age-1+ Coho Salmon Outmigrants				Median Impact Year			Severe Impact Year		
				0.0%			7.7%		

[1] Estimated proportion of age-1 juvenile coho salmon outmigrants from 2008-2018 at Kinsman RST site

Lower Klamath River, Salmon River, and Trinity River Populations

The Renewal Corporation expects that Lower Klamath, Salmon, and Trinity River coho populations outmigrating in the spring of Year 1 will be present in the Klamath River for shorter durations and exposed to lower SSCs than those encountered closer to Iron Gate Dam. To assess the impacts of suspended sediment on age-1+ coho salmon in the lower Klamath River due to the Proposed Action, the Renewal Corporation calculated the median and severe impact year values for daily SSCs at the Orleans station downstream of the Salmon River confluence, and upstream of the Trinity River confluence with the Klamath River (see Figure 5-4 in Appendix A of the BA). Using conservative outmigration times of 14 days to reach the estuary,

the Renewal Corporation calculated the 14-day median SSCs by outmigration period for Orleans to determine the potential effects of elevated sediment concentrations on age-1+ coho salmon.

Table H-18 presents the SSCs, SEV scores, and the predicted responses of outmigrating juvenile coho salmon under the median impact year and severe impact year for the background condition and the Proposed Action based on modeling results at the Orleans Station. Age-1+ outmigrating coho salmon from the Lower Klamath River, Salmon River, and the Trinity River populations will experience major stress under both the Proposed Action median and severe impact year scenarios, with up to 20 percent mortality of fish in the spring outmigration period in Year 1. In Year 2, age-1+ coho salmon from the Lower Klamath River, Salmon River, and the Trinity River populations will experience sublethal effects, including major stress, under both scenarios.

Table H-18: SSC, SEV Score, and Juvenile Coho Salmon Outmigration Response Scenarios at the USGS Orleans Station.

	Year 1 (Drawdown)			Year 2		
Scenario	14- day Median SSC Range (mg/L)	SEV	Response	14- day Median SSC Range (mg/L)	SEV	Response
Background Median Impact Year	7 to 23	6 to 7	Sublethal effects, including short – term reductions in feeding and moderate stress	1 to 27	5 to 7	Sublethal effects, including short – term reductions in feeding and moderate stress
Background Severe Impact Year	11 to 75	7 to 8	Sublethal effects, including reductions in feeding and major stress	34 to 134	7 to 8	Sublethal effects, including reductions in feeding and major stress
Proposed Action Median Impact Year	27 to 949	7 to 10	Major stress, reduced growth, and 0 - 20% mortality of smolts for 10% of the spring outmigration period	18 to 43	7 to 8	Sublethal effects, including reductions in feeding and major stress
Proposed Action Severe Impact Year	96 to 961	8 to 10	Major stress, reduced growth, and 0 - 20% mortality of smolts for 20% of the spring outmigration period	13 to 49	7 to 8	Sublethal effects, including reductions in feeding and major stress

To determine the timing of entry of age-1+ coho salmon into the Klamath River from the Salmon River (RM 66.3), Trinity River (RM 43.4), and lower Klamath River tributaries, the Renewal Corporation reviewed screw trap data collected in Blue Creek (RM 16.0), McGarvey Creek (RM 6.4), Trinity River, Salmon River, and the Big Bar Trap on the Klamath River (RM 49.7). In most years that data are available, screw traps were not installed in Klamath River tributaries until mid-March or April, most likely due to persistent high flows or access constraints. In most years of operation, peak catches of age-1+ coho salmon occurred in May.

Because of inconsistencies in trap data and low numbers of Age-1+ coho salmon recorded at some trap locations, the Renewal Corporation did not estimate the percentage of outmigrants by two-week

outmigration period for the Lower Klamath River, Salmon River, and Trinity River populations of coho salmon.

Table H-19 presents the 14-day median SSC, SEV scores, and estimated percent mortality of age-1+ coho salmon entering the mainstem Klamath River during the spring outmigration period for the median impact year and severe impact year scenarios.

Based on general coho salmon outmigration timing and suspended sediment modeling output at Orleans station, SSCs are not expected to be high enough at the start of outmigration period in mid-February to result in any mortality of outmigrating smolts. Under the median impact year scenario, a second suspended sediment peak in mid to late-June is expected to occur after a majority of coho salmon smolts have migrated downstream to the estuary or have already entered the Pacific Ocean. However, a small portion of coho salmon smolts migrating from lower Klamath River tributaries, including the Salmon River and Trinity River after mid-June could experience up to 20 percent mortality during Year 1. Under the severe impact year scenario, two elevated SSC events are expected to occur in mid-April and mid-June that are sufficiently high to cause mortality to a portion of juvenile coho salmon smolts outmigrating from the five populations during Year 1. The Renewal Corporation expects up to 20 percent mortality of coho salmon emigrating to the Pacific Ocean for 10 percent of the two-week outmigration periods under the median impact scenario, and for 20 percent of the two-week outmigration periods under the severe impact year scenario.

Table H-19: 14-day Median SSCs at the USGS Orleans Station and Associated Predicted Mortality for Coho Salmon Smolts Outmigrating from the Lower Klamath River, Salmon River, and Trinity River Populations during Year 1.

Exposure Period Year 1				Median Impact Year			Severe Impact Year		
Period	Start	End	Estimated % Run[1]	Median SSC	Median SEV	Est % Mortality	Median SSC	Median SEV	Est % Mortality
1	2/15	2/28	-	184.8	8.5	0%	105.0	8.1	0%
2	2/29	3/13	-	56.5	7.7	0%	96.4	8.1	0%
3	3/14	3/27	-	53.9	7.7	0%	394.4	9.1	0%
4	3/28	4/10	-	28.3	7.2	0%	266.8	8.8	0%
5	4/11	4/24	-	26.7	7.2	0%	961.1	9.7	20%
6	4/25	5/8	-	38.3	7.4	0%	336.8	9.0	0%
7	5/9	5/22	-	58.8	7.7	0%	244.4	8.7	0%
8	5/23	6/5	-	53.6	7.7	0%	133.6	8.3	0%
9	6/6	6/19	-	138.8	8.3	0%	324.7	8.9	0%
10	6/20	7/3	-	949.2	9.7	20%	818.1	9.6	20%
Potential Mortality to Age-1+ Coho Salmon Outmigrants				Median Impact Year			Severe Impact Year		
				Up to 20% mortality for 10% of outmigration periods			Up to 20% mortality for 20% of outmigration periods		

Table H-20 includes a summary of the anticipated potential mortality to varying populations of outmigrating juvenile coho salmon during the spring of Year 1.

Table H-20: Summary of Predicted Age-1+ Coho Salmon Mortality Related to Spring Outmigration.

Population	Estimated Mortality as Proportion of Population	
	Median Impact Year	Severe Impact Year
Upper Klamath River	0.2%	12.0%
Shasta River	0.1%	15.4%
Scott River	0.2%	6.7%
Middle Klamath River	0.0%	7.7%
Salmon River	0 – 20% mortality for 10% of spring outmigration period	0 – 20% mortality for 20% of spring outmigration period
Lower Klamath River	0 – 20% mortality for 10% of spring outmigration period	0 – 20% mortality for 20% of spring outmigration period
Upper Trinity River	0 – 20% mortality for 10% of spring outmigration period	0 – 20% mortality for 20% of spring outmigration period
Lower Trinity River	0 – 20% mortality for 10% of spring outmigration period	0 – 20% mortality for 20% of spring outmigration period
SF Trinity River	0 – 20% mortality for 10% of spring outmigration period	0 – 20% mortality for 20% of spring outmigration period

During the spring and summer (March 1 to July 1) drawdown and dam removal periods, as specified in AR-2 – Action 3 (see Section 2.6.1 of the BA), the Renewal Corporation will monitor 13 key tributaries for fish concentrations and behavior, as well as tributary stream temperatures and mainstem SSCs. If Klamath River SSCs remain at elevated levels into the summer rearing/redistribution period, and water temperatures in natal tributary streams become stressful for age 0+ juvenile coho salmon, AR-2 Action 3 will be implemented to reduce the impacts of the Proposed Action on outmigrating age 0+ and 1+ juvenile coho salmon.

H.4 Dissolved Oxygen Effects

As described in Sections 5.1.1.2 and 5.1.2.2, the Renewal Corporation analyzed short-term effects of the Proposed Action on dissolved oxygen levels and applied the previous long-term effects analysis presented in the 2012 Biological Assessment (USBR 2012b).

The Renewal Corporation used a dissolved oxygen spreadsheet model (Stillwater Sciences 2011) to assess dissolved oxygen conditions downstream of Iron Gate Dam during reservoir drawdown. Because the model is sensitive to initial dissolved oxygen concentrations, the Renewal Corporation used two initial dissolved oxygen levels for the model boundary condition. Although dissolved oxygen levels may reach 100 percent saturation as flow passes through the Iron Gate Dam outlet tunnel, the Renewal Corporation used 80 percent saturation as a conservative estimate for the High Initial Dissolved Oxygen Scenario. Model input parameters and boundary conditions, as well as results for the High Initial Dissolved Oxygen Scenario are presented in Section 5.1.2.2.

For the Low Initial Dissolved Oxygen Scenario, the Renewal Corporation used 0 percent saturation to account for the unknown effects of high SSCs on flow entering Iron Gate Reservoir from the upstream Copco No. 1

Reservoir drawdown. The Low Initial Dissolved Oxygen Scenario is considered by the Renewal Corporation to be an extreme condition that, with the High Initial Dissolved Oxygen Scenario, provides the full range of impacts that may occur due to depleted dissolved oxygen levels as a result of reservoir drawdown. Results for the Low Dissolved Oxygen Scenario are presented below.

H.4.1 Coho Salmon Low (0 Percent) Initial Dissolved Oxygen Saturation Scenario

Table H-21 includes the dissolved oxygen model output for the median and severe impact year scenarios associated with a 0 percent initial dissolved oxygen saturation. Under both scenarios, initial dissolved oxygen concentrations are input as 0.0 mg/L at Iron Gate Dam in all months to represent uncertainty in water quality conditions within Iron Gate Reservoir due to drawdown of the Hydroelectric Reach reservoirs. Under the median impact year, the greatest distance of depleted dissolved oxygen occurs in mid-January when SSCs peak at 16,226 mg/L. Dissolved oxygen levels recover to 7 mg/L and 5 mg/L at RM 88.3 and RM 113.2, respectively, during the mid-January event. For reference, Indian Creek is located at RM 108.3, and the Salmon River is located at RM 66.3. The mid-January event occurs as the reservoirs are drawn down, reservoir outflow exceeds inflow, and stored sediments are mobilized. In the other months, depleted dissolved oxygen levels recover to 7 mg/L and 5 mg/L by RM 153.6 and RM 164.1, respectively.

Based on the model inputs, dissolved oxygen at Iron Gate Dam does not increase above 0 mg/L as 0 mg/L is the input value for initial dissolved oxygen at the Iron Gate Dam station under the Low Dissolved Oxygen Scenario. The distance of depleted oxygen conditions downstream of Iron Gate Dam varies daily depending on SSC concentrations, water temperatures, dissolved oxygen saturation, and tributary discharge. Juvenile coho salmon from the Upper Klamath River, Shasta River, Scott River, and Middle Klamath River populations that are emigrating from tributary streams in mid to late January may experience high SSCs and diminished dissolved oxygen conditions that may result in sublethal or lethal effects.

Under the severe year (1970) scenario, depleted oxygen downstream of Iron Gate Dam varies daily depending on SSC concentrations, water temperatures, dissolved oxygen saturation, and tributary discharge. Dissolved oxygen recovers to 7 mg/L and 5 mg/L by RM 107.0 and RM 138.6, respectively, during the peak SSC event in mid-June. However, the mid-January event (highest flow) results in the greatest distance until dissolved oxygen recovery to 7 mg/L and 5 mg/L at the estuary and at RM 47.3, respectively. For reference, the Trinity River is located at RM 43.4. Under this scenario, all populations of coho salmon could be affected during the mid-January event that is primarily driven by high flows (greater than 10,000 cfs) at Iron Gate Dam.

Table H-21: Estimated Location of Minimum Dissolved Oxygen and Location at which Dissolved Oxygen will Return to 7 mg/L and 5 mg/L Downstream of Iron Gate Dam due to High Short-Term SSC under the Proposed Action Coho Salmon Median Impact Year and Severe Impact Year Scenarios with 0 percent initial dissolved oxygen saturation.

Date[1]	Boundary conditions at Iron Gate Dam			Spreadsheet model output			
	Initial dissolved oxygen (at 0% saturation)[2] (mg/L)	IOD (mg/L)	BOD (mg/L)	Minimum dissolved oxygen (mg/L)	Location of minimum dissolved oxygen[3]	Location at which dissolved oxygen returns to 7 mg/L[4] RM	Location at which dissolved oxygen returns to 5 mg/L[4] RM
Coho Median Impact Year (WY 1991 Conditions)							
10/27/2022	0.0	0.0	0.0	0.0	0.0	170.3	179.7
11/24/2022	0.0	0.0	0.2	0.0	0.0	171.0	179.7
12/31/2022	0.0	0.0	0.2	0.0	0.0	170.3	179.0
1/13/2023	0.0	10.2	57.1	0.0	0.0	88.3	113.2
2/1/2023	0.0	2.4	13.5	0.0	0.0	153.6	164.1
3/1/2023	0.0	0.3	1.7	0.0	0.0	169.1	179.0
4/2/2023	0.0	0.1	0.5	0.0	0.0	166.6	177.8
5/15/2023	0.0	0.4	2.2	0.0	0.0	167.8	179.0
6/17/2023	0.0	7.8	43.7	0.0	0.0	154.2	164.7
7/1/2023	0.0	0.8	4.7	0.0	0.0	172.8	182.1
8/2/2023	0.0	0.3	1.7	0.0	0.0	170.3	180.3
9/17/2023	0.0	0.2	0.9	0.0	0.0	170.3	180.3
Coho Severe Impact Year (WY 1970 Conditions)							
10/23/2022	0.0	0.0	0.0	0.0	0.0	164.7	177.2
11/14/2022	0.0	0.1	0.3	0.0	0.0	162.3	174.7
12/31/2022	0.0	0.0	0.2	0.0	0.0	163.5	176.5
1/7/2023	0.0	0.4	2.0	0.0	0.0	0.0	47.3
2/7/2023	0.0	0.4	2.2	0.0	0.0	107.0	138.6
3/16/2023	0.0	1.1	6.0	0.0	0.0	122.5	145.5
4/15/2023	0.0	3.1	17.5	0.0	0.0	120.6	142.4
5/5/2023	0.0	1.0	5.4	0.0	0.0	141.7	156.7
6/16/2023	0.0	8.3	46.5	0.0	0.0	133.7	149.2
7/4/2023	0.0	1.3	7.0	0.0	0.0	168.5	180.3
8/2/2023	0.0	0.2	1.1	0.0	0.0	171.6	181.5
9/1/2023	0.0	0.1	0.6	0.0	0.0	171.6	180.9

[1] Year values updated from 2012 BA to reflect 2023 reservoir drawdown.
[2] An initial dissolved oxygen at 0 percent saturation was used based on uncertainty of water quality conditions in Iron Gate Reservoir due to reservoir drawdown,
[3] Location is miles downstream of Iron Gate Dam.
[4] Minimum acceptable dissolved oxygen concentration for salmonids. WY = water year

As described in H3, juvenile fish in the mainstem Klamath River during periods of poor water quality conditions are expected to employ behavioral responses, such as rapid downstream movement, or the use of clear, well-oxygenated tributary junctions to minimize the impacts of high SSC and low dissolved oxygen due to the Proposed Action. Additionally, the implementation of AR-2 Actions 1 and 3 will reduce the impacts to fish rearing in the mainstem Klamath River prior to the onset of drawdown that would be impacted by the mid-January peak SSC event, or emigrating from tributaries to the mainstem Klamath between March 1 - July 1 of the drawdown year that could be impacted by the mid-June peak SSC event. However, any juvenile coho salmon present in the mainstem Klamath River during the drawdown year could be impacted by diminished dissolved oxygen concentrations, especially during peak SSC events expected in mid-January and mid-June.